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Article

Access to Risk Mitigating Weather Forecasts and Changes in Farming Operations in East and West Africa: Evidence from a Baseline Survey

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Abstract: Unfavorable weather currently ranks among the major challenges facing agricultural development in many African countries. Impact mitigation through access to reliable and timely weather forecasts and other adaptive mechanisms are foremost in Africa's policy dialogues and socio-economic development agendas. This paper analyzed the factors influencing access to forecasts on incidence of pests/diseases (PD) and start of rainfall (SR). The data were collected by Climate Change Agriculture and Food Security (CCAFS) and analyzed with Probit regression separately for East Africa, West Africa and the combined dataset. The results show that 62.7% and 56.4% of the farmers from East and West Africa had access to forecasts on start of rainfall, respectively. In addition, 39.3% and 49.4% of the farmers from East Africa indicated that forecasts on outbreak of pests/diseases and start of rainfall were respectively accompanied with advice as against 18.2% and 41.9% for West Africa. Having received forecasts on start of rainfall, 24.0% and 17.6% of the farmers from East and West Africa made decisions on timing of farming activities respectively. Probabilities of having access to forecasts on PD significantly increased with access to formal education, farm income and previous exposure to climatic shocks. Furthermore, probabilities of having access to forecasts on SR significantly increased ($p < 0.05$) with access to business income, radio and perception of more erratic rainfall, among others. It was recommended that promotion of informal education among illiterate farmers would enhance their climatic resilience, among others.

Keywords: unfavorable weather; resilience; perception; start of rainfall; pests/diseases; forecasts

1. Introduction

Favorable weather is one of the major prerequisites for enhancing agricultural productivity in Africa [1]. This, however, is often least guaranteed by farm households at the onset of every production season [2]. Obviously, agricultural production potentials of several African countries are currently facing severe constraints from unexpected weather conditions, many of which had led to unquantifiable farm production losses. Over the years, pronounced droughts, reduction in volume of rainfall, excessive rainfall leading to flooding, too high and/or low temperature, among others had been reported in many African countries [3–5]. Inability to perfectly understand future weather conditions often exposes farmers to several production uncertainties which could necessitate adoption of some conservative approaches that sacrifice potential farm productivity through some risk minimization decisions [6].

The premise for promoting sustainable agricultural development in Africa is now anchored on ability to perfectly predict some weather parameters [7], along with many other environment-related production constraints [8]. This can be justified given high dependence of many African economies on agriculture [9], which averagely accounts for about 30% of the Gross Domestic Product (GDP) [10]. Similarly, African smallholder farmers often exhibit high vulnerability to welfare shocks, among which uncertainties in weather is notable [7,11].

Specifically, some recent uncertainties in weather parameters have undermined ability of several farm households to produce enough food for domestic consumption and market surpluses [7]. One of the major consequences on African economy is periodic hunger, which often beckons for international food aids [12].This problem is more pronounced in arid and semi-arid regions, which geographically face high vulnerability from crop failures as a result of droughts. In some other parts of Africa, seasonal hunger due to exposure to adverse weather conditions is annually witnessed by many households, especially those in highly fragile ecological terrains [13,14]. Therefore, African policy makers must come to understand the need to provide adequate solutions to agricultural development problems, in order to salvage the region from persistent hunger, especially among poor farmers [3,15].

Furthermore, unfavorable weather often disrupts farm production goals, thereby portending a systematically devised crisis for which adaptive capacities are sometimes very low [16,17]. The need to safeguard farm production activities from unpleasant variability in weather has made provision of timely weather forecasts an essential adaptation initiative. The past few decades have witnessed growing interest in the mechanisms for ensuring delivery of weather forecasts in a manner that ensures wider coverage and minimizes utilization risk [18]. Provision of accurate seasonal weather forecasts is a way of enhancing farm households' preparedness and their coping ability with adverse weather situations [19] in order to reduce associated welfare losses [20].

Due to its substantial vulnerability to weather vagaries, rain-fed agriculture which is mostly practiced in Africa can substantially benefit from seasonal weather forecasts [21]. Some research findings have indicated the usefulness of weather forecasts for reducing vulnerability of rain-fed agriculture to drought, flooding and extremely low or high temperature [22–26]. Initiatives to promote access of African farmers to weather forecasts include formation of several regional Climate Outlook Forums (COFs) in the late 1990s [27–30]. Similarly, growing need of weather forecasts has triggered establishment of Global Framework for Climate Services [31] by the World Meteorological Organization (WMO).

Some evidence abounds on the impacts of weather forecasts [32,33]. Therefore, they are able to realign farmers' livelihoods. These forms of livelihoods could also hinder rapidity of using weather information, with some secondary impacts on farm production system's ability to cope with other environmental stressors [34]. Some authors have hinted that the actual usefulness of weather forecasts is always far less than the expected benefits [33]. Empirical investigations that explore the pathways through which farm households adapt to adverse weather conditions are therefore needed [35].

