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Farmers' Preferences for the Design of Fruit Fly Pest-Free Area (FF-PFA) in Kerio-Valley: A Latent-Class Approach

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Abstract
Fruit flies are a very important group of pests for many countries due to their potential to cause damage in fruits thus restricting access to international markets for plant products that can host fruit flies. The high probability of introduction of fruit flies associated with a wide range of hosts' results in restrictions imposed by many importing countries to accept fruits from areas in which these pests are established. For these reasons, establishment and maintenance of pest free areas for fruit flies (FF-PFAs) is receiving considerable attention in the current policy debates. Kenya Plant Health Inspectorate Service (KEPHIS) has taken the lead to establish and help maintain FF-PFAs in the main mango production zones of Elgeyo-Marakwet County of Kenya. However, as the ultimate success of the programme depends on farmers' judgment and acceptance, acquiring information about potential demand is of paramount importance for policy advice. In this paper, we assess the demand in terms of consumer preferences and willingness to pay for FF-PFAs using a stated choice experiment method (SCE). A novel feature of this paper is that it focuses on how the FF-PFA should be designed and presented. Results from the latent class model (LCM) reveal that farmers prefer FF-PFAs featuring training, market information with sales contract, large benefits to other mango value-chain actors and when they are recommended by officials.
Keywords: FF-PFA, SCE, LCM, Farmers' preference, Mango

1. Introduction

Mango production is continually gaining recognition for its potential as a major source of income especially for small-scale farmers (Griesbach, 2003; Isigi, 2015; KEPHIS, 2015). The total area under mango production in Kenya is estimated at 16,000 hectares, with exports from Africa estimated at 40 thousand tons annually and worth around Kshs 3 billion (USD 42 million). The European Union (EU) remains the largest destination market for exports from Africa, however, Kenya is currently expanding its market within the Eastern Africa Community (EAC) and the Common Market for Eastern and Southern Africa (COMESA) region (Isigi, 2015).

Historically, mango tree is not indigenous to Kenya, but has been cultivated in the country for centuries. Traders in ivory and slaves brought seed into the country during the 14th century. The mango is one of the most important fruit crops in the tropical and subtropical lowlands. It is native to India, Bangladesh, Myanmar and Malaysia, but can be found growing in more than 60 other countries throughout the world (Salim et al., 2002). There is a great diversity of mango fruit types which permits considerable manipulation for various purposes and markets: juice, chutney, pickles, jam/jelly, fresh fruit, canned and/or dried fruit etc. Given the multiple products, it is therefore a potential source of foreign exchange for Kenya; it is also a source of employment for a considerable seasonal labour force. In addition to income opportunities, the mango is noted for combating nutritional disorders as it compares favourably in food value with both temperate and tropical fruits (Griesbach, 2003).

The biggest threat to mango production and marketing is the fruit fly, especially of *Bactrocera invadens* species (KEPHIS, 2015). The female flies lay their eggs under the skin of mango fruit that hatches into whitish maggots, which feed on the decaying flesh of the fruit. Infested fruit rot quickly causing considerable losses. Traditionally, yield loss on mangoes in Kenya due to the fruit fly can range between 30-70% depending on the locality, season, and variety (ICIPE, 2010). This problem has been aggravated especially in lowland areas where *B. invadens* is now the dominant fruit fly pest. Quarantine restrictions on fruit fly-infested fruits has severely limited export of fruits to large lucrative markets in South Africa, Europe, the Middle East, Japan and USA, where fruit flies are considered as quarantine pests (KEPHIS, 2015).

Fruit flies are a very important group of pests for many countries due to their potential to cause damage in fruits and their potential to restrict access to international markets for plant products that can host fruit flies (Griesbach, 2003). The high probability of introduction of fruit flies associated with a wide range of hosts' results in restrictions imposed by many importing countries to accept fruits from areas in which these pests are established. For these reasons, there is a need for an International Standards for Phytosanitary Measures (ISPM) that provides specific guidance for the establishment and maintenance of pest free areas for fruit flies (ISPM, 2006A).

Following ISPM number five specification, a pest free area (PFA) is "an area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained" (ISPM, 2006B). Areas initially free from fruit flies may remain naturally free from fruit flies due to the presence of barriers or climate conditions, and/or maintained free through movement restrictions and related measures (though fruit flies have the potential to establish there) or may be made free by an eradication programme (ISPM, 2006A). Kenya Plant Health Inspectorate Service (KEPHIS) has therefore partnered with the county government of Elgeyo-Marakwet to establish a Fruit Fly-Pest Free Area (FF-PFA) in the county.

In order to ensure that the FF-PFA is effective in assuring a safe and more stable mango supply, producer compliance with established regulations is mandatory. Otherwise, the demarcation may create a price differential and provide an incentive for farmers to smuggle mangoes from a lower-priced infected region to a higher-priced FF-PFA during the flies outbreak. This may lead to eventual collapse of the programme, as noted by Otieno et al., (2011). In Kenya, however, the design of FF-PFAs is still at a pilot stage and is spearheaded by KEPHIS who establish, declare as well as maintain fruit fly pest free area/area of low pest preference (FF-PFA/ALPP) (KEPHIS, 2015). Information on farmers' preferences on the features that they would like to be included in a FF-PFA is useful to policy-makers on two grounds: to enable the assessment of potential acceptability of the FF-PFA programme; and to provide insights on some of the issues that may affect implementation of the FF-PFA, especially considering differences in production systems and relative resource endowments between mango farmers in Elgeyo-Marakwet and elsewhere.

