

The Political Economy of Genetically Modified Maize in Kenya

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Genetically modified (GM) crops have never been approved for commercialization in Kenya, but debates on their suitability have been going on for more than a decade. In this article we explore these debates in the context of GM maize in Kenya to better understand the positions of the different groups, and whether there is scope for policy change that would lead to the cultivation of GM crops. We evaluate the economic and political motives of groups that are likely to lobby against or for the GM crop cultivation, such as different types of farmers and consumers, local and foreign seed companies, grain processors, and environmental groups. A multimarket economic surplus approach is employed to estimate disaggregated benefits. The results of the surplus analysis modeling is evaluated in the context of the wider GM crop debate in Kenya and the stated positions of the different stakeholders.

Key words: genetically modified maize, Kenya, multimarket economic surplus, political economy.

Introduction

Although it has been 20 years since the first genetically modified (GM) crop was commercialized, the adoption of GM crops remains limited to a few crops, traits, and countries in spite of the fact that nearly 1,500 unique traits have been field tested across 150 crops in the United States alone, suggesting that technology exists for wider adoption (Information Systems for Biotechnology, 2016). The economic impacts of commercialized GM crops have been extensively studied, and the consensus from a number of meta-studies is that they are welfare increasing as they lower food prices while providing small and large farmers with higher yields, greater income, and decreased pesticide use (Areal, Riesgo, & Rodríguez-Cerezo, 2013; Finger et al., 2011; Klümper & Qaim, 2014). The rapid adoption of GM crops in countries where they have been introduced is another indication that farmers have a strong preference for GM crops.

In spite of the evidence that would lend support to further adoption of GM crops, many countries have made the decision to not allow their adoption. In these countries—notably in Europe—consumers still have concerns about the safety of GM crops and see little benefit to be had. More surprising, perhaps, is the decision by many developing countries to ban GM crop cultivation, as the gains to their farmers and consumers can be significantly higher (Qaim & Zilberman, 2003). In some countries, GM crops that are suitable for their agro-climatic conditions and markets have not yet been developed. But in many others, suitable GM crops are

available, but cultivation is not yet permitted. The restrictions on the cultivation of GM crops in developing countries are often rationalized in terms of possible loss of foreign markets where GM food is prohibited. While this could be the case in some instances, for a large number of countries such as Kenya that are net importers of food, this is unlikely to occur. Other reasons cited for limited spread of GM technology in developing countries are non-governmental organization (NGO) driven consumer resistance to GM crops, the lack of biosafety regulation, and difficulties in negotiating the underlying intellectual property (Qaim, 2016). In addition, there is the perception among consumers and agribusiness that multinational firms with proprietary GM traits and considerable resources will take over the local seed industry and control the food supply chain.

With a contested technology like GM crops, it is natural for interest groups to lobby government regulators and policy makers to advance their agendas. The strength of the lobbying effort often determines whether governments allow a technology to be adopted. Although experience with GM crops shows considerable benefits—on average—for technology providers, producers, and consumers, there may still be groups or sub-groups who would lose from GM crop adoption. In these instances, if their lobbying is well funded and organized then their policy position is likely to prevail, even if other (less organized) groups stand to benefit. To understand how policy change towards the adoption of GM crops can come about, it becomes important, as a

first step, to identify the affected groups and then estimate the benefit or loss that they might incur as a consequence of GM crop cultivation. Given the competing interests of the groups involved, policy change will only occur if government goals align with the interests of the groups who have the most influence.

Kenya is an example of a country where GM crops hold great promise, but have never been approved for cultivation. Debates on the suitability of GM crops for Kenya have been going on for more than a decade, and considerable resources have been spent by both the anti- and pro-biotechnology groups to advance their agendas. In this article, we explore these debates within the context of GM maize in Kenya to better understand the positions of the different groups and whether there is scope for policy change that would lead to the cultivation of GM crops. Specifically, we evaluate the economic and political motives of groups that are likely to lobby against or for the GM crop cultivation, such as different types of farmers and consumers, local and foreign seed companies, grain processors, and environmental groups. Using a multimarket economic surplus approach, we estimate the benefits accruing to some of these groups that lie along the maize value chain to identify the groups that are likely to gain/lose the most. We put the results of our surplus analysis in the context of the wider GM crop debate in Kenya and the stated positions of the different stakeholders.

The next sections reviews research activities on GM crops in Kenya in the last two decades and briefly the evolution of the regulatory system. This is followed by a review of the literature on *ex-ante* impacts of GM crops in Kenya, particularly maize (the most widely grown crop). The ensuing section describes the main attributes and stakeholders of the maize value chain from the input suppliers, to farmers, processors, and consumers. This is followed by the results of the multimarket economic surplus model. Then, we put these results in the context of literature on biotechnology development and field interviews with participants in an effort to assess whether the beneficiaries and losers identified in the model actually played a role in decision making in Kenya and if not, what alternative explanations work. The article concludes with some policy alternatives and speculation about the future of GM maize in Kenya.

Research and Development of GM Crops in Kenya

Currently, Kenya does not cultivate GM crops. The first research into GM crops in Kenya was a 1991 partner-

ship funded by the US Agency for International Development (USAID) between Kenya Agricultural Research Institute (KARI) and Monsanto to develop virus-resistant sweet potatoes. In 1999, the Insect Resistant Maize for Africa (IRMA) project was initiated by KARI and the International Maize and Wheat Improvement Centre (CIMMYT) with funding from the Novartis Foundation (now the Syngenta Foundation for Sustainable Development). The objective was to develop open-pollinated varieties of maize that had resistance to stalk borers using a *Bacillus thuringiensis* (Bt) gene. However, the project could not produce any Bt varieties to successfully control the two types of stalk borers prevalent Kenya.

The next major project to develop a GM food crop was the Water Efficient Maize for Africa (WEMA), which started in 2007. This public-private partnership was created to enhance food security in sub-Saharan Africa (SSA) countries by developing and deploying drought-tolerant GM maize hybrids that were royalty-free to smallholder farmers in Eastern and Southern Africa. The partners in this project were CIMMYT, Monsanto, and the National Agricultural Research Systems (NARS) of Kenya, Uganda, Tanzania, Mozambique, and South Africa. The project was led by the Kenya-based African Agricultural Technology Foundation (AATF), funded by the Bill and Melinda Gates Foundation (BMGF), the Howard Buffet Foundation, and USAID. Monsanto's Bt gene was added to the project to protect the drought-tolerant varieties from insects that would attack these plants during moderate drought. Like Monsanto's drought-tolerance traits, the Bt maize will also be distributed royalty free. Unlike the Bt in the IRMA project, Monsanto's Bt (MON810) is effective against both major stalk borers. Bt maize was recently (February 2016) approved for open field trials, which is the last step before commercial release. Drought-tolerant maize has been in confined field trials for several years.

The WEMA project has also developed hybrid cultivars that are drought tolerant and are not genetically modified. The first hybrids will come from CIMMYT and the NARS that were essentially developed as part of the Drought Tolerant Maize for African (DTMA) project.¹ The second generation of WEMA hybrids will also include lines from Monsanto, as well as the material from CIMMYT and NARS. For each country in the WEMA project there will be four or five conventional and GM hybrids for each major region, focused low and medium altitudes where droughts are most common. As of April 2015, the project had produced and approved

Table 1. GM field trials in Kenya.

