But what do rural consumers in Africa think about GM food?

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So far few African countries have accepted genetically modified (GM) crops, despite their high potential for increasing food production. The opinion of African consumers is missing in the debate, especially in rural areas, so a survey was conducted among rural consumers in the major maize growing areas of Kenya to gauge their acceptance of GM food. A third of respondents were aware of GM crops, mainly from the radio in rural areas. Most respondents would buy GM maize meal at the same price as conventional maize, and even pay a premium. The rural population of Kenya lacks access to the relevant information to make informed decision and contribute to the debate on the use of GM crops in Africa. A concerted, public policy effort is therefore needed, where the wider use of radio to reach the rural population should be explored. Provided with balanced information, rural consumers show a high degree of acceptability of GM maize.

But what do rural consumers in Africa think about GM food?

Genetically modified (GM) crops are widely adopted in the Americas and some Asian countries, but not in Europe or Africa (James, 2013). Despite the technology's high potential for increasing food production in Africa, few countries in the continent have so far accepted it. The political and economic elite tends to share the aversion of European consumer groups for GM food based on health and environmental concerns (Paarlberg, 2002). Most of the potential benefits, on the other hand, would go to farmers and rural consumers, whose opinion does not seem to carry much weight in the debate and is therefore rarely sought.

Transgenic transformation does expand dramatically the range of possibilities for increasing both quantity and quality of crops, by transferring desired genes between organisms that are not sexually compatible. The most important genes are the *Bt* gene, which causes the plant to produce a protein that is toxic to particular insect pests, and the HT or herbicide tolerant gene that renders plants tolerant to the herbicide glyphosate (FAO, 2004). Transgenic crops have been adopted at a rate unprecedented for agricultural technologies: from 1.7 million hectares in 1996 to 175 million hectares in 2013, in both developed and developing countries (James, 2013). Worldwide, 14 million farmers grow GM crops, the large majority (90%) are small and resource-poor farmers in developing countries, who grow mainly *Bt* cotton. Most countries in the developing world only produce GM crops for industrial us (cotton) or for feed (soybean and maize). So far, the only GM food staple crop is *Bt* maize, and it is only produced for food in South Africa (Gouse, 2012).

The nature of GM crops has raised many concerns about the ethics and safety of their use (ICSU, 2004), in particular to human health and the environment, as well as an unease about the 'unnatural' status of the technology (Nuffield Council on Bioethics, 1999). Several reviews document a general consensus in the scientific community that currently available GM foods are safe for human consumption, although this does not prevent that risk might be encountered in the future (FAO, 2004; ICSU, 2004). Moreover, GM crops provide additional benefits to human health by reducing exposure to mycotoxins (Miller, Conko, & Kershen, 2006), pesticides (Smale et al., 2009), and accidental pesticide poisoning (Bennett, Morse, & Ismael, 2003).

GM crops could, however, affect the environment, in particular by transferring genes to wild relatives of the host crop, and weediness and trait effects on non-target species (FAO, 2004). Still, hybridization with wild relatives is likely to transfer those genes that are advantageous in agricultural environments, but not in the wild (FAO, 2004; GM Science Review Panel, 2003) and, so far, no evidence of any deleterious environmental effects has occurred from the trait and species combinations currently available (ICSU, 2004). However, if GM varieties of open pollinated crops with dominant traits such as *Bt* are grown close to local varieties, these traits are likely to cross over, and special attention needs to be given to preserve these varieties (FAO, 2004). On the other hand, GM crops have been shown to provide substantial benefits to the environment by reducing the use of insecticides, herbicides and fuel, and promoting conservation agriculture (Brookes & Barfoot, 2012).

Despite the scientific evidence in its favor, the use of GM food remains controversial. A meta-analysis of 25 consumer studies found that European consumers were willing to pay, on average, 29% more for non-GM food than U.S. consumers (Lusk, Jamal, Kurlander, Roucan, & Taulman, 2005). In developing countries, consumers show a more positive attitude, and premiums for GM food have been observed in India (Anand, Mittelhammer, & McCluskey, 2007) and in China (Li, Curtis, McCluskey, & Wahl, 2002; Smale et al., 2009), although the acceptance of GM food by Chinese consumers has been declining lately (Huang & Peng, 2014). To our knowledge, only two consumer acceptance studies have been conducted in Africa, both with urban consumers. In Nigeria, two thirds of respondents disapproved of the use GM technology (Kushwaha, Musa, Lowenberg-DeBoer, & Fulton, 2008), but in Kenya most respondents had a positive attitude towards GM maize (S. C. Kimenju, De Groote, Karugia, Mbogoh, & Poland, 2005). Several factors have been shown to affect the acceptance of GM food by consumers, especially information, particularly negative messages and risk perceptions (Smale et al., 2009). The most reluctant consumers of GM foods are typically those relatively more risk conscious (Costa-Font, Gil, & Traill, 2008).