Although efforts by several stakeholders in providing weather forecast services in order to reduce farm production losses resulting from extreme weathers are commendable, there are some issues in respect of access and utilization. Specifically, Nhemachena and Hassan [35] found that lack of access to weather information was among prominent constraints to adaptation in selected sub-Saharan Africa (SSA). In addition, utilization of weather forecasts is an area of research on which little is known. Therefore, studying the correlates of farm households' access to weather forecast is a noteworthy research effort. Findings from such studies can facilitate policy formulation and strategic investment options that would alleviate associated welfare losses resulting from unfavourable weather conditions [35]. This is a critical issue because farm households often lack substantial adaptation capacity to individually take initiatives to reduce their vulnerability. The objective of this study is to analyze the factors influencing access to weather forecasts on incidence of pests and diseases and start of rainfall among some farmers in East and West Africa, using a baseline survey.

2. Materials and Methods

The Data

The study used data from a baseline survey that was conducted by Climate Change Agriculture and Food Security [36]. The data were collected in 2010/2011 cropping seasons. Farm households in selected sites in East and West Africa constituted the sampling unit. Four countries comprising Ethiopia, Kenya, Tanzania and Uganda were selected in East Africa with total respondents of 140, 139, 140 and 280 respectively. In West Africa, however, five sites comprising Burkina Faso, Ghana, Mali, Niger and Senegal were selected with total sampled respondents 140, 140, 141, 140 and 140 farm households respectively. The detailed procedures for sampling had been described [37].

Specification of the Probit Model

The data were analyzed with Probit regression model since the dependent variable is qualitative. This was coded as binary variable with value of one for those with access to weather forecasts and zero otherwise. In this study, there are two distinct forms of weather forecasts that are being analyzed. These are outbreaks of pests/diseases and the start of rainfall. Estimation of the parameters of the Probit model demands estimation of Maximum Likelihood Estimates (MLE). This will guarantee efficient and unbiasedparameters [38]. The estimated model is as specified in Equation (1) below:

$$Y_{ij} = \alpha_j + \beta_{kj} \sum_{k=1}^{l} Z_{ij} + v_j \quad (1)$$

where α_j are the constant terms, β_{kj} are the coefficients of the independent variables, v_j are the stochastic error terms. The included independent variables (Z_{ij}) after correcting for multicollinearity are East Africa (yes = 1, 0 otherwise), personal land (ha), personal degraded land (ha), exposure to weather-related crisis in the past five years(yes = 1, 0 otherwise), assistance received during weather-related crisis (yes = 1, 0 otherwise), household size, household more 60 years, gender (male = 1, 0 otherwise), formal education (yes = 1, 0 otherwise), farm employment income (yes = 1, 0 otherwise), other paid employment income (yes = 1, 0 otherwise), business income (yes = 1, 0 otherwise), remittances or gifts income environmental services income(yes =1, 0 otherwise), projects/government income(yes = 1, 0 otherwise), bank loan (yes = 1, 0 otherwise), informal loan (yes = 1, 0 otherwise), renting of machinery income (yes = 1, 0 otherwise), renting out land income (yes = 1, 0 otherwise), more erratic rainfall (yes = 1, 0 otherwise), has radio (yes = 1, 0 otherwise), has television (yes = 1, 0 otherwise) introduced new crop (yes = 1, 0 otherwise), testing new crops (yes = 1, 0 otherwise) and stopped growing a crop (yes = 1, 0 otherwise). Statistical significance of estimated parameters was based on 5% level of significance.

3. Results and Discussions

3.1. Access and Sources of Weather Forecasts

Table 1 shows the distribution of respondents based on their access to forecasts on outbreak of livestock and crop pests/diseases and start of rainfall. Specifically, 62.7% and 48.4% of the farmers from East Africa respectively received information on outbreaks of pests/diseases and start of rainfall as against 29.2% and 56.4% for West Africa. These results emphasize the fact that there have been several initiatives in many African countries to transmit weather forecasts to smallholder farmers [39].Precisely, Kenya Meteorological Department (KMD) is constitutionally charged with the responsibilities of providing daily, weekly, monthly and seasonal weather forecasts for households in urban and rural areas [40].

However, desirability of weather forecasts to farmers is directly related to their veracity [41]. Similarly, the lead time of weather forecasts could vary from time to time and sometimes the shorter the better [42]. In many instances, forecasting the start of rainfall can be significantly seasonal with some intervals of months as the expected lead time [43]. Sometimes, weather forecasts often come with associated implications for agricultural production in terms of plant and livestock pathogen development and expected incidence of some diseases.

The results further show access to weather forecasts among the farmers based on their gender. In East Africa, 23.5% and 27.6% of the respondents indicated that both sexes had access to weather forecasts on outbreak of pests/diseases and start of rainfall, respectively. However, male farmers had slightly higher access to weather forecasts than their female counterparts. In addition, in West Africa, women had very low access to weather forecasts on outbreak of pests/diseases and start of rainfall with 1.3% and 1.0%, respectively, as against 16.7% and 32.3% for men.