Crop	Trait	Institutions involved	Current status
Maize	Drought tolerance (WEMA)	AATF, CIMMYT, KARI, Monsanto	CFT, currently in fourth season
	Insect resistance	AATF, CIMMYT, KARI, Monsanto	CFT application approved by NBA in 2012; first season completed May 2013
Cotton	Insect resistance	KARI, Monsanto	CFT phase completed; application for general release being prepared in anticipation of commercial release in 2015
Cassava	Virus resistance (mosaic disease, brown streak)	KARI, DDPSC	CFT, second season
	Enhanced micronutrient levels (vitamin A)	KARI, DDPSC, IITA, CIAT	CFT, second season
Sweet potato	Virus resistance	KARI, DDPSC	CFT, first season
	Weevil resistance	CIP, Kenyatta University	Lab and GH transformation approved by NBA in 2011; ongoing
Sorghum	Enhanced micronutrient levels	Africa Harvest, Pioneer Hybrid, DuPont business, KARI	CFT, second season
Pigeon pea	Insect resistance	Kenyatta University, ICRISAT	Lab and GH transformation approved by NBA in 2011; ongoing

Note: WEMA=Water Efficient Maize for Africa; AATF=African Agriculture Technology Foundation; CIMMYT=International Maize and Wheat Improvement Center; KARI=Kenya Agriculture Research Institute; DDPSC=Donald Danforth Plant Science Center; IITA=International Institute of Tropical Agriculture; CIP=International Potato Center; ICRISAT=International Crops Research Institute for the Semi-Arid Tropics; CFT=Confined Field Trial; NBA=National Biosafety Authority.

Source: Clive (2012)

36 hybrids, which 23 private companies had licensed in five countries. These companies were primarily small and medium local companies but also included regional companies such as Seedco and international companies like Syngenta and Monsanto (M. Edge, personal communication, April 1, 2015).

In addition to maize, research to develop GM crops is being conducted on GM cotton, cassava, sorghum, and sweet potato. Kenyan public universities continue to train scientists on biotechnology, and international research organizations based in Kenya collaborate with KARI to advance the technology. The current state of GM crops as of 2012 is shown in Table 1.

The Kenyan biosafety regulatory system has evolved as GM crop research has progressed (see Chambers, 2013, for more detail). The first official regulation of

GM crops started in 1995 when the National Council for Science and Technology established a National Biosafety Committee (NBC) to develop biosafety guidelines and regulations. However, by 2000 it was recognized that the NBC had little authority and capacity to enforce the guidelines and regulations. The process of developing a Biosafety Law to overcome these problems became serious starting in 2002. A national biotechnology policy was passed in 2006. By this time, many GM traits were in confined field trials and Bt cotton was nearly ready for commercial production. Pressure for a National Biosafety Act, which provided a clear path to commercialization, was growing. The Act was passed in 2009 and then a National Biosafety Authority (NBA) was established in 2010. Regulations on field trials, release into the environment, imports and exports, and labelling were officially published in 2011.

Literature on Economic Impacts of the GM Maize in Kenya

Economists have been studying the impacts of GM crops ever since the introduction of the Flavr-Savr tomato in 1994. Over the course of two decades, as more GM crops were developed, researchers have sought to understand not only the economic but also the social, environmental, and health implications of GM crops.

1. *Drought Tolerant Maize for Africa (DTMA) is a project launched in 2006, jointly implemented by CIMMYT and the International Institute for Tropical Agriculture (IITA), in close collaboration with the NARS in participating nations. The cultivars released from DTMA project aims to mitigate drought and other constraints to maize production in sub-Saharan Africa, thus increasing maize yields under moderate drought benefiting 30-40 million people in 13 African countries.*

Reviews of the literature over the years reveal the diversity of the research issues addressed, covering a wide variety of crops, traits, and geographies (see for example, Naseem & Pray, 2004; Smale et al., 2009; Smyth, Kerr, & Phillips, 2015). Meta-analysis of the large number of empirical studies finds that in general GM crops are welfare increasing and benefit both farmers and consumers (Areal et al., 2013; Finger et al., 2011; Klümper & Qaim, 2014).

For the case of Kenya—where GM crop cultivation is banned—all impact assessments have been *ex-ante*. Many of these studies have been done to evaluate the research benefits of projects funded by private firms and donor agencies. Given the importance of maize for Kenya's agriculture and economy, most of these studies have explored the impacts of introducing GM maize. Early interest centered on Bt maize since Bt technology had been successfully adopted in other countries to combat losses due to stem borer and related pests. Using a standard economic surplus approach, De Groote, Overholt, Ouma, and Wanyama (2011) estimated that under standard assumptions about technology development and adoption patterns, the economic surplus from Bt maize adoption would be \$208 million over 25 years at a cost of only \$6.76 million to develop the technology. Wanyama et al. (2004) carried out field experiments to establish losses due to stem borer and, based on that information, extrapolate the benefits that would accrue from controlling the pest, which they estimate to be \$25-60 million annually.

The impacts of introducing at least three other GM traits into maize have also been studied for the case of Kenya—namely herbicide tolerance, nitrogen use efficiency, and drought tolerance. GM herbicide-resistant maize has been effectively used to control weeds in the United States and elsewhere, and holds promise for Kenya as well. While direct empirical evidence on yield losses from weed infestation is scarce, some indirect evidence suggests that ineffective weed control is responsible for high yield losses—as high as 60% for some smallholders in Eastern Kenya (Mwanda, 2000). Using a partial equilibrium modeling framework, Kalaitzandonakes, Kruse, and Gouse (2015) evaluate the aggregate economic benefits under four adoption scenarios (lower and upper bound for just HT adoption, as well as when stacked with Bt) and compare them to the no-adoption baseline. Over a 10-year period from the start of adoption, they find that with the HT trait alone, the net present value (NPV) of the total economic gains are in the range of \$41.4 to \$86.5 million. When the HT trait is stacked with Bt, the NPV estimates

increase significantly to the range of \$104.4 to \$146.0 million.

Raising crop yields will increasingly require crops to be more productive on ever more marginal lands and unfavorable climatic conditions. Research to develop crops with traits that could withstand abiotic stresses has also resulted in studies to understand their impacts if adopted. Kostandini, La Rovere, and Guo (2015) study the *ex-ante* impacts of adopting nitrogen-efficient maize for Kenya and South Africa using the economic surplus method and accounting for differences in fertilizer use across regions. Over a period of 15 years, they estimate that a total of \$248 million of surplus will be generated, with producers benefitting slightly more than consumers. They further estimate that this could result in 71,000 poor households escaping poverty, given that many of adopters use very limited amounts of fertilizers.

Kostandini, Mills, and Mykerezzi (2011) apply a similar framework in evaluating the *ex-ante* impacts of drought-tolerant (DT) varieties of maize, sorghum, and millet for countries in East Africa. The benefits of DT maize may not only be due to greater yield, but also from the reduction in yield variability. For the case of DT maize in Kenya, they find that all types of farmers benefit from yield stabilization, with those in drought-prone regions benefiting the most. When benefits are aggregated (consumers and producers), they estimate that annual benefits from non-GM DT maize to be \$41 million and \$63 million from GM. However since it is assumed that GM maize research will be performed by private firms, \$20 million of the \$63 million are firm profits. Kostandini, La Rovere, and Abdoulaye (2013) extend the analysis to additional countries in Africa but for only DT maize. For Kenya, they estimate total benefits—had the adoption taken place during the 2006-2016 period—to be in the range of \$46 to \$78 million, with the majority of the benefits (70%) accruing to producers. The benefits from yield variance reduction account for nearly 25% of the total benefits, suggesting an important role of yield stability.