Regulatory systems vary widely among countries and continents. In the US, based on the available scientific evidence comparing the benefits to the risk, GM crops have been basically deregulated (Paarlberg, 2000). In Europe, however, potential benefits are not that high, consumers have strong reservations and are well organized, and trade barriers offer protection for local farmers (Demont, Wesseler, & Tollens, 2004), and the European regulatory system has been built upon the precautionary principle (McMahon, 2003). In Africa, with stagnating yields for food crops, potential gains are much more important than in Europe. The political elite, however, often has strong cultural ties with Europe, a major source of information, and most African countries have copyied the European regulatory framework (Paarlberg, 2008).

Unfortunately, the opinion of farmers and rural consumers, the major potential beneficiaries, is rarely sought, let alone taken into account. Yet, their opinion is crucial, because they will shape the direction of the adoption and diffusion of GM crops. To fill the gap, this research was undertaken to gauge acceptance of GM food by urban and rural consumers in Kenya.

In Kenya, several GM crops have so far been tested, including sweet potato resistance to viruses (Qaim, 2001), *Bt* maize under the Insect Resistant Maize for Africa project (IRMA) (S. Mugo et al., 2005; S. N. Mugo et al., 2011), drought tolerant maize varieties, nitrogen efficient maize varieties and *Bt* cotton. So far, no GM crops have been commercially released, although an application for *Bt* cotton has been submitted to the National Biosafety Authority. In 2012, the Ministry of Health announced that the Kenyan government banned all imports of GM food, citing growing safety concerns about its consumption.

To fill the gap of information on consumers' attitudes and perceptions of GM food, a set of surveys were conducted in Kenya from 2003, with both urban and rural consumers. The first survey, with urban consumers in the capital only, used contingent valuation and showed that most urban consumers would be willing to buy GM maize flour at the same price as that of conventional maize flour, and even pay a small premium (S. C. Kimenju & De Groote, 2008). For the current study, a similar approach was used, now in rural areas. The objectives of the study were to obtain the opinion of rural consumers in Kenya on GM food, analyze their awareness, attitudes, perceptions and sources of information, and estimate their willingness to pay (WTP) for GM maize.

Methodology

Measuring consumers' WTP for new products: contingent valuation

The contingent valuation method with the double-bounded model was selected for this study, because it has a good theoretical justification, and has been used in many consumer studies on acceptance of GM food, including Kenya (S. C. Kimenju & De Groote, 2008), and its analysis is straightforward. In the CV method, respondents are asked about their WTP for a hypothetical product or service, contingent on there being a market for it.

However, participants' responses can be affected substantially by the way the questions are asked or the experiment is framed (Alberini & Cooper, 2000; Arrow et al., 1993; H. M. Hanemann & Kanninen, 2001), so the question needs to be carefully asked. For conventional maize products, markets are well known, making it easier for respondents. Revealed preference methods, where respondents use real money to purchase new products in an experimental setting, would arguably produce more realistic results, and premiums from revealed preferences for non-GM were found to be lower than premiums found by hypothetical methods (Lusk et al., 2005). Unfortunately, because of the ban on GM food in Kenya, revealed preference methods could not be used in Kenya.

In hypothetical methods and CV, open ended questions can be hard to answer, so close ended question are generally used. In the basic dichotomous choice method, respondents are asked if they would be willing to buy a product at a given price, ‘yes’ or’ no’, but this method does provides little information per respondent and is not efficient. In the double bound method, respondents are presented with a second bid: lower if they reject the first price, higher if they accept it. The level of the second bid is randomly assigned, so information over a wide range of values is gathered, over which a probability distribution can be estimated. This method is relatively efficient and provides reasonable estimates if the product is well described and understood by the respondent (M. Hanemann, Loomis, & Kanninen, 1991), and it is commonly used (Bateman & Willis, 2001), including for GM food.

Mathematically, the WTP of a group of consumers for a particular product to have a probability distribution function with probability decreasing with the price. The logistic distribution has a convenient format, and the price can be entered with other parameters and factors through an embedded index function, usually a linear function of the price (or bid) *B*. The cumulative distribution function can be estimated by:

$$P(WTP < B) = 1 - (1 + \exp(\alpha - \rho B)) \qquad (1)$$

(Hanemann et al., 1991; Hanemann and Kanninen, 1998).

