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# Effect of Global-GAP Policy on Climate Change Perceptions of Smallholder French Beans Farmers in Central and Eastern Regions, Kenya

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**Abstract:** The risks posed by climate change to Sub Saharan Africa's (SSA) smallholder fresh export fruit and vegetables production are amplifying the significance of farmers' climate change perceptions in enhancing adoption of suitable adaptation strategies. Production of fresh export fruit and vegetables in Kenya has increasingly been done under the Global-GAP standard scheme by smallholder farmers to improve both environmental conservation and market access. The objective of this study was to determine the effect of Global-GAP policy on climate change perceptions of smallholder French beans farmers. The analysis was based on data collected from a random sample of 616 households interviewed in the Central and Eastern regions of Kenya. The study used principal component analysis (PCA) to extract farmers' key prevailing climate change perceptions and logit regression model to examine the effect of Global-GAP policy on climate change perceptions among other socio-economic factors. The PCA analysis extracted three components proxying for 'droughts', 'delay in rainy seasons', 'diseases and pests' and three proxying for 'hot days', 'floods', and 'diseases and pests' as summarizing maximum variance in the perceptions in the Central and Eastern region respectively. The common, study area-wide climate change perception was identified as incidence of diseases and pest. Logit regression analysis found that Global-GAP policy significantly influenced and improved farmers' probability of perceiving climate change. Other factors found to influence farmers' probability of having the identified climate change perceptions included regional specificity, access to agricultural extension service, access to credit, plot size, and soil fertility. The policy implication of this study is that the government and service providers should mainstream factors like Global-GAP compliance and regional considerations found to improve probability of perceiving climate change in awareness creation extension strategies, towards enhancing adoption of adaptation measures in the smallholder fruits and vegetables farming sector.

**Keywords:** Global-GAP certification; climate change perception; principal component analysis; logit regression model; smallholder; French beans farming; Kenya

## 1. Introduction

The risks posed by climate change to Sub Saharan Africa's (SSA) smallholder fresh export fruit and vegetables production are amplifying the significance of farmers' climate change perceptions in enhancing adoption of suitable adaptation strategies [1]. Coupled with the reduced possibility for expansion of land under production, the impact of climate change on crop yields is already presenting serious livelihood consequences to smallholder farmers in SSA [2–5]. This situation is further complicated by consumers' increasing environmental conservation and food safety concerns in the developed countries [6,7]. These concerns have led most European Union (EU) countries providing

the key market for fresh fruit and vegetables from SSA to enforce regulatory mechanisms aimed at addressing climate change effects in accordance with Kyoto protocol [8–11]. On the other hand, these regulatory measures have triggered the enforcement of quality assurance standards by EU private buyers in smallholder farms through third party certification due to apparent commercial risks [11–14].

In the last decade, the SSA's fresh fruit and vegetables exports to EU and United Kingdom (UK) markets respectively increased to about 40% and 25% of the total imports with the fastest growth registered in chilies, green peppers and French beans [9,15,16]. This market supports the livelihoods of about one million people in SSA and at least a quarter a million people in East Africa [9,16–18]. Kenya exports the largest share of French beans to the EU [7,19,20], which accounts for 70 percent of all vegetables and 21 percent of horticultural exports [7,10]. About 60 percent of the French beans export is produced by Kenyan smallholder farms ranging between 0.15 and 2 hectares [21–23].

Evidence suggests that the survival of French beans farming as a significant contributor to rural Kenya's socio-economic development is increasingly under threat due to its vulnerability to climate change and weather variability, despite the growing export market demand [15]. For instance, the area under production, volume and value decreased by 37%, 39% and 45% respectively between 2008 and 2010, due to prolonged drought experienced in the year 2008 to 2009 [21]. The national climate change response report acknowledges that "the evidence of climate change in Kenya is unmistakable" [24,25]. Further evidence suggest that temperature and rainfall will respectively continue having increasing and decreasing trend with implications for smallholder French beans farming [24,26–28]. This provide an indication that adoption of targeted climate change strategies might be the key to securing the livelihood of farmers depending on French beans in the traditional production areas [29,30]. The existing literature suggesting that smallholder farmers are likely to be seriously affected by climate change notwithstanding, only a minority of them are said to have taken advantage of adaptation strategies [31]. The future challenge confronting smallholder French beans industry therefore remains two-fold: to adapt to a changing and more variable climate and to increase productivity [32–35].