A separate analysis done by Dalton, Pray, and Paarlberg (2011), however, suggests that the gains from DT maize are more modest. Evaluating the benefits of both non-GM and GM varieties across five East and Southern African countries, including Kenya, they estimate that the mean internal rate of return lies in the range of 3.8% to 7.5% for non-GM hybrids and from 7.8% to 13.0% for GM. The mean NPV for GM DT maize is estimated to be nearly \$55 million, but for a time period that spans 30 years and five countries. Since the authors considered the adoption of DT maize as a part of a

sequence of technological and adoption events—one that begins with the adoption of non-GM DT maize bred into existing varieties and culminates with the adoption of GM traits in new varieties—benefits are positive conditional on GM varieties being developed. Additionally, the benefits are sensitive to how quickly adoption occurs.

While the studies reviewed here confirm that there are considerable gains from the adoption of GM maize for Kenya, they do not reveal how those benefits are shared beyond the broad categories of “producers” and “consumers.” The development and eventual adoption of GM maize will affect a number of agents along the maize value chain, and benefits are unlikely to be equally distributed. Further, differences among agents—such as those due to farm and firm size, incomes, and geography—can be significant and result in unequal sharing of benefits. How benefits are shared amongst different groups can be used to understand whether particular groups have an incentive to lobby for particular policies related to GM crops.

In the next section, we describe the maize value chain and the main agents involved. We present a stylized model of the value chain in order to focus attention on key groups—input/technology suppliers, producers, processors, and consumers. The impact that GM maize would have on these groups is discussed in a later section.

The Kenyan Maize Value Chain

The Kenyan maize supply chain has been described and mapped by Chemonics (2010) and Kirimi et al. (2011). The key stages are production, collection, transport, trading, processing, retail, and final consumption. In most years, Kenya is able to meet its domestic maize requirement. However, in years when there is a major deficit, demand has to be met by imports, which requires a greater role for importers, large processors, and the National Cereals and Produce Board.

For our purposes, it is sufficient to simplify the value chain and model it as having three basic markets or nodes (Figure 1). At each node, transactions between different economic agents occur. In the first node, input suppliers provide maize farmers with key inputs such as seed, fertilizer, and chemicals. Maize is grown on 2.1 million hectares in Kenya, and the commercial seed market for Kenya is around 45,000-50,000 MT, valued at US\$60-70 million (Chemonics, 2010; FAO, n.d.). Of the total area, nearly 62% is under high-yielding varieties of maize (Olwande, 2012). Commercial seed supply

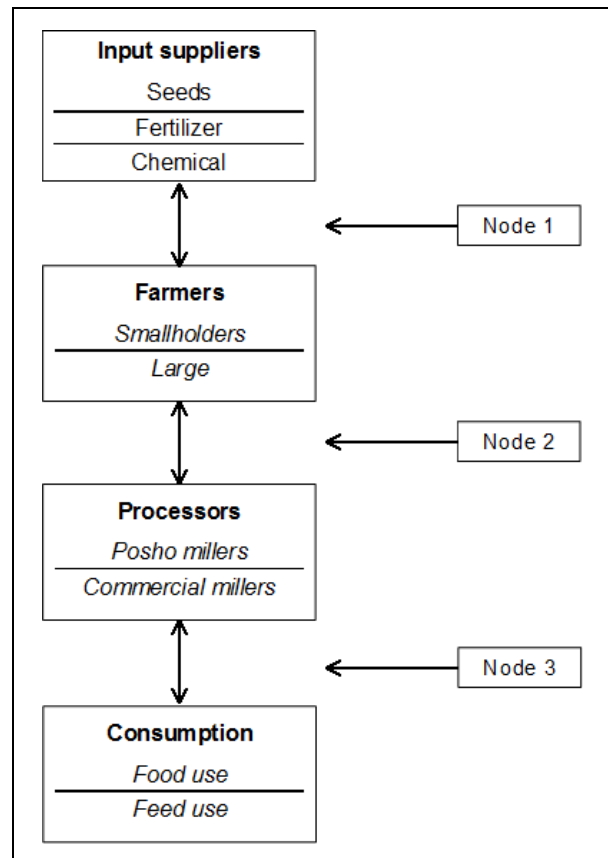


Figure 1. A stylized value chain for the Kenya maize sector.

is also split up between the public and private sector in Kenya. In addition, farmer-saved seed accounts for about 20% to 30% of the seed planted in Kenya. The main government seed supply program is the Kenya Seed Company (KSC), which has 70% to 80% of the maize seed, but it is no longer a monopolist (Funk & Wamache, 2012). The private sector is rapidly growing as a source of seed. In Kenya it has grown from about 8,000 tons in early 2000s to as much as 45-50,000 tons in 2012-13 partially at the expense of KSC and getting more farmers to buy seed rather than saving their own seed.

Table 2 shows the breakup of commercial seed sales of maize by different companies. In Kenya, most seed is produced in country, but as much as 30% is imported, nearly all by Pioneer, Monsanto, Pannar, and SeedCo. By far, KSC is the largest supplier, capturing 56% of the market. KARI has a seed unit (which is now registered as a seed company) that produces the foundation seed of public lines and hybrids. KSC and some of the others companies contract seed production with Ag Development Corporation (government owned). They also con-

Table 2. Market share for maize in Kenya—High, mid, and low altitude (based on 2012 estimates).

Firms	Total metric tonnes	Market share
Pioneer	3,000	5.61%
Monsanto	4,500	8.41%
Kenya Seed Co	30,000	56.07%
SeedCo	3,000	5.61%
Pannar	4,500	8.41%
East African	3,000	5.61%
Western Seed	2,500	4.67%
Fresh Co	500	0.93%
Dryland	1,000	1.87%
Other small firms	1,500	2.80%
Totals	53,500	100%

Source: Author's interview with companies (2012)

tract with big commercial growers. Total hybrid market has grown by 8,000 tons (20-25%) in last 4 years due to government projects for food security and farmers shifting from saved seed to hybrids (K. Owino, personal communication, March 21, 2013).

Two types of farmers—differentiated by the size of their landholding—use the inputs to grow maize and sell to maize processors. The majority of maize production in Kenya (70%) is by smallholder farmers, while the remaining is produced by large- and medium-scale farms (Chemonics, 2010). However the share in marketed surplus is closer to a 55-45% split (55% marketed maize from large/medium and 45% from smallholders) after subtracting for own consumption by smallholders (Chemonics, 2010).

Nearly all maize that is produced is processed into maize flour by two types of processors—small scale “posho” millers and the much larger industrial scale millers. Given their smaller scale, posho millers are much more numerous (estimates are that there are nearly 3,000 such enterprises) and closer to the farm gate. There are only 19 large-scale millers. According to the Cereals Millers Association, which represents large millers, the total milling capacity is estimated to be 1.62 MT per year, of which 1.41 MT is due to the 19 large millers and 0.21 MT due to the small posho millers (Chemonics, 2010). Besides the difference in scale, the two types of millers have different processing technologies, such that extraction rate among large-scale millers is on the order of 80% to 95%, while for small-scale posho millers it is only 70% (Chemonics, 2010). The third and final node consists of the retail market where the processed maize is sold to consumers. Some of the

maize is channeled into the feed market, but this tends to be relatively small (3%).

Maize production in Kenya is protected by a 50% tariff on all imports from countries outside the East African Community (EAC), and very little of it is traded in any given year. The exception was 2009 and 2011, when as a response to drought-induced production shortfall, the government waived the tariff to allow greater imports to meet the demand. To keep the modeling simple, we assume that the Kenyan maize sector is closed with no price or technology spillovers given the default government policy to protect the market. Since Kenya is a small consumer and producer of maize, whether the market is open or closed, will not have any impacts on the world price of maize.