We use a stated choice experiment (SCE) approach (Louviere et al., 2000) to investigate farmers' preferences for key attributes in the design of a FF-PFA policy. A SCE is a stated preference approach for ex ante analysis of preferences for goods ⁄ services such as FF-PFA that are not yet in the market and would therefore not be possible to evaluate using revealed preference methods (Louviere et al., 2000). Furthermore, SCE is preferred over other stated preference techniques, such as contingent valuation (Mitchell and Carson, 1989), because it enables the evaluation of trade-offs for various components (features/attributes) of a good ⁄ service rather than the good ⁄ service per se (Hanley et al., 2001).

The remainder of the paper is structured as follows. The next section presents the SCE design process and econometric specification followed by the section describing the data. The final two sections present the results, and the discussion and conclusion, respectively.

2. Methodology

2.1. Stated Choice experiment (SCE) design

2.1.1. Definition of attributes and their levels

FF-PFAs have two types of attributes or features: compulsory and optional/voluntary. The compulsory attributes are those that must be adhered to by all farmers in the FF-PFAs and all other people passing through FF-PFAs, in order to prevent the spread of these pests. The compulsory features are necessary to enforce the public policy (Olson, 1965) and include: First, a public awareness programme that is most important in areas where the risk of introduction is higher. An important factor in the establishment and maintenance of FF-PFAs is the support and participation of the public (especially the local community) close to the FF-PFA and individuals that travel to or through the area, including parties with direct and indirect interests. The need for farmers' participation is a pre-requisite for acceptance and smooth implementation of any given policy/programme as stipulated in the article 40 of the Kenya's Agriculture, Food and Fisheries Authority Act No. 13 of 2013 (GoK, 2013). The public and stakeholders should be informed through different forms of media (written, radio, TV) of the importance of establishing and maintaining the pest free status of the area, and of avoiding the introduction or reintroduction of potentially infested host material. This may contribute to and improve compliance with the phytosanitary measures for the FF-PFA.

The second compulsory feature for FF-PFA is documentation and record keeping. The phytosanitary measures used for the establishment and maintenance of FF-PFA should be adequately documented as part of phytosanitary procedures. They should be reviewed and updated regularly, including corrective actions, if required. Lastly, supervision of activities is also mandatory. The FF-PFA programme, including regulatory control, surveillance procedures (for example trapping, fruit sampling) and corrective action planning should comply with officially approved procedures.

The optional or voluntary features are those that allow farmers some choice and are the ones that enter the SCE design. These features enable individuals with diverse interests to exercise collective action, which Ostrom (1990) notes is necessary when individuals face a common problem, such as fruit fly, that may threaten their collective livelihoods. The SCE design process began with the identification of policy-relevant FF-PFA features through literature review, in-depth interviews of key officials from KEPHIS, and focus-group discussions with mango farmers. The focus-group discussions were also used to validate important attributes identified and their levels for inclusion in the SCE. Five FF-PFA attributes were selected for the SCE design from the validation exercise: training of farmers; provision of market support; benefit; recommendation and membership participation fee (cost).

Due to differences in the levels of access to agricultural extension advisory services in Kenya (Otieno et al., 2011), it was envisaged that some farmers would need *training* in order to fully comply with the three compulsory FF-PFA requirements. Training mango farmers on the general requirements for establishing a FF-PFA including, the preparation of a public awareness programme, the management elements of the system (for example, documentation and record keeping), and monitoring activities, would enable them participate effectively in the programme. Moreover, the *provision of market support* would enable farmers to earn better incomes and sustain their long-term participation in the programme.

The third attribute, economic *benefits* to other value-chain actors, including trap manufacturers (i.e., the monitoring activities for FF-PFA are conducted using lure-responsive trapping methods), was included in the SCE to test the hypothesis that in addition to experiencing economic benefits related to the quality/quantity of the private service (i.e., fruit fly free mango), farmers may derive benefits from social and economic factors, such as higher incomes for those who manufacture the traps (Kikulwe et al., 2011). Recent SCE studies found that respondents in both developed and developing countries derive benefits from knowing that others are employed; earn higher incomes, or have improved livelihoods outcomes as a result of a policy or programme change (e.g., Otieno et al., 2011; Pambo et al., 2015). In addition, a portion of respondents had trap-producing relatives so may derive positive values from this attribute, whether due to altruistic reasons or self-interest.

The *recommendation* attribute was included to acknowledge that farmers' preference decisions can be affected by contextual factors in addition to programme attributes. While contextual factors can influence the choice and preference goods and services, they have been overlooked in most food preference studies as observed by Jaeger and Rose (2008). The attributes *training* had two levels, while *provision of market support* and *benefit* each had three levels where as the *recommendation* attribute had four levels. Finally, the payment of an annual *membership fee* would guarantee the ease of maintaining FF-PFAs at all times without any extra membership charges, and would also enhance the financial sustainability of the programme, given that the county government of Elgeyo-Marakwet (that host Kerio-Valley) is unlikely to be able to provide full funding for maintaining the FF-PFAs. The value of the cost attribute was determined during the FGD given the price of fruit-flies eradication traps (the pest management method adopted for FF-PFAs; KEPHIS, 2015). Table 1 below summarizes the description of attributes and their respective levels.

