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Effect of Global-GAP policy on smallholder French beans farmers' climate change adaptation strategies in Kenya

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This study analyzed the role of Global-GAP policy, on smallholder French beans farmers' climate change adaptation strategies in, fruit and vegetables farming. It considered: (1) the prevailing adaptation strategies used by the farmers; (2) regional differences in the farmers' adaptation strategies; and (3) how Global-GAP policy influence the farmers' decisions on the use of adaptation strategies. A total of 616 French beans growing households were randomly selected from Central and Eastern regions of Kenya and data collected through semi-structured questionnaire. Principal Component Analysis (PCA) and a logistic regression model were used to analyze the data. PCA results showed that, the French beans farmers' prevailing adaptation strategies were soil conservation, water harvesting, off-farm employment, leasing out of land, changing crop variety, irrigation and livestock rearing. The common study area-wide adaptation strategies to climate change were found to be, soil conservation and leasing out land. The empirical results of the logistical model showed that, Global-GAP policy compliance significantly and positively increased the probability of the farmers to undertake changing crop variety, water harvesting, finding off-farm jobs and soil conservation as adaptation strategies to climate change. The policy implication of this study is that, government and service providers should mainstream such factors as Global-GAP compliance and regional considerations which enhance the probability of adopting adaptation strategies to climate change related projects and programmes in the smallholder fruits and vegetables farming sector.

Key words: Global-GAP policy, climate change adaptation, prevailing adaptation strategies, principal component analysis, logistical regression model, smallholder farming.

INTRODUCTION

With the increasing climate change risks facing small-holder fresh fruit and vegetables farming in Sub Saharan Africa (SSA), the need for farmers supplying markets in the developed countries to adopt suitable adaptation

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strategies is becoming more pronounced (FAO, 2013; IPCC, 2001). Climate change is progressively having negative effect on crop yields in SSA (Niang et al., 2014; Kabubo-Mariara and Karanja, 2007). This, coupled with growing environmental consciousness among consumers in European Union (EU) forming the main market for fresh fruit and vegetables, is already presenting real and potential livelihood consequences to smallholder farmers (Macgregor, 2010; Wangler, 2006).

About 40% of all fresh fruit and vegetables exports into the EU are produced in SSA and this supports the livelihoods of about 1 million people (Legge et al., 2006; World Bank, 2010a). In East Africa, it supports the livelihood of at least a quarter of million people with the fastest growth being registered in chillies, green peppers and French beans (Edward-Jones et al., 2009). Among the fresh vegetables, Kenya is currently the leading exporter of French beans to the EU and is mostly grown by smallholders (Minot and Ngigi, 2004; Mutuku et al., 2004). French beans accounts about 60% of all vegetables and 21% of horticultural exports in Kenya (Okello et al., 2007). About 90% of French beans are produced in smallholdings, ranging between 0.15 to 2 hectares (Odero et al., 2012).

Despite the growing export market demand for French beans, the area under production, volume and value have been declining due to climate related effects. Between 2008 and 2010, the area, volume and value decreased by 37, 39 and 45%, respectively due to prolonged drought experienced in Kenya in the year 2008 to 2009 (HCDA, 2010). This provide an indication that, climate related risks coupled with poor adaptation strategies, might be compounding the livelihood challenges of smallholder French beans farmers in the traditional production areas (Legesse and Drake, 2005; O'Brien et al., 2000). Adoption of suitable adaptation strategies is thus a pre-requisite to supporting majority of smallholder farmers in reducing effects of climate change and changing socioeconomic conditions like, changes in local and export markets (Bryant et al., 2000; Boko et al., 2007; Fussel, 2007).

Over the period, most EU countries providing the market for French beans have enforced regulatory mechanisms aimed at addressing climate change's impacts (Appleton, 2007; MacGregor and Vorley, 2006; Rigby and Brown, 2003). These regulatory measures, coupled with commercial risks have led private buyers in EU to enforce their own private voluntary standards (PVS), pertaining to environmental risks (Bingley, 2008; Jaffee et al., 2005).