Economic Surplus from GM Crop Adoption

Conceptual Framework

This simplified and stylized characterization of the Kenyan maize supply chain can be used to calculate the economic surplus/loss from the adoption of GM maize to the different groups along the supply chain. Although the adoption occurs at the farm level, given the backward and forward linkages as described above, it has an implication for all those on the supply chain. To explore these impacts we employ a multimarket economic surplus model to evaluate the additional benefits/losses received by different stakeholders (Alston, 1991; Alston, Norton, & Pardey, 1995). The multimarket approach allows one to estimate for the distribution of benefits by disaggregating the change in surplus into multiple factors and multiple product markets. The multimarket approach is simply an extension of the basic economic surplus model but disaggregates more finely the level of benefits that are obtained (Alston, 1991). The total change in surplus is calculated by simply aggregating the surplus across the different markets.

Figure 2 presents the distribution of benefits in terms of supply and demand defined at the farm level, retail level, and the intermediate stage of processing. These three basic levels allow us to estimate the producer, consumer, and processor surplus. However, we augment the analysis by differentiating between the size of the different types of producers and processors. Furthermore, we calculate the profits that accrue to the seed and technology firms. Since the majority of the maize produced in Kenya is for human consumption (>95%), we ignore any impacts on the livestock industry.

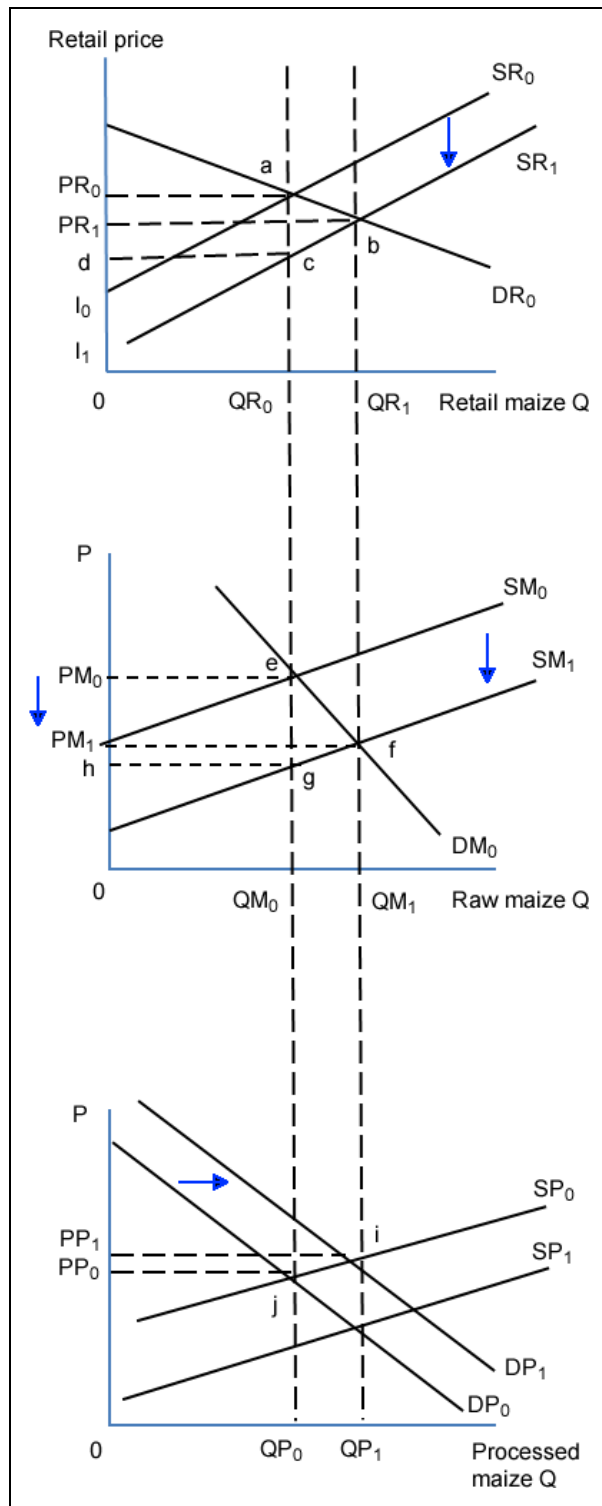


Figure 2. Differential impact of a supply shock due to adoption of GM maize in Node 2.

In Figure 2, we assume that raw maize and a processing input is used in fixed proportions to produce a refined maize product for human consumption. The supply functions for the two factors of production are SM_0 for the raw maize and SP_0 for the processing inputs, whereas the demand function for the processed (retail) maize is DR_0 . Given that factors are used in fixed proportions, the retail supply function (SR_0) is simply the vertical sum of the underlying supply functions (SM_0 and SP_0). We can obtain the derived demand function for raw maize (DM_0) by taking the difference between the retail demand (DR_0) and the supply of processing inputs (SP_0). In similar fashion, the derived demand for processing inputs (DP_0) is given by subtracting the supply function (SM_0) of the raw maize from the retail demand function (DR_0).

Equilibrium initially is the intersection of the retail supply and demand (i.e., PR_0 and QR_0), which can also be obtained in terms of one of the factor markets. Consider now the case where, due to a technology shock such as the adoption of GM maize that increases yields, the supply function for raw maize shifts down in parallel from SM_0 to SM_1 . As a result of this shift in the raw maize market, the supply of retail processed maize shifts down from SR_0 to SR_1 and the demand for the processing input shifts up in parallel from DP_0 to DP_1 . In both instances, the shift is by the same absolute amount per unit. Quantities across the three markets increase in proportion (to QR_1 , QM_1 , and QP_1). Prices of the raw maize and the retail maize product fall (to PM_1 and PR_1 , respectively) and the price of the processing input rises (to PP_1).

Change in welfare can be measured by the change in consumer and producer surplus. Consumer surplus is given by PR_0abPR_1 and producer surplus by PR_1bcd ; hence, the total surplus is I_0abI_1 . The producer surplus in turn is distributed among the processors (PP_1ijPP_0) and farmers (PM_1fgh). Since the processing and farmer supply curves are simply the horizontal summation of the individual supply curves (i.e., supply by posho and commercial millers to form the processing supply and small and large farmers to form the raw maize supply), the processor and farmer surplus can be further disaggregated at the level of posho/commercial and small/large farmer, respectively.

Algebraically, consumer, producer, and total surplus are expressed as

$$\Delta CS = PR_0 QR_0 Z (1 + 0.5Z\eta) \quad (1)$$

$$\Delta PS = PR_0 QR_0 (K - Z) (1 + 0.5Z\eta), \quad (2)$$

where K is the vertical shift of the raw maize supply function expressed as a percentage of the initial retail price (PR_0).

$$K = \left[\left(\frac{y}{\varepsilon} \right) - \left(\frac{E(Costs)}{1+y} \right) \right] A(1-d), \quad (3)$$

where y is the expected proportionate yield change; $E(Costs)$ is the expected proportionate change in variable input costs; (y / ε) converts the proportionate yield change to a proportionate gross reduction in marginal cost per unit of output; and $\left(\frac{E(Costs)}{1+y} \right)$ converts proportionate input costs change per hectare to a proportionate input cost change per unit of output. Subtraction of the last two expressions (shown in the square bracket) gives the maximum potential net change in marginal cost per unit of output, which calculates to K when multiplied by adoption rate A .²

A defines the adoption pattern of technological innovation as a result of research, usually following some logistic path. η is the absolute value of the elasticity of demand at retail, ε is the elasticity of supply to retail, and $Z = K\varepsilon / (\varepsilon + \eta)$ is the percentage reduction in retail due to the supply shift.³

The producer surplus can be disaggregated into surplus accruing to processors (ΔRS) and farmers (ΔMS).

$$\begin{aligned} \Delta RS &= PP_0 QP_0 (K - Z) (\varepsilon / \varepsilon_p) (1 + 0.5Z\eta) \quad (4) \\ &= \Delta PS(\varepsilon PP_0 / \varepsilon_p PR_0) \end{aligned}$$

2. Note that the supply shift (K) is the aggregate shift due to the two types of farmers—small and large—and is a function of their share in total output and magnitude of the productivity shift for each. That is, $K = \theta K_s + (1 - \theta)K_l$, where θ is the share of maize production by the small farmer, and

$$K_j = \left[\left(\frac{y_j}{\varepsilon_j} \right) - \left(\frac{E(Costs)_j}{1+y_j} \right) \right] A_j \text{ for } j = s, l.$$

While such disaggregation may provide more precise estimates of the supply, it does require additional data and parameters at the level of producer that may not be available.

