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Abstract

This paper presents findings of a study to examine smallholder French bean farmers' perception of climate change and effect of Global-GAP policy on their perception in Central and Eastern regions of Kenya. A random sample of 616 households were interviewed in Kirinyaga (Central), Makueni and Meru (Eastern) counties leading to identification of 7 climate change perceptions. Using principal component analysis (PCA) to derive a few latent variables summarizing maximum variance in the perceptions, three components (latent variables) proxying for 'droughts', 'delay in rainy seasons', 'diseases and pests' and three proxying for 'hot days', 'floods', and 'diseases and pests' risk factors were extracted for Central and Eastern region respectively. The results show that common study area-wide climate change perception risk factor was incidence of diseases and pest. Using logit regression method to analyze factors influencing perceptions, the results found that Global-GAP policy positively and significantly influence perception on long term changes in temperature and rainfall. Climate change risk factors of droughts, diseases and pests, floods, and increase in number of hot days were found to influence farmers' perception of long term changes in temperature and rainfall. Other socio-economic factors found to influence perception of long term changes in temperature and rainfall were access to extension services, formal education and acreage under French bean production. The study concluded that farmers' past experience with Global-GAP is a predictor of climate change attitudes. The policy implication of this study is that incorporating promotion of Global-GAP policy compliance in awareness creation strategies in a manner that considers local context and local farmers' views can bring about progress in smallholder farm sector by resolving some of the climate change related constraints.

Key words: Global-GAP, climate change perception, Principal Component analysis, OLS regression model, smallholder, French bean, Central region, Eastern region, Kenya

1. Introduction

Farmers' climate change perception is critical in identification and implementation of useful adaptation strategies in agriculture (Maddison, 2006). This is even of more significance in Kenya's export vegetables production as the smallholder farmers forming the majority will have to contend with climate change and weather variability to ensure livelihoods. Among the fresh export vegetables, French bean contributes 60 percent and is of growing socio-economic importance as it is grown mostly by smallholder farmers as a source of income and foreign exchange earnings (HCDA, 2007; McCulloh and Ota, 2002; Mutuku *et al.*, 2004; Minot and Ngigi, 2004; Odero *et al.*, 2012). Increasingly, the French bean production is becoming more sensitive to climate change despite the expectation for the industry to continue growing as a result of the increased food demand. For instance, in 2010 the area under production reduced by 37 percent. Between 2008 and 2010, the production volume and value decreased by 39 and 45 percent respectively due to prolonged drought in 2008 – 2009. In addition, during the year 2010, out of 55,841 metric tons produced, only 34 percent were exported (HCDA, 2010).

The situation is complicated further for the smallholder farmers due to the fact that developed countries' consumers forming the bulk of the market for high value fruits and vegetables are increasingly becoming concerned about environmental conservation and food safety (Diop and Jaffee, 2005; Okello *et al.*, 2007). This move has been informed by various evidences showing that climate change is generally detrimental to agriculture sector and pointing to the possibility of reducing vulnerability to it through adaptation (Smit and Skinner, 2002; FAO, 2013). These climate change's real and potential socio-economic and environmental impacts have become a major concern to policy makers in Kenya's traditional European markets.

Most European governments where these markets are, have revised their regulations pertaining to labeling of fruits and fresh vegetables with stringent information in line with the Kyoto Protocol for the benefit of the environment and the consumers (Legge *et al.*, 2006, MacGregor and Vorley, 2006; Van Hauwermeiren *et al.*, 2007; Rigby and Brown, 2003). The regulatory changes, together with perceived commercial risks, have in turn led private fresh produce retailers, especially the major supermarket chains in Europe, to respond by developing their own standards pertaining to environmental risks and passing them downstream to developing-country exporters (Bingley, 2008).