Table 1: Attributes and their levels

Attribute	Levels
Training	<u>No training</u>, Training is provided
Market support	<u>No market support</u>, Market information is provided, Market information is provided and contract sale is guaranteed.
Benefit	<u>No benefit</u>, Moderate benefit, Large benefit
Recommendation	<u>No recommendation</u>, Recommendation from relatives & friends/peers, Recommendation from the media, Recommendation from official sources like government agencies
Cost/Membership fee	900, 1,<u>500</u>, 2,100

Notes: Underlined levels indicate the status quo. Membership fee in Kshs. 1 USD was around Kshs 100 by the time of the field survey

2.1.2. Experimental design

The attributes and their levels produced a full factorial orthogonal main-effects design of 216 (i.e., $2^1 * 3^3 * 4^1 = 216$) possible FF-PFA alternatives (Adamowicz et al., 1994). The full factorial design was, in general, very large and not tractable in a SCE (Huber and Zwerina, 1996). Therefore, a subset of all possible combinations was chosen, following optimality and design efficiency criteria, and then the choice sets were constructed.

In SCE, design techniques used for linear models were popular in the past. Orthogonality in particular has often been used as the main component of an efficient design. More recently, researchers in marketing have developed design techniques based on 'D-optimal' criteria for nonlinear models in a SCE context (Huber and Zwerina, 1996). A design is said to be 'D-efficient' or 'D-optimal' if it yields data that enable estimation of parameters with sufficiently low standard errors (Kuhfeld, 2005). Bliemer and Rose (2010) noted that efficient designs generally increases sampling efficiency (reduces sampling size hence cost effective). Therefore, design efficiency implies sampling efficiency. To capture full information across the entire farmer diversity, at a reasonable sample size (considering costs constraints), an efficient criterion was adopted. Specifically, the study focused on maximizing the 'D-optimality' in two stages. In the first stage, a conventional fractional factorial orthogonal design generated from the attributes was selected and applied in a preliminary survey of 34 mango farmers to obtain prior coefficients. The second stage involved using the 'priors' (from first stage) to generate an efficient design, whose application could estimate both main effects and interaction effects as explained in Ruto et al., (2008).

The design had a relatively good level of D-optimality (i.e. D-efficiency measure of 91%). In addition, the design had good utility balance (i.e. a B-estimate of 88%)-surpassing the minimum threshold (B-estimate of

70%), which signals the fact that none of the alternatives in the choice options had any significant dominance. Worthwhile to mention is that most SCE-designs rarely achieve good D-efficiency, utility balance and orthogonality simultaneously (Huber and Zwerina, 1996). Furthermore, A-efficiency of 81% implied that the variance matrix generated reliable estimates (Kuhfeld, 2005). The efficiency procedure in the NGENE (Choice Metrics, 2012) statistical software was applied to produce the design.

The final design had 36 paired choice sets that were randomly blocked into six profiles of six choice tasks. Respondents were randomly assigned to one of the six profiles. Each choice task consisted of two FF-PFA alternatives (A and B) and the neither option, which was the *status quo.* When making choices, respondents were asked to consider only the attributes presented in the choice tasks and to treat each choice task independently. An example of a choice set/card presented to respondents is shown in Table 2.

Table 2: Example of FF-PFA choice set

	FF-PFA A	FF-PFA B	FF-PFA C
Training	Training is provided	No training	Neither type A or type B
Market support	Market information & contract	No market support	
Benefit	Moderate	Large	
Recommendation	Media	Official	
Annual membership fee	1500	900	
Which ONE would you prefer?			

2.1.3. Data and the experimental context

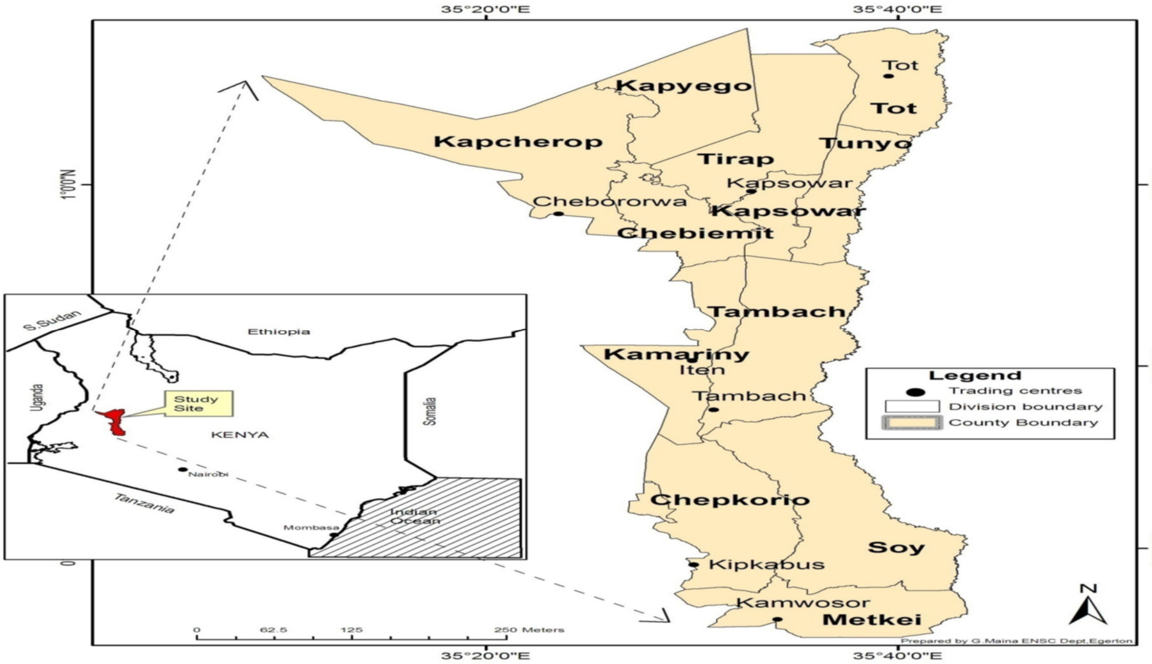
The target population included mango farmers who reside in Kerio-Valley of Elgeyo-Marakwet County. This region is suitable for this study because it's known to be the best in production of mangoes (for juice industry in the external market) and water melons. Mangoes from the region are highly sought by juice processors due to its high quality. The recently introduced apple variety fetches the highest prices in the market and is only grown in Kerio-Valley and the Eastern region of Kenya (Isigi, 2015). More importantly, the county was selected by KEPHIS for piloting the FF-PFA programmes in Kenya (KEPHIS, 2015). Data was collected using a semi-structured questionnaire by four enumerators who are experienced in collecting SCE data, from August-October, 2015. The questionnaire contained three main sections. First, a section asking questions regarding socioeconomic and demographic characteristics of the farmers. The second section enquired on farm specific features, including the degree of losses due to fruit flies, while the last section contained the SCE constructs.

