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Full Length Research Paper

Options for pro-poor maize seed market segmentation in Kenya

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New agricultural technologies have to be affordable to make a difference in poor farmers' livelihoods. Their cost to the poor can be reduced through subsidies by the public sector or humanitarian use exemption from Intellectual Property Rights (IPR) by the private sector. Either option needs market segmentation, common in the health sector, but not in agriculture. This paper analyzes options for pro-poor market segmentation for maize seed in Kenya, the most important agricultural technology in the country. Survey data from 1800 households were analyzed to calculate maize seed use by wealth category and agroecological zone. Different market segmentation options were compared by calculating the number of beneficiaries, and the number and proportion of poor beneficiaries. Geographic targeting is not efficient; targeting the poorest districts leads to a high proportion of non-poor beneficiaries, while targeting low potential areas leads to low numbers of beneficiaries because of sparse population and low maize production. Self-selection by targeting technologies like varieties and small seed packages is also not efficient because poor and non-poor farmers use similar technologies. Two options have potential: direct targeting, expensive but with limited leakage, and tiered pricing, likely much cheaper but with high proportions of non-poor beneficiaries.

Key words: Maize, poverty, market segmentation, seed.

INTRODUCTION

Sub-Saharan Africa is the one region in the world where both the number and proportion of malnourished children is increasing (Rosegrant et al., 2001). Maize is the major food crop in East and Southern Africa and, therefore, is an important factor in solving the food security problem in this region. Unfortunately, maize yields in the region have remained stagnant in the last 20 years. In Kenya, yields increased in the 1960s and 1970s from 1 to 1.5 tons/ha, but have remained there since the mid-1980s (Figure 1). At the same time, the area has not increased, so production remains fairly constant. However, the population is increasing at 2.9% (CBS, 2001), so the maize production per capita is decreasing at the same rate (Figure 2). While human consumption of maize is currently estimated at 95 kg/person/year, the average production per person over the last 10 years has been less than 80 kg/person/year (FAO, 2010), with the difference covered by imports.

Modern production technologies, in particular new maize varieties, are being developed to increase yields, but few reach the poor. New ways to bring these technologies to the poor are therefore needed. Market segmentation is one way, so far untested in agricultural input supply, to increase poor farm households' access to new technologies. This process could be financed through either public means, by subsidizing input use by the poor, or through private means, by providing humanitarian use exemption (HUE). The general tendency towards liberalization in agricultural development has

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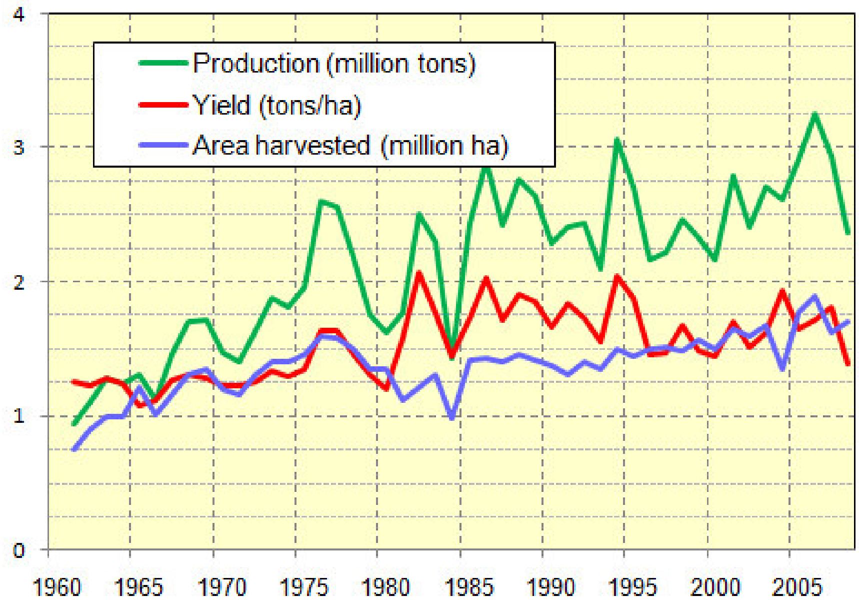

Figure 1. Evolution of maize production in Kenya. Source: FAOSTAT.

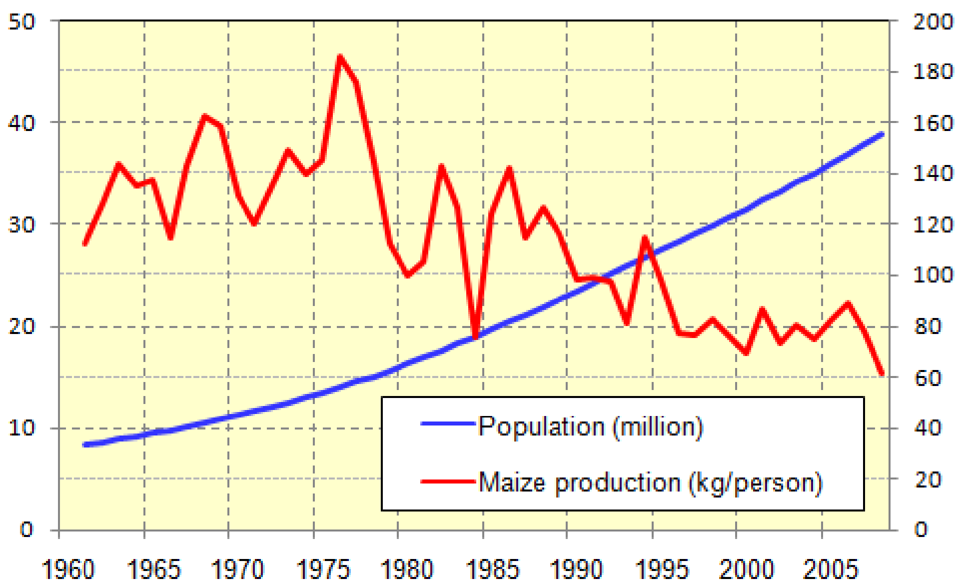

Figure 2. Population growth and maize production per person. Sources: FAOSTAT.

clearly discouraged the use of input subsidies (Kherallah et al., 2002). Recent developments, however, in particular the success of the subsidies in Malawi (Dorward et al., 2007), and in Millenium Development Villages (Sanchez et al., 2009) have put subsidies back on the agenda, and forced economists to review their opinion on market liberalizations.