The voluntary food safety standards, notably Global-GAP which is widely operational in Kenya's French bean industry has been revised and benchmarked with environmental standards since 2009. The most prominent environmental standard that has been linked to Global-GAP is Linking Environment and Farming (LEAF) global standard (Rigby and Brown, 2003). Farms that are LEAF standard accredited should already have achieved a certificate for Global-GAP or a benchmarked scheme approved by Global-GAP for each enterprise on the farm. The benchmarking of Global-GAP with LEAF makes it a viable environmental Policy that enables farmers commit to optimize usage of power, water and other consumables through adoption of integrated farm management (IFM).

To developing country exporters, the upstream changes means that French bean produce must be sourced from farmers (who are mostly smallholders) under tightly coordinated Global-GAP compliance mechanisms enforced through third party certification (Humphrey, 2008, Henson and Humphrey, 2009; Mithöfer *et al.*, 2007). This demand for produce grown while taking a combination of issues into consideration has hence shifted the focus to how the smallholder producers, as part of the supply chain, are aligning their production practices with the

environmental and ethical objectives of the buyers as a prerequisite for staying in business.

Smallholder production of fruits and fresh vegetables under increased climate variability and stringent Global-GAP environmental policy have led to growing concern. The concern is that the food safety and environmental standards will lead to exclusion of smallholder farmers who may not be perceiving climate change and instituting appropriate adaptation measures from the lucrative fresh export vegetables business (Kurukulasuriya and Rosenthal 2003). In Kenya there is growing anxiety that thousands of smallholders may be driven out of fresh export vegetables business by climate change and strict implementation of Global-GAP environmental mechanisms (Mungai, 2004).

Recent studies suggest that past experiences with environmental policies like Global-GAP will more strongly affect a farmers' climate change beliefs (Meredith *et al.,* 2013). Hence upstream policy changes like Global-GAP are seen as having the potential of influencing farmers' climate change perception. In Kenya, a number of smallholder farmers have complied and are producing French bean under Global-GAP regulatory measures. The future challenge confronting smallholder French bean industry is therefore three-fold: to adapt to a changing and more variable climate, to increase production and to reduce GHG emissions (Kristensen *et al.*, 2011; Nakashima, 2010).

This paper addresses the first part in relation to smallholder French bean farming given that climate change perception is seen as a first step to adaptation (Maddison, 2006). A number of theoretical approaches in the literature have been used to study the effect of policies on climate change perceptions (Belliveau *et al.* 2006; Meredith *et al.* 2013; Wall and Smit 2005). The current study builds upon such emerging literature applying psychological distance theory to

climate change by testing whether smallholder French bean farmers' Global-GAP experiences affect their climate change beliefs. 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 (Spencer *et al*, 2012). This theory suggests that a firsthand encounter can help clarify risks often leading to heightened assessment of risk (Whitmarsh, 2008). According to Myers *et al.* (2013) and Moser and Dilling (2004), 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 (Haden *et al*., 2012). Factor analysis has been used to explore the alignment of perceived latent perception variables (Costello and Osborne, 2005; Helene *et al*. 2000; Sarbu and Pop 2005). On the other hand, regression models have been used to assess the factors influencing farmers' climate change perception (Gbetibouo, 2009).

This paper hypothesized that past experiences of smallholder French bean producing farmers with Global-GAP policy affects their climate attitudes in line with biophysical climate change (measured in precipitation and temperature) as observed in national studies. For instance, in Kenya, analysis of trends in temperature, rainfall, sea levels, and extreme events points to clear evidence of climate change (King'uyu *et al.*,2000; Kilavi, 2008; GoK,2010; SEI, 2009). These analyses indicate that temperatures have generally risen throughout the country, with other projections also showing increase in mean annual temperature of 1 to 3.5°C by the 2050s. This can be seen in the statement by Government of Kenya's published National Climate Change Response report that "*the evidence of climate change in Kenya is unmistakable*" and that in many areas rainfall has become irregular and unpredictable; extreme and harsh weather is now

the norm; and some regions experience frequent droughts during the long rainy season while others experience severe floods during the short rains (GoK, 2010).