Among the PVS, Global-GAP policy has notably gained significance in supporting access to required production management skills and climate change adaptation capacity in Kenya's French beans farming (Amekawa, 2009; Edward-Jones et al., 2009; Government of Kenya, 2010a; Kariuki, 2014; Liu, 2009). At the national level, the environmental objective of Global-GAP is seen to be consistent with climate action plans, which aims to support initiatives for helping farmers to adopt appropriate climate change adaptation strategies, towards enhancing food security (Government of Kenya, 2010b).

Evidence suggest that, although smallholder farmers are likely to be seriously affected by climate change, only a minority of them have taken advantage of adaptation strategies (Fosu-Mensah et al., 2012). Identification of trends that advocates local climate change adaptation strategies and influencing factors are therefore considered vital in guiding farmers' adaptation decisions (Belliveau et al., 2006; Bryant et al., 2000; Maddison, 2006). A number of factors, among policies and markets, have been identified to define responses of the farmers to climate change shocks (Blengini and Busto, 2009; Bradshaw et al., 2004; Bryant et al., 2000; Nhemachena and Hassan, 2007).

While much has been done on farm-level adaptation strategies, very little focus has been given to the link between Global-GAP policy and prevailing climate change adaptation strategies of smallholder French beans producers. This underlies the growing concern that, unless this link is established, it will be difficult to support increased compliance among developing-country smallholder producers and may lead to reduced market access (Minae et al., 2006). A clear understanding of the role of Global-GAP policy on the decision by smallholder French beans farmers to use certain climate change adaptation strategies is therefore essential in, supporting policy makers and industry service providers in designing suitable strategies in smallholder fresh fruit and vegetables farming (Mabe et al., 2012). The question therefore remains: what is the prevailing climate change adaptation strategies used by French beans farmers; are there regional differences in climate change adaptation strategies; does Global-GAP compliance influence the decisions on specific adaptation strategies used by farmers?

MATERIALS AND METHODS

The data used in the analysis was collected in Central and Eastern regions of Kenya, which are the leading French beans producing areas in the country. About 90% of the total national French beans output is produced by smallholder farmers in these regions under increasing challenge of climate effects. A higher proportion of French beans farmers in these areas are also complying with Global-GAP policy to enhance their export market access. The integrated farm management practices and technologies promoted under Global-GAP policy in these areas are also assumed to be climate change adaptation related, targeted at reducing vulnerability and improving agricultural production potential (Government of Kenya, 2010b; Amekawa, 2009). The study interviewed a random sample of 616 Global-GAP complying and non-complying farmers 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. Systematic random sampling was used to select farmers to be interviewed in each of the selected region. Only household decision maker/spouse was interviewed. Data collected included information on Global-GAP compliance, weather related risks and adaptation strategies applied by farmers. Factor analysis and logistic regression methods were used to analyze data. Descriptive statistics such as mean and percentages were generated using Statistical Package for Social Scientists (SPSS). Factors affecting adoption of adaptation strategies were analyzed using Limdep software.

Assessment of prevailing climate change adaptation strategies

The study modelled climate change adaptation in smallholder French beans farming on technology adoption theory since adaptation to climate change in agriculture is mostly through, adoption of appropriate technologies (Gbetibouo, 2009). The models were based on farmers' utility and profit maximizing behaviors. The study identified underlying climate change adaptation strategies, applied by the farmers using factor analysis. This was used to reduce large numbers of observed farmers' variables to fewer underlying dimensions, viewed as a more authentic measure of that factor (Helena et al., 2000; Sarbu and Pop, 2005).

To ensure that all the variability in the observed variables was used, the study applied the principal component analysis (PCA) as the data reduction method during the factor analysis (Lwayo and Obi, 2012). In addition, the study used Likert scale to find out the general clustering of variables for explanatory purposes, under the believe that variable correlation is less than 0.6 (Kim and Mueller, 1987). 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, the second component accounted for the maximum that was not accounted for by the first and was completely uncorrelated with the first principal component (Rao,1964). The computation of the principal component was as follows:

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

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 (n) of principal components is greater than 1, then each principal component is 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 relationship is an additive and hence the value of the principal component can be obtained by, addition of the products as shown in the equation:

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

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. Since key climate change adaptation strategies of the farmers were derived from actual observed data, assumption was made in the study that, there was no difference in adaptation strategies used in the two study regions. Further assumption was made, climate change adaptation measures was an "aggregate of indicators", then adaptation strategies of French beans smallholder farmers aggregated region-wide reflected factors that speak to the complex latent measures used by farmers to adapt to climate change in the two regions. For this purpose, data for all farmers' responses across the region were combined for each region. The farmers gave their responses on the measures adopted for climate change adaptation on the Likert scale of one to three (where 1 = disagree, 2 = unsure/neutral, and 3 = agree).