Increased market liberalization and international trade, has also sparked new interest in Intellectual Property Rights (IPR) systems. The major argument for developing IPRs, and a system of protecting them, is to provide incentives for innovations (Pray and Tripp, 1998). To ensure that inventors are properly rewarded for their efforts and continue making their investments, it is important that the results of their research is protected (Giannakas, 2001). Still, IPRs are not a natural phenomenon but a human construct, and the results of a bargaining and political economy process (Food Ethics Council, 2002). The implementation of the Trade Related Aspects of Intellectual Property Rights (TRIPS) requires that all participating countries establish a system of IPR. Critics, however, question if this agreement was reached will full participation of all stakeholders, and if its consequences for poor farmers are clearly understood.

An increase in intellectual property rights is likely to increase the cost of the technologies, at least in the short run, which is likely to reduce access to new technologies by the poor. A reduction in IPR, on the other hand, can reduces the incentives for companies to develop, market and distribute them, which could ultimately also reduce access by the poor. Public welfare could therefore be increased if the market can be split into a commercial segment, where buyers are able and willing to pay the extra cost for IPR, and a non-commercial segment, where the product would be sold without royalty fees. Such market segmentation is clearly interesting to policy and decision makers, but private companies have also shown interest. While these companies are clearly profit maximizers, they would be interested in forgoing some IPR revenue, especially if it is small, and if a large increase in public welfare can be obtained. Such humanitarian action also provides the company good-will and name recognition. Moreover, if such action brings the poor in contact with new technologies, the poor could turn into valuable customers in the future.

Market segmentation where IPR royalties are waved for the poor have also been called Humanitarian Use Technology Transfer (HUTT) (Lybbert, 2002) or humanitarian access to innovation (Brewster et al., 2005), or Humanitarian Use Exemption (HUE) (Hansen, 2004). Since the last term is clear, short, and convenient, we will use it for this paper. Some HUE cases in the pharmaceutical industry have been very successful. Several companies have allowed the license-free production and distribution of their drugs against Acquired Immunodeficiency Syndrome (AIDS) and tuberculosis in developing countries (Lybbert, 2002). This cost cut reduced their prices substantially, while increasing access to them by the African poor.

For the company holding the IPR, it is important that the license-free product can be targeted to the poor with limited negative effects on profitable markets. It is therefore essential that the market can be segmented between poor and non-poor, and that the administration cost of such a scheme is reasonable. In the pharmaceutical industry, these conditions seem to be more easily met than in agriculture: drugs can be provided license-free in targeted low-income countries where the market for expensive drugs is very small. Alternatively, generic drugs can be produced license-free, while for branded products, which target higher income groups, royalties are charged.

In agriculture, however, market segmentation is much more difficult. Many developing countries have a commercial agricultural sector next to a subsistence or semi-subsistence sector, but both sectors often operate in the same area and use similar technologies. While several HUEs for agriculture have been developed, to our knowledge none is currently operational – at least not for a major crop. The HUE around golden rice, genetically modified to contain high levels of vitamin A, has received much attention: several companies have pledged to forgo their IPR to allow farmers to sell up to $10,000 of their harvest without paying royalties (Brewster et al., 2005). Unfortunately, golden rice is not on the market yet, and it is far from clear how the market segmentation will be organized in practice. Monsanto has also provided genes for other genetically modified (GM) crops such as virus resistance for sweet potatoes in Kenya (Qaim, 2001), but they were not effective against local virus strains. Papaya has also benefited from HUEs in South East Asia (Lybbert, 2002), but this fruit is not a major food staple. In a HUE in India, the private seed company Mahyco donated the *Bacillus thuringiensis* (Bt) gene royalty-free to public institutes to develop Bt open-pollinated varieties (Kolady and Lesser, 2006). The varieties were approved in 2009, but put on hold again in 2010 (http://news.bbc.co.uk/2/hi/8506047.stm).

More recently, private companies have agreed to forgo IPR on GM maize for the Water Efficient Maize for Africa (WEMA) and Improved Maize for African Soils (IMAS) projects. In the WEMA project, launched in 2008, the company Monsanto will provide drought-tolerance transgenes developed in collaboration with BASF to the project to develop varieties that will be made available royalty-free to seed companies that sell to the region's smallholder farmers. In the IMAS project, launched in 2010, the International Maize and Wheat Improvement Center (CIMMYT) and its partners received nitrogen efficient maize transgenes from DuPont Business and Pioneer Hi-Bred, to breed varieties that will be made available royalty-free to seed companies that sell to the region's smallholder farmers. Varieties from these projects will, however, take many years to be developed. Regardless whether market segmentation is financed through subsidies or HUE, it remains an unexplored policy for increasing the access to and the use of agricultural inputs by the poor. Therefore, in this paper, we explore and discuss the options of such policy for the Kenyan maize seed sector. We calculate the potential of different strategies to reach the poor, based on the Institute of Rural Management, Anand (IRMA) baseline survey.

DEVELOPING A HUE STRATEGY FOR AGRICULTURE

Options and strategies for HUE in African agriculture

Several options are available to segment the market in a poor and a non-poor segment for a practical application of HUE or input subsidies for new agricultural technologies (Lybbert, 2002). All options have in common that targeted beneficiaries will access the technology with little or no extra cost, and that these beneficiaries need to be identified, directly or indirectly.

Direct identification of beneficiaries is straightforward, but has its problems. First, appropriate and acceptable criteria need to be established by which beneficiaries can be classified as poor. Second, a mechanism needs to be developed to identify the poor through the measurement of those criteria. Criteria could be farm size, level of subsistence, level of sales (like the $10,000 proposed for Golden Rice), or level of income. These two problems make direct identification difficult to establish and to administer. However, once the beneficiaries are identified, modern identification (ID) technologies such as smart cards, and even finger or eye scans could be used for future applications. Once established, however, a scheme based on direct identification still has major draw backs: it provides incentives to cheat on the side of the farmers, as well as rent seeking behavior from the side of the administrators. To reduce this risk, the identification could be done by a third party that has no direct benefit from the program, such as non-govermental organizations (NGOs) or projects working in the targeted areas.

Indirect identification of beneficiaries reduces the incentives for cheating and is cheaper to administrate. Indirect identification uses either objective criteria closely linked to poverty, such as geographic location or participation in certain programs, or self-selection mechanisms. Geographic targeting limits HUE to particular administrative units such as marginal areas or even countries, which is often used for HUEs in the pharmaceutical sector. Indirect identification through program participation is feasible when programs, e.g. food for work, are popular with the poor but not with well-off farmers. HUEs can use such programs to identify all participants as beneficiaries.