Inequity in access to weather forecasts across gender had been perceived as a major issue in enhancing adaptive capacity of female farmers, despite the fact that they are already deprived by inadequate access to production resources. Disparity in access to weather forecasts can be directly linked to the medium of forecast transmission. In a study by African Climate Change Resilience Alliance (ACCRA) [44], it was found that women generally advocated for weather forecast transmission through church, local community groups and markets, while the men preferred radio stations, newspapers and local council meetings. In another study, Cherotich *et al.* [45] found that the majority of Kenyan's vulnerable women preferred to obtain weather forecasts through radio, while those who were elderly preferred to use indigenous knowledge.

The results further reveal that the majority of the farmers with access to forecasts got them through radio transmissions. This was followed by friends. It is also important to note that involvement of extension officers in weather forecast dissemination was highest for pests/diseases in East Africa. A good number of the farmers indicated that they were monitoring the weather on their own using some form of indigenous knowledge. Radio as a foremost source of accessing weather forecasts by farm households can be strongly linked to its affordability, portability and low maintenance cost. Chavas [46] noted that radio is among the major channels for reaching farmers with several technology-driven pieces of information. However, it was emphasized that efficiency of this medium in linking forecast information to rural farmers in sub-Saharan Africa is not well known [47,48].

Table 1. Percentage distribution of households' access to weather forecasts and their sources.

	East Africa		**West Africa**	
	Pest and Disease	**Start of Rainfall**	**Pest and Disease**	**Start of Rainfall**
Information received				
No	51.7	37.3	70.8	43.6
Yes	48.4	62.7	29.2	56.4
Person that received information				
Men	12.7	19.3	16.7	32.3
Women	12.0	15.3	1.3	1.0
Both	23.5	27.6	11.2	22.9
No response	51.8	37.8	70.8	43.8
Sources of Information				
Radio	36.2	53.8	24.2	51.5
Extension officers	13.7	2.0	0.6	2.2
NGOs	1.0	1.4	0.3	4.0
Friends	14.2	16.0	11.6	17.2
Traditional forecaster and Indigenous Knowledge	1.6	8.4	0.1	1.3
Own Observation	6.4	13.2	10.4	5.6
Local groups	6.0	3.7	4.0	1.0
Television	2.3	2.7	0.9	2.9
Meteorological offices	0.1	0.3	0.00	3.0
Newspaper	0.9	1.3	0.7	1.3
Religious Organizations	0.6	0.4	0.1	0.9
Cell-phone	0.0	0.0	0.0	2.0
Others	0.1	0.0	0.1	0.0

3.2. Weather Forecasts' Advice and Associated Changes in Farming Systems

One of the major issues of concern in weather forecast dissemination to farmers is their inability to properly decode disseminated weather information for best farm decision making. This becomes very critical in Africa, where the majority of the farmers are illiterate or possess inadequate formal education required for proper decision making as a result of complexity in climatic scenarios [49]. Therefore, recent dynamics in weather parameters have mesmerized the majority of African farmers and reckon ineffective their acquired indigenous adaptation knowledge. Therefore, farmers are in critical need of institutional supports from different agencies in order to cope with emerging and precarious weather conditions.

The results in Table 2 show that weather stations and other stakeholders that are directly involved in disseminating weather information to farmers do accompany them with pieces of advice on the implications that the forecasts are having for farmers' production decisions. The results further show that 39.3% of the farmers in East Africa indicated that the forecasts that they received on the outbreak of pests/diseases were accompanied by pieces of advice. In addition, 49.4% indicated that forecasts on start of rainfall were accompanied with advice of what the farmers could do. In West Africa, 18.2% and 41.9% of the farmers respectively indicated that weather forecasts on outbreak of pests/diseases and start of rainfalls were accompanied with advice. Due to the high illiteracy level among African farmers, the ability to properly utilize advice received on climatic forecasts would vary from one farmer to another farmer. The results, however, indicated that 33.2% and 44.2% of the farmers from East Africa were able to take some specific farm decisions based on pieces of advice received on outbreak of pests/diseases and start of rainfall, respectively. Among West African farmers, 13.3 and 34.0% of the farmers were able to use weather forecasts received on outbreak of pests/diseases and start of rainfall, respectively.

The need to supplement weather forecasts with such information is to ensure that farmers are properly guided on the implications of weather projections that they have received. The intent is also to bridge the lapses in educational attainments by farmers. However, the adoption perception model of Wossink *et al.* [50] emphasizes that ultimate use of a technology is a function of perception of its value, which is also directly linked several socio-economic characteristics such as education, farming experience, personality and their overall human values of the receivers [51].

Table 2. Percentage distribution of farmers that indicated inclusion of advice in forecasts and the ability to use them.