The adaptation strategies tested include twelve items. The 12 items include: changing crop variety, building a water harvesting scheme, planting shaded trees, irrigating more, changing from crop to livestock, increasing number of livestock, reducing the number of livestock, migrating to another area, finding off-farm jobs, leasing their land, buying insurance and investing in soil conservation techniques. These were reduced using PCA while still reflecting a large proportion of the information contained in the original dataset. The data was screened to ensure no outliers and the minimum amount of data for factor analysis was satisfied for each group with a sample size of 307 for the eastern region farmers 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 above the threshold of 0.5 and any value below 0.5 was considered miserable according to Everitt and Hothorn (2011). The Bartlett's test of sphericity for the two regions was done at 1% level of significance. The varimax rotation which is a form of orthogonal rotation strategy was used since there was no relationship between the components.

Assessment of the influence of Global-GAP policy on farmers' climate change adaptation strategies decisions

The study assumed that use of identified adaptation strategies was influenced by socio-economic factors among them Global-GAP policy compliance. Other factors deemed to influence adoption of modelled adaptation strategies which were based on literature review and included respondents' socio-economic and institutional factors (Nhemachena and Hassan, 2007). The dependent variable was binary (1 if farmer used identified adaptation strategies, 0 otherwise). The climate change adaptation strategies function for smallholder French beans farmers was specified as:

$$CCS_i = f(G_i, FE_i, E_i, GGC_i \ldots\ldots\ldots) \qquad (3)$$

Where: CCA = binary (1 if farmer was using adaptation strategy i, 0 otherwise); G = Gender; FE = Farming experience; E = extension and GGC = Global-GAP Compliance. The estimated model was specified as:

$$CCA = X_i \beta_i + \mu \qquad (4)$$

Where X was a vector of explanatory variables, β was a vector of coefficients and μ was a random variable accounting for unobservable characteristics. Logistic regression model was used to estimate the explanatory variables, influencing the adoption of the identified climate change adaptation strategies by the farmers.

Empirical model for determinants of climate change adaptation

The dependent variable for the logistic regression equation was, whether a farmer adopted the identified climate change adaptation strategies or not. The explanatory variables for the equations were chosen, based on climate change adaptation literature and data availability. The description and hypothesized signs of the modelled variables are presented in Table 1.

Table 1. Variables hypothesized to affect decisions on adaptation strategies by farmers in Central and Eastern regions.

Variable	Description	Value	Expected sign
	Household characteristics		
Gender	Gender farm household head	1 if male, 0 otherwise	+ or -
Household size	Number of family members of a household	Number	+ or -
Farming experience	Years of farming experience for household head	Number	Positive
Wealth	Measured in tropical Livestock Unit index	Number	Positive
Farm size	Acreage of land put under French beans	Hectare	Positive
Soil fertility	Farmer's perception on the fertility level of his/her land	0 = infertile, 1 = fertile, 2 = highly fertile	Positive
	Institutional factors		
Extension	If household has access to extension services	1 if accessed, 0 otherwise	Positive
Distance to market	Distance to the nearest market in km	Number	Negative
Weather information	If household gets information about weather, climate from any source	1 if accessed, 0 otherwise	Positive
Credit	If household has access to credit from any sources	1 if accessed, 0 otherwise	Positive
Land ownership	If land use is owned or rented	1 if owned, 0 otherwise	Positive
Global-GAP compliance	If complying with Global-GAP policy	Probability of complying with Global-GAP policy	Positive
Region	Region where the farmer is operating from	1 if Central, 0 otherwise	Positive
Reduction in rainfall	Perception on reduction in rainfall	1 if reduced, 0 otherwise	Positive
Increase in temperature	Perception on increase in temperature	1 if increased, 0 otherwise	Negative

Source: Survey data, 2013.