Self-selecting mechanisms include linking the benefits to particular technologies, using tiered pricing, or increasing transaction costs (Lybbert, 2002). The poor might prefer particular technologies because they are cheaper or more suitable, such as open pollinated varieties (OPVs) which can be recycled, or seed in smaller packages. In tiered pricing, the first small amount purchased is subsidized, but royalties are charged for larger quantities. Finally, transaction costs to obtain HUE can be introduced so only the really needy will bother, but this raises substantial issues of ethics and efficiency, and is therefore not further considered here.

The potential of these methods for agriculture in Africa, and specifically improved maize seed in Kenya, were evaluated through a review of the literature, sharing our own expertise, and wide consultations. These included discussions with key informants from research organizations such as CIMMYT and Kenya Agricultural Research Institute (KARI), seed companies such as Monsanto and the Kenyan Seed Company, and NGOs such as the Catholic Relief Services. This evaluation narrowed down the options to direct identification through a third party and indirect identification through geographical targeting and self-selection, the latter either through technology choice or tiered pricing (Table 1).

Options for market segmentation in the Kenyan seed sector

The different options for market segmentation for the Kenyan seed market each have their advantages and disadvantages. Indirect identification methods include geographic targeting and self-selection methods. In geographic targeting, the intervention is limited to areas with high numbers or proportions of poor farm households, such as particular districts or agroecological zones. Subsidized seed would be made available through stockists in the target areas. Since the target areas are well defined, the scheme is easy to administer. The major drawback is leakage: farmers or traders could easily buy the subsidized seed in targeted areas and sell in other areas.

Self-selection mechanisms can be organized by targeting particular technologies favored by poor farmers or through tiered pricing. In technology targeting, the intervention is channeled through particular technologies that poor farmers might prefer as compared to richer farmers. Poor farmers might prefer smaller seed packages, which would not be of interest to large-scale commercial farmers. Poor farmers might also prefer open pollinated varieties, the seed of which they can recycle, or hardy and robust varieties that need less inputs. If such preference can be identified, the subsidies can be provided for these package size or varieties, which is very easily administered.

Indirect identification through tiered pricing would allow farmers to by a limited amount, the first tier, royalty free, for example the amount needed to produce enough maize to feed a family. Farmers who like to buy more, the second tier, would pay the full price for that part. It is hypothesized that large-scale commercial farmers would not want to take the time to obtain the small amounts at a lower cost. The drawback of this mechanism is the high cost of administration. Buyers of the subsidized maize need to be identified so they cannot come back for a second purchase. Also, sales of subsidized seed in the market need to be prevented.

In direct identification, finally, beneficiaries are identified through the measurement of poverty indicators, through a community exercise, or by a third party. Such direct identification might be less prone to leakage, but it is expensive and difficult to administer. Advantages and disadvantages of the different methods are presented in Table 1, together with the research questions that this paper tries to answer to compare the different options.

METHODOLOGY

Conceptual framework: Evaluating the effect of different hue strategies

In market segmentation, where the same product is offered under different conditions to two segments, the target populations need to be defined, and a mechanism developed to effectively separate the

Table 1. Options for maize seed market segmentation in Kenya.

Category	Strategy: HUE limited to:	Advantages	Disadvantages	Research questions
Geographic targeting	Districts with high poverty levels	Ease of administration	Leakage	How many poor people live in these districts, how much maize area they grow, adoption rate?
	Marginal AEZs	Ease of administration	Leakage	How many poor people live in these districts, how much maize area they grow, adoption rate?
Self-selection trough technology	Small seed packages	Ease of administration	Non-poor can switch to smaller package	How does seed packages size differ between poor and non-poor?
	Particular varieties	Ease of administration	Non-poor might like the same varieties	How does variety use differ between poor and non-poor?
Tiered pricing	First amount of seed per farmer	Promotion of new Technology in small quantities	Harder to administrate: how to prevent people from coming back	What quantities do poor and non-poor buy?
Direct identification	Poor farmers, as identified by Let projects or NGOs	Limited leakage	Expensive, need third party	How much seed does the non-profit sector currently distribute?

two segments. As discussed, the objective of the HUE is to make a technology available to the poor at a cheaper price (with little or no royalties). To analyze and compare different distribution methods, some evaluation criteria need to be developed. Two criteria can be easily understood: efficiency and reach. Efficiency can be defined as how much of the product goes to the poor, while inefficiency can be defined as how much went to the non-poor. Reach, on the other hand, can be defined as the number of poor reached with the HUE.

The analysis differs if the IP holder limits the amount of product that is available under HUE (as is likely the case with Bt maize), or if this amount is unlimited (as with generic drugs for AIDS). The efficiency of the HUE strategy can be measured by the proportion of the technology distributed under the strategy that reaches the poor. We can call this the technology efficiency of the HUE strategy. The public–private partnership (PPP)'s objective is to distribute a targeted amount of X_t to the poor, so if only X_p actually reaches the poor, the efficiency of the HUE could be calculated as X_p / X_t, .. Technology inefficiency or leakage can then be estimated as 1- X_p / X_p.

An alternative measure of efficiency is the proportion of poor among beneficiaries. We can call this people efficiency. If the HUE reaches Y_p poor people, but Y_{np} non-poor people also use the royalty-free product, both absolute reach Y_p and relative reach Y_p /(Y_p + Y_{np}) or people efficiency can be seen as a measures of success.

Assessing the impact of different options

The likely impacts of different market segmentation options were analyzed based on secondary and primary data. Secondary data included the Kenya poverty map, production statistics from the Ministry of Agriculure. Primary data include IRMA's Participatory Rural Appraisals (PRAs) and the IRMA baseline survey. A detailed poverty map for Kenya, based on the 1999 population census, provides poverty levels for each sublocation, the lowest administrative unit (CBS, 2003). CIMMYT, in collaboration with KARI, has also characterized six agroecological zones for the country, based on climate and a socioeconomic survey (Hassan et al., 1998). These zones are geographically defined and georeferenced. By overlaying the agroecological zones with the poverty map, the number of households, as well as the proportion of poor, can be calculated for each zone.