3. Like K , Z can be disaggregated into the percentage reduction due to small and large farmers: $Z_j = \varepsilon_j K_j / [\varepsilon_j + \eta]$ for $j = s, l$.

$$\begin{aligned} \Delta MS &= PM_0 QM_0 (K - Z) (\varepsilon / \varepsilon_M) (1 + 0.5Z\eta) \quad (5) \\ &= \Delta PS(\varepsilon PM_0 / \varepsilon_M PR_0), \end{aligned}$$

where ε_M and ε_p are, respectively, the elasticity of supply for farmers and processors. The processor surplus in turn is shared among the large commercial (c) and small posho millers (p). For the sake of simplicity, we assume distribution of the processor surplus is according to the respective shares of these two processors. Define α as the market share of the commercial processors,

$$\Delta RS_c = \alpha \Delta RS \quad (6)$$

$$\Delta RS_p = (1 - \alpha) \Delta RS \quad (7)$$

Likewise, the farmer surplus can be disaggregated among the two types of farmers.

$$\Delta MS_s = \beta \Delta MS \quad (8)$$

$$\Delta MS_l = (1 - \beta) \Delta MS, \quad (9)$$

where β is the smallholder's share of the total maize supply.

Using the Moschini and Lapan (1997) framework for analyzing welfare effects of proprietary technologies, we follow Falck-Zepeda, Traxler, and Nelson (2000) and Hareau, Mills, and Norton (2006) to calculate profits or surplus for the innovator of a technology and seed companies as

$$\Delta \pi = \mu \times A \times L, \quad (10)$$

where μ is the additional cost per acre due to the trait, which is calculated as a difference in seed costs per acre of a new variety and a conventional variety; A is the adoption rate of (or proportion of area under) a new technology; and L is the corresponding maize area. Some of the additional seed cost is in the form of a technology fee charged by the innovator (for the case of GM maize, usually a multinational company), while the remaining is the premium charged by the seed company. Define θ as the share of profits going to the seed company, so that the profits for the seed firms and multinational firms are, respectively,

$$\Delta \pi_{seed} = \theta \Delta \pi \quad (11)$$

$$\Delta \pi_{innovator} = (1 - \theta) \Delta \pi \quad (12)$$

Total surplus is simply the aggregate of the individual consumer, producer, and seed/innovator surplus.

$$\Delta TS = \Delta CS + \Delta PS + \Delta \pi \tag{13}$$

Lastly, the NPV of adapting GM technology to local conditions moving it through the regulatory process and producing foundation seed is calculated as

$$NPV = \sum_{t=0}^T \frac{\Delta TS_t - RCost_t}{(1+r)^t}, \tag{14}$$

where T is the time-horizon, ΔTS_t is the total surplus, $RCost_t$ is the research costs, in year t , and r is the discount rate.

Data and Parameters

Parameter values and changes in relevant variables were obtained from the literature and publicly available data sources. Since no GM crops are grown in Kenya, we obtained forecasts for the three GM maize traits under consideration from the literature as well as researchers actively engaged in the development of these traits in Africa.

Data on maize acreage and yield were obtained from FAOSTAT and the Regional Agricultural Trade Intelligence Network (RATIN) website. Production and acreage data is the average for the period 2009-2013, and we assume that 80% of cultivated area and 70% of production is due to smallholder farmers (Chemonic, 2010). Given these assumptions, the implied yields for smallholder farmers is 1.52 tonnes/ha and 2.61 tonnes/ha for large landowning farmers (Table 3).

Based on our discussions with seed firms and scientists/policymakers and the current adoption of hybrid or improved seeds for maize in Kenya, we have projected the adoption pattern for the uptake of GM maize upon approval for cultivation (Figure 3). The adoption rate under GM maize for different traits is expected to reach 70% of the total hybrid adoption by 2025. The total GM area under maize is expected to cover four traits or combination of traits—insect resistance (IR); double-stacked IR and drought tolerance (DT); herbicide tolerance (HT); and triple-stacked IR, DT, and HT.

As discussed above, the Kenyan maize seed market is dominated by a public-sector firm Kenya Seed Company (KSC), with a 56% market share. Domestic private seed firms are mostly small to medium and they contribute 20% of the market. The multinational corporations (MNCs)—both global and regional/African—supply 10% of maize seeds in Kenya.

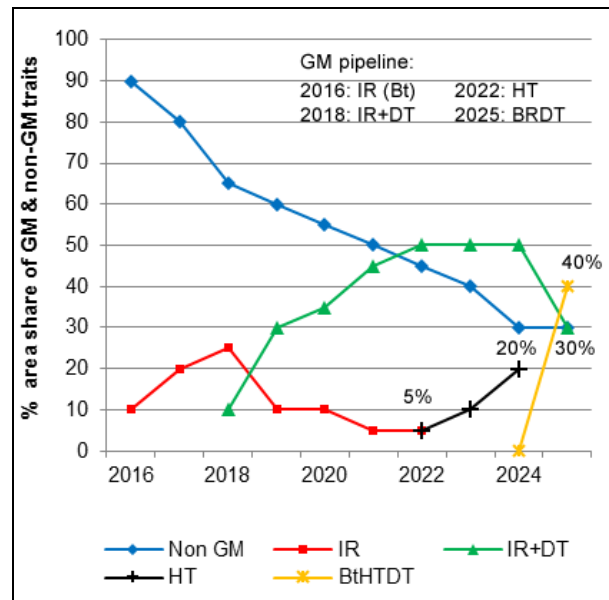


Figure 3. Projected adoption of GM maize in Kenya (2016-2025).

Source: Based on author's assumption as described.

Currently 35-40% of the farmer use of seeds is still farm saved and does not pass through markets. The Kenyan maize seed market offers opportunities to increase adoption of hybrids (i.e., from farm saved/recycled OPVs to hybrids). The area under maize, however, may not expand from the existing acreage (2.1 mill hectares).

The government is keen on improving the productivity of maize. The national averages of maize yields are around 1.7 t/ha (FAO, n.d.). Kenya often experiences drought in a cyclic manner (once every three years—moderate to severe drought). This has affected the output of maize in the country (as high as 70-80%), resulting in poor yields and food deficit. Maize is grown as a rainfed crop during short and long rain seasons in Kenya. So we assume that crop losses due to drought will be reduced, which will increase yields by 12% (Table 3).

In addition to crop losses due to frequent droughts, losses or damage due to pest (stem borers) is also extensive. De Groote et al. (2011) estimated that crop losses in Kenya due to maize stem borers account for 12.5% of the yield. The efficacy of control using GM Bt developed in the Insect Resistant Maize for Africa project (IRMA) varied depending upon the pest species. Using the distribution of pest pressure and the base yields of the differing agroecologies combined with the lack of efficacy in controlling *B. fusca*, potential damage abatement from Bt ranges from 9% in the highlands to 20%

Table 3. Baseline model parameter values.