The sample was drawn using a two-stage sampling procedure. The first stage involved the purposive selection of locations in Elgeyo-Marakwet County where FF-PFA programme had been launched by KEPHIS. The second stage involved random selection of mango farmers in these locations. Specifically, within each location a list of all mango farmers was drawn with help of KEPHIS officials and the village elders. Adequate samples were then selected, with regard to the distribution of farmers (population) within each location. A total sample size of 362 mango farmers was interviewed. This was within the project budget and time constraints.

Prior to asking respondents to make their choices among the three FF-PFA alternatives (A, B, or the baseline option) in the six consecutive choice sets, the attributes and the choice exercise was explained slowly and clearly. The enumerators reminded the respondents that there were no wrong or right answers, and that only their honest opinion was being sought. Enumerators also reminded the respondents' that even though the choices they were going to make were hypothetical in nature, they were expected to think carefully about them, as if they were actually going to join the FF-PFA they selected in each choice set. In addition, they were also reminded it was likely that the results of this study would inform the type of FF-PFA in their location. These rigorous reminders were intended to reduce the hypothetical bias that is inherent in SCE studies.

2.1.4. Study area

Elgeyo-Marakwet County is located along the basin of the Kerio River in the Rift Valley region of Kenya. It borders Uasin Gishu County in the west, Baringo and Pokot Counties in the east, and Turkana County in the north as shown in Figure 1. The county can be divided into three agro-ecological zones: highlands in the west, escarpment in the central parts, and the valley floor. The valley floor is flat and dry with sandy soils, ideal for drought-resistant perennial crops such as mangoes due to frequent heavy soil erosion during rainy seasons (Isigi, 2015). In the highlands (upper valley), homesteads are located on relatively flat to moderately sloped land with sandy and clay soils. Horticulture is currently practiced in this region with mango, water melon and the purple passion fruits dominating. Escarpment is very steep, but staples and drought-resistant crops are cultivated.



Source: Regional Centre for Mapping of Resources for Development (RCMRD)

Figure 1: Map of Elgeyo Marakwet County

The region is famed for producing some of the sweetest mangoes in the country. Among the varieties produced include; Apple, Ngoe, Kent, Boribo, Keith, Sebine, Tommy and Vandyk. KEPHIS report that a total of 518 hectares of land are under mangoes in the county, with an annual production of 24,285 tonnes valued at Kshs 383,449,850. However, some farmers lose more than 50% of their produce because of fruit fly infestation (Griesbach, 2003). As a result, KEPHIS has opted to work with mango growing counties to establish pest free areas (especially for fruit fly), with Elgeyo Marakwet being the first (pilot) county (KEPHIS, 2015).

2.2. Theoretical framework and econometric specification

The SCE is used to an increasing extent to measure demand for goods and services in various fields including marketing and preferences for various services (see Pambo et al., 2015 for extensive literature review). They were originally developed by Louviere and Hensher (1983) to forecast consumer demand in marketing research. SCE is highly suited to measure and forecast demand for products and services which are absent in the market or those at the design stage. In the SCE setting, goods and services are described in terms of their attributes/characteristics (Lancaster, 1996). Furthermore, SCE is based on random utility model (RUM) (McFadden, 1986) which provides a theoretical framework for modelling choices based on observable as well as unobservable utility components. In addition, the RUM postulates that an individual chooses an alternative among a given bundle of alternatives that maximizes her utility. Based on these theoretical frameworks, different models can be formulated to analyze SCE data.

In this paper, we applied the latent class model (LCM) to model mango farmers' choices in the FF-PFA choice tasks. This modeling approach is particularly suitable for capturing heterogeneity in preferences across segments. Focus groups had indicated that a great deal of heterogeneity could be expected due to the cultural mix within the county. In addition, designing efficient policies usually requires ex-ante information about the target population to address a certain problem (Boxall and Adamowicz, 2002). In this respect, the LCM can provide an important analytical tool to estimate data at class level in which subjects in the same class are likely share homogenous preferences and subjects across classes likely exhibit heterogeneous preferences.