The Ministry of Agriculture collects agricultural statistics each year for all districts, including maize area and production, and makes these available upon request. By combining these data with the poverty map, maize statistics can be calculated by poverty class. At the beginning of the IRMA project, several surveys were conducted, including participatory rural appraisals (PRAs), in selected sublocations of all agro-ecological zones (AEZs) (De Groote et al., 2004). The PRAs also included a survey of the stockists of the nearest town, who were interviewed about their sales of maize seed, fertilizer and pesticides over the last year. These data provide information of preferred technologies, such varieties and package size, for the different AEZs. The project also conducted a baseline household survey in 2001-2002, during which 1,850 farmers were randomly selected using a stratified two-stage design with sublocations at the first stage and households at the second, and AEZs as strata (De Groote et al., 2006). Farmers were asked about their maize production practices in these zones (De Groote et al., 2006).

Poverty levels were not explicitly assessed, but they can be derived from indicators such as maize production per household. Since maize is the major food crop, its production is directly related to wealth, and because the sample was randomly selected, we can assign the lesser producers to the poor, up to the percentile indicated by the poverty map. For example, in the Lowland Tropics, 67% of the households have an income falling under the poverty level. The maize production of the 67th percentile is 1.1 tons per year, so all households with a maize production under that level can be classified as poor.

MAIZE SEED USE BY THE POOR IN KENYA

Maize production in Kenya

In Kenya, six major agroecological zones for

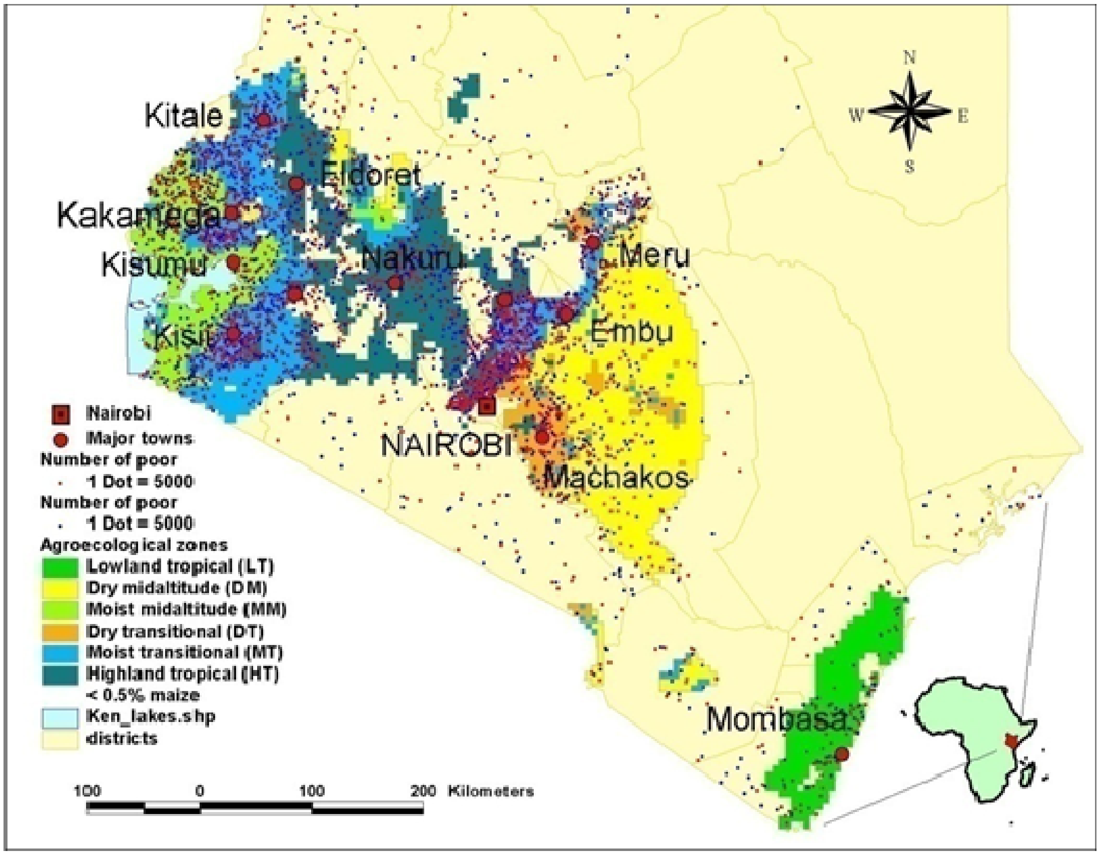

Figure 3. Poverty map and agroecological zones. Each red dot represents 10,000 poor people. Sources: (CBS, 2003; Hassan et al., 1998)

maize production can be distinguished (Hassan et al., 1998). Starting from the east, the Lowland Tropics (LT) can first be identified as a coastal strip, followed by the Dry Mid-altitudes, and the Dry Transitional zones around Machakos (Figure 3). These three zones are characterized by low yields (below 1.5 tons/ha) and can be called low-potential. Although these zones cover 29% of Kenya's maize area, they only produce 11% of the maize (Table 2). Central and Western Kenya are dominated by the Highland Tropics (HT), bordered on the West and East by the moist transitional (MT) zone. The "transitional" indicates its location between the Mid-altitudes (up to about 1500 masl) and Highland zones (above 2000 masl). These high-potential zones have high yields (more than 2.5 tons/ha) and produce 80% of Kenya's maize on 30% of Kenya's maize area. The area around Lake Victoria, finally, has medium potential, and produces 9% of the national production on 14% of the area. Population densities there are high, however, resulting in poor soil fertility management and low yields (1.4 tons/ha).

Spatial distribution of poverty

The Government of Kenya defines the poor as those who do not have enough income for food and basic necessities, and calculated the income for rural and urban households (Ministry of Finance and Planning, 2000). The 2009 census estimated the population in Kenya at 38.6 million (KNBS, 2010), up from 28.6 million in 1999. Based on a subsample of households from the 1999 census, whose income was estimated in detail, the number of people living below the poverty level was estimated as 48% or 13.2 million (Ministry of Finance and Planning, 2000). Using a technique called small area estimation, the number of poor were calculated for each division and location (Statistics, 2003). By combining the administrative map with the divisions and the poverty level of each division, the spatial distribution of poverty can be presented in a poverty map (Figure 3).

The poverty map shows that the proportion of poor people is highest in the marginal areas, especially in the drylands and at the coast. The number of poor people, however, is much higher in the high-potential areas, because of their high population densities. The map clearly shows three areas with a high density of poor people: North and South of the Lake Victoria basin (around Kakamega and around Kisii) and the southeastern slopes of Mt. Kenya (around the axis Nairobi-Embu). Overlaying the map of the maize agroecological zones (AEZ) with

Table 2. Poverty and agroecological zones in Kenya.