In the double-bounded dichotomous choice model, the consumer is presented with two consecutive bids, with the second bid depending on the response to the first: participants who answer “yes” to the first bid (B_i) are subsequently offered a higher bid (B_i^u), while those who answer “no” to the first bid are offered a lower bid (B_i^d), so four outcomes are possible: “yes, yes” , “yes, no”, “no, yes” and “no, no”.

The probabilities of these outcomes can be derived using the logistic distribution from Equation (1) and the log-likelihood function derived (M. Hanemann et al., 1991). Estimations of the parameters can then be obtained by maximizing the likelihood function, the mean WTP is calculated as α / ρ (H. M. Hanemann & Kanninen, 2001; M. Hanemann et al., 1991), and the standard error calculated using the bootstrap method.

Apart from the bid B_i offered to consumer i, acceptance of the bid for a product and its quality also depends on an the person’s knowledge and perception of that quality, and other cognitive and socio-economic factors, represented here by a vector $\mathbf{z}_i$. The probability of a bid being accepted (either the first or the second bid in the double-bounded method), becomes:

$$\pi^y(B_i, \mathbf{z}_i) = 1 - 1/(1 + \exp(\alpha - \rho B_i + \lambda' \mathbf{z}_i)) \qquad (7)$$

From there, the appropriate log-likelihood function can then be constructed.

Study design

To obtain a representative sample of rural consumers, a subset was selected of sub-locations from an earlier household survey, which used a stratified two-stage sampling design, with agro-ecological zones (Hassan, 1998) as strata and administrative units (sublocations) as the first stage of sampling (H. De Groote et al., 2005). The present study is based on three consecutive surveys, each using a subset of households from the earlier survey.

The first survey was conducted in January 2006 in eastern Kenya, in the dry transitional (DT) zone, and retained the sub-locations of the DT zone which fell in two districts, Machakos and Makueni (Figure 1). Half of the sub-locations from the earlier study in each district were randomly selected, and in each sub-locations a list of households was established from which 200 were randomly selected, 140 household in Machakos and 60 households in Makueni (Table 1).

[Table 1]

The second survey was conducted in the moist transitional zone districts of Kericho and Kisii in Western Kenya in April 2006. These districts contained eleven sub-locations in the previous survey, with twelve households in each sub-location, which were retained for this survey, leading to a total of 121 respondents. The third survey took place in July 2009 in the central part of the moist transitional zone was selected, and ten sub-locations of the previous survey were retained, dropping the most distant sub-locations to the East for budgetary reasons. Each sub-location had around 10 households in the sample, leading to a total of 107 households.

A structured questionnaire was then used for data collection. Different enumerators were hired and trained for each survey.The gender of the respondents was determined by availability of respondents in the households selected, resulting in slightly fewer women in the West and Central survey areas (46% and 49%), but substantially more in the East (89%) (Table 2).

[Table 2]

Data collection

Participants in the different surveys were asked the same questions, with minor variations, based on the questionnaire from the Nairobi study (S. C. Kimenju et al., 2005).. First, the consumers' awareness of GM crops was assessed by checking if they had heard or read something about biotechnology and GM crops in general, and about *Bt* maize, *Bt* cotton and virus-resistant sweet potato in particular.

Second, consumers' opinion of GM crops were evaluated by asking if they agreed or disagreed with statements on associated benefits and risks, and how strongly (in five ordered categories from "totally disagree", to "totally agree"). These statements were on five types of perceptions: benefits (four statements), health risks (three), environmental risks (three), ethics six), and equity concerns (six). The replies were transformed into a score (from -1 for 'totally disagree', - 0.5 for 'disagree', 0 for 'neutral', 0.5 for 'agree', and 1 for 'totally agree'), which were averaged into a perception index for each of the five categories. In Eastern Kenya, where the survey was added to another survey, time was limited and these questions were not asked.

For the CV exercise, consumers were first asked if they had heard of GM crops. Those who had not were given a short presentation on the benefits and risks of GM food (see Appendix) and then asked if they would be willing to purchase GM maize meal at the base price, a rounded price close to the price observed in the nearby market. Those who answered "yes" were then asked if they would be willing to buy GM maize meal at a higher price. Different premium levels were used (5%, 10%, 20%, 30% or 50%), and one randomly assigned to each respondents. All prices were in KShs for the standard 2 kg packet. Respondents who answered "no" to the first bid were offered a lower price; reduced by a randomly assigned discount (5%, 10%, 20%, 30% or 50%).