Region	East Africa		West Africa	
Nature of Forecast	**Pest and Disease**	**Start of Rainfall**	**Pest and Disease**	**Start of rainfall**
Forecast included advice				
No	8.4	12.3	11.0	14.3
Yes	39.3	49.4	18.2	41.9
No response	52.2	38.3	70.8	43.8
Able to use advice				
No	6.3	5.4	4.6	7.7
Yes	33.2	44.2	13.3	34.0
No response	60.5	50.4	82.1	58.2

Information on specific farm decisions that were made by the farmers was also collected during the survey. The results in Table 3 show that decisions on timing of farming activities were made by 24.0% and 17.6% of the farmers in East and West Africa, respectively, given that they had received weather forecasts on the start of rainfall. In addition, access to forecasts on the start of rainfall induced 20.0% and 12.7% of the farmers from East and West Africa to make land management related decisions. In East Africa, 5.2% and 5.3% of the farmers indicated that given that forecasts on the outbreak of pests/diseases were received, their farm inputs and types of livestock to be reared were altered. These results can be compared in West Africa with 4.3% and 2.4% of the farmers changing their farm inputs and livestock types respectively due to receipt of forecasts on pest/disease outbreak.

Sensitivity of farming operations to changes in weather explains to a very large extent how vulnerable the whole production systems are. The degree of understanding the nature of changes to be effected by farmers in response to access to weather forecasts underscores the degree of households' adaptability. It should be emphasized that adaptation effectiveness depends on many factors. Among these are degree of accuracy of received forecasts, farm households' endowment of resources such as land, other assets, family labour and receptiveness to changes. In some recent studies, Roudier *et al.* [38] found that among smallholder farmers from Senegal's two agro-ecological zones, access to weather forecasts induced about 75.0% of the farmers to significantly change their farming practices.

Table 3. Changes effected in farming due to forecasts and advice received by farmers.

Changes in Farming due to Forecast	East Africa		West Africa	
	Pest and Disease	Start of Rainfall	Pest and Disease	Start of Rainfall
None	4.3	3.7	1.9	1.9
Land management	4.4	20.0	0.9	12.7
Crop type	4.6	8.7	0.9	4.6
Crop variety	3.9	8.2	1.7	7.6
Use of manure/compost/mulch	0.0	4.4	0.6	3.2
Land area	0.0	0.0	0.3	0.6
Timing of farming activities	3.7	24.0	1.3	17.6
Soil & water conservation	0.3	4.3	1.0	2.2
Irrigation	0.3	0.6	0.0	0.0
Water management	0.0	1.3	0.0	0.3
Tree planting	0.3	3.0	0.0	1.9
Feed management	4.3	2.7	0.0	0.0
Change in inputs	5.2	0.9	2.4	1.7
Field location	0.0	0.0	0.0	0.0
Livestock type	5.3	0.1	4.3	0.0
Livestock breed	1.3	0.0	1.7	0.0
Field location	0.0	1.0	0.0	1.0
Others	13.5	0.4	1.9	1.4

3.3. Probit Regression Results of Factors Influencing Access to Weather Forecasts

Some descriptive statistics of the variables included in the Probit regressions models for East Africa, West Africa and the combined dataset are presented in Table 4. The table also shows the diagnostic indicators for ensuring that multicollinearity does not seriously exist among the selected variables. However, testing for multicollinearity among Probit regression variables using STATA 13 software (StataCorp LP, TX, USA) is not always directly executed. The available option was to invoke the Variance Inflation Factor (vif) command after subjecting the data to linear probability modeling. The results showed that multicollinearity was not a problem based on a high level of tolerance of the variables. Specifically, VIF for the results for East Africa, West Africa and combined data are 1.17, 1.16 and 1.19, respectively.It had been indicated that multicollinearity should be worried about if VIF is considerably higher than 1.0 [52].

However, recent econometric analyses emphasize a robustness check as a way of ensuring that parameters from regression analysis are not sensitive to removal of some important variables or reduction in the number of observations. In order to test for robustness of the results, the Probit regressions were run separately with East African data, West African dataand a combination of the two datasets. The aim was to test for sensitivity of the results to reduction in the number of observations. It also seeks to determine if there are differences in the parameters across the two African regions.

Tables 5 and 6 present the results of Probit regression data analyses for access to forecasts on outbreak of pests and diseases and start of rainfall respectively. Statistical significance of the Likelihood Ratio Chi Square statistics ($p < 0.05$) in all of the results implies that the estimated models produced good fits for the data in all the estimated models. The results show that compared to the results across regions, estimated models for the combined data have a higher number of the parameters being statistically significant at 5% level. The implication is that the results must be interpreted with cautions. All the models are therefore considered in the final interpretation of results.

In Tables 5 and 6, region-specific parameters (East Africa) which were included in the first model for the combined dataset are with positive sign and show statistical significance ($p < 0.05$). These results imply that compared to those respondents from West Africa and holding other variables constant, farmers from East Africa had significantly higher access to weather forecast on start of rainfall and outbreak of pests/diseases. The issue of access to weather forecasts in African agriculture had been perceived as major keys to enhancing adaptive capacity of farmers [53]. However, insurmountable obstacles include inadequate access as a result of limitations in transmission equipment, timeliness and usefulness of the information to the largely illiterate smallholding African farmers [20,53].