Zone	Area (1992)	Area (97-05)	Production (97-05)		Yield	Population (1999)		People under the poverty line	
	1000 ha	1000 ha	1000 ton	%	(t/ha)	1000	%	%	1000
Lowland Tropics	41	54	49	2	0.91	1,987	7	67	1,328
Dry Midaltitude	166	217	147	6	0.68	2,342	8	60	1,405
Dry-Transitional	66	86	73	3	0.85	1,304	5	56	728
Moist-transitional	466	610	1,126	46	1.84	7,537	26	40	3,048
Highlands	316	414	832	34	2.01	3,812	13	38	1,447
Moist Midaltitude	173	227	220	9	0.97	3,018	11	61	1,855
< 0.5% maize						5,942	21	54	3,183
Other						2,637	9		
Total	1,244	1,630	2,448	100	1.50	28,579	100	48	13,200

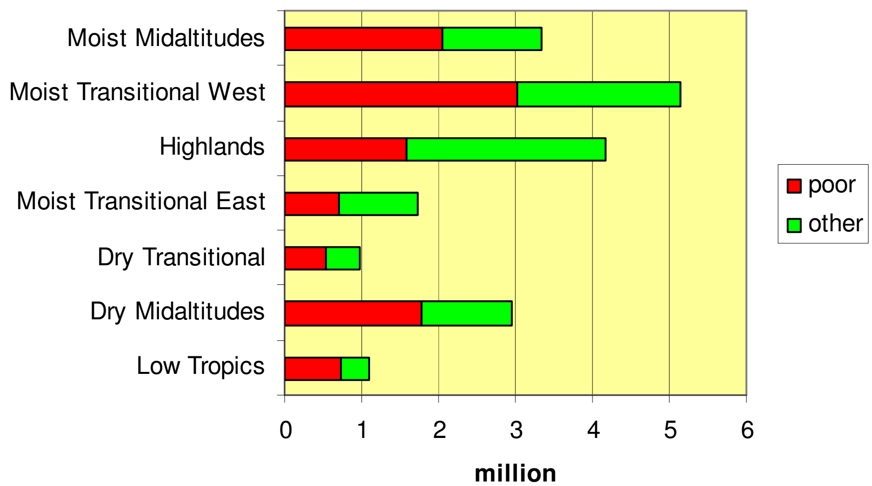

Figure 4. Population distribution by wealth category and agroecological zone.

the poverty map shows the importance of poverty for each zone (Figure 4). By allocating each division to the agroecological zone in which most of its area falls, the population and the number of poor can be calculated for each zone (Table 2). Most people in Kenya (70%) live in the major maize agroecological zones. Since Nairobi and its surroundings fall largely outside these zones, almost all rural households can be considered living inside them. There is, however, a major difference between proportion and numbers of poor people. While the low-potential zones have, understandably, the highest proportion of poor people (61%, as compared to 40% in the high-potential zones), they actually have fewer poor inhabitants (3.5 million) than the high-potential zones (4.5 million). The medium-potential Moist Mid-altitudes has both a high proportion (61%) and a high number (1.8 million) of poor people. All three areas with major concentrations of poor people fall mostly in the moist transitional zone. In western Kenya, part of it also falls in the moist mid-altitude zone; in eastern Kenya, part of it falls in the highlands.

Maize production and seed use by wealth category

To analyze maize production by the poor, the households from the 2002 survey were split in poor and non-poor households. The results show that poor households only produce 400 kg of maize per year, a tenth of non-poor households (Figure 5). One factor is land availability: poor households cultivate only half the maize area of non-poor households. The major cause of the difference between the groups, however, is the yield: maize yield in poor households is, on average, a very low 327 kg/ha, compared to the 1,547 kg/ha for non-poor households (Figure 5).

The same method was used to analyze the differences in seed use between agroecological zones and wealth categories, in particular the use of improved maize varieties (IMV) (Table 3). There is a large difference between the high potential zones, where farmers purchase most of their seed, on average 25 kg (MT) or 36 kg (HT) of maize seed per year. In the low potential areas, on the other hand, farmers on average buy only 5 kg or less of maize

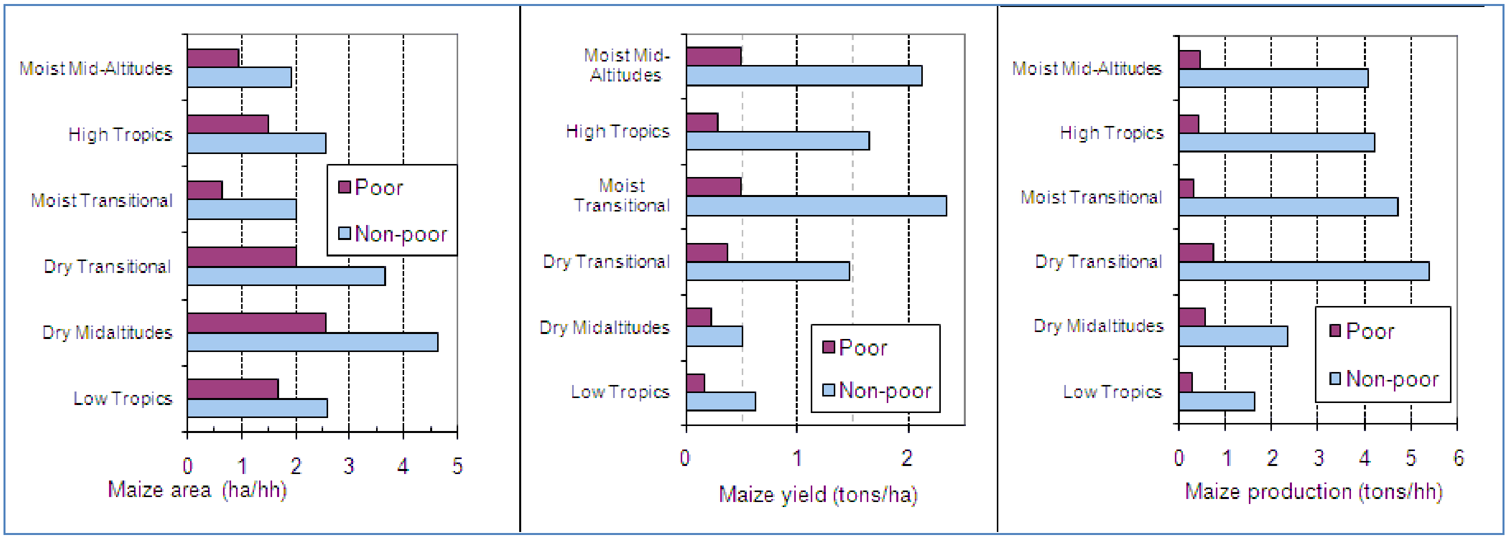

Figure 5. Maize and poor farmers.