Policies and markets are considered among key factors defining responses of the farmers to climate change shocks like water stress and drought [32,36–38]. In the last decade, a number of smallholder farms in Kenya have embraced quality assurance standards for improved environmental conservation, better prices, and market access [39,40]. Among the quality assurance standards, Global-GAP policy has increasingly gained significance in supporting access to required production management skills and climate change adaptation capacity in Kenya's French bean farming through third party certification [7,13,16,25,41,42]. This has over the period been revised with the inclusion of different accreditations such as Linking Environment and Farming (LEAF) [11]. The benchmarking of Global-GAP, for instance with LEAF, makes farmers commit to adoption of integrated farm management with a focus on aspects like improved soil, water, fertility management and optimized use of production resources [43,44]. This makes Global-GAP policy acquire the status of an agri-environmental policy bolstering management practices towards benefiting the environment and providing economic incentives for adoption of climate change adaptation strategies to farmers [40,45].

Recent studies suggest that past experiences with environmental policies like Global-GAP will more likely affect climate change perceptions of farmers with a bearing on their response decisions [46]. In Kenya, significant support has been offered towards enhancing farmers' capacity on economic and environmental management among Global-GAP standards certified smallholder producers [47]. While Global-GAP policy certification is considered as providing farmers with the opportunities for improved climate change adaptation and acquisition of good management skills, only a minority are said to have taken advantage of it [31,40]. It is also unclear how Global-GAP policy certification has translated into improved perceptions among smallholder farmers undertaking fresh fruit and vegetables farming [32]. Hence, a clear understanding of the role of Global-GAP policy on climate change perceptions of smallholder French beans farmers is essential in supporting policy makers and

industry service providers in designing suitable and more focused adaptation strategies for fresh fruit and vegetables farming [32–35]. A number of previous studies have applied factor analysis and regression models to determine the effect of agri-policies on farmers' climate change perceptions [46]. However, these analyses did not include smallholder French beans farms, which are significant and fast becoming vulnerable to climate change with respect to export vegetables produced in SSA.

This paper explores the relationship of smallholder farmers' climate change perceptions with Global-GAP policy certification. The Global-GAP policy certification may affect the capacity of smallholder fresh fruit and vegetables farmers to perceive climate change if they acquire necessary skills for implementing integrated farm management with a focus on exacerbating vulnerabilities and improving market access. The study assesses two dimensions of perception: farmers' prevailing climate change perceptions and the effect of Global-GAP policy compliance through certification on the key perceptions.

## 2. Data and Methods

### 2.1. Global-GAP Policy Compliance through Certification in the Study Area and Sampling

Smallholder farmers in the Central and Eastern regions of Kenya produce 90 percent of the total national French beans output [14,21]. To enhance their access to export market, a higher proportion of French beans farmers in these areas have been complying with Global-GAP policy through certification compared to other areas. Under Global-GAP standards, the capacity of certified farmers is improved in areas such as integrated farm management (IFM). The acquired skills and technologies are assessed to support reduction of vulnerability to climate change and improves agricultural production potential [24,25,41].

Smallholder French beans farmers are usually certified under the Global-GAP standards option for producer groups upon compliance with farm audits [44]. To acquire certification status, individual farmers normally form producer group which then pursue compliance with certification regulation points. Through interactions with a marketer such as an export firm looking for a stable source of quality and safe supplies for EU market, producers are usually sensitized to get certified to access targeted certified markets [44]. The targeted markets normally get high or premium quality from organized Global-GAP certified farmers [40]. In return, farmers are driven by expected price premium, market pressure and reputation to actualize Global-GAP requirement [40,48].

Whereas noncertified farmers might meet minimum market quality standard, the difference in quality is assessed to vary when farmers are Global-GAP certified [40]. The quality variation is because wholesalers dealing mostly with intermediaries usually target mass consumer markets while retailers dealing with export firms target high maintenance consumer markets. This helps overcome a situation where French beans producers self-select themselves into these two categories of groups and the dishonesty of quality across smallholder producers.

The formation of smallholder farmer groups with cohesive members in the study area takes place within manageable distances to ease establishment of a quality management system notably in villages [44]. This allows the company buying produce from the certified groups in a particular village to easily undertake periodic trainings, intensive monitoring on compliance with the requirement and tracking of evidence of produce traceability in the immediate supply chain [34,49]. Based on this exposure, certified farmers are assessed to have superior skills and drive on environmental conservation management compared to non-certified farmers.