In Tables 5 and 6, the parameters of personal land areas owned by farmers did not show statistical significance in all the models, although they consistently have negative sign ($p > 0.05$).Table 5 shows that in the East African, West African and combined dataset models for access to forecasts on incidence of pests and diseases, the parameters of personal degraded land (ha) did not show statistical significance ($p > 0.05$). When the East Africa dummy was removed from the combined model, it shows statistical significance ($p < 0.05$) and implies that increasing degraded land areas owned by farmers would decrease the probability of having access to forecasts on incidence of pests and diseases. In Table 6, results for combined dataset and East Africa show that as the number of degraded land owned by farmers increased, probability of having access to forecasts on commencement of rainfall significantly decreased ($p < 0.05$).

Some studies have emphasized the complex interrelationships between land ownership, tenure patterns and exposure to unfavourable weather conditions [54]. The above result emphasizes the fact that farmers with more degraded land areas would have little incentives to seek for information on weather. Similarly, land ownership patterns can influence natural resource conservation, which invariably influences some climatic parameters. In addition, the size of farm land owned and fertility status would influence farmers' ultimate farm investment decisions and weather information seeking behaviour due to the enormity of expected losses in the event of unexpected weather [19]. Saka *et al*. [55] and Lawal *et al.* [56] emphasized that soil fertility status would influence the pattern of crop combination although degraded plots of land are often left to fallow and regain fertility for future uses.

In Table 5, all of the results consistently reveal that farmers with previous exposure to weather-related crises had significantly higher probability of having access to forecasts on incidence of pests and diseases ($p < 0.05$). Table 6, however, shows that, except for the parameter in West Africa's model, farm households that previously got exposed to weather-related crises had significantly higher probability of having access to forecasts on start of rainfall. Similarly, in Table 5, except for West African farmers, those who previously received assistance during climatic crisis had significantly higher probability ($p < 0.05$) of having access to forecasts on incidence of pests and diseases. In Table 6, except for East African farmers, those who previously received assistance during climatic crisis had significantly higher probability ($p < 0.05$) of having access to forecasts on start of rainfall. Rational farmers with previous exposure to climatic shocks are expected to guard against future occurrences by seeking weather-related information from every available source.

The results in Tables 5 and 6 further show that except in the results for East Africa on access to forecasts on start of rainfall, household size parameters did not show statistical significance in the estimated models. In some previous studies on factors influencing farmers' decisions on climate change adaptation, statistically insignificant parameters had been reported. For East Africa, access to weather forecasts on start of rainfall decreases significantly as household size increases. Similar result had been reported by Oyekale [20]. Accessing weather forecast is a form of production risk mitigation for which large households may possess high risk aversion adaptation may be risky subject to their peculiar circumstances [57–62].

The results presented in Table 5 further reveal that none of the parameters of members that are 60 years old or above are statistically significant ($p > 0.05$), while those for combined dataset and West Africa show statistical significance ($p < 0.05$) in Table 6. These results imply that as the number of household members that are 60 years or above increases, probabilities of accessing forecasts on the start of rainfall significantly decreases ($p < 0.05$). Table 5 shows that the probability of accessing weather forecasts on the incidence of pests and diseases increased significantly ($p < 0.05$) with attainment of formal education across all the estimated models. However, in Table 6, the parameter of education for West Africa did not show statistical significance ($p > 0.05$). The observed relationship between education and access to climate forecasts is expected given the fact that education would enhance farmers' awareness on existing media channels for sourcing weather forecast information [20]. Education may also enhance understanding of farmers on the consequences of adverse weather conditions and impact mitigating options. However, the probability of accessing weather forecasts on incidence of pests and diseases decreased significantly ($p < 0.05$) as the number of household members that are 60 years or more increased. Obayelu *et al.* [63] reported similar findings where the age of farmers reduced adoption of adaptation methods to unfavourable weather conditions in Nigeria.

The parameters of most of the livelihood sources variables in Tables 5 and 6 are with a positive sign, although many did not show statistical significance ($p > 0.05$) in Table 5. Except in access to the start of the rainfall model for East Africa, parameters of farm employment income are with a positive sign and statistically significant ($p < 0.05$). These results imply that farmers with production surpluses that bring some income for their households have higher probabilities of accessing forecasts on incidence of pests and diseases and the start of rainfall. This is expected since farming is among the occupations that are most vulnerable to weather vagaries [64].

Moreover, parameters of involvement in other paid employment in Table 5 did not show statistical significance ($p > 0.05$), while only that for East African farmers did not show statistical significance in Table 6. This implies that in the model for combined dataset and West Africa, involvement in other paid employment significantly increased the probability of having access to forecasts on start of rainfall. The parameters of access to business income also have positive sign and statistically significant ($p < 0.05$), except for West Africa in Table 5. These imply that access to business income increases probability accessing weather forecasts on incidence of pests and diseases and start of rainfall. The results go in line with the assertion of Rosenzweig and Udry [65] that rainfall forecasts enhance labour allocation. Farmers that are engaged in other wage employments and businesses would be cautious in their labour time allocation, due to existence of serious constraints, and would ensure that consequences from weather vagaries are maximally avoided.