Table 3. Seed use by Kenyan farmers, by poor and non-poor.

AEZ	All households		Non poor		Poor	
	Seed purchased (kg)	Seed purchased (% of use)	Seed purchased (kg)	Seed purchased (% of use)	Seed purchased (kg)	Seed purchased (% of use)
Lowland Tropics	4	26	4	24	4	28
Dry Mid-altitudes	3	4	3	3	3	7
Dry Transitional	4	13	9	19	1	4
Moist Transitional	25	87	33	89	12	79
High Tropics	36	93	45	92	21	96
Moist Mid-altitudes	5	35	6	36	4	34

seed per year, 35% of their total seed use. In the high potential areas, there is also a big difference between wealth categories: the wealthier farmers purchase, on average, 20 kg more maize seed than the poor. In the low potential areas, however, that distinction is much less clear. There is no difference between wealth categories in the lowlands and dry mid-altitudes, and only a small difference in the moist mid-altitudes (2 kg). But there is a large difference in the dry transitional, where the wealthier group buys 8 kg more maize seed than their poorer counterparts.

Extrapolating the household seed demand from the survey households to all households in each AEZ results in estimates of improved maize seed used in each zone, with a total of 21,000 tons (Table 4). This total corresponds with estimates obtained through informal discussions with seed companies, although it is lower than an estimate of 26,000 tons obtained through a more recent seed company survey (Langyintuo et al., 2008). As expected, most of the seed market (18,000 tons) is in the high potential areas, in particular in the moist transitional zone (a share of 51% of the total market and in the highlands (37%).

The market share can be calculated for each wealth class by extrapolating the average use of each class over their maize area, by agroecological zone. It is estimated that the poor annually buy 6000 tons of maize, or 29% of the total. This proportion ranges from 11% in the dry transitional zone to 43% in the lowland tropics (Table 4). From the seed bought by the poor, again a large majority (87%) was purchased in the high potential areas.

ANALYSIS OF DIFFERENT MARKET SEGMENTATION OPTIONS

Assumptions

In this section, we analyze the different HUE approaches under consideration by quantifying their efficiency, reach, benefits and costs. Basic assumptions include a total seed market of 21,000 tons, with a future market share for *Bt* maize of about 30% of that (6,300 tons). Since we do not have any particular information on how this would be distributed, we assume for now that this share is constant in the different AEZs and wealth classes. If the

Table 4. Estimated national maize seed market, by wealth class and AEZ (extrapolation of household data).

Agroecological zones	Maize area (1000 ha)			Adoption rate (% area)			Adopters (% households)			Seed market (tons)		
	Poor	Non-poor	Total	Poor	Non-poor	Total	Poor	Non-poor	Total	Poor	Non-poor	Total
Low Tropics	21	33	54	28	24	26	36.6	48.1	40.7	116	154	278
Dry Midaltitudes	78	140	217	7	3	4	12.3	7.5	10.2	108	81	187
Dry Transitional	31	56	86	4	19	13	12.7	24.4	18	24	209	220
Moist Transitional	145	465	610	79	89	87	79.2	82.1	81	2,299	8,269	10,597
High Tropics	152	262	414	96	92	93	86.4	88.6	87.7	2,906	4,841	7,705
Moist Mid-Altitudes	74	152	227	34	37	35	49.7	50.5	50	505	1,117	1,600
Total	501	1,108	1,609	59	66	64				5,957	14,671	20,587

IP holder allows HUE for 30% of the Bt maize seed market, this would translate in a total of about 2,000 tons of royalty-free *Bt* maize seed annually.

Geographic targeting

To analyze the option of geographic targeting of the poorest districts, all 69 districts from the 1999 census sorted in descending order of poverty levels, and the number of poor and non-poor households tabulated. For each district, the average maize production, area and yield was calculated for the period of 1997 to 2005 (Ministry of Agriculture, unpublished data). Adoption rates and average seed use for poor and non-poor households for each districts were assumed to be equal to those of the AEZ where the largest part of its area falls (Table 4). For example, the poorest district in Kenya is Kuria: 79% of its inhabitants live below the poverty line. This district produces on average 18,000 tons of maize on 9,000 ha, or a yield of 2 tons. Kuria falls in the moist-transitional zone, and in this zone, 87% of maize area is planted with improved maize seed. At an average seed rate of 20 kg/ha, the market for maize seed can be estimated at 157 tons. Since the poor in this zone buy, on average, 22% of the maize seed, the seed market segment for the poor in Kuria is estimated at 34 tons (Table 5).

Geographic targeting would imply the selection of districts with highest poverty levels, up to the number needed to reach the target. To reach that target, 2000 tons of seed distributed under HUE, the 15 districts with highest poverty levels (the lowest with 63%), would need to be selected. Calculations show that these districts have a population of 4.5 million people, with 3 million of them living under the poverty line. In these districts, about 2,359 tons of maize seed are sold annually, of which 633 to the poor. A market segmentation strategy targeting the 15 poorest districts with *Bt* maize under HUE (assuming a 30% market share) is therefore likely to sell about 700 kg of HUE Bt seed, of which (assuming same preference of varieties) 28% would go to the poor.

To calculate the number of poor people reached through this HUE strategy, we return to the example of the poorest district, Kuria. Since the district is located in the moist transitional zone, 79.2% of the poor are likely to adopt IMV. A third of these farmers, as assumed, adopt *Bt* maize, that would be 26.4% of poor farmers. Ignoring the small urban population, *Bt* maize would thus be reaching 36,000 poor people in the district. Among non-poor farmers, 82.1% are adopters of IMVs. Since the HUE *Bt* maize would be available to all farmers, it can be assumed that a third of them, 27.4%, would buy this seed, benefiting 8,000 non-poor people. Adding up the people reached in all 15 poorest districts, led to an estimated number of 813,000 people reached, of which 540,000 (66%) are poor.

To reach the target of 2000 tons of HUE *Bt* maize seed sold, we would need to increase the number of districts to the 31 poorest, with the last one having a poverty level of 51%. This area has a seed market of 6.8 tons, or roughly 2.3 tons for *Bt* maize seed, of which 24% would be bought by the poor. This strategy would reach 1.5 million people, 52% of whom are poor. While this strategy would reach more poor than non-poor people, the larger portion of the HUE seed would actually go to the wealthier group. A similar exercise to effort to estimate the benefits of limiting the HUE to the poorest districts in the low potential areas, the drylands and the lowlands, resulted in similar results. While a large number of people can be reached through this market segmentation method, the proportion of non-poor was always larger than the proportion of poor. The main reason is that the non-poor are more likely to buy improved maize seed, and do so in larger quan-

Table 5. People, by wealth category, reached through geographic targeting.