Though not extensively explored previously in Kenya, the above hypothesis is consistent with the statements from researchers who have observed that climate change attitudes are heavily affected by the broader social, economic, and policy issues (Gbetibouo, 2009; Brulle *et al*., 2012). Adger *et al*. (2005) describes climate adaptation as "an adjustment in ecological, social or economic systems in response to observed or expected changes in climatic stimuli and their effects and impacts in order to alleviate adverse impacts of changes or take advantage of new opportunities". This study also appreciates that "policies and non-climatic drivers currently play perhaps an even more important role (than climatic drivers) in influencing adaptive behaviours to climate change". Other studies opine that adaptation is a two-step process involving climate change perception then adaptation (Wall and Smit 2005; Belliveau *et al.* 2006). According to Bryant *et al.* (2000), these studies have raised new research questions regarding how farmers perceive climatic change and variability; have identified those climatic properties that are of most importance to farmers in their decision making; and have suggested the types of adaptive responses that can be anticipated. This assumption is consistent with other sociological work demonstrating that policy discourses and processes among other factors can affect people's attitude towards an issue (Gbetibouo, 2009; Hageback *et al*., 2005; Meredith *et al.*, 2013).

Since the findings from factor analysis may not indicate whether the results are sensitive to other factors, the study assumed that farmers' perceptions of long term changes in temperature and rainfall are associated with a number of other factors. To test this, other studies have used econometric techniques. For instance, Nhemachena and Hassan (2007) used a multivariate probit econometric technique to describe farmer perceptions to changes in long-term temperature

and precipitation as well as various farm-level adaptation measures and barriers to adaptation at the farm household level. Gbetibouo (2009) on the other hand used probit, multinomial logit and Heckman's probit models to study farmers' climate change perceptions and adaptation to climate change in Limpopo Basin, South Africa. The study showed that education, experience, access to water for irrigation, access to extension, location of the farmer, and fertility of the soil affect farmer' perception of climate change. Moreover, other factors such as sex, membership in environmental groups, newspaper readers, education, access to extension, tenure status, agro-climatic conditions, availability of water, geographical site and soil types, and access to irrigation (Maddison 2006) affect perceptions of climate change.

While much has been said about farmers' perception to climate change and the relationship to policies in some regions, the same, however, cannot be said of research regarding smallholder French bean farming. This study therefore posits, based on the psychological distance theory, that these involuntary private policies are "closer" (temporally, socially, and geographically) and more tangible to smallholder French bean farmers and will have a greater effect on climate change attitudes. The previous studies have not addressed effect of climate change policy like Global-GAP on the perception of farmers to climate change in smallholder farms (Liberman *et al.,* 2002). More importantly in Kenya, no studies have set out to examine the effect of Global-GAP policy among other factors on farmers based on empirical smallholder French bean farm-level data. The purpose of this study was therefore to assess the farmers' climate change perception and the effect of Global-GAP policy on their climate change perception at the farm-level.

2. Data and Methods

The data used in the analysis was collected on the last crop of French bean from a random

sample of 616 smallholder farmers during a primary field survey conducted between September and October 2013 using a semi-structured questionnaire. This was done in major French bean growing areas of Central (Kirinyaga county) and Eastern (Makueni and Meru Counties) regions of Kenya. According to horticultural crops development authority (HCDA) 2010 report, these regions produced 90 percent of the total national French bean output mainly through smallholder farming. A higher proportion of smallholder producers in these regions have complied with Global-GAP policy making it an ideal area to study the effect of Global-GAP policy on farmers' climate change perception. The climate change perception and socio-economic data was collected and farmers' latent perception variables and factors influencing climate change perceptions (long term changes in temperature and rainfall) in each region were analyzed.