Variable	Value	Source
Acreage (million ha)^a		FAO (n.d.), Chemonics (2010)
Small holder farmers	1.63	
Large farmers	0.41	
Total	2.04	
Production (million tonnes)^b		FAO (n.d.), Chemonics (2010)
Small holder farmers	2.48	
Large farmers	1.06	
Total	3.55	
Yield (tonnes/ha)^c		Author's calculation
Small holder farmers	1.52	
Large farmers	2.61	
Total	1.74	
Demand elasticity^d		
η	-0.4	De Groote et al. (2011), Kiori and Gitu (1992), Omamo et al. (2007)
Supply elasticity^d		
ϵ	0.8	De Groote et al. (2011), Kiori and Gitu (1992), Omamo et al. (2007)
Farmers' supply elasticity ϵ_f	0.4	Author's assumption
Processors' supply elasticity ϵ_p	0.9	Author's assumption
Average maize seed price (KES/MT)		RATIN (n.d.)
Retail	36,032	
Wholesale	32,756	
Farm	26,785	
Market clearing quantities (MT)		FAO (n.d.), RATIN (nd.)
Retail	3.743	
Wholesale	3.750	
Farm	3.546	
Yield increase (% over base yield)		Dalton et al. (2011), De Groote et al. (2011), Kalaitzandonakes et al. (2012)
Bt	13.5	
BtDT	24.7	
HT	10	
BRDT	30	
Input use reduction (% reduction)^e		Dalton et al. (2011), De Groote et al. (2011), Kalaitzandonakes et al. (2012)
Bt	5	
BtDT	5	
HT	10	
BRDT	15	
Assumption regarding maize seed^f		
Seed price (\$/kg)	2.1	
Seed rate (kg/ha)	25	

Note: Abbreviation used for GM traits: Bacillus thuringiensis (Bt); Bacillus thuringiensis and drought tolerant (BtDT); herbicide tolerant (HT); Bacillus thuringiensis, herbicide tolerant, and drought tolerant (BRDT)

a) Average of national acreage for the period 2009-2013 from FAO

b) Based on the assumption that 80% of cultivated area is due smallholders and 20% to large landowners (Chemonics, 2010)

c) Based on the assumption that 70% of production is due smallholders and 30% to large landowners (Chemonics, 2010)

d) Average value as reported in cited literature

e) Reduction in insecticide cost for Bt and BtDT; Reduction in labor cost for HT and increase in herbicide use

f) Bt seed price expected to cost 25% higher, Bt+DT price 30% higher, Bt+DT+HT 40% higher, and royalty is 40% of price increase as that of South Africa/Burkinafaso-Bt cotton

in the dry transitional zone, but averages 12.5% across all ecologies (De Groote et al., 2011). Through Bt introduction, an overall 5% reduction in use of insecticides for borers and a 12.5% increase in yields is expected.

Though the current use of herbicides is very limited—around 15% (Gianessi & Williams, 2011)—HT introduction is expected to increase the use of herbicides and its demand. The weeding costs represent 45-75% of total labor cost in maize, and herbicides costs are less than 2% of cultivation expenses in Kenya (Kalaitzandonakes et al., 2015). Table 3 summarizes our assumptions regarding yield increases and reduction in input use for the four traits.

Supply and demand elasticities of maize were assumed to be 0.55 and -0.465, respectively, and are average of various elasticities estimates as reported in the literature (Table 3). Since there are no estimates for elasticities at the level of producers or processors, we assume processors have a more elastic supply while producers less elastic supply than the assumed average. There is considerable excess processing capacity, which would suggest that processors could easily increase supply due to price and supply shocks (Chemonics, 2010). Farmers—especially smallholders who produce the majority of the maize—are more limited in their ability to increase production given their low modern input use.

Table 3 also lists the base values for maize price and market-clearing quantities—averaged over the period 2010-2013—along the maize supply chain. Wholesale and retail prices are from the RATIN website and the producer market-clearing quantities from FAOSTAT.

Our assumptions regarding the costs to develop traits are based on what has been reported in the literature and from our discussions with the research scientists. For Bt, since most of the research on developing it has been done and is only awaiting approval, we do not foresee any further research costs. That is, all research costs to develop the Bt trait are assumed to be sunk. For the drought-tolerance trait that is being developed as part of the WEMA project, we use Dalton et al.'s (2011) assumption of \$35 million for Phase II of the project spread over four years across five counties, or \$8.75 million per year. It should be noted, however, that since WEMA is a philanthropic organization and being funded by foreign donors, it may not be appropriate to include in our surplus calculation, which go to domestic stakeholders.

The cost to introduce HT traits that we project will be commercialized starting in 2022, is assumed to be \$15 million in total. The basis for this assumption is that HT trait is a mature technology and has been introduced

in a number of crops around the world. The research cost will therefore be limited to introducing the trait into local varieties and conducting safety trials. Finally, for the triple-stacked BRDT trait, we assume the research costs to be \$20 million.

Results

The results of the economic surplus model are presented in Table 4. Surplus is broken down by consumer, producer, and processor surplus by trait and in total. Additionally, the surplus is further disaggregated at the level of farmer (small/large) and processor (posho/commercial).

If all traits are commercialized and follow the adoption pattern and yield profile as specified, the NPV of the total benefits is estimated to be \$425 million. We estimate that the trait that yields the highest benefits is the double-stacked Bt and DT trait, with a net consumer and producer surplus of \$117.4 million. This is followed by the Bt, BRDT, and HT traits, which give a total discounted surplus of \$107.6, \$97.3, and \$28 million, respectively. Since the benefits of the Bt trait come early, the discounted surplus is higher than the other traits even though the undiscounted surplus from BRDT is the largest.

Of the total benefits, 82.4% accrue to farmers, millers, and consumers, while the remaining 17.6% goes to seed firms (15.2%) and as royalty to owners of the herbicide tolerance trait (2.4%). Disaggregating the distribution of benefits further, we find that farmer surplus is about 22% (14% for smallholders and 8% for large), miller surplus is 23% (7% for posho and 16% for commercial millers), and consumer surplus is 36%.

The benefit distribution is sensitive to our assumptions regarding supply elasticity. For example, if we assume an inelastic supply for the farmer and elastic supply for the miller, more benefits accrue to the farmers relative to the millers—and vice versa. Producer surplus is highest when supply curves of both millers and farmers are assumed to be inelastic. On the other hand, consumers gain more (relative to producers) as the supply of both millers and farmers becomes elastic. If the government continues to protect the maize market from international competition, prices will remain above the international price and farmers will capture most of the benefits.

If GM maize is introduced in 2016, the maize seed market in Kenya is projected to double in sales—around US\$119 million in 2025, with 75% of market from the sale of GM maize seeds of different traits. Our estimated

benefits show that major share of profits will go to Kenyan seed companies (public and private-domestic), capturing 87% of the profits. In our analysis, the technology provider does not gain much because Bt and DT genes are provided on a humanitarian, royalty-free basis. With the introduction of herbicide tolerance, which is expected farther down the road, the innovators are expected to earn some profits through royalties.

Though domestic firms in Kenya are dominant in commercial sales, their access to new traits is highly dependent on public research (national and international). In Kenya, currently less than 4 firms (out of 40 firms selling maize seeds) have their own breeding program on maize. More than 50% of germplasm used by private or public breeding programs are contributed by CIMMYT or IITA maize germplasm pool (Langyintuo, Diallo, MacRobert, Dixon, & Banziger, 2008; Tahirou, Sanogo, Langyintuo, Bamire, & Olanrewaju, 2009).