Analysis

To calculate the mean WTP, the simple model was estimated first, and the average WTP calculated as α / ρ. Next, the long model was estimated, with consumer characteristics, and the expected WTP is calculated by adjusting the α to include the estimated parameters and the average values for the vector of factors $\bar{\mathbf{z}}$ (Haab & McConnel, 2002), (p. 35):

$$E(WTP \mid \alpha, \lambda, \rho, \bar{\mathbf{z}}) = [(\alpha + \lambda' \bar{\mathbf{z}}) / \rho] \tag{8}$$

For both models, the standard error was calculated using the bootstrap method (Greene, 1991). The cognitive factors included were awareness of GM technology, perceptions of GM food as measured by the five perception indices, and the socio-economic variables age, gender, the presence of children in the household, education and income.

Results

Characteristics of the respondents

The sampling methodology resulted in about an equal number of male and female consumers, except for Eastern Kenya where more women were interviewed (Table 2). Most respondents had primary education, and some secondary schooling. Few respondents were formally employed: most respondents were farmers or self-employed. The average farm size ranged from 1.3 ha in the densely populated Central Kenya to 2.5 ha in the East. The area in maize varied from 30% in the Western province to almost half in the East. Most consumers interviewed belonged to the lower income groups, although many respondents were not able to estimate their income.

Awareness of biotechnology and GM technology

About half the respondents in the different surveys were aware of biotechnology, although this differed substantially between groups (Figure 2). In the East, about 60% were aware of biotechnology but only few respondents in the Central (38%) and Western zones (16%) were aware.

The respondents were generally more aware of biotechnology than about GM crops. The zone closer to urban centers were substantially more aware of GM crops (about a third in Central and in the East), than those further away (13% in the West). Within the GM crop category, respondents were more aware of GM sweet potatoes, followed by *Bt* maize and *Bt* cotton, likely reflecting their history in Kenya. There were significant differences by gender and age: women were generally more aware of biotechnology and GM crops than men, and awareness of the different concepts generally decreased with age.

Sources of information

Respondents aware of biotechnology were further asked what the source of that information was. Radio was by far the most important source of information on biotechnology (31%), followed by relatives and friends (18%) and, to a much lesser extent, schools (10%). Agricultural research institutes and agricultural extension were also mentioned (9% each) (Table 3).

[Table 3]

The sources of information differed between the different regions. Agricultural research was only mentioned in the East, likely because of the proximity of the research stations in Katumani and Kiboko of the Kenyan Agricultural Research Organization (KALRO), which conducted research on *Bt* maize and other GM technologies. Further, agricultural extension and research were also frequently mentioned in the East and the Central study areas while in the East barazas (community meetings) were also frequently mentioned..

Perceptions

Participants in all surveys, except in Eastern Province, were asked if they agreed or disagreed with a selected number of carefully selected statements (Table 4). The responses were recoded and an average perception score for each category calculated, where a zero score indicates neutrality, negative scores disagreement and positive scores agreement.

[Table 4]

Respondents generally appreciated the potential benefits of GM technology such as increasing productivity and decreasing pesticide residues. Three quarters or more agree with the benefits statements, with an average perception score of 0.4 to 0.6 depending on the region.

However, many respondents also expressed concerns about the different risks, in particular environmental and health risks. Environmental concerns were the most important, in particular death of untargeted insects and loss of local varieties, to which a quarter to a third of respondents agreed. Since most respondents disagreed, the average scores were negative, albeit small.

Some respondents had concerns about health risks of GM crop (16%-20%). Few respondents expressed ethical or equity concerns. Respondents in the East were more concerned than those in the West: a quarter of rural consumers in Eastern Kenya thought GM crops would not benefit small-scale farmers, while in the West only 7% agreed.

Willingness to pay for GM food

The proportion of consumers who were willing to buy GM maize at the same price as conventional maize during the CV exercise ranged from 83% (Central) to 96% (Eastern) (Table 5). From the responses, a logistic distribution function of the bids was estimated and the mean WTP calculated. The results show that WTP for GM maize was substantially higher than that for conventional maize: respondents were willing to pay a premium for GM maize: 39% in the West, and more than 100% in the Central and Eastern study zones. Almost all the respondents accepted the first bid, so the distribution is estimated with few data points on the lower part of the distribution, which might affect its precision.

[Table 5]

The results of the long model (Table 6) showed that benefit and risk perceptions had strong effects on WTP. Benefit perceptions had a large positive and significant effect in the Central area, indicating that consumers who appreciate the benefits of GM there are also more likely to have a higher WTP. Even though the benefits are mostly for producers, not consumers, most rural consumers were also farmers, which might explain this effect. Coefficients on risk perceptions were all negative except for one, but only the coefficient for environmental concern in Western Kenya was significant. Socioeconomic factors seem to play only a small role in explaining the WTP. In the Central region, men had a higher WTP for GM than the women, and household size also had a positive effect, while in the East land size had a negative effect. Otherwise, factors such as income, age, education, did not have any significant effect. The long model was also used to calculate the expected WTP of GM food according to Equation (2), and this calculation provided similar estimates as the short model. Table 6).