The origin of the LCM traces back to earlier marketing research by Swait, (1994) and there are several studies which have employed these models to identify class-specific segments of a population based on their choice decisions. For instance, Ruto and Garrod, (2009); Birol et al. (2011) and Kikulwe et al, (2011) have applied the LCM approach to study farmers' preferences for the design of agri-environment schemes, consumer preference for bio-fortified staple food crops in developing countries and consumer preferences for genetically modified banana in Uganda, respectively. All of these studies discerned the role of LCM in unraveling policy relevant results based on homogeneous class-specific groups.

Similar to other logit models, the LCM rely on random utility theory to analytically deal with decision makers' choice behaviour which is usually difficult to fully account for (Boxall and Adamowicz, 2002). Assuming that we have s sets of classes, we can specify the following general utility expression:

$$U_{ntk} = \begin{cases} V(X_{ntk}, Z_n, \beta_s, \gamma_s, \mu) + \varepsilon_{ntk|s}, k = 1,2; \\ V(ASC_s, X_{ntk}, Z_n, \beta_s, \gamma_s) + \varepsilon_{ntk|s}, k = 3(optout) \end{cases} \quad (1)$$

where the indirect utility function, V, is a function of the observed explanatory variables related to the attributes, X_{ntk}, and farmer characteristics, Z_n, and the associated parameters, β_s and γ_s, respectively. Notice that the utility expression in equation (1) can be decomposed into two parts: one for the choice model and the other for the membership model. Assuming that the error term ε_{nk} is Gumbel-distributed, the probability of choosing alternative k in class s can be represented as:

$$P_{nt}(k) = \frac{e^{\mu\beta_s' x_{ntk}}}{\sum_j^J e^{\mu\beta_s' x_{ntj}}} \quad (2)$$

where β' is the vector of all betas estimated for the attributes, μ is the scale parameter which is normalized to unity, and the alternative specific constant (ASC), which is specified following Scarpa et al. (2005), and the error term are left out for simplicity. The latent grouping of subjects into different classes is a function of their characteristics such as socio-economic variables. As a result, the probability that an individual belongs to class s can be given by:

$$P_{ns} = \frac{e^{\gamma_s' Z_n}}{\sum_{s=1}^S e^{\gamma_s' Z_n}} \quad (3)$$

where γ_s' denotes the class-specific vector of estimated parameters, and Z_n represents the individual characteristics. For the sake of model identification, the estimated parameters of the last class S are usually normalized to zero and results from the other classes are compared relative to this class (Boxall and Adamowicz, 2002). Combining equations (2) and (3) makes it possible to simultaneously estimate both β_s and γ_s. Following Boxall and Adamowicz, (2002), the probability becomes:

$$P_n(k) = \sum_{s=1}^S \left(\frac{e^{\gamma_s' Z_n}}{\sum_{s=1}^S e^{\gamma_s' Z_n}} \prod_{t=1}^T \frac{e^{\beta_s' x_{ntk}}}{\sum_j^J e^{\beta_s' x_{ntj}}} \right) \quad (4)$$

Equation (4) can be estimated using the maximum likelihood framework, and once parameters are obtained, class-specific willingness-to-pay (WTP) values can be estimated using the equation:

$$WTP = \frac{\beta_s(non\ price\ attribute)}{\beta_s(price\ attribute)} \quad (5)$$

The variables used in the FF-PFA analysis as well as how they were coded are given in Table 3. All the indicated utility parameters (variables) entered the model as random parameters assuming normal distribution, except the cost attribute that was specified as fixed in order to facilitate the estimation of WTP, by eliminating the risk of obtaining extreme negative and positive trade-off values (Train, 1998).

Table 3: Variables used in the analysis of WTP

Variable	Description
TRAIN	Training is provided (1= yes; 0= otherwise)
MKIP	Market information is provided (1= yes; 0=otherwise)
MKISC	Market information is provided and sales contract is guaranteed (1= yes; 0= otherwise)
BENM	Moderate benefit received (1= yes; 0= otherwise)
BENL	Large benefit is received (1= yes; 0= otherwise)
RCP	Recommendation by peers (1= yes; 0= otherwise)
RCM	Recommendation by media (1= yes; 0= otherwise)
RCO	Recommendation by officials (1= yes; 0= otherwise)
COST	Annual FF-PFA membership fee (900, 1,500 or 2,100)

3. Results and discussions

3.1. Socioeconomic characteristics

As shown in Table 4, more male respondents (59%) answered than females because individuals in the study area were selected based on availability and responsibility for mango-orchard management. It also indicate that most household heads were male. The implication is that males' shoulders heavy responsibility for mango production in the region and should be incorporated in the design of innovative policy programmes such as FF-PFAs.

The mean number of years of formal education of the respondents was 10 with approximately 30% of the respondents having a tertiary education. The reported high levels of education is important for FF-PFA-management information dissemination as it enhances grasp and enabled the respondents' understand the SCE choice tasks during the survey (Pambo et al., 2015). Only 42% of the respondents reported off-farm income from business activities such as shops, flour mills, transport business or other forms of employment in the public and private sectors of the economy, while 40% exclusively derived most of their income from mango farming. This confirms the importance of mango to the livelihoods of the respondents and justifies the FF-PFA policy discourse to promote the enterprise.