However, a few regional MNCs (such as Seed Co) who have superior maize germplasm are entering the Kenyan seed market. Pannar (owned by DuPont Pioneer since 2013) also is expanding their maize seed market in Kenya. With this background—though local firms earn more profits by the sale of GM seeds—it is expected that both regional African and MNCs will expand their market share up to 40% by offering a wider portfolio of cultivars suiting different agro-ecologies. By the introduction of HT in 2022, the MNCs will start earning royalties in addition to market margins since they provide technologies that involve royalty. At that point, it is expected the market will be much more competitive and several licensing arrangements will take place between MNCs and domestic or regional firms for seed sales.

In brief, MNCs will gain substantially from approval of HT and triple-stacked GM maize traits, as they expect to earn royalties along with seed profits and expanded hybrid seed sales. Most medium- to large-size local companies will profit from selling GM maize traits, especially those who are already in the non-GM market and have invested in maize breeding. Any kind of licensing arrangements with technology providers will earn profits for the local seed firms, especially parastatal like KSC.

The Politics of GM Crop Policies

The results of the multimarket model presented in the previous section suggest that there are considerable benefits from GM maize that could accrue to important economic interest groups across the maize value chain. Our estimates for the aggregate benefits over 10 years are

higher than those reported by previous studies. But, are these groups active in the GM policy debates and are they effective in encouraging policy change? The main policies that have been the focus of GM debate have been the Biosafety Act passed in 2009, the ban on imports of GM food in 2012, and the testing of GM varieties in Kenya in closed and open field trials. After examining the benefits, perceptions, and activities of each Kenyan economic interest group, we focus on the groups that helped pass the policies and the foreign organizations that also participated in the process.

Consider consumers, who we estimate will be the largest beneficiaries of the four main groups in the value chain, capturing more than 36% of the total benefits. However, the aggregate consumer surplus—while large (\$155 million)—is not significant on a per-capita basis (only \$3.40 per person given the current population of 44.5 million) and even less so when we account for the fact that this amount accrues over 10 years. This means that few Kenyan consumers would even notice the impact if they knew about it. Despite this, Kenyan consumers have generally been accepting of GM crops, as reported in surveys done in 2003 and 2009; however, an important minority of urban consumers were concerned about the food safety of GM maize while rural consumers had little concern about food safety and environmental issues (Kimenju & De Groote, 2008).

Since the time of these studies, the safety of GM technology was challenged by foreign and local environmental and health NGOs during the debate leading up to the passage of the Biosafety Act in 2009. Then, the Cabinet banned imports of GM crops in 2012 based on the Minister of Health's claim that there was evidence linking GM maize to cancer (Snipes & Kamau, 2012). It seems likely that urban consumers are now more concerned about the food safety of GM maize than they were from 2003 through 2009, although no new studies of consumer attitudes confirm this suspicion.

Urban consumers in Kenya are not organized supporters of GM foods nor are they strong opponents except a few that are organized through NGOs. Paarlberg (2009) argued that the anti-biotech groups which opposed the Biosafety Act were primarily financed by European NGOs and European governments. This continues to be the case today for the NGOs in the Kenya Biodiversity Coalition, which now leads the opposition to GM crops. For example, the NGO Participatory Ecological Land-Use Management (PELUM), which has opposed the biosafety law since 2004 and currently is a leader of the Kenya Biodiversity Forum, reports in its 2013 Annual Report that 98% of its funding comes from

outside Kenya. The leading source of funds in 2013 was the Swedish Society for Nature Conservation (SSNC) at 54%, followed by Evangelischer Entwicklungsdienst (EED) at 16%, and Bread for the World at 12% (PELUM-Kenya, 2014). The African Center for Biosafety of South Africa, which provides background research and information for the Kenya Biodiversity Coalition, is funded by organizations such as the Dutch Ministry of Foreign Affairs and Brot für die Welt/Evangelische Entwicklungsdienst. One of the leaders of the Kenya Biodiversity Coalition that has been campaigning against GMOs told us that Greenpeace does not provide them with any finances but does provide important strategies, information, and training in 2013.

Farmers' organizations in other parts of the world, such as Brazil, have been strong enough to overcome the concerns of urban consumers (Scoones, 2008), but this has not been the case in Kenya even though farmers' share of the surplus from GM crops was substantial. The farmer surplus is estimated to be \$95 million, with 63% of it going to smallholders. Given the diversity of farm sizes and farmers' interest, Kenyan farmers' organizations are split and not proactive on technology policy. The Cereal Growers Association (CGA) is in favor of improved maize seeds—including GMOs—but is not mentioned as an active supporter of the Biosafety Act according to (Karembu, Otunge, & Wafula, 2010). CGA claims to represent 80% of commercial farmers in Kenya but is led by the larger commercial wheat and maize farmers. Other farmer organizations, such as Kenya National Federation of Agricultural Producers (KENFAP)—which is led by commercial farmers who export non-GM and organic horticultural products to Europe—have opposed the Biosafety Act and GM crop production in general. They would not gain from GM maize and fear that they might lose exports to Europe. CGA supported the 2009 Biosafety Act while KENFAP opposed it (Paarlberg, 2010).

No organization appears to speak for the smallholder farmers who were the major beneficiaries in our model. The one organization in Kenya that claims to speak on their behalf, the Kenya Small Scale Farmers Forum (KSSFF), was opposed to the Biosafety Act but has limited credibility as it is mainly funded by foreign donors. It was started in 2002 by PELUM-Kenya as a component of the Eastern and Southern Africa Small Scale Farmers' Forum (ESAFF). According to ESAFF's financial report in the year ending June 2015 (ESAFF, 2015), 65% of ESAFF's income comes from EU grants, 14% from Oxfam Netherlands, 7% from Bread for the

World, 7% from South African Foundations, and 8% from "other income."

Our surplus estimates reveal that seed industry profits would be significant, in part because the GM maize hybrids will be supplied royalty free. Six of the eight seed companies (two global MNCs, two regional MNCs, Kenya Seed Co., and three Kenyan seed companies) interviewed in 2011 were positive about the prospect of selling GM drought-tolerant, royalty-free maize. One global MNC and a regional MNC thought that there was considerable potential for improvement of existing hybrids for drought tolerance without having to complicate things with GMOs. Bt maize to control stalk borer did not generate a lot of interest among the companies, since stalk borer was a problem on only about 10% of the maize area. Despite the general level of support for GM, a number of companies expressed concerns about the prospect of Monsanto using royalty-free Bt and DT traits to open the market to GM maize and then in the future taking over the most lucrative part of the market—the commercial maize farmers in the relatively well-watered high lands—by introducing HT maize.

The Seed Trade Association of Kenya (STAK), which represents the Kenyan seed industry including the subsidiaries of MNCs was an active partner in the coalition that supported the Biosafety Act (Karembu et al., 2010). Monsanto is supportive of regulatory approval of GM maize through the WEMA project with AATF. AATF, the African Biotechnology Stakeholders Forum (ABSF), and the International Service for the Acquisition of Agri-biotech Applications (ISAAA) are the three organizations that are most visible in their support of GM crops (such as an end to the ban on imports of GM maize and permissions for open field trials of GM maize). MNCs also can influence GM policy through their public-sector research collaborators on cotton at KARI and their KARI collaborators in the WEMA project and other AATF public-private partnerships and to a certain degree through the US Embassy.

In Kenya, almost all maize is used by consumers after it has been milled either in large-scale mills or small "posho" mills. Only about 3% of the grain is used as animal feed (Chemonics, 2010). Our estimates find that millers would obtain substantial increases in their profits (Table 4). Surveys of operators of mills and retailers further support the finding that as a group they support GM maize due to the benefits. Bett, Ouma, and Groote (2010) surveyed the attitudes of managers of 15 mills and 24 supermarkets towards GM maize. Most respondents in both groups believed that GM food would have a positive impact, and only a minority were

Table 4. Distribution of cumulative economic surplus from adoption of GM traits (in US\$ million) 2016 to 2025.

