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# 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 of those in rural areas. Therefore, a survey was conducted among rural consumers in the major maize-growing areas of Kenya to gauge their acceptance of GM food. One-third of respondents were aware of GM crops, and their main information source was radio. Most respondents would buy GM maize meal at the same price as conventional maize meal and even pay a premium. Results show that the rural population of Kenya lacks access to relevant information to make informed decisions and contribute to the debate on the use of GM crops in Africa. A concerted, public-policy effort is therefore needed in which the wider use of radio to reach the rural population should be explored. Provided with balanced information, rural consumers show a high degree of acceptance of GM maize.

***Key words:*** Africa, biotechnology, consumer, contingent valuation, GM.

## Introduction and Background

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 accepted it thus far. The political and economic elite in Africa 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 rarely sought.

Transgenic transformation dramatically expands the range of possibilities for increasing both the quantity and quality of crops by transferring desired genes between organisms that are not sexually compatible. The most important genes are the *Bacillus thuringiensis* (Bt) gene—which causes the plant to produce a protein that is toxic to particular insect pests—and the herbicide-tolerant (HT) gene—which renders plants tolerant to herbicides such as glyphosate (Food and Agriculture Organization of the United Nations [FAO], 2004; Qaim, 2009). 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 use (cotton) or for feed (soybean and maize). So far, the only GM food staple crop is Bt maize, and in Africa it is only grown in South Africa (Gouse, 2012).

The nature of GM crops has raised many concerns about the ethics and safety of their use (International Council for Science [ICSU], 2004), in particular to human health and the environment. As well, there is 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 preclude any risks that 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 US 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 of GM technology (Kushwaha, Musa, Lowenberg-DeBoer, & Fulton, 2008), but in Kenya most respondents had a positive attitude towards GM maize (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 United States, 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, trade barriers offer protection for local farmers (Demont, Wesseler, & Tollens, 2004), and the European regulatory system has been built upon the Precautionary Principle to help allay consumer concerns about food safety (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 copied 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 rural consumers in Kenya.

In Kenya, several GM crops have been tested so far, including sweet potato resistance to viruses (Qaim, 2001); Bt maize under the Insect Resistant Maize for Africa project (IRMA; Mugo et al., 2005, 2011); and, lately, drought-tolerant maize varieties, nitrogen efficient maize varieties, and Bt cotton. So far, no GM crops have been commercially released in Kenya. An application for environmental release of Bt maize was submitted to the National Biosafety Authority in July 2015, public participation conducted in August 2015, and an approval for growing in national performance trials (NPT) granted in February 2016; however, it is conditional to the National Environmental Management Authority (NEMA) assessing and approving the trial sites, which is still pending (Stephen Mugo, personal communication). Likewise, an application for environmental release of Bt cotton was submitted to the National Biosafety Authority in 2015, public participation conducted, but the approval is still pending. In 2012, the Ministry of Health announced that the Kenyan government banned all imports of GM food, citing growing safety concerns about its consumption. The ban was still in place by August 2016. Milled grain had been legally imported into or through Kenya prior to this ban.

To fill the gap of information on consumers' attitudes and perceptions of GM food, a set of surveys were conducted in Kenya since 2003 using with both urban and rural consumers. The first survey, with urban consumers (conducted in the capital Nairobi) 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 would pay a small premium (Kimenju & De Groote, 2008). For the current study, a similar approach was used—this time 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 (CV) 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 (Kimenju & De Groote, 2008), and the analysis of the data it generates is now 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; Hanemann & Kanninen, 2001), so the information presented needs to be carefully formulated and the question asked in an appropriate manner. 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 here.

In hypothetical methods and CV, open-ended questions can be hard to answer, so close-ended questions are generally preferred. In the basic dichotomous choice method, respondents are asked if they would be willing to buy a product at a given price, and to answer with a 'yes' or 'no.' However, this method provides little information per respondent and is therefore not efficient. In the double-bounded method, respondents are presented with a second bid: lower for those who rejected the first price, higher for those who accepted 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 (Hanemann, Loomis, & Kanninen, 1991). CV methods are now commonly used (Bateman & Willis, 2001), including for GM food.