RESULTS AND DISCUSSIONS

Prevailing climate change adaptation strategies of farmers

The study results showed that 70% of smallholder French beans farmers interviewed used at least one type of adaptation strategies in response to long term changes in rainfall and temperature. By region, 59% and 79% of farmers interviewed in Central and Eastern regions respectively used at least, one type of adaptation strategies. Factor analysis was undertaken to understand the specific prevailing climate change adaptation strategies, used by smallholder French beans farmers to reduce the effects of changes in rainfall and temperature. A total of three and one items were eliminated respectively in Central and Eastern regions because they did not contribute to a simple factor structure and failed to meet a minimum criterion of having a primary factor loading of 0.5 or above. All the extracted components in both regions had an eigen values of above 1. The suggested KMO values in the analysis in the two regions were all above 0.6 and Bartlett's test of sphericity, were significant at 1%, supporting the factorability of correlation matrix.

Adaptation strategies to changes in rainfall

The study extracted three principal components (PCs) each from responses of farmers in Central and Eastern region on their adaptation strategies, to long term changes in rainfall. The components represented major adaptation strategies used by farmers in the two regions. In Central region, the three extracted PCs contributed about 53% of the variance. Based on the items loadings, the

Table 2. Factor loadings and communality for adaptation strategies to long-term shift in rainfall in Central Region (n = 253).

Items	Soil Conservation	Leasing out land	Water harvesting	Communality
Invested in Soil Conservation techniques	0.74	0.02	-0.04	0.54
Planted shaded trees	0.70	-0.07	-0.01	0.50
Changed crop variety	0.66	0.03	0.47	0.65
Have found off-farm jobs	0.62	0.21	-0.28	0.51
Leased their land	0.04	0.80	0.12	0.66
Migrated to another area	-0.04	0.68	0.29	0.55
Changed from crop to livestock	0.07	0.60	-0.34	0.49
Built a water harvesting scheme	0.08	0.07	0.71	0.51
Irrigated more	-0.33	0.08	0.49	0.35
Eigenvalue (4.76)	2.02	1.55	1.19	-
% of variance explained (52.89)	22.45	17.20	13.23	-

Kaiser-Meyer-Olkin Measure of Sampling Adequacy, 0.601; Bartlett's Test of Sphericity significant at 1%; method: varimax rotation.

Table 3. Factor loadings and communality for adaptation strategies to cope with long-term shift in rainfall in Eastern Region (n = 240).

Items	Leasing out land	Changing crop variety	Soil conservation	Communality
Leased their land	0.90	0.19	0.07	0.85
Migrated to another area	0.85	0.12	0.03	0.73
Changed from crop to livestock	0.69	.01	-0.12	0.48
Increased number of livestock	0.56	0-.03	0.26	0.38
Changed crop variety	-0.05	0.75	0.16	0.59
Reduced the number of livestock	0.19	0.66	0.18	0.50
Built a water harvesting scheme	0.14	0.56	0.11	0.35
Invested in Soil Conservation techniques	-0.02	0.34	0.73	0.65
Planted shaded trees	-0.12	0.43	0.61	0.56
Have found off-farm jobs	0.19	0.16	0.56	0.39
Irrigated more	-0.05	0.48	-0.60	0.59
Eigenvalue (6.05)	2.87	1.98	1.20	-
% of variance explained (55.02)	26.10	18.04	10.88	-

Kaiser-Meyer-Olkin Measure of Sampling Adequacy, 0.689; Bartlett's Test of Sphericity is significant at 1%; method: varimax rotation.

component factor one was named soil conservation, two leasing out land, and three water harvesting strategies (Table 2).

The proportion of variance accounted for by the component soil conservation was 22%. Farmers were investing in soil conservation techniques to facilitate adaptation to changes in rainfall. They also planted shaded trees, changed crop variety and found off-farm employment, towards addressing effects of changes in rainfall. The second factor leasing out land, explained 17% of the variance. French beans farmers in Central region leased out land, migrated production activity to other areas and changed from crop to livestock as solutions to the recurrent problem of changes in rainfall. The proportion of variance accounted for by the third factor water harvesting was, 13%. Farmers built a water harvesting scheme in Central region to reduce the effects of challenges occasioned by changes in rainfall.

In Eastern region, three components representing major prevailing climate change adaptation strategies were, extracted from the farmers' responses. These contributed about 55% of the variance. Based on the items loadings, the component factor one was named leasing out of land, two changing crop variety, and three soil conservation strategies (Table 3).