Trait	Farmer surplus			Miller surplus			Total producer surplus	Consumer surplus	CS+PS	Seed industry profits	Innovator profits for herbicide tolerance	Total
	Small	Large	Total	Posho	Commercial	Total						
Bt	22.5	15.0	37.5	2.2	5.0	7.2	44.6	63.0	107.6	11.97	0	119.6
Bt+DT	28.6	12.3	40.9	2.4	5.4	7.8	48.7	68.7	117.4	44.02	0	161.5
HT	1.1	2.6	3.7	5.9	13.1	19.0	22.7	5.3	28.0	2.92	5.83	36.8
BRDT	8.0	4.9	12.9	20.4	45.5	65.9	78.9	18.4	97.3	5.78	4.33	107.4
Total	60.2	34.8	95.0	31.0	69.0	100.0	195.0	155.4	350.4	64.69	10.17	425.3
% total	14.16%	8.18%	22.34%	7.29%	16.22%	23.51%	45.85%	36.55%	82.40%	15.21%	2.39%	100%

Source: Authors' calculations

concerned about possible food safety or environmental effects. When asked whether they would handle GM foods, only 20% of the millers said yes and 64% of the firms interviewed said that they would consider it on a case-by-case basis (Bett et al., 2000).

The large millers are well organized into the Cereal Millers Association (CMA) as mentioned above. They are very interested in biotechnology as a way to reduce the cost of controlling aflatoxin in maize flour (P. Fernandez, personal communication, March 2014) and as indicated by our analysis to capture significant financial gains. The large millers are also very interested in importing GM maize—which has less aflatoxin and high grain quality than local maize—particularly when there are shortages.

The other groups that are active in the debates are international organizations and donors that support opposing views with regards to the passage of the Biosafety Act. The long political process of passing a Biosafety Act—which originated in 2004 and was finally passed in 2009—is described in considerable detail by Karembu et al. (2010).

Key environmental and consumer organizations that opposed the bill under an umbrella organization called the Kenya GMO Concern Group (KEGKO, now evolved into the Kenya Biodiversity Coalition) were supported by foreign organizations. The original group included PELUM-Kenya, Action Aid International Kenya, Bridge Africa, Ecoterra, Greenbelt Movement, INADES, Intermediate Technology Development Group, International Consumer Organization, and Kenya Small Scale Farmers Forum (KESSFF). As mentioned above, PELUM is supported by Swedish and German organizations and KESSFF and its parent EASSFF by the EU and Dutch and German NGOs.

The pro-biotech group that supported the Biosafety Act in 2008 consisted of ISAAA AfriCenter, the National Council on Science and Technology, the Afri-

can Biotechnology Stakeholders Forum, the Program for Biosafety Systems (PBS), and the Seed Trade Association of Kenya (STAK; Karembu et al., 2010). Like the opponents of GM crops, much of the support for the Biosafety Act came from outside Kenya. ISAAA's funding comes from US government agencies, non-profit foundations, corporations, and African organizations (ISAAA, 2014). The Program for Biosafety Systems is a USAID-funded project. The African Agricultural Technology Foundation (AATF) is funded by the Bill and Melinda Gates Foundation, USAID, the Syngenta Foundation, and others.

The 2012 ban on imports of GM food was precipitated by the Kenya Biodiversity Coalition, which brought the article by the anti-biotech French scientist Gilles-Eric Séralini (Séralini et al., 2012) to the Public Health Minister Beth Mugo. That article argued that there was a link between GM maize and cancer, and the Minister used this article as justification for the ban⁴. The Africa Biotechnology Stakeholders Forum, African Agricultural Technology Foundation, International Service for the Acquisition of Agri-biotech Applications, Program for Biosafety Systems, Africa Harvest Biotech Foundation International, Biotechnology Trust Africa, Seed Trade Association of Kenya, Cereal Millers Association, and the East African Grains Council tried to prevent the ban and now are working to have this position reversed (Snipes & Kamau, 2012).

The ban is still in place, with Americans pushing to lift the ban and the EU trying to keep it in place. An article in the national newspaper *The Standard* in June 2014 shows some of the pressures on the government (Gathura, 2014).

4. *The findings of the article were subsequently found to be incorrect, and the article was retracted by the journal.*

Health Cabinet Secretary James Macharia told the Parliamentary Committee on Agriculture, Livestock and Co-operatives that there is a lot of local and international pressure to have the ban lifted. Among the organisations campaigning for the lifting of the ban is the Melinda Gates Foundation. “There has been a lot of lobbying. We had a meeting with Melinda Gates, but we didn’t take a position; we had to wait for a report of the task force that we formed to investigate the issue,” said Dr Macharia.

At the same time, the EU’s Ambassador to Kenya is warning Kenyan farmers that they could lose markets if they adopt GM crops (Gathura, 2014).

Local farmers will find it difficult to export their crops to Europe if they adopt the genetically modified (GM) crops, according to the head of the EU delegation to Kenya, Lodewijk Briet.... “We have made this crystal clear to South Africans and I am telling the same to Kenyan farmers that it will be almost impossible to export GMOs to Europe,” Mr Briet said during Citizen TV’s breakfast show, Cheche, on Wednesday.

One major Kenyan economic interest group—the seed industry—actively supported the Biosafety Act. The Kenyan groups opposed to the GM import ban included the seed industry and cereal millers association. Other Kenyan economic groups were absent either because they did not perceive substantial economic benefits and/or they were not organized and influential with the government. The only other Kenyan interest group that was active in both debates was the Kenyan scientific community, represented by the National Council on Science and Technology.

Conclusions

Whether Kenya will approve GM maize in the near future is unclear. AATF, some government scientists, seed and biotech firms, the US government, and Gates Foundation have been pushing hard for GM maize production and consumption, but support from local industry is limited and opposition from civil society groups and urban consumers is strong. At the same time, the EU has been supporting anti-GM NGOs and warning against GM crop adoption.

Several things have happened that seem favorable to GM technology. First, the new government—which

took office in 2013—is more pro-biotech than its predecessor. The new Deputy President Ruto was influential in passing the Biotechnology Law when he was Minister of Agriculture in 2009. There is a new Minister of Public Health, although the former minister is still a member of Parliament. Deputy President Ruto is now speaking out in favor of GM technology (Wahome, 2014). However, changes in the ban have been complicated by the new constitution of 2013, which has completely changed the structure of the government from a Parliamentary system to Presidential system. It is not clear who has responsibility for changing the ban.

Second, a GM insect-resistance gene has been added to the drought-tolerant hybrids and successfully tested in confined field trials in Kenya. In 2016 this Bt corn trait was approved for environmental release, which means it can be tested in open field trials (Nakweya, 2016). Scientists, government officials, and farmers can now clearly see the benefits from the insect-resistant gene in the experiment station trials and soon will be able to see it in open field trials. Third, higher yielding, drought-tolerant non-GM maize hybrids have been licensed by 23 companies in five countries including Kenya and are being sold to farmers. These hybrids or even-higher-yielding hybrids will be the carriers of the GM traits to farmers in the future and they are showing seed companies and farmers the value of improved hybrids from WEMA.

However, the opposition remains strong as shown by the fact that years after the ban on GM food imports, the ban remains in place. The open field trials for GM maize are a positive step, but commercial production of GM maize—the main food crop in Kenya—will not happen without a fight. Without strong support from Kenyan political groups such as farmers, seed companies, and small- and large-scale food processors, it is hard to believe that Kenya will approve GM maize in the near future.

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