Latent perception variables were estimated from actual observed smallholder producers' data. The assumption was made that there is no difference in climate change perceptions among smallholder French bean producers in the two study regions. It was further assumed that if climate change and variability is an "aggregate of indicators" then French bean smallholder farmers' perceptions aggregated region-wide should reflect factors that speak to the complex ways that farmers perceive climate change in the two regions. For this purpose, the data for all farmers' responses were combined for each region. Farmers' responses on some of the attributes regarding climate change were recorded on a Likert scale of one to three (where 1 = disagree, 2 = unsure/neutral, and 3 = agree). Factor analysis method was used to explore the alignment of perceived latent variables within each region of survey results (Costello and Osborne, 2005; Helene *et al*. 2000; Sarbu and Pop 2005). The results were compared to ascertain whether there were sustainable and robust factors common to all two regions. The common items of each

identified factor scale were compared to find out the farmer's perceptions levels in each of two regions. The study created a scale to combine questions measuring similar latent concepts to average responses, which had a cronbach's alpha coefficient higher than .60, a generally accepted cut-off point for reliability (Amudavi, 2005). This approach provided a way of tracking farmer perceptions and gauging the reliability of each factor scale. Following prior authors, principal component factor analysis was expressed as:

$$z_{ji} = a_{fi} f_{2i} + a_{f2} f_{2i} + ... + a_{fm} f_{mi} + e_{fi} \qquad (1)$$

Where z is the component score, ***a*** is the component loading, ***f*** is the factor score, ***e*** is the residual term accounting for the errors or other source of variation, ***i*** is the sample number and ***m*** is the total number of variables. Principal component analysis (PCA) using statistical package for social science was used to reduce the number of the variables but still reflex a large proportion of the information contained in the original dataset. Table 1 and 2 contains complete list of questions, variables, scales, and their descriptive statistics used in this analysis for Central and Eastern region respectively.

Since the findings from factor analysis may not indicate whether the results are sensitive to other factors, the study assumed that farmers' perception of climate change (long term change in temperature and rainfall) was associated with a number of other factors. For instance, it was assumed that perceptions to climate change and variability among French bean producing farmers was also influenced by Global-GAP policy. In the literature other socio-economic factors that were found to influence perceptions were used (Gbetibouo, 2009). 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 (whether the farmer was perceiving long term changes in temperature and/or rainfall equals 1, 0 otherwise). The climate change perception function for smallholder French bean farmers was assumed to be:

$$CCP_i = f(G_i, PS_i, E_i, GGC_i \ldots\ldots\ldots) \quad (2)$$

Where: CCP = Climate Change Perception; G = Gender; PS = Plot Size; E = extension and GGC = Global-GAP Compliance.

The estimated model was therefore written as:

$$CCP = X_i \beta_i + \mu \quad (3)$$

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 farmers' climate change perception. The reduced perception values from were entered as additional explanatory variables in the specified logit model.

3. Results and discussion

3.1 Farmers' climate change experience

The study found that farmers have perceived changes in temperature and rainfall over time in the study area. Majority (64 percent, n=394) of French bean farmers felt that temperature had increased over time while approximately 22 percent (n=135) felt it had decreased over time. About 14 percent (n=87) felt it had stayed the same. On the other hand, 66 percent (n=407) of French bean farmers felt that rainfall had decreased over time while approximately 30 percent (n=185) felt it had decreased over time. About 4 percent (n=96) felt it had stayed the same. The

results on farmers' impressions regarding changes in temperature and rainfall was found to be consistent with prior studies and the National Climate Change Response report which indicates an increasing trend and further states that Central and South Eastern Kenya regions have observed temperature changes in the period 1960 to 2006 on an increasing trend ((GoK, 2010; Kilavi, 2008; King'uyu *et al.,* 2000; SEI, 2009). 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, farmers' perception of a reduction in rainfall over the period is explained by the fact that, as Maddison (2006) noticed, some farmers place more weight on recent information than is efficient.