Principal component one, leasing out of land, explained 26% of the variance. Under this strategy farmers were respectively leasing out their land, migrating production activity to other areas, changing crop variety and increasing number of livestock to cope with the adverse effects. Principal component two, changing of crop variety contributed 18% of the variance. Through this

Table 4. Factor loadings and communalities on adaptation strategies to cope with long-term shift in temperature in Central Region (n = 253).

Items	Off-farm Jobs	Water harvesting	Leasing out land	Communality
Have found off-farm jobs	0.75	0.03	0.08	0.57
Reduced the number of livestock	0.65	-0.03	0.11	0.43
Planted shaded trees	0.63	0.24	0.05	0.46
Invested in Soil Conservation techniques	0.61	0.31	-0.05	0.47
Built a water harvesting scheme	-0.14	0.74	0.04	0.56
Changed crop variety	0.37	0.64	0.01	0.55
Increased number of livestock	0.15	0.61	0.04	0.39
Leased their land	0.05	-0.04	0.71	0.51
Migrated to another area	-0.06	0.13	0.70	0.50
Changed from crop to livestock	0.08	0.01	0.51	0.26
Irrigated more	-0.47	0.34	0.11	0.34
Eigenvalue (5.05)	2.40	1.44	1.21	-
% of variance explained (45.90)	21.84	13.06	11.00	-

Kaiser-Meyer-Olkin Measure of Sampling Adequacy, 0.661; Bartlett's Test of Sphericity significant at 1%; method: varimax rotation.

strategy, farmers were changing crop variety by reducing the number of livestock and building water harvesting scheme, to cope with the effect of changes in rainfall. The proportion of the variance explained by principal component three has soil conservation of 11%. The specific items that improved this factor were respectively planting shaded trees and finding off-farm jobs for income.

The study results showed that, soil conservation and leasing out of land were the common climate change adaptation strategies applied by smallholder French beans farmers in both Central and Eastern regions to cope with the effects of changes in rainfall. While water harvesting was more common in central, change of crop variety was more common in Eastern region, as an adaptation strategy to cope with changes in rainfall.

Adaptation strategies to changes in temperature

Regarding responses to changes in temperature, three principal components were extracted in Central and four Eastern regions. These components represented the major adaptation strategies to changes in temperature used by smallholder farmers in the two regions. The extracted principal components in Central region contributed 46% of the variance. Based on the items loadings, the component factor one was named off-farm employment, two water harvesting and leasing out land strategies (Table 4).

The proportion of variance accounted for by the component off-farm jobs was 22%. French beans farmers in Central region sought off-farm jobs, reduced the number of livestock, planted shaded trees and invested in soil conservation techniques towards coping with the effects of changes in temperature. The second factor water harvesting, contributed 13% of the variances. Under this strategy, farmers built water harvesting schemes, changed crop variety and increased number of livestock kept. The third factor leasing out of land, explained 11% of the variance. Through this strategy farmers leased out their land, migrated production activity to other areas and changed from crop to livestock activity.

In Eastern region, four principal components extracted from the farmers' responses explained 61% of the variation. These components were summarized as soil conservation, irrigation, leasing out land, and livestock rearing (Table 5). The proportion of variance accounted by factor, one soil conservation was 23%. Through soil conservation strategy, farmers invested in soil conservation techniques, planted shaded trees, reduced the number of livestock and found off-farm jobs to cope with the effects of changes in temperature. The second factor irrigation contributed 15% of the variation. The farmers irrigated more changed crop variety and built water harvesting scheme to address the effects of changes in temperature on their French beans production activity. The third factor leasing out land explained 13% of the variation. Under this strategy farmers leased out their land and migrate their production activity to other areas. The fourth factor livestock rearing contributed 10% of the variation. Under this strategy, farmers increased the number of livestock and changed from crop to livestock as means of coping with the effects of changes in temperature in Eastern region.

The study results revealed that the common climate change adaptation strategies used in the two regions in

Table 5. Factor loadings and communalities on adaptation strategies to cope with long-term shift in temperature in Eastern Region (n = 241).