Parameters of access to remittances or gifts income in Table 5 only showed statistical significance ($p < 0.05$) in the model with combined dataset. In Table 6, however, this variable shows statistical significance ($p < 0.05$) in all the models, except that for East Africa. Except in the model for East Africa, access to environmental services income and project/government income significantly increased ($p < 0.05$) probability of accessing forecasts on incidence of pests and diseases and start of rainfall, respectively. However, except in the model for East Africa, access to project/government incomes significantly reduced access to forecasts on incidence of pests and diseases ($p < 0.05$). Similarly, access to the renting out of machineries' income significantly increased ($p < 0.05$) access to forecasts on the start of rainfall (except in East Africa).Remittances and government supports for agricultural farmers are crucial ways of adapting to weather vagaries in agricultural production [66,67]. It had been shown that remittances are vital options for reducing rural poverty [68], which is the utmost development policy goal in many developing countries. The results have emphasized the need for enhanced income and farmers' livelihood diversification in the quest towards weather vagaries' impact mitigation. This finding is in line with that of Lyimo and Kangalawe [69]. Farmers that obtained bank loans had significantly lower probability of having access to forecasts on pests and diseases in the combined model and the start of rainfall in the models for East and West Africa. Access to informal loans significantly increased access to forecasts on incidence of pests and diseases in East Africa but reduced it in West Africa.

Table 5 shows that perception of more erratic rainfall significantly increased the probability ($p < 0.05$) of accessing forecasts on incidence of pests and diseases in the combined and West Africa models. Pests and disease causing pathogens often regain more vigour due to changes in weather parameters, thereby producing biotic and abiotic ecosystems where survival is optimized. Some pests/diseases that are associated with certain crops are often more pronounced during the rainy season or when rainfall is exceeding the usual average. Tubby and Webber [70] noted that changes in some weather parameters influence pests and disease incidences through changes in physiology of the host plants, enhancement of pests' and pathogens' developmental processes, inability of the pests' and pathogens' predators to survive and favourability of reported changes to non-native pests and pathogens [71].

Table 4. Descriptive statistics of selected variables and their multicollinearity diagnostics.

Variables	East Africa			West Africa			All Farmers		
	Mean	Std. Err.	Tolerance	Mean	Std Err.	Tolerance	Mean	Std. Err.	Tolerance
Personal land (ha)	2.83	0.12	74.75	5.54	0.37	88.55	4.18	0.20	83.44
Personal degraded land (ha)	0.25	0.03	91.66	1.08	0.07	90.24	0.67	0.04	92.27
Exposure to weather-related crisis (previous five years)	0.72	0.02	86.17	0.74	0.02	84.35	0.73	0.01	86.38
Assistance received during weather-related crisis	0.20	0.02	94.89	0.17	0.01	94.56	0.19	0.01	96.60
Household size	6.24	0.12	83.10	12.72	0.37	87.12	9.48	0.21	85.83
Household more 60 years	0.38	0.02	85.62	0.94	0.04	88.30	0.66	0.02	89.39
Gender (male)	0.37	0.02	89.19	0.42	0.02	90.63	0.39	0.01	84.00
Formal education	0.18	0.01	85.14	0.17	0.01	88.05	0.17	0.01	90.31
Farm employment income	0.34	0.02	85.78	0.47	0.02	95.24	0.41	0.01	93.85
Other paid employment income	0.36	0.02	92.37	0.26	0.02	92.48	0.31	0.01	93.20
Business income	0.02	0.01	87.21	0.03	0.01	91.88	0.03	0.00	94.25
Remittances or gifts income	0.07	0.01	92.15	0.15	0.01	90.83	0.11	0.01	91.37
Environmental services income	0.10	0.01	80.02	0.17	0.01	85.96	0.13	0.01	87.74
Projects/govt income	0.17	0.01	86.19	0.47	0.02	86.32	0.32	0.01	87.67
Bank loan	0.04	0.01	84.15	0.11	0.01	83.57	0.07	0.01	87.84
Informal loan	0.06	0.01	77.99	0.04	0.01	86.18	0.05	0.01	84.63
Renting of machinery income	0.25	0.02	82.27	0.44	0.02	93.57	0.35	0.01	82.62
Renting out land income	0.74	0.02	90.68	0.96	0.01	75.14	0.85	0.01	73.43
More erratic rainfall	0.90	0.01	81.10	0.75	0.02	68.14	0.83	0.01	62.69
Has radio	0.54	0.02	74.22	0.50	0.02	82.85	0.52	0.01	83.66
Has Television	0.18	0.01	94.86	0.10	0.01	88.12	0.14	0.01	86.13
Introduced new crop	0.46	0.02	88.36	0.27	0.02	75.03	0.37	0.01	78.09
Testing new crops	0.69	0.02	85.57	0.83	0.01	86.63	0.76	0.01	85.14
Stopped growing a crop	0.06	0.01	86.36	0.06	0.01	88.36	0.06	0.01	89.84

Table 5. Probit regression results of factors influencing access to forecasts on incidence of pests and diseases.