3.2 Types of farmers' climate change perceptions

The results of PCA analysis of the climate change perception attributes of the farmers in Central and Eastern regions is presented in table 1 and 2.

Table 1 Factor loadings and communalities for Central region control farmers' perceptions of climate change (n = 253)

	Droughts	**Delays in rainy seasons**	**Diseases and pests**	**Communality**
There have been more rains	**-0.64**	-0.18	**0.43**	0.63
There have been more frequent droughts	**0.79**	0.11	0.20	0.67
There have been more frequent floods	**0.67**	0.45	**0.65**	0.66
There have been delay in start of rainy seasons	-0.18	**0.86**	0.03	0.76
Rainy seasons have been ending sooner	0.15	**0.81**	-0.03	0.78
Number of hot days have been increasing	0.36	0.24	0.09	0.53
Incidences of diseases and pests have been increasing	**0.68**	-0.16	**0.74**	0.68

Eigenvalue (4.72)	2.43	1.22	1.07	
% of variance explained (67.40)	34.71	17.45	15.24	
Kaiser-Meyer-Olkin Measure of Sampling Adequacy				0.664
Bartlett's Test of Sphericity	Approximate χ^2 (df)			324.10 (21)
	Sig.			0.01

Source: survey data, 2013

Table 2 Factor loadings and communalities for Eastern region control farmers' perceptions of climate change (n = 241)

	Hot days	Floods	Diseases and pests	Communality
There have been more rains	**-0.76**	0.13	-0.004	0.59
There have been more frequent droughts	**0.77**	0.23	-0.06	0.66
There have been more frequent floods	-0.11	**0.86**	0.15	0.78
There have been delay in start of rainy seasons	**0.61**	0.38	**-0.47**	0.73
Rainy seasons have been ending sooner	**0.45**	**0.48**	**-0.43**	0.62
Number of hot days have been increasing	**0.78**	-0.08	**0.05**	0.61
Incidences of diseases and pests have been increasing	0.10	0.15	**0.88**	0.81
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	Approximate χ^2 (df)			345.83(21)
	Sig.			0.01

Source: survey data, 2013

The PCA results found that smallholder farmers' climate change perceptions revolve around risks namely droughts, delayed rainy seasons, and diseases and pest epidemics in Central region and around hot days, floods, and diseases and pest epidemics in Eastern region. The study area-wide climate change risk perception was found to be increased incidence of diseases and pests. In Central region, the extracted three principal components from the response of French bean

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 Eastern region, PCA resulted in extraction of three principal components from the response of French bean 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.

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 (GoK, 2010). King'uyu *et al.* (2000) and (Kilavi, 2008) also arrived at similar conclusions. In the loadings for droughts and delays in rainy seasons in the two regions (as reflected in table 1 and 2), the focus of French bean farmers' perception seemed to be on the variability in rainfall and temperature that includes reduced amount of rains, more frequent droughts, delay in the start of rainy seasons, and rainy seasons ending sooner. The survey items reflecting French bean farmer's perceptions of climate change were slightly higher for items delay in the start of rainy seasons and rainy seasons ending soon in Central region, while in Eastern region reduced amount of rains and more frequency of droughts were slightly higher. The common climate change perception in the two region was increase in incidence of diseases and pests.

3.3 Factors influencing climate change perceptions

The analysis of which types of French bean producing farmers were likely to notice climate change (temperature and/or rainfall changes) was carried out for both Central and Eastern regions using logit regression model. The analysis was limited to explaining the twin perception of change in both temperature and precipitation in the two study regions. The independent variables used in the model were Global-GAP compliance (reduced form), reduced perception risk factors (droughts, delay in rainy season, floods, hot days, diseases and pests), gender, education, area under production, access to extension services and farming experience. Table 3 show the logit model estimates for the factors that influenced farmers' perception of changes in temperature and/or rainfall. The F-statistic values were significant at 1 percent, 1 percent, 1 percent, and 5 percent respectively. The R^2 that explained the variation in the dependent variable caused by the independent variables (Gujarati, 2004) were .27, .22, .18 and .23 percent respectively. The results indicated that the variables considered could explain 67, 95, 84, and 97 percent of the variation notable in the farmers' perception of changes in temperature and rainfall in the two regions respectively.