Mathematically, the WTP of a group of consumers for a particular product can been seen as having a particular cumulative probability distribution, usually denoted as G(.). The logistic distribution has a convenient and closed format, and the price can be entered with other parameters and factors through an embedded index function $v$, usually a linear function of the price (or bid) $B$. This distribution function can then be presented by

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

(Hanemann et al., 1991; Hanemann & Kanninen, 2001). The willingness of a price or bid $B$ being accepted by a consumer in the CV exercise then equals the probability that the WTP is higher than the bid offered, or

$$P\ (WTP > B) = 1 - G(v) = 1/(1 + \exp(\alpha - \rho B)) \qquad (2)$$

In the double-bounded dichotomous choice model, the consumer is presented with two consecutive bids, and the level of the second bid depends on the response to the first bid: 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 (Hanemann et al., 1991). Estimations of the parameters can then be obtained by maximizing the likelihood function, the mean WTP is calculated as $\alpha / \rho$ (Hanemann & Kanninen, 2001; 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 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

$$\pi^y\ (B_i, \mathbf{z}_i) = 1 - 1/(1 + \exp(\alpha - \rho B_i + \lambda' \mathbf{z}_i\ )) \qquad (3)$$

From there, the appropriate log-likelihood function can then be constructed and the mean WTP calculated. The mathematics are presented in more detail in a previous paper on acceptance of GM maize among urban consumers (Kimenju & De Groote, 2008).

### Study Design

To obtain a representative sample of rural consumers, a subset of sub-locations was selected from those used in an earlier household survey. That study used a stratified