Variables	Coefficient.	Z stat	Coefficient.	Z stat	Coefficient.	Z stat	Coefficient.	Z stat
	Combined Data		Combined Data		East Africa		West Africa	
East Africa dummy	0.3763	3.84 *	-	-	-	-	-	-
Personal land (ha)	−0.0165	−1.87	−0.0171	−1.93	−0.025	−1.42	−0.009	−0.88
Personal degraded land (ha)	−0.0468	−1.70	−0.0686	−2.52 *	−0.087	−1.40	−0.023	−0.77
Exposure to weather-related crisis (previous five years)	0.4701	5.15 *	0.4518	4.98 *	0.458	3.42 *	0.544	3.95 *
Assistance received during weather-related crisis	0.2456	2.43 *	0.2403	2.38 *	0.557	3.54 *	0.03	0.2
Household size	−0.0002	−0.03	−0.0054	−0.94	−0.025	−1.34	0.003	0.42
Household more 60 years	−0.0230	−0.48	−0.0609	−1.28	−0.040	−0.45	0.008	0.13
Gender (male)	0.081	0.71	0.0076	0.07	0.084	0.6	0.161	0.61
Formal education	0.5067	4.50 *	0.6091	5.56 *	0.483	2.16 *	0.378	2.69 *
Farm employment income	0.2979	3.80 *	0.2806	3.60 *	0.352	2.94 *	0.28	2.47 *
Other paid employment income	0.121	1.22	0.1312	1.33	0.181	1.2	−0.126	−0.85
Business income	0.1961	2.43 *	0.1917	2.40 *	0.416	3.44 *	0.035	0.3
Remittances or gifts income	0.1693	2.00 *	0.1985	2.37 *	0.235	1.9	0.086	0.67
Environmental services income	0.8323	3.30 *	0.8239	3.26 *	0.369	0.86	1.046	3.23 *
Projects/govt income	−0.3601	−2.86 *	−0.4047	−3.26 *	0.404	1.83	−0.697	−3.94 *
Bank loan	−0.2795	−2.43 *	−0.2941	−2.57 *	−0.301	−1.58	−0.147	−0.96
Informal loan	−0.0385	−0.44	−0.1085	−1.29	0.493	3.18 *	−0.278	−2.48 *
Renting of machinery income	−0.2748	−1.84	−0.3272	−2.22 *	0.001	0	−0.284	−1.55
Renting out land income	0.4569	2.64 *	0.5036	2.94 *	0.431	1.77	0.332	1.19
More erratic rainfall	0.2174	2.65 *	0.1561	1.95	0.052	0.38	0.244	2.17 *
Has radio	0.515	5.28 *	0.504	5.16 *	0.853	6.19 *	−0.082	−0.55
Has Television	0.2479	1.55	0.2779	1.74	0.306	1.26	0.203	0.89
Introduced new crop	0.1642	2.06 *	0.1748	2.20 *	0.173	1.4	0.14	1.21
Testing new crops	0.103	0.95	0.1416	1.32	−0.221	−1.48	0.335	1.88
Stopped growing a crop	0.3431	4.24 *	0.3969	5.00 *	0.41	3.55 *	0.183	1.46
Constant	−2.1988	−1.83 *	−1.9056	−1.29 *	−2.118	−8.00 *	−1.528	−4.78 *
Log likelihood function	−769.26		−776.65		−44.448		−373.94	
LR Chi Square	328.39 *		313.61 *		279.37 *		96.230 *	
Pseudo R Square	0.1759		0.168		0.289		0.114	
Number of observations	1398		1398		699		699	

Note: * statistically significant at 5 percent.

In addition, Table 6 shows that farmers that perceived more erratic rainfalls had significantly higher probability ($p < 0.05$) of having access to forecasts on the start of rainfall in all of the estimated models. This result goes in line with the expectation, given the centrality of rainfall adequacy for production activities of crop farmers. The role of accurate forecasts cannot be downplayed, although the ability of farmers to decode the provided forecasts for optimum decision making is very critical for reducing the impacts of climatic uncertainties on farm production and decision making.

Table 6. Probit regression results of factors influencing access to forecasts on start of rainfall.