Table 3: Results of logit model on factors influencing French bean farmers' climate change perceptions

	Central		**Eastern**	
	Perceive	Perceive	Perceive	Perceive change

	change in temperature	change in rainfall	change in temperature	in rainfall
Constant	1.59**	5.72***	2.48**	2.94
Gender	0.14	0.08	0.60	0.40*
Formal education (years)	0.004	0.04	-0.07	-0.24*
Area under production (Ha)	-0.20	0.44	0.46	1.96***
Access to extension services	0.61	1.89	1.51*	0.67
Farming experience	0.02	0.02	0.01	0.03
Global-GAP compliance	1.17	8.42*	5.43*	-0.02
Droughts	1.35***			
Delay in rainy seasons	0.05			0.51
Diseases and pests	0.98***	1.9**	0.55**	0.26
Floods		1.01*	0.10	0.55
Hot days		0.77**	0.79***	
Number of observations	309	309	307	307
F (log L)	-140.30	-51.22	-112.55	-34.09
p>F	0.00	0.00	0.00	0.029
R^2	.27	.22	.18	.23
% correct prediction	68.6	94.5	83.7	96.7

Note: *, ** and *** implies statistically significant at 10%, 5% and 1% respectively

Source: Survey data, 2013

Global-GAP was found to influence positively and improve the farmers' likelihood of perceiving rainfall and temperature by 8 and 5 times in Central and Eastern regions respectively. Perceptions of increased incidences of diseases and pests was found to influence positively and to improve the likelihood of farmers' perceiving changes in temperature and rainfall in Central and temperature in Eastern region by 0.98, 1.9 and 0.55 times respectively. Increased number of hot days was found to influence positively and improve farmers' likelihood of perceiving changes in rainfall in Central and temperature in Eastern region. Perception of increase in droughts was found to positively influence and improve the likelihood of farmers' perceiving changes in temperature in Central. Perception of incidences of more floods was found to positively influence and improve farmers' likelihood of perceiving changes in rainfall in Central.

Acreage under French bean production was found to influence positively and improve the likelihood of farmers' perceiving changes in rainfall in Central region. Access to agricultural extension services positively influences and improves the likelihood of perceiving changes in temperature by 1.5 times.

Factor found to influence negatively the perception of changes in rainfall in Eastern region was level of formal education. This conformed with the study by Gbetibouo, (2009) which found that education seems to decrease the probability that the farmer will perceive long-term changes in rainfall. Thus, educated farmers are more likely to see that rainfall does not have a significant trend over the long run.

The key finding of the study is that farmers' past experience with Global-GAP is a predictor of perception of changes in temperature and rainfall in the study area. This implies as suggested in the study by Meredith *et al*. (2013) that policies for instance Global-GAP policy may be more psychologically close to farmers producing French bean for export, thus influencing their climate risk perceptions with direct impacts on their farming systems.

4. Conclusions

This study concludes that Global-GAP policy compliance, awareness of specific climate change risks linked to the farmers' production activity (increased droughts, diseases and pests, floods, increase in hot days) and acreage under production improves the farmers' likelihood of perceiving long term changes in temperature and rainfall. It confirms that risk perceptions, not climate change beliefs may be more important than previously recognized (Meredith *et al*., 2013). The implication of this study is that incorporating promotion of Global-GAP policy compliance in climate change awareness creation strategies in a manner that considers local

context and local farmers' views can bring about progress in smallholder farm sector by resolving climate change related constraints.

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