Items	Soil Conservation	Irrigation	Leasing out land	Livestock rearing	Communality
Invested in Soil Conservation techniques	0.82	0-.06	-0.03	0.22	0.72
Planted shaded trees	0.75	0.14	-0.11	0.16	0.61
Reduced the number of livestock	0.50	0.36	0.15	-0.20	0.43
have Found off-farm jobs	0.59	-0.12	0.30	-0.12	0.47
Irrigated more	-0.22	0.81	-0.09	-0.004	0.71
Changed crop variety	0.49	0.59	0.07	-0.19	0.63
Built a water harvesting scheme	0.22	0.56	0.08	0.35	0.49
Leased their land	0.12	0.00	0.83	0.01	0.70
Migrated to another area	-0.03	0.03	0.80	0.22	0.69
Increased number of livestock	0.22	-0.15	0.02	0.75	0.63
Changed from crop to livestock	-0.17	0.22	0.24	0.70	0.62
Eigenvalue (6.70)	2.50	1.62	1.43	1.15	-
% of variance explained (60.93)	22.74	14.76	13.00	10.43	-

Kaiser-Meyer-Olkin Measure of Sampling Adequacy, 0.619; Bartlett’s Test of Sphericity significant at 1%; method: varimax rotation.

response to changes in temperature was leasing out land. While off-farm employment and water harvesting strategies were common in central region, soil conservation, irrigation and livestock rearing were common strategies to farmers in Eastern region. The distinct feature revealed by these results was that, smallholder French beans farmers’ intention with the prevailing adaptation strategies seems to be in line with those found by other studies. As highlighted by Chiotti et al. (1997) and de Loë et al. (1999), these farmers change crop varieties to the ones that are recommended for higher drought or heat tolerance to increase farm efficiency in circumstances of changing temperature and moisture stress. They also change from crop production to livestock rearing that may tolerate increased changes in climatic conditions (Delcourt and Van kooten, 1995). These farmers seem to undertake soil conservation practices as an adaptation strategy in order to conserve moisture and nutrients (Hucq et al., 2000). Implementing irrigation practices and water harvesting are aimed at, enhancing the production under climate related changes to ensure continued economic benefits (Klassen and Gilpen, 1998). Looking for off-farm employment and leasing out land are employed by farmers to diversify income sources to reduce vulnerability to climate related income loss (de Loe et al., 1999). These strategies should therefore be considered by stakeholders in efforts to enhance adaptation to both changes in rainfall and temperature in the study area.

Factors influencing farmers’ adaptation strategies

The study analyzed the influence of socio-economic factors such as Global-GAP policy compliance on the identified climate change adaptation strategies. The results of the maximum likelihood-binary logit estimates for factors influencing adoption of the identified adaptation strategies are presented in Table 6.

The results suggest that Global-GAP compliance significantly promotes adoption of changing crop variety, water harvesting and soil conservation as adaptation strategies to climate change. It also tends to be associated with off-farm employment among complying farmers as an adaptation strategy to climate change. The Global-GAP policy complying French beans farmers have a probability of 3.743, 4.174, 8.949 and 2.720, respectively of adopting changing crop variety, water harvesting, off-farm employment and soil conservation as adaptation strategies to climate change, compared to those who do not comply. This conclusion is drawn based on the positive sign of the marginal effect and the significant level of compliance with, Global-GAP. The results show that, the effect of Global-GAP policy compliance was higher on adoption of off-farm employment, as an adaptation strategy to climate change. As observed by Okello et al. (2007), this implies that the requirements for adapting to other strategies like changing of crop variety, irrigating more and soil conservation under Global-GAP policy requires more capital which the farmer may not be having and hence, they tend to seek this from off-farm employment.

Perception of reduced rainfall among farmers, have a strong positive influence on their adoption of increased irrigation as an adaptation strategy to climate change. This means that as suggested by Hassan and Nhemachena (2008), the drier it gets the higher the demand for more irrigation, among French beans farmers. On the other

Table 6. Factors influencing smallholder French beans farmers' adoption of climate change adaptation strategies.