The integrated farm management skills acquired under Global-GAP policy by farmers in these areas is assessed to have a bearing on how they perceive and adapt to climate change [25,41,46]. The study interviewed a random sample of 616 Global-GAP complying and noncomplying farmers in 77 villages between September and October 2013 using a semi-structured questionnaire.

The number of smallholder French beans farmers interviewed from each region was arrived at using proportionate to size criteria. Multistage sampling was used to select the counties, sub-counties,

wards and the villages from which farmers were selected. The updated lists of counties, sub-counties, wards and villages with active French beans production activities and the list of all the active French beans farmers in each of the villages totaling 1451 forming the sampling frame was obtained from the Ministry of Agriculture staff in each area. Systematic random sampling was used to select farmers to be interviewed in each of the selected region. Enumerators were trained and questionnaire pre-tested to enhance its effectiveness and data reliability. The trained enumerators conducted the interviews with the household respondent using a face-to-face approach. Only household decision maker/spouse was interviewed. The principal question was whether the farmer had noticed long term changes in weather elements in the last 20 years and whether they were complying with Global-GAP through certification. All sampled households were interviewed, through the support of the local agricultural extension officers and village heads in identification of households. The high response rate was achieved due to the sampling approach which targeted active French beans farmers, and the developed trust of the farmers as a result of the pre-contact visit by the local agricultural extension staff and local administrative chiefs to set up the interviews using the letter from the national council of science and technology authorizing the survey. It was also enhanced by the short length of the questionnaire, the timing and the adopted face-to-face method of implementation. Data collected included information on Global-GAP compliance through certification, weather related risks, climate change perceptions and other socio-economic characteristics of the farmers. Data analysis was done using factor analysis and regression methods. Descriptive statistics such as mean and percentages were generated using Statistical Package for Social Scientists (SPSS). Factors conditioning climate change perceptions of farmers were analyzed using Limdep software. The descriptive statistics of key variables are presented in Table 1. The statistics show that about 20% of respondents were complying with Global-GAP through certification in the study area. It also indicates that 76%, 70% and 54% respectively had noticed increase in hot days, decrease in rains and increased incidences of pest and diseases. About 42% and 31% have noticed increase in frequency of droughts and delay in start of rainy season respectively.

**Table 1.** Descriptive statistics of key variables and their hypothesized signs.

| Variable | Description | Value | Mean | Std Dev | Expected Sign |
|---|---|---|---|---|---|
| | Dependent variables | | | | |
| INHD | Increase in number of hot days | 1 if perceived, 0 otherwise | 0.763 | 0.426 | |
| MFD | More frequent droughts | 1 if perceived, 0 otherwise | 0.424 | 0.495 | |
| DSRS | Delay in start of rainy seasons | 1 if perceived, 0 otherwise | 0.305 | 0.481 | |
| LR | Less rains | 1 if perceived, 0 otherwise | 0.701 | 0.458 | |
| MFF | More frequent floods | 1 if perceived, 0 otherwise | 0.424 | 0.495 | |
| IIDP | Increase in incidences of diseases and pests | 1 if perceived, 0 otherwise | 0.542 | 0.499 | |
| RSES | Rainy seasons ending sooner | 1 if perceived, 0 otherwise | 0.203 | 0.403 | |
| | Independent variables | | | | |
| Gender | Gender of household head | 1 if male, 0 otherwise | 0.360 | 0.481 | + or − |
| Household size | Number of family members of a household | Number | 4.470 | 1.819 | + or − |
| Farming experience | Years of farming experience | Number | 15.762 | 10.316 | + |
| Wealth | Measured in tropical Livestock Unit index | Number | 2.047 | 2.307 | + |
| Farm size | Area under French beans | Hectare | 0.203 | 0.206 | + |