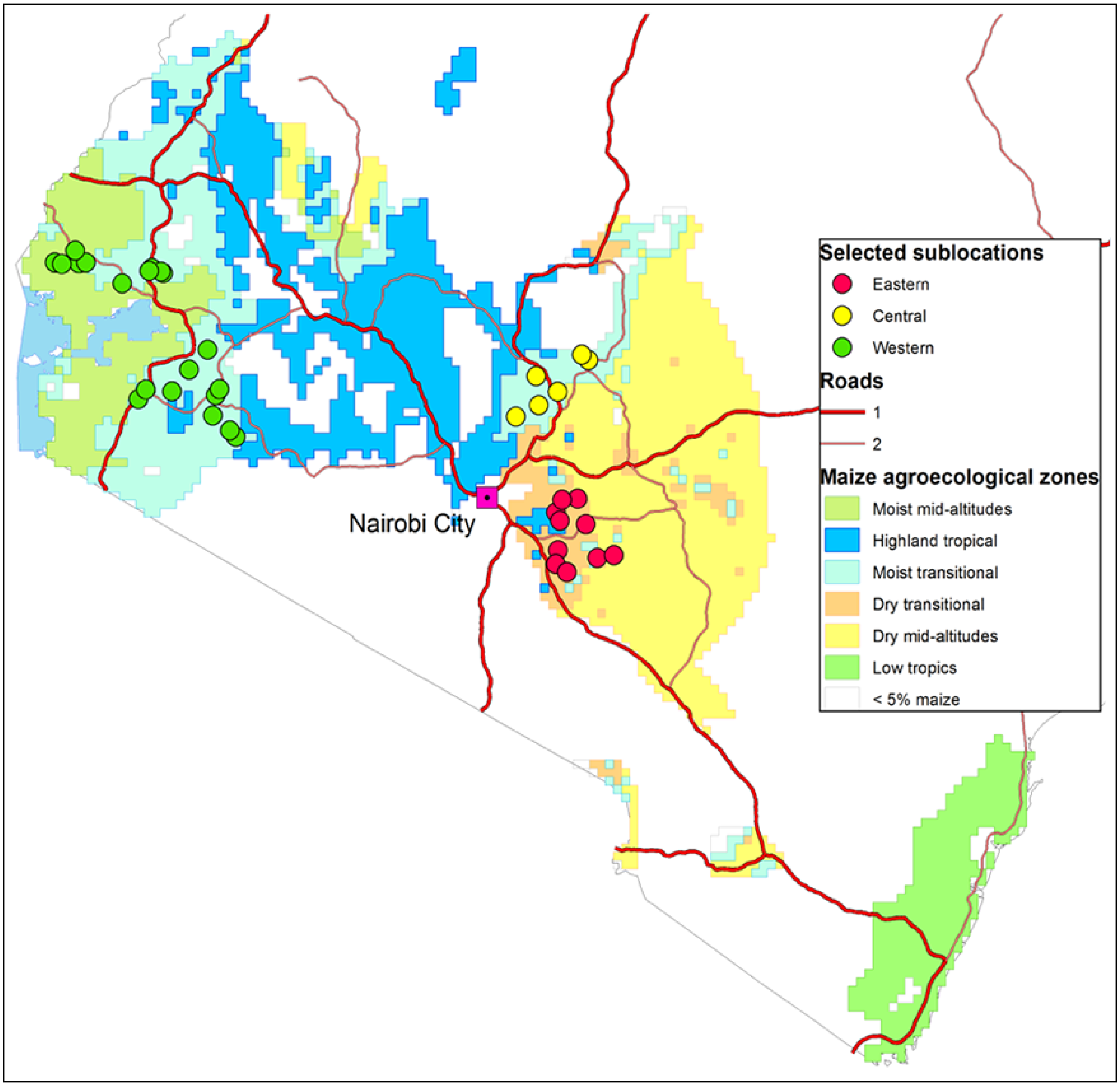


**Figure 1. Map of study areas.**

two-stage sampling design with agro-ecological zones (Hassan, 1998) as strata and administrative units (sub-locations) as the first stage of sampling (De Groote et al., 2005). The present study is based on three surveys in different rural areas of Kenya, 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-location a list of households was established from which 200 were randomly selected, 140 households in Machakos and 60 households in Makueni (Table 1).

The second survey was conducted in the moist transitional zone, in the districts of Kericho and Kisii in Western Kenya, in April 2006. In the previous survey, in these districts 11 sub-locations were selected and 12 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

**Table 1. Sampling methodology.**

| | West | Central | East |
|---|---|---|---|
| **Year of survey** | 2006 | 2009 | 2006 |
| **Agroecological zone** | Moist transitional | Moist transitional | Dry transitional |
| **Province** | Western | Central, Eastern | Eastern |
| **Counties** | Bomet, Kericho, Kisii, Nyamira | Embu, Kirinyaga, Muranga, Nyeri | Machakos, Makueni |
| **Number of primary sample units (sub-locations)** | 11 | 10 | 10 |
| **Number of respondents/primary sample unit (average)** | 12 | 11 | 20 |
| **Total number** | **121** | **107** | **200** |

**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 |
| **Employment status (%)** | Formally employed | 6 | 7 | 6 |
| | Self-employed (incl. farmers) | 46 | 50 | 77 |
| | Unemployed [a] | 32 | 42 | 17 |
| | Student | 2 | 2 | 1 |
| **Household** | Total farm size (ha) | 2.2 (2.9) | 1.3 (1.5) | 2.2 (3.1) |
| | Maize area | 0.6 (0.5) | 0.6 (1.0) | 1.0 (1.2) |
| | % maize area/ total area | 28.9 | 48.7 | 46.7 |
| | Cattle | 3.6 (4.4) | NA.[b] - | 2.9 (3.5) |
| | Household size | 7.1 (3.6) | 4.8 (2.6) | 6.0 (3.0) |

[a] *Unemployed: often, small-scale farmers indicate they are unemployed*

[b] *N.A. = not available (question was not asked)*

part of the moist transitional zone, and 10 sub-locations of the previous survey were retained, dropping the most distant sub-locations to the east for budgetary reasons. Each sub-location had roughly 10 households in the sample, leading to a total of 107 households.