Poverty rank	District	Population			Area (1000 ha)	AEZ	Adoption				Seed segment poor		Adoption of Bt maize, poor		Adoption of Bt maize, non-poor	
		Population (1999, x 1000)	Poor (%)	Number of poor (1000)			Area (1000 ha)	AEZ	Adoption (% area)	Seed market (tons)	% market	tons	% of farmers	People reached (1000)	% of farmers	People reached (1000)
1	Kuria	137	79	109	9	MT	9	MT	87	157	22	34	26.4	29	27	8
2	Kilifi	462	72	332	18	LT	18	LT	26	93	42	39	12.2	41	16	21
3	Homa Bay	243	71	173	25	MM	25	MM	35	174	32	55	16.6	29	17	12
4	Rachuonyo	289	71	205	16	MM	16	MM	35	116	32	37	16.6	34	17	14
5	Bondo	217	71	153	9	MM	9	MM	35	66	32	21	16.6	25	17	11
6	Kitui	490	70	345	53	DM	53	DM	4	45	58	26	4.1	14	3	4
7	Nyamira	467	69	322	19	MT	19	MT	87	333	22	72	26.4	85	27	40
8	Suba	144	67	97	10	MM	10	MM	35	69	32	22	16.6	16	17	8
9	Busia	335	67	224	17	MT	17	MT	87	288	22	62	26.4	59	27	30
10	Malindi	214	65	140	14	LT	14	LT	26	73	42	31	12.2	17	16	12
11	Siaya	449	64	285	33	MM	33	MM	35	235	32	74	16.6	47	17	28
12	Kisumu	294	63	186	10	MT	10	MT	87	166	22	36	26.4	49	27	30
13	Mbeere	166	63	104	16	DM	16	DM	4	14	58	8	4.1	4	3	2
14	Tharaka	100	63	63	5	DM	5	DM	4	4	58	2	4.1	3	3	1
15	Kakamega	533	63	335	30	MT	30	MT	87	524	22	114	26.4	88	27	54
Poorest 15		4,539	68	3,073		284				2359	27	633		540		272
Poorest 31		11	63	6,855		844			45	7661	26	1979		49		30

tities.

Self selection through technology targeting

The second option for beneficiary targeting with HUE is self-selection by limiting subsidies to specific technology options. We consider those options that are likely to be preferred by the poor, in particular package size or type of varieties.

A survey of stockists showed that seed packages larger than 2 kg are only sold in the highlands; in other zones, even the larger farmers buy the standard 2 kg package (Table 6). Using this distribution, and assuming that Bt varieties will have a market share of 30%, or 6182 tons, the Bt maize sold in 2 kg packages can be estimated at 4095 tons. Assuming wealthier farmers in the highlands do not buy the small packages, the poor would buy 28% of the Bt maize seed in small packages, or 1147 tons.

If a HUE strategy would sell 2000 tons of Bt maize seed in small packages, only 560 would reach the poor. Since the poor households buy on average 8.6 kg, this would reach, 133,000 households or 665,000 poor people. Wealthier households buy more seed, on average 28 kg, so 551,000 people in this category would be reached.

The other technology option for HUE would be to target specific varieties, more appreciated by the poor. Analysis of the farmer survey data indicated only small differences in use of varieties by the poor and non-poor, in particular, open pollinated varieties versus hybrids, or varieties targeted for the low-potential areas, such as drought tolerant or coastal varieties (Table 8). The poor show a slight preference for coastal varieties and mid-altitude varieties (the KSC’s 500 series), so this option was pursued. Still, the wealthier farmers buy more of these varieties (29 kg/household) than the poor households (14 kg/household) (Table 7). If these varieties were converted into Bt

Table 6. Maize seed sales by package size.

AEZ	Sales by package size (%)				Bt Seed market (tons)			After HUE, <2 kg		
	2 kg	5 kg	10 kg	25 kg	Total	Non-poor	Poor	Total	Non-poor	Poor
Low tropics	100				83	46	35	83	46	35
Dry Transitional	100				56	24	32	56	24	32
Dry Midaltitude	100				66	63	7	66	63	7
Moist Transitional	100				3179	2481	690	3179	2481	690
High Tropics	10	10	35	45	2311	1452	872	231	0	231
Moist Mid-Altitudes	100	0	0	0	480	335	151	480	335	151
Total					6176	4401	1787	4095	2949	1147

Table 7. Farmers' use of targeted varieties (TV) (coastal hybrids and mid-altitude hybrids.

AEZ	TV (kg/hh)		Other (kg/hh)	
	Non-poor	Poor	Non-poor	Poor
Low tropics	9.77	7.19	3.29	3.03
Dry Transitional	5.19	1.78	14.68	12.1
Dry Midaltitude	5.31	1.24	9.17	1.45
Moist Transitional	3.53	1.75	29.85	12.5
High Tropics	1.44	0.67	44.07	20.9
Moist Mid-Altitudes	3.32	1.14	3.39	2.3
Total	28.56	13.8	104.45	52.3

Table 8. Percentage of farmers purchasing different quantities of fresh seed (in % by AEZ and wealth class).

Wealth	AEZ	Proportion of farmers buying fresh seed, by amount (in kg/hh)							
		0	>0 - 1	>1 - 2	>2 - 5	>5 - 10	>10 - 25	>25 - 50	>50 - 100
Non-poor	Low Tropics	51.9	0.0	11.3	9.4	16.0	7.5	3.8	
	Dry Midaltitudes	92.5				1.3		5.0	1.3
	Dry Transitional	75.6			4.4	6.7	6.7	2.2	4.4
	Moist Transitional	17.9	0.3	2.7	6.8	16.6	33.4	13.9	8.4
	High Tropics	11.4	0.4	1.6	4.5	22.0	31.4	13.1	15.5
	Moist Mid-Altitudes	49.5	1.0	5.0	9.9	11.9	17.8	5.0	
	Total	32.5	0.3	3.3	6.1	15.7	24.2	10.3	7.6
Poor	Low Tropics	63.4	3.1	9.3	8.2	8.2	5.2	2.1	0.5
	Dry Midaltitudes	87.7			1.9	2.8	2.8	2.8	1.9
	Dry Transitional	87.3	1.8		3.6	3.6	3.6		
	Moist Transitional	20.8	3.5	15.6	20.3	20.3	11.3	2.6	5.6
	High Tropics	13.6		3.9	13.6	25.3	29.2	8.4	5.8
	Moist Mid-Altitudes	50.3	1.3	4.0	17.4	18.8	8.1		
	Total	45.9	1.9	7.4	12.8	15.2	11.0	2.9	2.8

varieties, with 30% market share, equally spread over the different AEZ and categories, their market would be 694 tons. A HUE strategy using these varieties would see 530 tons purchased by the wealthier households, and 163 by the poor. Extrapolating this in the same way as the previous technology estimates the number of non-poor reached at 4.7 million, compared to 3.1 million poor.