**Table 1.** *Cont.*

| Variable | Description | Value | Mean | Std Dev | Expected Sign |
|---|---|---|---|---|---|
| Soil fertility | Farmer's perception of soil fertility level | 0 = infertile, 1 = fertile, 2 = highly fertile | 0.810 | 0.527 | + |
| Extension | If accessed extension services | 1 Yes, 0 otherwise | 0.334 | 0.472 | + |
| Weather information | If accessed weather and climate information | 1 if Yes, 0 otherwise | 0.047 | 0.212 | + |
| Credit | If accessed credit sources | 1 if Yes, 0 otherwise | 0.360 | 0.480 | + |
| Land ownership | If owned land | 1 if Yes, 0 otherwise | 0.030 | 0.169 | + |
| Global-GAP | If Global-GAP certified | 1 if Yes, 0 otherwise | 0.198 | 0.147 | + |
| Region | Farmer's region | 1 if Central, 0 otherwise | 0.500 | 0.500 | + |
| Off-farm job | If having off-farm employment | 1 Yes, 0 otherwise | 0.890 | 0.316 | + or − |

MFD—more frequent droughts; MFF—more frequent floods; DSRS—delay in start of rainy seasons; INHD—increased number of hot days; IIDP—increased diseases and pest incidences; LR—Less rains; RSES—rainy season ending soon. Source: Survey data, 2013.

## 2.2. Assessment of Prevailing Climate Change Perceptions

The study was based on emerging literature applying psychological distance theory to climate change by testing whether smallholder French beans farmers' Global-GAP experiences affect their climate change perceptions [46,50]. The psychological distance theory posits that events that are temporally, socially, or geographically close to a person are more tangible and this experience results in greater likelihood to adapt to or mitigate the problem. This theory suggests that a firsthand encounter with Global-GAP's integrated farm management skills trainings aimed at mainstreaming environmental conservation can help clarify risks often leading to heightened assessment of risk [51]. According to [52,53], these personal experiences can also affect climate belief and intentions and behaviours to deal with such risks. Previous studies for instance show that farmers who felt water availability had decreased overtime were more likely to belief climate change is risky and adopt behaviours for adaptation and mitigation [54].

The study identified the underlying French beans farmers' climate change perceptions using factor analysis. This was applied to reduce large numbers of observed farmers' climate change perception variables to fewer underlying dimensions viewed as representing more authentic measure of climate change perception factors [55,56]. The principal component analysis (PCA) was used as the data reduction method during the factor analysis to ensure that all the variability in the observed variables were used [57]. In addition, the study used Likert scale to find out the general clustering of variables for explanatory purposes under the believe that variable correlation was less than 0.6 [58,59].

The principal components were ordered in such a way that the first component accounted for the largest possible amount of variation in the original variables [60]. The second component, accounted for the maximum not accounted for by the first and was completely uncorrelated with the first principal component. The third component accounted for the maximum that the first and the second did not account for and so forth. Following the approach used by [57], the principal component was computed as follows:

$$PC_n = f(a_{ni}X_i \ldots a_{1k}X_k) \tag{1}$$

where PC is the component score, n is the total number of PCs, a is the component loading, X is the measured value of variable, i is the component number and k is the total number of variables. If the number of principal components is greater than 1, say n numbers, then each principal component will

be a continuous variable or quantity related to the products of the values of the constituent variables and their respective weightings or component loading (a). The study by [57] further observes that the relationship is an additive one hence the value of the principal component can be obtained by addition of the products as shown in the equation:

$$PC_n = f\,(a_{11}X_1 + a_{12}X_2 + \ldots + a_{1k}X_k) \tag{2}$$

where PC1 is the first principal component, $a_{1k}$ is the regression coefficient for the kth variable that is the eigenvector of the covariance matrix between the variables, and $X_k$ the kth variable.

In the present study, the key climate change perceptions of the farmers were estimated from actual observed data. The study examined the difference in climate change perceptions among smallholder French beans producers in the two study regions. The study hypothesized that if climate change and variability is an 'aggregate of indicators' then the perceptions of smallholder French beans farmers aggregated region-wide should reflect factors that speak to the complex ways that they perceive climate change in the two regions. For this purpose, the data on all the farmers' responses were combined for each region. The farmers gave their perceptions on some of the attributes regarding the changes in temperature and rainfall on the Likert scale of one to three (where 1 = disagree, 2 = unsure/neutral, 3 = agree). The perceptions tested included changes in rainfall, drought, temperature, floods and diseases and pests. The 7 items were: more rain, more frequent droughts, more frequent floods, delays in start of rainy seasons, late ending of rainy seasons, increase in number of hot days, and increase in incidences of diseases and pests. These were reduced using PCA while still reflecting a large proportion of the information contained in the original dataset. Data was screened to ensure no outliers. The minimum amount of data for factor analysis was satisfied for each group with a sample size of 307 for Eastern and 309 for Central region farmers. All the variables analysed satisfied several well-recognized criteria for factorability of correlation. The Kaiser-Meyer-Olkin measure of sampling adequacy considered was that of above the threshold of 0.5. Any value below 0.5 was considered miserable according to [60]. The Bartlett's test of sphericity for the two regions was done at 1 percent level of significance. Since there was no relationship between the components, varimax rotation, which is a form of orthogonal rotation strategy was used.