[Table 6]

Conclusion

The results show that awareness of GM crops among rural consumers in Kenya is low. Further, there are major differences in sources of information on GM crops:, but radio dominates in the rural areas. The study in Nairobi found newspapers and television to be the most important sources for urban consumers

Finally, when consumers are provided with balanced information on GM crops and food, there is a high degree of acceptability of GM maize, especially in rural areas. The majority of urban consumers are willing to pay the same price for GM maize as for conventional maize, and almost all rural consumers are willing to do so. Generally, consumers are willing to pay a premium for the GM maize, and the premium is large in the rural areas.

The positive reaction of Kenyan consumers towards GM food is similar to that of other developing countries (Smale et al., 2009), and does not reflect the attitudes of European consumers. However, attitudes can change, as has been observed in China where consumers' attitudes reversed from positive to negative over a fairly short time span (Huang & Peng, 2014), despite the embracing of the technology by the Chinese scientific community.

Because of the current ban on GM food, this study had to be conducted with stated preferences, in contrast to revealed preferences. The results of this method depend heavily on the way the new product is presented and described. To analyze changes in attitudes, it is important that future studies use similar methods to make comparisons possible. Similarly, to assess a possible change in benefit and risk perceptions, future studies should use similar questions. The contingent valuation method, used for the studies presented here, has its limitations. The premiums for GM maize over conventional maize, a basic food crop, reaches more than 100% in some areas, which does seem unrealistic. Likely, the appreciation of technology by the respondents as farmers, not as consumers, played a role in this assessment. The premiums could also reflect the novelty factor: an increased consumer interest for new and untested products.

Further, since the time of these surveys, several studies have used experimental methods to assess acceptance of new food products by rural consumers in Kenya (Hugo De Groote, Kimenju, & Morawetz, 2011) and in other African countries (Banerjee, Duflo, Cole, & Linden, 2007; Hugo De Groote, Chege, Tomlins, & Gunaratna, 2014). When and where GM food can be used for experimental purposes, these methods should be considered. Unfortunately, this is not yet possible in Kenya, but it could be tried in South Africa, where GM crops have been accepted and are being grown on a large scale.

We conclude that, for now, the rural population lacks access to the relevant information to make informed decisions and contribute to the debate on the use of GM crops in Africa. A concerted effort is therefore needed to bring that information to the Kenyan consumer, and the wider use of radio to reach the rural population is indicated for that purpose. The results of this study show that, if presented with a balance fact sheet on the benefits and risks of GM technology, a large majority of Kenyan consumers are willing to pay the same price for GM maize as for conventional maize. Perceptions on the technology are the main drivers of this acceptance, and those perceptions are largely positive. Consumers do have some concerns, however, in particular about health and environmental risks, which need to be addressed. Overall, Kenyan consumers are likely to accept GM crops and their derived foods.

The results indicate that the opinion of the rural consumers, still a majority in most African countries, likely differs substantially from those of European consumers. It is therefore important that the development of biotechnology policies for Africa takes into account their opinion. Efforts should be made to inform both urban and rural consumers, engage them in the debate, and give their opinion the weight it deserves in policy decisions on GM crops.

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Tables and Figures

Table 1. Sampling methodology

	West	Central	East
Year of survey	2006	2009	2006
Agro-ecological zone	Moist transitional	Moist transitional	Dry transitional
Province	Western	Central, Eastern	Eastern
County	Bomet, Kericho, Kisii, Nyamira	Embu, Kirinyaga, Muranga, Nyeri	Machakos, Makueni
Number of primary sample units (points of sale or sub-locations)	11	10	10
Number of respondents/PSU	12	11	20

(average)			
Total number	134	107	200

NA: not applicable

Table 2. Characteristics of rural consumers in the sample, by region

Variable	Category	West	Central	East
Female respondents (%)		46	49	80
Highest level of education (%)	None	16	5	11
	Some primary	60	54	49
	Some secondary	22	35	37
	Some tertiary	2	7	3
	Some university	0	0	0
Employment status (%)	Formally employed	6	7	54
	Self-employed	46	50	12
	Unemployed	32	42	17
	student	2	2	1
Income level per month (USD)	0 (student)	0		1
	0 (non-student)			
	0 to 200	25		17
	200 to 667	0		0
	over 667	0	0	0
Household	Total farm size (ha)	2.2	1.3	2.5
		(2.9)	(1.5)	
	Maize area	0.6	0.6	1.1
		(0.5)	(1.0)	
	% maize area/total area	28.9	48.7	46.3
	Cattle	3.6	0.0	3.0
		(4.4)	-	
	Household size	7.1	4.8	6.0
		(3.6)	(2.6)	