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

### *Data Collection*

Participants in the different surveys were asked the same questions, with minor variations, based on the questionnaire from a similar study in Nairobi conducted in 2003 (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 1) 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 level randomly was assigned to each respondent. All prices were in Kenyan shillings (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%).

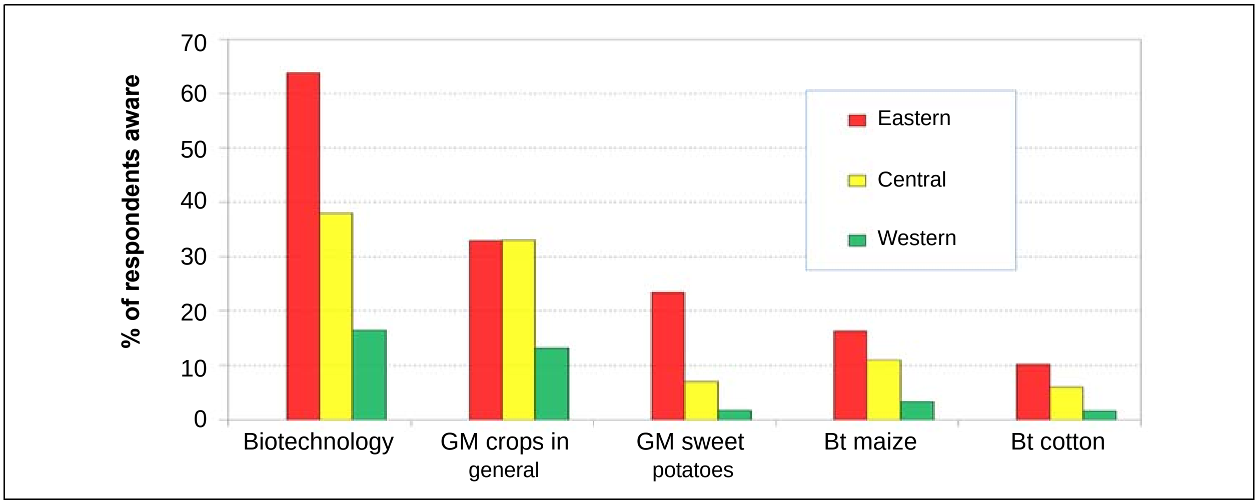


**Figure 2. Awareness of rural consumers of biotechnology.**

### *Analysis*

To calculate the mean WTP, the short model was estimated first, and the average WTP calculated as $\alpha/\rho$, and the standard error estimated using the delta method using the nlcom command in STATA version 13.1 (see Appendix 2). Next, the long model was estimated with consumer characteristics using the STATA command *doubleb* (Lopez-Feldman, 2012), and the expected WTP was then calculated by adjusting the $\alpha$ to include the estimated parameters and the average values for the vector of factors $\overline{z}$ (Haab & McConnel, 2002, p. 35)

$$E\,(WTP \mid \alpha,\lambda,\rho,z) = [(\alpha + \lambda'\,\overline{z}\,)\,/\,\rho] \tag{4}$$

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 generally resulted in roughly equal numbers of male and female consumers, except for Eastern Kenya, where more women were interviewed (Table 2). Most respondents had received some primary education, and some secondary schooling. Most respondents were farmers, and few respondents were formally employed, except in Eastern Province (in particular around Machakos). 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 roughly 30% of cultivated land in the Western Province to almost half in Central. Most consumers interviewed belonged to the lower income groups, and 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). While in the east, roughly 60% of respondents were aware of biotechnology, much fewer were aware in the central zone (38%) and, especially, the western study zone (16%). The respondents were generally more aware of biotechnology than of GM crops. The zones closer to major urban centers were substantially more aware of GM crops (about one-third in Central Province 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 the history of these crops 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 (mentioned by 31% of the respondents), fol-