*2.3. Binary Regression of Factors Influencing Farmers' Climate Change Perceptions*

The study assessed the determinants of identified farmers' climate change perceptions, since the findings from PCA were deemed as insufficient to indicate whether the results are sensitive to other factors. The study tested whether they were influenced by socio-economic factors among them Global-GAP policy compliance. Other factors deemed to influence the modelled climate change perceptions were based on literature review and included respondents' socio-economic and institutional factors [31,32,37]. Factors likely to influence the farmers' perceptions were assessed by estimation of a model that allows the inclusion of these respondents' socio-economic and institutional factors as independent variables into the perception function. The dependent variable was binary (= 1 if the farmer stated the identified climate change perceptions; or 0 if otherwise). The climate change perception function for smallholder French beans farmers was hence specified as:

$$CCP_i = f\,(G_i, PS_i, E_i, GGC_i \ldots\ldots\ldots) \tag{3}$$

where: *CCP* = binary (1 if farmer stated the identified climate change perception *i*, 0 otherwise); *G* = Gender; *PS* = Plot Size; *E* = extension; and *GGC* = Global-GAP Compliance.

The estimated model was therefore written as:

$$CCP = X_i\beta_i + \mu \tag{4}$$

where *X* is a vector of explanatory variables, *β* is a vector of coefficients and *μ* is a random variable accounting for unobservable characteristics. Logit model was used to estimate the explanatory variables that influenced the identified climate change perceptions of the farmers. The descriptive statistics and hypothesized signs of the modelled variables are presented in Table 2.

**Table 2.** Factor loadings and communalities for climate change perceptions of farmers in the Central region (*n* = 253).

| | Droughts | Delays in Rainy Seasons | Diseases and Pests | Communality |
|---|---|---|---|---|
| There have been more frequent droughts | 0.79 | 0.11 | 0.20 | 0.67 |
| There have been more rains | −0.64 | −0.18 | 0.43 | 0.63 |
| There have been delay in start of rainy seasons | 0.16 | 0.86 | 0.03 | 0.76 |
| Rainy seasons have been ending sooner | 0.36 | 0.81 | −0.03 | 0.78 |
| Incidences of diseases and pests have been increasing | 0.33 | −0.16 | 0.74 | 0.68 |
| There have been more frequent floods | −0.18 | 0.45 | 0.65 | 0.66 |
| Number of hot days have been increasing | 0.36 | 0.24 | 0.09 | 0.53 |
| Eigenvalue (4.72) | 2.43 | 1.22 | 1.07 | |
| % of variance explained (67.40) | 34.71 | 17.45 | 15.24 | |

Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy, 0.664; Bartlett's Test of Sphericity significant at one percent. Method: varimax rotation.

## 3. Results

### 3.1. Farmers' Climate Change Experiences

The study solicited farmers' responses to their overall experienced changes in key climatic variables of temperature and rainfall in the last 20 years. The study found that the majority of French beans farmers (64 percent, *n* = 394) felt that temperature had increased over time while approximately 22 percent (*n* = 135) and 14 percent (*n* = 87), respectively, felt it had decreased or it had stayed the same. On the other hand, 66 percent (*n* = 407) of the farmers felt that rainfall had decreased over time while approximately 30 percent (*n* = 185) felt it had decreased; only about four percent (*n* = 96) felt it had stayed the same. The results on impressions of farmers regarding changes in temperature and rainfall was found to be consistent with prior studies and the National Climate Change Response report. This report indicates an increasing trend and further states that Central and Eastern Kenya regions have observed temperature changes in the period 1960 to 2006 on an increasing trend [24,26–28]. The high proportion of farmers noticing a decrease in precipitation could be explained by the fact that during the last few years, there was a substantial decrease in the amount of rainfall. Thus, perception of farmers of a reduction in rainfall over the period is explained by the fact that, as [1] noticed, some farmers place more weight on recent information than is efficient.