Tiered pricing

The second option of indirect selection is through tiered pricing. Here, the first tier of the product is offered at a discount, reflecting the HUE from IPR. We examine here the options of providing the first 2 or 5 kg of Bt maize seed purchased at a discount. We first analyze how

Table 9. Comparing the efficiency of different HUE approaches.

Category	Strategy: HUE limited to:	Definition target area	Reach (amount of technology)			Reach (number of people)		
			Seed needed	Amount to poor	Technology efficiency	Number of non-poor reached	Number of poor reached	People efficiency
Geographic targeting	Districts with high poverty levels	10 poorest (<65%)	2,359	633	27	272	540	66
		31 poorest (<60%)	7,661	1,979	26	2,294	3,600	61
	Marginal AEZs	Poverty >60%, LT	413	173	42	212	314	60
		Poverty >60%, Drylands	490	124	25	126	203	62
		Poverty >60%, MM	820	259	32	351	660	65
		Poverty >60%, MT	2,370	514	22	765	1,363	64
Self-selection trough technology	Small seed packages	Packages >=2 kg	4,095	1,147	28	552	665	55
	Particular varieties	Mid-altitude and coastal hybrids	530	163	31	4,689	3,141	40
Indirect selection	Tiered pricing	First 2 kg	1,631	711	44	6,894	5,336	44
		First 5 kg	5,229	1,737	33	6,894	5,336	44
Direct identification	Let projects or NGOs identify the poor, and provide them with the seed		2,000	1,700	85	400	340	85.0

many farmers buy seed at different quantities (Table 8). The results show that not many farmers buy small quantities. Only 3.6% of the wealthier and 9.3% if the poor buy 2 kg or less. Based on the distribution of farmers' seed purchase, we can calculate that a tiered pricing strategy providing the first 2 kg under HUE would sell 1,631 tons of seed. Almost half (44%) or 711 tons, would be bought by the poor. A tiered pricing strategy providing the first 5 kg would need 5,229 tons of seed, of which a third or 1,737 tons would go the poor. This does not take into account the likelyhood that wealthier farmers would be less inclined to go through the hassle of the HUE procedure.

Direct identification

Finally, direct identification of the poor is done in Kenya by government agencies and NGOs. This method incurs high costs, the possibility of rent seeking behavior, and only limited areas can be covered. If well executed, however, the leakage should be small, maybe 10%. So if 2000 tons of maize seed is distributed to directly identified poor, about 1800 can be estimated to reach the poor. If 5 kg were to be distributed, 350,000 poor households with 1.8 million people can be reached. The administrative and organizational capacity and resources required are, however, considerable. The costs of the exercise also needs to be considered.

COMPARING METHODS

To analyze the strengths and weaknesses of the different HUE strategies we calculate and compare their efficiencies (Table 9). The geographic targeting has a low product efficiency: 26% for the poorest 11 and 27% for the poorest 31 districts. This is caused by the much higher quantities of seed the wealthier farmers purchase. The people efficiency, the proportion of poor among the beneficiaries, is much higher, about two thirds. This reflects the fairly high proportion of poor who buy improved maize seed. Combining high poverty levels with low-potential agroecological zones can improve the product efficiency, in particular in the lowland tropics (up to 42%) and the moist transitional zones (32%), but not the people efficiency.

Self-selection through technology targeting is not very efficient either. Less than a third of the HUE seed under such schemes would reach the poor. Only about half of the beneficiaries would be poor, although this would be higher with the small packages size (55%) than with targeted varieties (40%). Tiered pricing would have a better product efficiency, up to 44% for the lowest quantity. If the wealthier farmers fully participate in this scheme, the people efficiency is calculated at 44%, for either quantity. This is, however, likely an underestimate. The direct identification, finally, has the best efficiency, estimated at 85% for both product and people. This mechanism is, however, also the most difficult and most expensive.

Conclusion

We conclude that indirect identification of the poor is difficult: Poor farmers live in the same areas and use the same technologies as the non-poor. Targeting the low potential areas is also not indicated, since not many people live there and they produce little maize. Therefore, two options remain. The first option is direct targeting, which is likely to be expensive but will also lead to limited leakage. The second option is tiered pricing, which is likely to be a lot cheaper, but at the same time likely have high leakage. Tiered pricing would also need a control mechanism to avoid people coming back for a second batch of the seed at HUE prices.

To compare the costs and the benefits of both methods, further research is needed. A pilot study is therefore needed to quantify the trade-off between administrative and leakage costs. The optimal amount of discount and the optimal amount of seed that could be provided at a reduced price need to be determined. The administration of such schemes needs to be studied, comparing the costs and benefits of different systems such as vouchers, smart cards, electronic identification by finger print, and so forth. This pilot study will need to include extensive monitoring and evaluation, to quantify the number of poor reached, the change in improved seed use through the project, and the amount of leakage.

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ABBREVIATIONS

HUE, Humanitarian use exemption; **IPR**, intellectual property rights; **TRIPS**, trade related aspects of intellectual property rights; **HUTT**, humanitarian use technology transfer; **AIDS**, acquired immunodeficiency syndrome; **GM**, genetically modified; **Bt**, *Bacillus thuringiensis*; **WEMA**, water efficient maize for Africa; **IMAS**, improved maize for African soils; **CIMMYT**, International Maize and Wheat Improvement Center; **IRMA**, Institute of Rural Management, Anand; **OPVs**, open pollinated varieties; **KARI**, Kenya Agricultural Research Institute; **NGOs**, non-govermental organizations; **PPP**, public–private partnership; **PRAs**, participatory rural appraisals; **AEZs**, agro-ecological zones; **LT**, lowland tropics; **HT**, highland tropics; **MT**, moist transitional; IMV, improved maize varieties.

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