Table 3. Sources of information on biotechnology (% of respondents who are aware who received their information on biotechnology from this source)

Source	West	Central	East	Total
School/college	0.0	0.0	16.7	10.5
Newspapers	13.3	0.0	6.1	5.7
Media			4.5	2.9
Relatives and friends	6.7	12.5	22.7	18.1
Radio	40.0	70.8	15.2	31.4
Television	0.0	4.2	0.0	1.0
Agricultural institutes	0.0	0.0	13.6	8.6
Books	0.0	0.0	0.0	0.0
Seminars and conferences	0.0	0.0	1.5	1.0
Extension officer	0.0	4.2	12.1	8.6
Agricultural show	0.0	8.3	1.5	2.9
Magazines	0.0	0.0	0.0	0.0
Professional/scientific publications	20.0	0.0	0.0	2.9
Work place	0.0	0.0	0.0	0.0
Barazas (community meetings)	0.0	0.0	6.1	3.8
Internet	0.0	0.0	0.0	0.0
Other sources	20.0	0.0	0.0	2.9
N (sample)	134	107	200	241

N (aware of biotechnology)	15	24	66	39

Table 4. Perceptions of rural consumers concerning GM technology (% of respondents who agree or strongly agree, scores in italics)

Concerns	Statement	Western	Central
Benefits	GM technology increases productivity and offers solution to world food problem	98	90
	GM can reduce pesticides on food	85	80
	GM can create foods with enhanced nutritional value	71	82
	GM has potential of reducing pesticide residues in the environment	85	80
	Benefit perception score[a]	*0.6*	*0.5*
Environmental risk	GM threatens the environment	17.4	16.2
	Insect resistant GM crops may cause death of untargeted insects	38.0	41.0
	GM can lead to a loss of original plant varieties	34.7	25.7
	Environmental risk perception score	*-0.2*	*-0.1*
Health risk	Consuming GM foods can damage one's health	18.0	21.0
	People could suffer allergic reaction after consuming GM foods	16.0	20.0
	Consuming GM foods might lead to an increase in antibiotic-resistant diseases	20.0	17.1
	Health risk perception score	*-0.3*	*-0.2*
Ethical concerns	GM is tampering with nature	16	28.6
	GM technology makers are playing god	4	29.5
	GM food is artificial	5	41.9
	Ethical perception score	*-0.5*	*-0.1*
Equity concerns	GM products only benefit multi-nationals making them	6.6	19.0
	GM products don't benefit small-scale farmers	6.6	26.7
	GM products are being forced on developing	8.3	11.4

countries by developed countries		
Equity perception score	*-0.5*	*-0.2*

[a]Average scores are calculated from individual scores with following values: strongly disagree = -1, disagree = -0.5, neither agree nor disagree = 0, agree = 0.5, strongly agree = 1

Table 5. Willingness to pay for GM maize (results of the regression of the short model and derived WTP)

	West	Central	Eastern
Willingness to pay at same price (%)	89	83	96
Constant (α)[a]	3.69***	3.49***	4.82***
	(0.46)	(0.49)	(0.42)
Bid (ρ)	0.05***	0.03***	0.081***
	(0.01)	(8.52)	(0.01)
N	121	104	200
Chi-square	252		250
Loglikelihood	-126	-196	-176
Mean WTP	79.00***	108.90***	59***
	(7)	(13)	(2.08)
Premium for GM maize (%)	39	110	98

[a] Numbers in brackets are standard errors

[b]The standard error of the mean WTP is calculated by bootstrap

*significant at 10%, ** significant at 5%, *** significant at 1%

Table 6. Willingness to pay for GM food (long model)