### 3.2. Types of Farmers' Climate Change Perceptions

The study collected responses to changes in specific climatic aspects in relation to their French beans production activity. The results of PCA analysis of climate change perceptions among farmers in the Central and Eastern regions are summarized in Tables 2 and 3.

**Table 3.** Factor loadings and communalities for climate change perceptions of farmers in the Eastern region (*n* = 241).

| | Hot Days | Floods | Diseases and Pests | Communality |
|---|---|---|---|---|
| Number of hot days have been increasing | 0.78 | −0.08 | 0.05 | 0.61 |
| There have been more frequent droughts | 0.77 | 0.23 | −0.06 | 0.66 |
| There have been delay in start of rainy seasons | 0.61 | 0.38 | −0.47 | 0.73 |
| There have been more rains | −0.76 | 0.13 | −0.004 | 0.59 |
| There have been more frequent floods | −0.11 | 0.86 | 0.15 | 0.78 |
| Incidences of diseases and pests have been increasing | 0.10 | 0.15 | 0.88 | 0.81 |
| Rainy seasons have been ending sooner | 0.45 | 0.48 | −0.43 | 0.62 |
| Eigenvalue (4.81) | 2.62 | 1.12 | 1.07 | |
| % of variance explained (68.75) | 37.46 | 15.96 | 15.34 | |

Kaiser-Meyer-Olkin Measure of Sampling Adequacy, 0.723; Bartlett's Test of Sphericity significant at one percent. Method: varimax rotation.

The PCA results showed that smallholder farmers' climate change perceptions revolve around risks in the two study regions. In the Central region, the extracted three principal components from the response of French beans growing households common across the region contributed about 67 percent of the variance. The three Central region-wide principal components were summarized and proxied for droughts, delays in rainy seasons, and diseases and pests. The proportion of variance accounted by the component droughts was about 35 percent, delays in rainy seasons was 17 percent while diseases and pests was 15 percent.

In the Eastern region, PCA resulted in extraction of three principal components from the response of French beans growing households common across the region which contributed about 62 percent of the variance. The three Eastern region-wide principal components were summarized and proxied for hot days, floods, and diseases and pests. The proportion of variance accounted by the component hot days was about 37 percent, floods was about 16 percent while diseases and pests was 15 percent.

The results show that French beans farmers' climate change perceptions are linked to their concerns around rainfall variability, increasing temperature, increasing incidences of diseases and pests and flooding during rainy seasons. In the loadings for droughts and delays in rainy seasons in the two regions (Tables 2 and 3), the focus of French beans farmers' perception seemed to be on the variability in rainfall and temperature that includes reduced amount of rains, more frequent droughts, delay in start of rainy seasons, and rainy seasons ending sooner. The survey items reflecting French beans farmer's perceptions of climate change were slightly higher for items delay in start of rainy seasons and rainy seasons ending soon in the Central region, while in the Eastern region reduced amount of rains and more frequency of droughts were slightly higher. The common climate change perception in the two regions was increase in incidence of diseases and pests. This means that reduction in precipitation and increase in temperature, is increasing the incidences of diseases and pests' attacks on smallholder farmers' French beans crop.

The increasing incidences of diseases and pests presents growing concerns to smallholder farmers and might be exacerbating the increase in expenditure on pesticides and fungicides to save the crop, leading at times to compromise of the quality of produce for export [7]. Hence if as many French beans farmers as possible could be able to perceive increase in diseases and pests and its link to climate change in fresh fruit and vegetables farming, then they might be able to take appropriate remedial

adaptation action. These findings are aligned to the government of Kenya's observed annual trend which consistently suggests rainfall amount and reliability as being at the core of perceptions about risks in agriculture [24]. Studies by [26,27] also arrived at similar conclusions.

The perceptions about increase in temperature confirms intergovernmental panel on climate change (IPCC) predictions about an overall increase in temperature between 0.7 and 3.5 °C in Africa by 2050 [33]. They are also in line with results of the studies by [1,61] which have shown that farmers reported that they have experienced delayed rainfall and early cessation, and excessive rain and strong winds, which sometimes lead to flooding in Kenya. In addition, they are also in line with other empirical results by Gbetibuou [37] showing that there have been frequent (noticed by the short drought returning period) and extended drought periods in southern and East Africa, which implies no rainfall in these regions for an extended period. There is therefore need by policy and industry stakeholders to support the development of targeted adaptation strategies that takes into consideration the unique regional differences in climate change risks that confronts and are perceived by the farmers.