Variables	Coefficient.	Z stat	Coefficient.	Z stat	Coefficient.	Z stat	Coefficient.	Z stat
	Combined Data		Combined Data		East Africa		West Africa	
East Africa	0.3332	3.36 *	-	-	-	-	-	
Personal land (ha)	0.0105	1.42	0.0101	1.38	0.018	0.99	0.013	1.53
Personal degraded land (ha)	−0.0701	−2.71 *	−0.0870	−3.42 *	−0.159	−2.43 *	−0.037	−1.25
Exposure to weather-related crisis in the previous five years	0.2296	2.63 *	0.2208	2.54 *	0.358	2.74*	0.133	1.05
Assistance received during weather-related crisis	0.4631	4.21 *	0.4574	4.18 *	0.241	1.46	0.588	3.74 *
Household size	−0.0007	−0.11	−0.0048	−0.85	−0.056	−2.98 *	0.005	0.73
Household more 60 years	−0.1204	−2.52 *	−0.1517	−3.25 *	−0.078	−0.91	−0.157	−2.65 *
Gender (male)	−0.0302	−0.26	−0.0949	−0.84	−0.121	−0.87	0.462	1.75
Formal education	0.1465	1.41	0.2273	2.25 *	0.413	2.12 *	0.045	0.34
Farm employment income	0.3573	4.45 *	0.3442	4.31 *	0.217	1.76	0.375	3.34 *
Other paid employment income	0.2527	2.43 *	0.2565	2.47 *	0.225	1.40	0.309	2.11 *
Business income	0.3704	4.55 *	0.3624	4.47 *	0.343	2.68 *	0.373	3.33 *
Remittances or gifts income	0.2222	2.52 *	0.2476	2.83 *	0.125	0.98	0.270	2.08 *
Environmental services income	0.1053	0.41	0.1146	0.45	0.047	0.11	0.231	0.67
Projects/govt income	0.4556	3.53 *	0.4124	3.20 *	0.152	0.67	0.654	4.04 *
Bank loan	0.1005	0.86	0.0904	0.77	−0.39	−2.00 *	0.438	2.83 *
Informal loan	0.1775	2.03 *	0.1111	1.31	0.293	1.79	0.112	1.03
Renting of machinery income	0.5532	3.14 *	0.5001	2.87 *	0.832	1.91	0.523	2.60 *
Renting out land income	0.1346	0.70	0.1768	0.93	0.033	0.13	0.197	0.61
More erratic rainfall	0.2631	3.11 *	0.1969	2.41 *	0.406	2.75 *	0.234	2.09 *
Has radio	0.6232	6.71 *	0.5969	6.45 *	0.891	6.84 *	0.288	1.98 *
Has television	0.4731	2.49 *	0.5004	2.65 *	0.571	1.97 *	0.427	1.68
Introduced new crop	0.1604	2.00 *	0.1683	2.11 *	0.139	1.10	0.138	1.22
Testing new crops	−0.0938	−0.83	−0.0574	−0.52	−0.201	−1.34	0.117	0.64
Stopped growing a crop	0.2418	2.88 *	0.2868	3.47 *	0.377	3.15 *	0.105	0.83
Constant	−1.4419	−8.18 *	−1.1692	−7.52 *	−1.093	−4.75 *	−1.625	−5.11 *
Log likelihood	−758.24		−763.92		−339.49		−392.42	
LR Chi Square (25)	370.65 *		359.29 *		244.71		172.820	
Pseudo R^2	0.1964		0.1904		0.265		0.181	
No of observations	1398		1398		699		699	

Note: * statistically significant at 5 percent.

The results in Tables 5 and 6 further show that access to the radio significantly increased the probabilities of receiving forecasts on the incidence of pests/diseases (except in the model for West Africa) and the start of rainfall ($p < 0.05$). However, access to television also shows statistical significance

($p < 0.05$) in the model of the access to forecasts on the start of rainfall in the combined and East African models. It has been noted that enhancing accessibility to climatic forecasts among farmers relies so much on access to radios due to its low cost of maintenance and wide coverage [45–47]. Tables 5 and 6 also show that farmers that introduced new crops and stopped growing a crop had significantly higher probabilities of having access to forecasts on incidence of pests and diseases and the start of rainfall in the combined and East African models. These results are in line with expectations given that these underscore vulnerability to unfavourable weather situations, which may have necessitated farmers to adapt.

4. Conclusions

Mitigating the impacts of exposure to unfavourable weather in Africa requires utmost assistance from meteorological agencies in disseminating weather forecasts in order to enhance preparedness of farmers for some weather-related adversities. However, the development of our weather stations to meet the growing challenges of uncertain weather becomes very critical given that disseminated forecasts must present the reality of expected climatic problems. In many African countries, infrastructure and human capacities that are needed for attaining such efficiency are acutely lacking. Therefore, linkages with international weather forecasting institutions have been initiated, although dissemination and interpretation of weather forecasts at local and community levels is critical for enhancing adaptive capability of farmers. The findings from the study have emphasized integration of more efforts by African governments in disseminating weather forecasts to farmers. This should be ensured in a manner that properly takes farmers' genders and associated complexity into consideration. The medium for transmitting the forecast was also found to be of importance, with radio being the most effective channel. This underscores the need to annex efforts to facilitate transmission of weather forecasts in local languages that can be properly understood by several illiterate farmers. Once the information is received, extension agents should be properly trained to discharge the responsibility of properly decoding received weather forecasts for utmost decision making by farmers. Informal education from extension agents can bridge the education gap among farmers. This is very critical because attainment of formal education was found to be of significant relevance in promoting access of farmers to weather forecasts. Such education should also integrate their indigenous knowledge for proper perception of future changes in weather parameters. Moreover, promotion of income diversification through engagement of farmers in several livelihoods would enhance farmers' access to necessary resources for adapting to future changes in weather parameters.

Conflicts of Interest

The author declares no conflict of interest.

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