**Table 3. Sources of information on biotechnology: Percent of respondents who are aware who received their information on biotechnology from this source.**

| Source | West | Central | East | Total |
|---|---|---|---|---|
| **Radio** | 40.0 | 70.8 | 15.2 | 31.4 |
| **Relatives and friends** | 6.7 | 12.5 | 22.7 | 18.1 |
| **School/college** | 0.0 | 0.0 | 16.7 | 10.5 |
| **Agricultural institutes** | 0.0 | 0.0 | 13.6 | 8.6 |
| **Extension officer** | 0.0 | 4.2 | 12.1 | 8.6 |
| **Newspapers** | 13.3 | 0.0 | 6.1 | 5.7 |
| **Barazas** | 0.0 | 0.0 | 6.1 | 3.8 |
| **Media** | 0.0 | 0.0 | 4.5 | 2.9 |
| **Agricultural show** | 0.0 | 8.3 | 1.5 | 2.9 |
| **Professional/scientific publications** | 20.0 | 0.0 | 0.0 | 2.9 |
| **Television** | 0.0 | 4.2 | 0.0 | 1.0 |
| **Seminars and conferences** | 0.0 | 0.0 | 1.5 | 1.0 |
| **Other sources** | 20.0 | 0.0 | 0.0 | 2.9 |
| **N (sample)** | 134 | 107 | 200 | 241 |
| **N (aware of biotechnology)** | 15 | 24 | 66 | 39 |

lowed 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).

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 and Livestock 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 frequently mentioned.

### *Perceptions*

Participants in all surveys, except in Eastern Province, were asked if they agreed or disagreed with a small number of carefully selected statements (Table 4). The responses were recoded into numerical variables and an average perception score for each category was calculated, where a zero score indicates neutrality, negative scores (the lowest being -1) indicate disagreement, and positive scores (with a maximum of 1) indicate agreement.

Respondents generally appreciated the potential benefits of GM technology, such as increasing productivity and decreasing pesticide residues. Three-quarters or

**Table 4. Perceptions of rural consumers concerning GM technology: Percent of respondents who agree or strongly agree, scores in italics.**

| Concerns | Statement | Western | Central |
|---|---|---|---|
| **Benefits** | GM technology increases productivity and offers a 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 to reduce 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 reactions 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 countries by developed countries | 8.3 | 11.4 |
| | *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 | |
|---|---|---|---|---|---|---|
| **Respondents' willingness to buy GM maize at the same price (%)** | 89 | | 83 | | 96 | |
| **Constant (α)[a]** | 3.60 | *** | 3.69 | *** | 4.82 | *** |
| | (0.46) | | (0.44) | | (0.42) | |
| **Bid (ρ)** | 0.05 | *** | 0.034 | *** | 0.081 | *** |
| | (0.01) | | (0.004) | | (0.01) | |
| **N** | 114 | | 95 | | 188 | |
| **Log likelihood** | -126 | | -149 | | -146 | |
| **Mean WTP** | 79.58 | *** | 109.98 | *** | 60.00 | *** |
| | (4.92) | | (5.62) | | (2.16) | |
| **Price of conventional maize** | 40 | | 86 | | 30 | |
| **Premium for GM maize (%)** | 99 | | 27 | | 100 | |

*[a] Numbers in brackets are standard errors*

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

**, **, *** Significant at 10%, 5%, and 1% levels, respectively*

more agreed with the benefit 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 associated with GM technology, in particular environmental and health risks. Environmental concerns were the most important, in particular the possible death of untargeted insects and loss of local varieties; one-quarter to one-third of respondents agreed to the two statements relating to those risks. Since most respondents disagreed with the risk statements, the average scores were negative, albeit small.