### 3.3. Factors Influencing Climate Change Perceptions

The binary regression model was applied to identify factors influencing smallholder French beans farmers' climate change perceptions basing on the five extracted proxies. To eliminate the possibility of interactions among the perceptions of farmers, different binary logit regression models were generated for each extracted perception. The results of the maximum likelihood-binary logit estimates are presented in Table 4.

**Table 4.** Factors influencing climate change perceptions.

|  | MFD | MFF | DSRS | INHD | IIDP |
| --- | --- | --- | --- | --- | --- |
| Region | 2.075 *** | −0.582 ** | 0.867 *** | −1.060 *** | 0.614 *** |
| Gender | 0.217 | 0.115 | 0.081 | −0.365 | 0.052 |
| Formal education | 0.054 | 0.019 | 0.028 | 0.018 |  |
| Extension | 1.245 *** | −0.453 | 0.280 | 0.024 | 0.151 |
| Experience | −0.005 | 0.007 | 0.010 | 0.003 | −0.010 |
| Weather info | −0.283 | −0.332 | −0.580 | 0.147 | −0.465 |
| Plot size | −2.811 *** | 0.587 | −0.222 | 1.067* | −0.525 |
| Soil fertility | −0.101 | 1.134 *** | 0.056 | 0.255 | 0.158 |
| Wealth | −0.055 | 0.003 |  | 0.049 | 0.055 |
| Credit | 0.911 *** | 0.344 | 0.492 ** | 0.398 * | 0.386 ** |
| Land ownership | 0.186 | −0.114 | −0.265 | −0.314 | −0.350 |
| Household size | 0.003 | 0.061 | 0.032 | 0.047 | −0.039 |
| Off-farm employment | 0.512 | −0.033 | −0.174 | −0.295 | 0.078 |
| Global-GAP | 4.539 *** | 0.135 | 1.002 | −1.021 | −0.199 |
| Constant | 1.338 ** | −0.660 | −1.131 * | −0.044 | 1.224 ** |
| Observations | 616 | 616 | 616 | 616 | 616 |
| Chi-square | 132.844 | 52.367 | 27.464 | 40.283 | 25.828 |
| p-value | 0.000 | 0.000 | 0.017 | 0.000 | 0.027 |
| Pseudo R-squared | 0.158 | 0.077 | 0.036 | 0.056 | 0.030 |

MFD—more frequent droughts; MFF—more frequent floods; DSRS—delay in start of rainy seasons; INHD—increased number of hot days; IIDP—increased diseases and pest incidences; Note: *, ** and *** implies statistically significant at 10%, 5% and 1% respectively.

The analysis results showed that Global-GAP policy compliance significantly and positively influenced farmers' perception of more frequent droughts. The Global-GAP policy certified French beans farmers have a probability of 4.539 of perceiving increase in frequency of droughts. This conclusion is drawn based on the positive sign of the marginal effect and the significant level of

farmers' Global-GAP compliance through certification. It indicates that farmers' progressive experience with Global-GAP policy improves their capacity to perceive climate change. This may be linked to the ability of Global-GAP policy to enhance the skills of certified smallholder farmers on integrated farm management to identify and exacerbate the risks occasioned by climate change through adoption of appropriate adaptation response measures [44].

The region where the farmer lives significantly affects farmers' perception of increase in frequency of drought, increase in frequency of floods, delay in the start of rainy season, increase in the number of hot days and increase in the incidences of diseases and pests. The results reveal that farmers who are in the Central region have improved probability of perceiving increase in the frequency of floods, delay in start of rainy seasons and increased incidence of diseases and pests. On the other hand, farmers who are in the Eastern region have increased probability of perceiving increase in the frequency of floods and increase in the number of hot days. Hence regional specificity is one of the key findings of the study. This result seems to suggest that regional specificity takes into account any underlying specific institutional arrangements having a bearing on the ability of the farmers to perceive climate change within a region [37].