		Western		Central		Eastern	
Class	Variable	Coeff.	SE.	Coeff.	SE.	Coeff.	SE
	Constant	2.68	5.74 ***	1.94	0.40	3.98	8.39 ***
	Bid	0.03	0.23 ***	0.02	0.00	0.05	0.39 ***
Perceptions	Awareness of GM crops	-8.93	11.78	1.12	11.70	8.59	4.25 **
	Benefit perception index	-34.05	19.64 *	59.54	21.38 ***		
	Health risk perception index	9.01	10.39	15.54	16.94		
	Environment risk perception index	18.40	10.12 *	-22.87	17.52		
	Ethical concerns index	7.74	14.78	-14.46	17.11		
	Equity concerns index	21.98	14.61	-0.86	17.43		
Demographic	Age (years)	-0.43	0.32	0.32	0.38	-0.16	0.16
	Gender	-2.94	8.14	19.29	11.48 *	-5.36	4.91
	Household size	-0.37	1.35	5.83	2.33 ***	-0.37	0.63
	Education (years of schooling)	0.30	1.25	-0.58	1.73	-0.61	0.59
	Land size	-0.52	0.65	-2.71	1.85	0.30	0.29
	Government						
WTP	Mean WTP (long model)	80.03	4.77 ***	91.25	7.98 ***	63.57	4.37 ***
Model	Observations	109.00		102		198	
	Prob> chi2	0.003		0.02		0.22	
	Wald chi2(10)	28.55		22.96		8.23	

Log likelihood	-91.52		-150.52		-166.33	
Sigma	29.855	4.30 ***	46.94	4.64 ***	20.00	1.74 ***