Table 4: Socioeconomic characteristics of the respondents

Variable	Descriptive	No. of observations
Average age of respondent (years)	46.4(12.2)	362
Have off-farm income (% Farmers)	42.3	153
Derive more than half of income from mangos (% Farmers)	39.5	143
Average household size	5.4 (2.2)	362
Average Years of schooling completed	10.1(3.2)	362
Gender of respondent (% Male)	59.3	213
Source of labour in mango farms (% Hired)	27.4	99
Attitude of the farmer on FF-PFA (% Positive)	67.7	245
Aware of benefits from FF-PFA (% Yes)	41.3	151
Have joined FF-PFA (% Yes)	29.0	105
Have access to credit (% Farmers)	37.0	134
Average distance to the market (km)	8.4 (5.6)	362
Mangoes produced mainly for juice industry (% Farmers)	63.9	232
Average land size (hectares)	2.1 (0.6)	362

* Standard deviations are in parentheses (for continuous variables).

3.2. Estimation results

The LCM enables incorporating socio-economic variables as well as attitudinal statements in the membership function for specific classes. Table 5 presents the different explanatory variables included in the membership function.

Table 5: Explanatory variables used for model estimation

Variable	Description	Mean	SD	Min	Max
Age (AGE)	Age of the respondents in years	46.4	12.2	29	56
Education (EDUCATION)	Years of formal schooling	10.1	3.3	4	16
Gender (Male)	1 if respondent is male	0.59	0.3	0	1
Size of household (HHS)	The number of people living in the household	5.41	2.2	2	15
Have off-farm income (OFFICM)	1 if respondent has income from other non-farm sources	0.42	0.4	0	1
Farming main income source (FARICM)	1 if the respondents earns more than 50% income from mangoes	0.40	0.4	0	1
Juice industry/Commercial farmers (COMMERC)	1 if the respondent mainly sell mangoes to the juice industry	0.27	0.3	0	1
Credit access (CACCESS)	1 if the respondent borrows capital from formal financial sources	0.37	0.42	0	1
Joined FF-PFA (JOINPFA)	1 if the respondent has registered as a member of FF-PFA	0.29	0.37	0	1
Pro-FF-PFA attitude (PFFATT)[1]	Scores are calculated for each individual based on the weights obtained from the PCA	-0.0021	1.44	-4	2.3
Benefits attitude (BATT)	Scores are calculated for each individual based on the weights obtained from the PCA	-0.0024	1.08	-5.5	2.7

The application of LCM entails the determination of the optimal number of classes. This is commonly done by relying on minimizing information criteria such as the Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC) (e.g., Scarpa and Thiene, 2005). However, following Ruto et al. (2008) and Kikulwe et al. (2011) observations, relying solely on these two criteria can mislead preference and welfare estimation, possibly due to large number of resulting classes. Consequently, the selection of the appropriate number of classes must

[1] We identified six attitudinal statements relevant to assess farmers' attitudes toward joining FF-PFA. Following Kikulwe et al. (2011), we analyzed the data using a principal component analysis (PCA) to identify components across attitudinal statements. The PCA results give us two distinct components based on a linear weighted combination of the statements (Cronbach's alpha = 0.8431). The first component is highly related to the statements concerning acceptability or preparedness to join FF-PFA, thus, we label this component *'Pro-FF-PFA'* attitude. The second component concerns statement regarding marketing and livelihood benefits from FF-PFA, which we label '*benefits'* attitude.

also take the significance of parameters into account (Scarpa and Thiene, 2005). In addition, model interpretability and the agreement of results with the accepted theoretical foundations should also be considered (Ruto et al. 2008). For these reasons, we present results from a specification of the LCM with four classes even though both the BIC and AIC reached their minimum when specifying five classes, as shown in Table 6. Statistical Innovation's Latent Gold Choice 5.0 (Vermunt and Magidson, 2014) was used to estimate the LCM.

Table 6: Number of classes and goodness-of-fit measures

Number of classes	Number of parameters (npar)	Log-likelihood (LL)	BIC (LL)	AIC (LL)	P^2
1	7	-6832.208	14334.785	13873.143	0.06
2	35	-5747.543	13010.465	12195.791	0.22
3	59	-5534.455	12044.942	11986.963	0.28
4	83	-5252.232	11834.969	11671.983	0.34
5	97	-5100.919	10786.183	11415.654	0.34
6	131	-5032.778	10971.832	11226.608	0.32

Number of observations (N) = 6516, AIC (Akaike Information Criterion) is −2(LL−P); BIC (Bayesian Information Criterion) is −LL+(P/2)*ln(N).

In LCM, the population consists of a finite and identifiable number of groups of individuals (i.e., classes as shown in Table 6), each characterised by relatively homogenous preferences. These classes, however, differ substantially in their preference structure. This approach can accommodate preference heterogeneity while allowing for the number of segments to be determined endogenously by the data. In the LCM, belonging to a segment with specific preferences is probabilistic, and depends on the social, economic and attitudinal characteristics of the respondents (Birol et al., 2006). The LCM, therefore assumes that respondent characteristics affect choice indirectly through their impact on class membership. After extensive trials with the respondent characteristics that were collected in the survey, the variables that affect segment membership the most are reported in this paper. Variance inflation factor (VIF) was used to test for possible multicollinearity between variables used in the model by regressing each variable on the rest of the variables, i.e. using each variable as dependent and the rest as independent variables (Kikulwe et al., 2011). We found no evidence of multicollinearity implying that these variables were suitable for this analysis.