The study found that agricultural extension service positively and significantly influenced farmers' perception of increase in the frequency of droughts. Farmers who access extension service had a probability of 1.245 of perceiving increase in the frequency of droughts. Access to credit significantly and positively improved the farmers' probability of perceiving increase in the frequency of droughts, delay in the start of rainy seasons, increased incidences of diseases and pests, and increase in the number of hot days. This implies that extension services boosts awareness among farmers on the status of crop production environment, risks of climate change, the need to take suitable response measures and the opportunities that exists like complying with Global-GAP through certification. Hence farmers with access to extension cervices are more likely to have enhanced awareness on climate change and develop the ability to perceive the risks presented by climate change to their French beans production activity. They are therefore seen to be able to translate these perceptions into French beans production decisions [33].

Plot size was found to significantly influence the probability of the farmers perceiving increase in the frequency of drought and increase in the number of hot days. Farmers with bigger plot sizes had improved probability of perceiving increase in the number of hot days. On the hand, farmers with smaller plot sizes were more unlikely to perceive increase in the frequency of droughts. The results also found that the level of the fertility of soil significantly and positively influenced the farmers' perception of increase in the frequency of floods. The farmers with highly fertile soils are more likely to perceive increase in the frequency of floods.

The key finding of the study was that past experience of the farmers with Global-GAP is a predictor of perception of climate change in the study area. This implies as suggested in the study by [46] that policies for instance Global-GAP policy may be more psychologically close to farmers producing French beans hence influencing their climate change perceptions with direct impacts on farming systems.

The findings on access to extension, soil fertility and the region of the farmer are consistent with those of [37], which found that access to extension increases the probability of perceiving climate change. Their study also found that farmers with highly fertile soils are more likely to perceive changes in rainfall.

## 4. Conclusions

The study aimed at providing an understanding of Kenya's smallholder French beans producing farmers' perceptions of climate change and the effect of Global-GAP on their perceptions. The study concluded that Global-GAP policy compliance, region of the farmer, access to agricultural extension service, access to credit, plot size, and soil fertility influence the farmers' probability of perceiving climate change. The findings show that Global-GAP policy compliance through certification may improve the capacity of smallholder fresh fruit and vegetables farmers to perceive climate change

as part of the acquired necessary skills for implementing integrated farm management with a focus on exacerbating vulnerabilities and improving market access. The results support the psychological distance theory to climate change, which suggest that farmers' progressive encounter with Global-GAP policy's integrated farm management skills trainings improves their climate change perceptions for enhanced response measures. It confirmed that French beans farmers' perceptions may be more important than previously recognized as it defines how they undertake response measures to minimize losses occasioned by climate change in their specific crop production systems [46]. The policy implication of this study is that the government and service providers should mainstream such factors like Global-GAP policy certification, alongside other factors which enhance the probability of perceiving climate change, in awareness creation extension strategies, with the aim of enhancing adoption of suitable adaptation measures in the smallholder fruits and vegetables farming sector. Since the study results identify regional specificity as one of the key factors, this should be considered in awareness creation extension strategies as it seems to take care of underlying specific institutional arrangements having a bearing on the ability of the farmers to perceive climate change within a region. In addition, since the findings also indicate that farmers' progressive experience with Global-GAP policy improves their capacity to perceive climate change, the integrated farm management skills trainings should be enhanced with aspects that build their capacity to identify the risks in fresh fruit and vegetables farming.

However, due to lack of information the study did not investigate how farmers respond to identified area-wide prevailing climate change perception in French beans farming. There is need for further research to assess for instance, more specifically, how Global-GAP certified smallholder French beans farmers respond to perception of increased incidences of pest and diseases. Future research should investigate the economic status of certified farmers who have perceived increase in incidences of pest and diseases compared to those who have not. This is because increased incidences of pest and diseases is hypothetically seen to reduce French beans yields in the face of climate change and weather variability.

**Author Contributions:** Peter Shimon Otieno is the primary author who designed the field study, executed data collection and analytical methodology. The work presented here is part of his PhD thesis to be defended for Doctor of Philosophy in Agricultural Economics. Chris Ackello Ogutu is the faculty main advisor of Peter Shimon Otieno. He contributed to the project inception, identification of methodological framework and writing of the thesis document on which this paper is based in an advisory capacity. John Mburu and Rose Adhiambo Nyikal are other advisors of Peter Shimon Otieno in the faculty who also contributed in advisory capacity to the project in their specialty areas touching on environment and resource economics covered in the thesis on which this article is based.

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