* significant at 10% ; ** significant at 5%; *** significant at 1%

Figures

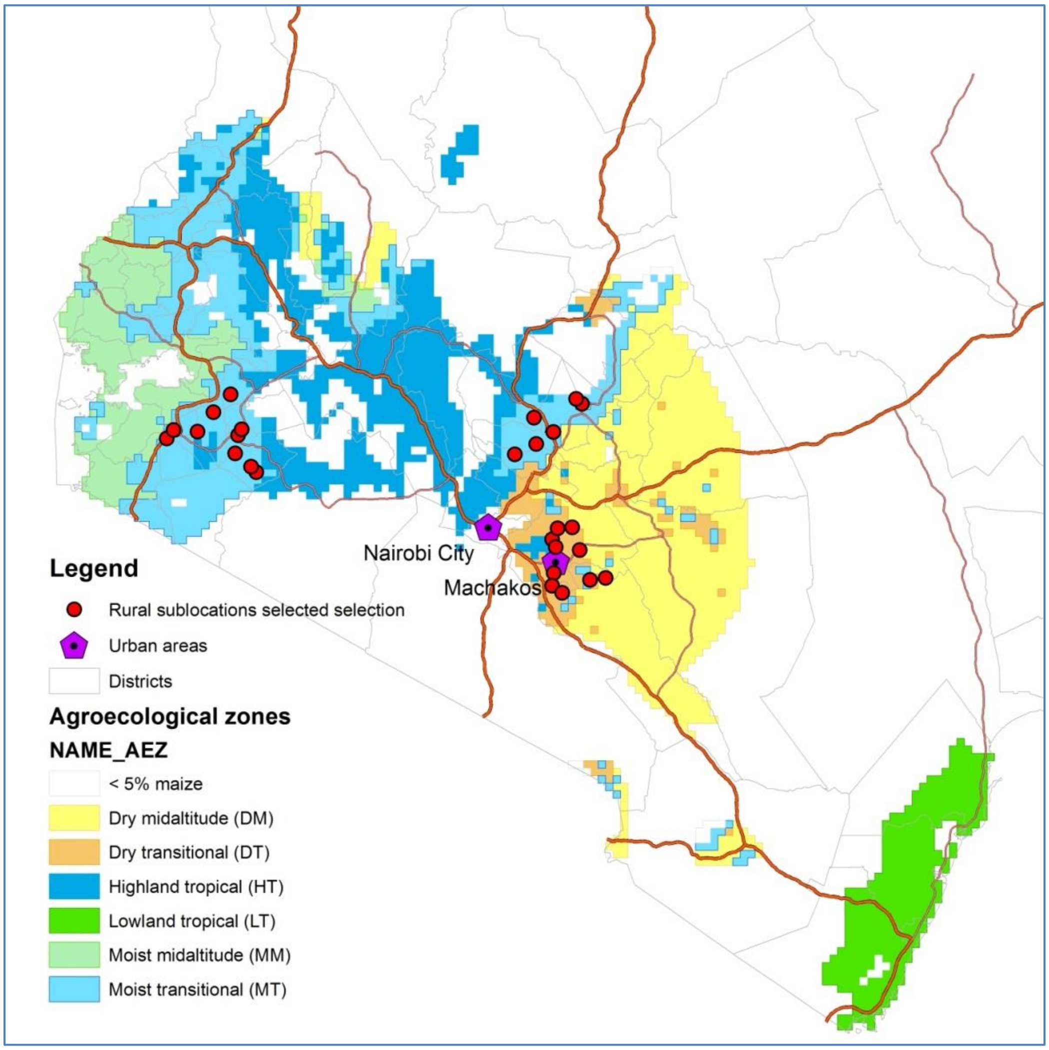

Figure 1. Map of study areas

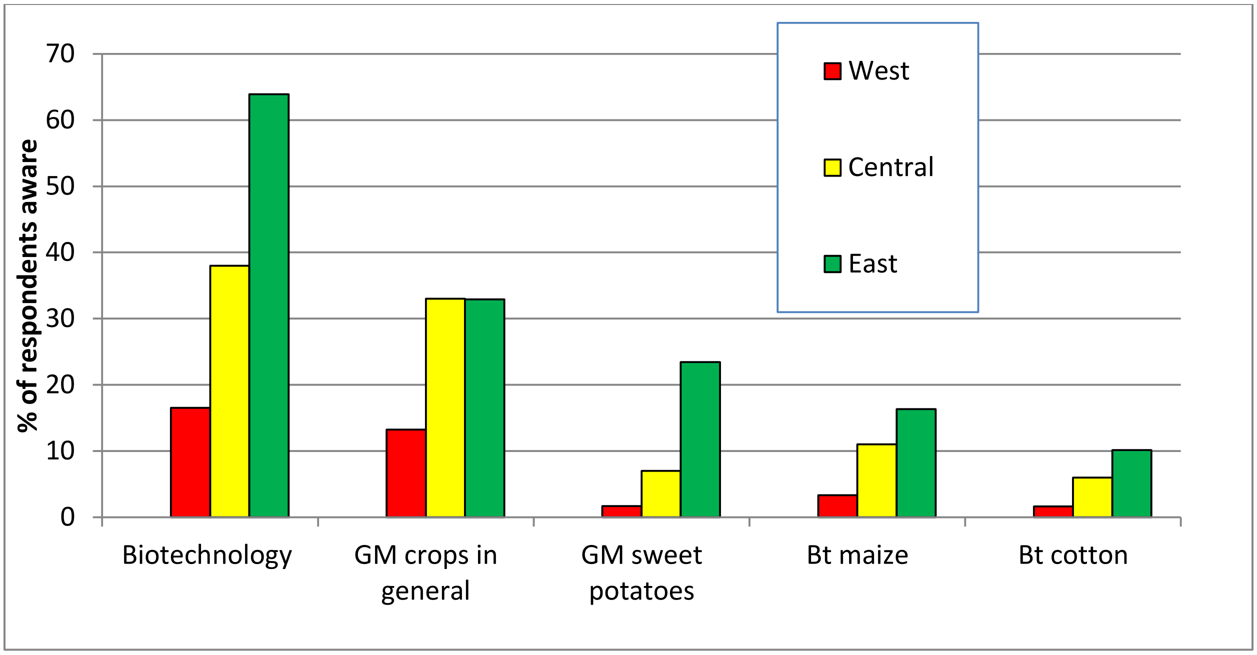

Figure 2. Awareness of rural consumers of biotechnology

Appendix: Information text read to consumers unaware of GM crops *(text from the latest survey in Central Kenya, 2009)*

Genetically modified crops contain genes that have been artificially inserted by scientists. The inserted gene may come from plants of the same species, another unrelated plant, or from other organisms such as bacteria. Characteristics targeted by plant breeders for genetic modification include increased yields, disease resistance and pest resistance, and consumption traits such as food color, size, shape, nutrition and taste.

The Kenya Agricultural Research Institute (KARI) together with international research organizations are undertaking research to develop pest resistant crops which protect themselves against the pest by producing its own pesticide. These crops are maize which is resistant to stem borer, cotton which is resistant to pests and sweet potato which is resistant to virus diseases.

Some of the benefits of GM crops are: 1.High yields reducing food shortages and lower food prices; 2. Reduced losses from pest and diseases and therefore reduced pesticide costs and residues in the environment.

The potential risks and perceived concerns about GM crops include: introduced genes through genetic modification might cross to wild relatives of the crops, in particular weeds, making them stronger; pests might develop resistance to the pesticide produced by GM crops; substances from these crops might affect non-target and beneficial insects and might contain allergic substances or toxins.

To ensure the safe use of GM crops, the Kenya government has passed the Biosafety Act in 2009. Plants are tested in a special biosafety green house to check their effectiveness such as insect resistance. If these trials proceed without problems, the authorities may give permission for trials on test plots in quarantine stations. If those trials go well, scientists may seek permission to try the varieties on the farm. After successful trials for several years, authorities can grant permission to commercialize and sell these varieties to farmers.

Most GM crops are grown in developed countries especially the United States of America and Canada; some developing countries such as China, India and Brazil grow Gm cotton. Kenya is not growing them commercially but is doing research in order to develop insect-resistant maize, cotton and virus-resistant sweet potato.