The LCM results show that the estimated cost parameters are significant and negative in all classes. In addition, the ASC parameter, which was specified to represent the 'none of these' option are negative and significant in all classes indicating that farmers favour either FF-PFA option A or option B over the *status quo* (FF-PFA option C). The estimated model also exhibit good explanatory power as indicated by the pseudo-R^2 value of 42%.

Table 7: Four classes LCM estimates for FF-PFA attributes

	Class 1	Class 2	Class 3	Class 4
	Price conscious farmers	Mainly-for-sale farmers	Pro-FF-PFA farmers	Random choosers
Choice model				
ASC (no choice)	-6.11 (0.22)***	-5.37 (0.18)*	-5.59 (0.54)***	4.44 (5.94)
TRAIN	0.43 (0.21)***	0.31 (0.14)***	0.65 (0.33)***	0.22(0.25)***
MKISC	0.26 (0.31)***	2.44 (0.25)***	2.22 (0.19)***	2.05 (2.11)
MKIP	0.13 (0.29)*	0.23 (0.15)*	0.87 (0.41)***	-1.31 (1.18)
BENL	0.26 (0.20)***	-0.22 (0.15)**	0.88 (0.31)***	1.19 (2.14)**
BENM	-0.12 (0.11)	0.22 (0.45)**	0.35 (0.21)***	0.53 (2.12)
RCO	0.29 (0.28)**	0.34 (0.19)***	1.06 (0.78)***	0.46 (2.52)*
RCM	0.21 (0.08)	-0.24 (0.16)**	0.43 (0.21)	0.21 (0.22)
RCP	0.38 (0.37)*	0.16 (0.71)*	-0.22 (0.19)	0.51 (2.55)
COST	-0.41 (0.19)***	-0.17 (0.12)***	-0.10 (0.06)***	-0.16 (0.09)
Class membership-model				
Constant	6.55 (2.91)***	5.33 (2.15)***	5.52 (2.26)***	
AGE	-0.16 (0.13)***	-0.16 (0.12)**	-0.19 (0.09)***	
EDUCATION	-1.23(0.76)*	-0.61 (0.78)	-0.86 (0.74)	
GENDER	-0.55 (0.48)	-0.52 (0.51)	-1.16 (0.97)*	
HHS	0.30 (0.28)	0.13 (0.12)	0.32 (0.14)*	
OFFICM	-0.57 (0.72)*	-0.84 (0.67)	-0.66 (0.72)	
JOINPFA	1.63 (1.52)***	2.86 (1.15)***	3.45 (0.88)***	
COMMERCE	-0.35 (0.49)*	3.23 (0.59)***	1.8 (0.94)*	
FARICM	-1.15 (0.74)	1.63 (1.42)*	-0.22 (0.37)	
PFFATT	0.92 (0.49)***	1.13 (0.89)***	2.66 (0.34)**	
BATT	-0.27 (0.23)	0.22 (0.21)	0.72 (0.41)**	
CACCESS	-0.55 (0.74)	0.96 (0.72)*	0.97 (0.74)	
Class probability	0.40	0.35	0.17	0.08
Log-likelihood	-3952.92			
ρ^2	0.42			
N (choices)	2172			

Notes: Statistical significance levels: ***1%; **5%; *10%. Corresponding standard errors are shown in parentheses

The relative size of each class is calculated by inserting the estimated coefficients into Eq. (3) and using it to generate a series of probabilities that a chosen farmer belongs to a given class. Farmers are then assigned to a class based on the larger of the two probability scores as shown in Table 7. These results reveal that mango farmers behave differently when making their decision concerning the FF-PFA choice, hence justifies the application of the LC models to trace heterogeneity in their preferences. The first class (40%) accommodates farmers who are less educated and accustomed to selling their mangoes for local consumption in the local market (i.e., variable 'COMMERCE' in the class membership model is negative). They are labeled as price *conscious farmers* as the absolute value of the estimated price coefficient is relatively higher than the other groups. These farmers strongly prefer FF-PFAs which are characterized by training farmers on their responsibility for FF-PFA, large benefit to the participating farmers and recommended by peers rather than media or official sources. Given that these farmers mainly sell for local consumption, they most likely rely on their social networks for marketing hence their preference for peer-recommendation.

Farmers in the second class (35%) are likely those producing mangoes for the juice industry (mostly for export or specialized market), and are labeled as *mainly-for-sale farmers*. In addition, mango farming contribute larger portion of their income given the positive and significant coefficient for farm income (FARICM). These farmers have access to credit facilities and show positive attitudes for FF-PFAs which is consistent with the finding that members of this class have joined FF-PFAs. In terms of their utility for the other attributes, they prefer FF-PFAs where market information is provided with sales contract and when recommended by officials rather than peers or media. In the third class (17%) farmers are likely to be females and with relatively larger household sizes. They put more weight on joining FF-PFA than any other class, and thus, they are labeled as *pro-FF-PFA farmers*. The membership probability model also shows that these farmers are strongly associated with positive pro-FF-PFA attitude (PFFATT), and livelihood benefits attitudes (BATT). Moreover, these farmers strongly prefer FF-PFAs with large benefit to other value chain actors, including farmers, and when recommended by officials.