Some respondents had concerns about the health risks of GM food (16%-21%). Few respondents, however, expressed ethical or equity concerns. Respondents in the east had more equity concerns than those in the west: one-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 was very high; it ranged from 83% in the central study zone to 96% in the eastern study zone (Table 5). From the responses, a logistic distribution function of the bids was estimated and the mean WTP calculated. The results show that the WTP for GM maize was substantially higher than that for conventional maize. Respondents were willing to pay a substantial premium for GM maize, ranging from 29% in the western to 99% in the central and 100% in the eastern study zones. However, because almost all respondents accepted the first bid, the estimated distribution of WTP—from which the mean is calculated—is estimated with only a few data points on the lower part of the distribution, which might affect the precision and accuracy of the estimates.

The results of the long model (Table 6) showed that awareness only had a significant and positive effect on WTP in the eastern study zone. Further, among the benefit and risk perceptions, only the benefit perceptions had a significant effect, and only in the central study zone, indicating that consumers in this area who appreciate the benefits of GM crops are also more likely to have a higher WTP. Even though the benefits of GM maize are mostly reaped by the producers—not the consumers—most rural consumers were also farmers, which might explain this effect. Otherwise, coefficients on risk perceptions did not have a significant effect on WTP for GM maize. Similarly, socioeconomic factors seemed to have little or no effect on WTP for GM maize. WTP increased with household size, but only in the central zone. Otherwise, factors such as income, age, and education did not have any significant effect. The long model was also used to calculate the expected WTP for GM food according to Equation 4, and this calculation provided similar estimates as the short model (Table 6).

## Conclusion

The results show that awareness of GM crops among rural consumers in Kenya is low, and that the major source of information on GM technology in rural areas is the radio. Further, when rural consumers are provided with balanced information on GM crops and food, there

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

| Class | Variable | Western Coeff. | Western SE | | Central Coeff. | Central SE | | Eastern Coeff. | Eastern SE | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Constant | 2.45 | 5.74 | *** | 2.33 | 0.40 | | 3.00 | 8.39 | *** |
| | Bid | 0.03 | 0.23 | *** | 0.02 | 0.00 | | 0.05 | 0.39 | *** |
| Perceptions | Awareness of GM crops | 0.52 | 13.34 | | 1.40 | 11.80 | | 8.59 | 4.25 | ** |
| | Benefit perception index | 39.39 | 24.32 | | 63.59 | 21.61 | *** | | | |
| | Health risk perception index | 15.81 | 16.99 | | 21.18 | 16.83 | | | | |
| | Environment risk perception index | -10.57 | 19.26 | | -26.04 | 16.67 | | | | |
| | Ethical concerns index | 21.10 | 27.83 | | 9.51 | 15.43 | | | | |
| | Equity concerns index | 14.49 | 25.13 | | -28.24 | 17.52 | | | | |
| Demographic | Age (years) | -0.66 | 0.35 | | 0.31 | 0.39 | | -0.16 | 0.16 | |
| | Gender (male=1, female=0) | -1.71 | 9.10 | | 15.78 | 11.13 | | -5.36 | 4.91 | |
| | Household size | -0.31 | 1.42 | | 5.71 | 2.33 | *** | -0.37 | 0.63 | |
| | Education (years of schooling) | 0.00 | 1.37 | | -1.00 | 1.75 | | -0.61 | 0.59 | |
| | Land size | -0.46 | 0.74 | | -3.10 | 1.88 | | 0.30 | 0.29 | |
| WTP | Mean WTP (long model) | 81.67 | 5.26 | *** | 109.42 | 5.36 | *** | 60.03 | 2.03 | *** |
| Model | Observations | 109 | | | 101 | | | 198 | | |
| | Prob> $chi^2$ | 0.09 | | | 0.01 | | | 0.22 | | |
| | Wald $chi^2$(10) | 17.57 | | | 23.57 | | | 8.23 | | |
| | Log likelihood | -97.57 | | | -147.98 | | | -166.33 | | |
| | Sigma | 33.34 | 4.77 | *** | 46.97 | 4.70 | *** | 20.00 | 1.74 | *** |

*, **, *** *Significant at 5%, 1%, and 0.1% levels, respectively*

is a high degree of acceptability of GM maize. Almost all rural consumers are willing to pay the same price for GM maize as for conventional maize, and most consumers are willing to pay a substantial premium for GM maize.