Items	CCV	WH	IM	OFJ	SC
Region	0.012	1.644***	0.733***	0.693*	1.116***
Gender	0.069	0.015	0.055	0.470	-0.165
Extension	0.889**	0.649	0.026	2.457***	1.316***
Experience	-0.006	-0.005	0.010	-0.029*	-0.004
Weather information	-0.308	-1.578	-3.048***	1.059*	1.321***
Plot size	0.017	-0.322	0.840*	-0.352	-0.505
Soil fertility	0.177	0.086	0.236	0.120	0.154
Wealth	0.033	0.018	0.005	0.010	-0.017
Market distance	0.032	-0.047	-0.103*	0.015	-0.001
Credit	0.198	0.232	0.173	0.006	-1.079***
Land ownership	0.440	-0.869	-0.694	-1.161*	0.694
Household size	0.026	-0.004	-0.119**	0.184*	0.041**
Global-GAP	3.743***	4.174**	1.340	8.949***	2.720**
Reduction in rainfall	-0.068	0.068	0.511***	-0.443***	-0.256**
Increase in temperature	0.803***	0.641**	0.550***	-0.334	0.799***
Constant	1.841***	3.730***	0.445	2.503***	2.670***
Observations	616	616	616	616	616
Chi-square	55.741	62.518	118.004	63.512	116.654
p-value	0.000	0.000	0.000	0.000	0.000
Pseudo R-squared	0.076	0.141	0.140	0.174	0.165

CCV – changing crop varieties; WH – water harvesting; IM- Irrigating more; OFJ – off-farm jobs; SC – soil conservation; Note: *, ** and *** implies statistically significant at 10%, 5% and 1% respectively.

hand, farmers who perceive increase in rainfall tend to adopt off-farm employment and soil conservation as adaptation strategies to, climate change in the study area. Similarly, the study results indicate that perception of increased temperature among French beans farmers positively and significantly influence the adoption of water harvesting, irrigation and soil conservation as adaptation strategies to climate change. This implies that, perception of increased temperature tends to trigger the fear of losing the crop and the expected benefits and hence, most farmers adopt increased irrigation, water harvesting and soil conservation to sustain crop water requirement and to minimize moisture loss.

The study results suggest that farmers with large plot sizes tend to adopt increased irrigation as an adaptation strategy to climate change. This could be linked to the fact that as the size of investment increases most farmers tend to internalize the risks posed by climate change and hence adopt increased irrigation strategy, to ensure that the produce and returns are not lost. The study further suggests that farmers with smaller families tend to adopt increased irrigation as an adaptation strategy to climate change. This was contrary to the expectation that, increased irrigation requires more labour supply from the household members. This could be explained by the fact that French beans production is becoming more specialized due to the costs involved and more smallholder farmers would rather hire experienced casuals to irrigate their farms at the times of need. This is further confirmed by the study results that showed that, farmers with larger household sizes tend to adopt off-farm employment and soil conservation as adaptation strategies. While off-farm employment promotes households' income diversification, the more the members engaged in it the better adoption of soil conservation, as adaptation strategy is quite labour demanding and hence farmers with larger household sizes are advantaged.

Better access to extension seems to have a strong positive influence on the probability of adopting changing crop variety, off-farm employment and soil conservation as adaptation strategies to climate change. This means that through extension services farmers may be obtaining information on income sources diversification and the need to manage well the soils improved production and productivity. On the other hand, long distances to the market tend to significantly improve adoption of increased irrigation as an adaptation strategy to climate change. This was contrary to the expectation and could be explained by the fact that water is critical in the production of French beans and most water sources which are streams are far away from the market. Hence despite the need for proximity, market farmers will still go nearer to the water sources to undertake production of French beans.

Farmers with access to weather information tend to adopt off-farm employment and soil conservation as climate change adaptation strategies. This implies that based on availed weather information, these farmers are able to assess the risks and hence opt to adopt off-farm employment, in order to diversify the income sources. They also opt to conserve soil, to preserve the soil moisture for increased production in the face of changes in climate and weather variability. On the other hand, farmers without access to weather information are more likely not to adopt increased irrigation as climate change adaptation strategy. This is contrary to the expectation.

Farmers, who have access to credit, tend to adopt soil conservation in farms more than those who do not have access to credit. As expected, access to credit increased the likelihood of adaptation of irrigation as an adaptation strategy. As reported by Gbetibouo (2009) and O'Brien et al. (2000) in Tanzania, despite numerous adaptation options that farmers are aware of and willing to apply, access to credit is crucial in adaptation of soil conservation strategies.