3.3. Willingness-to-pay

Table 8 reports the WTP estimates for the FF-PFA attributes in the classes. WTP estimates in the first class are generally lower than others due to the relatively high price sensitivity in this class. However, these farmers are still willing to pay amounts ranging from Kshs 90 to Kshs 255 for FF-PFAs, and they are willing to join FF-PFAs. The highest WTP amounts are for training farmers on their responsibility for FF-PFAs (Kshs 4.063) and for provision of market information with sales contract (Kshs 1,117.5), by the farmers in class 3 and class 2, respectively. Results also show that the WTP for FF-PFAs recommended by officials ranges from approximately Kshs 300 to Kshs 1350.

In general, consumers are willing to pay more for training, market information with sales contract and large benefits for other value-chain actors as revealed by the class weighted WTP values. The indication is that most farmers in the sample derive significant utilities from realizing that their actions benefit other mango value-chain actors. Although it is difficult to draw a conclusion based solely on results presented here, future commercialization of FF-PFAs in Kenya may benefit from introducing FF-PFA programmes as beneficial both to the user as well as the producers. This finding corroborates that of Kikulwe et al. (2011) who also found out that consumers of genetically modified bananas in Uganda drove positive utilities from benefits made by farmers.

Table 8: Marginal willingness to pay

	Class 1	Class 2	Class 3	Class 4	
	Price conscious farmers	Mainly-for-sale farmers	Pro-FF-PFA farmers	Random choosers	Class weighted WTP
TRAIN	308.5 (43.5)***	699.0 (122.0)***	4,063.4 (1185)***	-	1,026.0
MKISC	253.8 (42.9)***	1,117.5 (168.8)**	1,082.2 (131.6)***	-	621.6
MKIP	127.5 (22.7)*	251.1 (28.1)*	408.1 (87.6)***	-	313.7
BENL	254.4 (32.2)***	-204.4 (23.3)**	813.2 (141.2)***	-	463.9
BENM	-126.9 (19.4)	203.8 (36.8)**	413.9 (98.5)***	-	187.6
RCO	257.4 (57.8)***	428.3 (61.1)***	887.9 (241.6)***	-	468.2
RCM	85.7 (13.5)	96.4 (69.9)**	149.9 (119.8)	-	95.8
RCP	302.7 (43.5)*	113.0 (30.2)*	-219.5 (16.5)	-	54.1
Class probability	0.40	0.35	0.17	0.08	1

Notes: Statistical significance levels: ***1%; **5%; *10%. Corresponding standard errors are shown in parentheses. Kshs 100 = $1 during time of the study

Results further show that most farmers value recommendation attribute when they are asked to make decisions regarding FF-PFA, particularly when offered by peers or official sources. This implies that when farmers are asked to join a programme, they may tend to reduce the risk of new experience by seeking information, for example, through word of mouth or from their respective officials. However recommendations from media sources have less impact in the study maybe due to low-feedback mechanisms. Following Kozinets et al. (2010), farmers experience great deal of uncertainties and barriers when faced with new products or services that they normally relaxed by acquiring a learned experience from others.

Farmers also prefer training on the general requirements for establishing a FF-PFA including, the preparation of a public awareness programme, the management elements of the system (for example, documentation and record keeping), and monitoring activities, to enable them participate effectively in the FF-PFA programme. This finding may signify farmers' lack of satisfaction with the current agricultural extension services provided in the county (Otieno et al., 2011). As expected, preferences for the market support attributes are fully consistent with the choice axiom of transitivity; market information and sales contract is preferred to market information only or to no market support, in all the classes.

4.0 Conclusions and policy implications

Four distinct farmer classes are herein identified through a latent segment analysis of the FF-PFA SCE data collected from Elgeyo Marakwet County. The first, labeled *price conscious farmers,* comprises 40% of the sampled mango farmers. They value training, followed by recommendation by peers and large benefit for other value-chain actors. These farmers are older and generally less educated and have positive opinions regarding the benefits of FF-PFAs. They have relatively large families and are less often employed off-farm, and hence have relatively lower monthly incomes. In contrast, our analysis identifies 35% of the sampled farmers as *mainly-for-sale farmers*, who prefer FF-PFAs where market information is provided with sales contract and recommended by officials. However, these farmers derive negative utilities from knowing that their actions benefit other value-chain actors. The third class (17%), labeled as *pro-FF-PFA farmers* prefer market information with sales contract, official recommendation and large benefits for others. They are likely to be females and with a relatively large household sizes with strong approval for FF-PFAs. The *random choosers* forms the last segment for our analysis.

In sum, most farmers prefer and are willing to pay more for FF-PFAs characterized by training, provision of market information with sales contract, an official recommendation as well as large benefits to other mango value-chain actors. Based on the results so far, two policy implications can be drawn. First, promoting FF-PFAs would be effective in improving mango export (producing healthy mangoes) if officials (from agriculture sector, KEPHIS and county government) take an active role in engendering the programme to farmers. National regulations in terms of, e.g. standardization of FF-PFAs management rules and training methods are scanty. Nevertheless, if FF-PFAs are to be effective, administrative frameworks should come into play (Otieno et al., 2011). This is consistent with our findings' that farmers would trust and accept the programme if they get information from their respective officials or peers. The institutions mandated to provide extension services therefore need capacitation. Second, the fact that farmers in our sample showed significant demand for FF-PFAs would seem to be very policy relevant in relation to transforming the mango value-chains in the county and the country, at large. In other words, the results presented in this paper serve as initial guidance for policy development aimed at overcoming potential challenges and barriers to start upscaling FF-PFAs and subsequently promote a compendium mango value-chain in Kenya.

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