The attitudes of rural consumers towards GM technology are similar to the positive attitudes earlier observed in urban areas (Kimenju & De Groote, 2008) and slightly more positive. Awareness of the technology is generally lower in rural areas, though, and the major source of information in rural areas is radio in contrast to newspapers and television in urban areas. The benefit perceptions of rural consumers with respect to GM technology are very high, while the environment and health risk perceptions are lower than in urban areas. As a result, acceptance of GM is higher in rural areas than in urban areas, and rural consumers are generally willing to pay a higher premium. Finally, in contrast to urban consumers, benefit perceptions have a positive effect on rural consumers' WTP, which is, on the other hand, not affected by risk perceptions.

The positive reaction of Kenyan consumers towards GM food is similar to that of other developing countries (Smale et al., 2009) and stands in contrast to 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, the present study had to be conducted with stated preferences as opposed 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 (De Groote, Kimenju, & Morawetz, 2011) and in other African countries (Banerjee, Duflo, Cole, & Linden, 2007; De Groote, Chege, Tomlins, & Gunaratna, 2014). These experimental, incentive-compatible methods should therefore be considered to evaluate consumers' WTP for GM food. 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. Therefore, a concerted effort is 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 balanced fact sheet on the benefits and risks of GM technology, a large majority of rural consumers in Kenya are willing to pay the same price for GM maize as for conventional maize. Perceptions of 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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## Appendix 1

## Informational 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),[1] together with international research organizations, is undertaking research to develop pest-resistant crops that protect themselves against the pest by producing their 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).

Two of the benefits of GM crops include 1) high yields that reduce food shortages and create lower food prices; and 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 1) introduced genes through genetic modification might cross to wild relatives of the crops—in particular weeds—making them stronger; 2) pests might develop resistance to the pesticide produced by GM crops; 3) substances from these crops might affect non-target and beneficial insects; and 4) might contain allergic substances or toxins.

To ensure the safe use of GM crops, the Kenyan government passed the Biosafety Act in 2009. Plants are tested in a special biosafety greenhouse 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 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, and cotton and virus-resistant sweet potato.

## Appendix 2

### Commands to Estimate Average WTP from Double-bound Method in STATA

```
*/ Define double bound

capture program drop doubleb_cv

program doubleb_cv

args lnf xb bid

qui replace `lnf' = ln(invlogit($ML_y6*`bid'+`xb')) if $ML_y1 == 1

qui replace `lnf' = ln(invlogit(-($ML_y7*`bid'+`xb'))) if $ML_y2 == 1

qui replace `lnf' = ln(invlogit(-($ML_y6*`bid'+`xb')) - invlogit(-($ML_y5*`bid'+`xb'))) if $ML_y3 == 1

qui replace `lnf' = ln(invlogit(-($ML_y5*`bid'+`xb')) - invlogit(-($ML_y7*`bid'+`xb'))) if $ML_y4 == 1

end


*/ Estimate the short double bound CV model

ml model lf doubleb_cv (xb: YY NN YN NY = )(bid: bit_init bid_high bid_low = )

ml search

ml maximize


*/ Estimate mean WTP with standard error with the delta method

nlcom (WTP:- _b[xb:_cons]/_b[bid:_cons]), noheader


*/ Estimate long model with explanatory variables x1 to xk

ml model lf doubleb_cv (xb: YY NN YN NY = x1 x2 x3) (bid: bit_init bid_high bid_low = )

ml search

ml maximize


*/ Estimate mean WTP with standard error with the delta method

nlcom (WTP:- (_b[xb:_cons] +_b[xb:x1]*x1m + ... / _b[bid:_cons]), noheader
```

1. *Now the Kenya Agriculture and Livestock Research Organization (KALRO)*