The more experienced French beans farmers are, more likely to adopt off-farm employment as an adaptation strategy to climate change. This implies that experience enables the farmer to assess and adopt off-farm employment for improved income diversification, in the face of climate change. Experienced farmers have an increased likelihood of adopting off-farm employment, as an adaptation strategy. These results confirm the findings of Nhemachena and Hassan (2007) in a similar study of adaptation in the Southern Africa region. Experienced farmers have high skills in farming techniques and management and are more likely to spread risk when faced with climate variability.

The study results revealed that, whereas soil conservation and leasing out of land are common adaptation strategies to changes in rainfall and temperature, there are also region-specific strategies, which defines French beans farmers' response to climate change risks. This implies that to support development of more efficient and effective climate change adaptation strategies in the fruit and vegetables farming, research should appreciate regional or sub-regional diversity in farmers' responses. This validates the findings of Smithers and Smit (1997) and Smit and Skinner (2002) that, adaptation in agriculture is defined by various spatial scales including plant, plot, farm, region and nation. The findings further implied that, there are differences in level of complexity and requirements to adopt the various strategies used in each region. For instance, while water harvesting, soil conservation, change of crop variety are more strategic adaptation strategies to changes in rainfall and temperature and require longer-term, others like looking for off-farm jobs are a bit tactical and requires shorter-term to adopt. This corroborate the findings of Smit et al. (1996), that short-term adaptation strategies might include, adjustments made within a season like looking for off-farm jobs and irrigation while longer-term adaptation strategies might involve structural changes in the management that would apply in subsequent seasons like water harvesting, taking up livestock rearing, and soil conservation. This further implies that, resource endowment and capacities should be some of the key considerations in identifying climate change adaptation strategies in other to promote among smallholder French beans farmers, in each specific region.

In addition, the results revealed that food safety and environmental policies enforced by private sector players such as Global-GAP standards, plays an important role in enhancing adoption of climate change adaptation strategies in smallholder fresh fruit and vegetables farming. As suggested by Smit and Skinner (2002), it is therefore important for the policy makers and stakeholders to evaluate and recognize the specific roles played by such private policies, with respect to adaptation in order to enhance adoption of response strategies. This is validated by Bryant et al. (2000) and Bryant (1994)'s assertion that, farmers make adaptation decisions in the context of prevailing policy, economic conditions, financial systems, and social norms. Hence other significant variables identified by this study as, influencing farmers' decisions on adaptation of specific strategies like region, extension, weather information, plot size, market and credit access, reduction in rainfall and increase in temperature should also be considered by the policy-makers and stakeholders in the measures designed, to enhance adoption of climate change adaptation strategies in fruit and vegetables farming.

Conclusions

The study analyzed the French beans producing farmers prevailing climate change adaptation strategies and the factors affecting their adoption in Central and Eastern regions of Kenya using factor analysis and binary logit regression model. The adaptation strategies of the farmers identified, using factor analysis include soil conservation, water harvesting, off-farm employment, leasing out of land, changing crop variety, irrigation and livestock rearing. The common study area-wide adaptation strategies to climate change were found to be soil conservation and leasing out land.

The empirical results of the logistical regression model showed that, Global-GAP policy compliance significantly and positively increased the probability of the farmers to undertake changing crop variety, water harvesting, finding off-farm jobs and soil conservation as adaptation strategies to climate change. Other identified factors like access to extension, region of the farmer, access to credit, access to weather information, distance to the market, household size, plot size, and perception on reduction in rainfall and increase in temperature, should be included in climate change adaptation strategies promotion, to enhance adoption of adaptation strategies. The policy implication of this study is that, the government and service providers should mainstream such factors as Global-GAP compliance and regional considerations among other factors, which enhance the probability of adopting adaptation strategies to climate change related projects and programmes in the smallholder fruits and vegetables farming sector.

However, the study did not investigate the effect of area-wide prevailing adaptation strategies on the French beans productivity performance among farmers due to lack of information. There is need for further research to probe for example the effect of leasing out of land activities of smallholder French beans farmers which the study found to be common prevailing adaptation strategy on productivity performance. Future research should endeavor to investigate this further, the economic status of farmers who have leased out land, since leasing out of land is hypothetically seen to diminish the area under French beans especially, if the land is converted to totally different activities.

CONFLICTS OF INTEREST

The authors have not declared any conflict of interests.

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