Title of the Poster:

'Does land use Patterns Matter for Bt-Maize: The case of Maize Farming System in Kenya'

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Abstract

Population pressures and the need to optimize the use of limited available land has led to increasing cropping affluence levels within the maize agro-ecologies in Kenya, and a shift from large to smallholder intensification and multiple cropping patterns. Using a geographic information system, this study relates cropping patterns, by area share, maize productivity and household incomes across maize agro-ecologies, with the purpose to establish a decision support system for optimizing land allocation and in priority setting for introduction of new technologies such as Bt maize varieties. Results show that land use patterns and maize productivity in maize farming systems differ between agro-ecological zones. The high potential areas experience high maize yields, with maize grown alongside major cash crops such as tea and coffee. In contrast, lowland coastal strip and lake Victoria region tend to grow drought tolerant tuber crops (such as cassava and sweet potatoes) alongside maize in appreciable land sizes. Similarly the dry areas grow drought tolerant legumes such as pigeon pea alongside maize. These low potential areas thus concentrate on meeting their subsistence food self-sufficiency needs, pointing at risk management strategies against drought and pests such as stem borer, unlike high potential areas with high value cash crops. Maize breeders should therefore consider insertion of Bt- genes in maize varieties that would achieve high production and which are also capable of safely growing side by side with crops that meet different food security conditions in different agro-ecological zones in Kenya.

Key Words: Land use, Smallholders, Maize production, Food security, Kenya

1. Introduction

1.1 Land Scarcity, population growth and Land Use Distribution

Land use according to Lundgren, (1975) is defined as the application of human controls, in a relatively systematic manner, to key elements within any ecosystem, in order to derive benefit from it. The use may be permanent or cyclic intervention. Land scarcity in Kenya has emerged due to increases in rural population as well as due to improved market access; both of which have subsequently resulted in increased value of output. As a result, land has become a marketable commodity, attracting both old and young families, and leading to increased intensification with multiple crop enterprises. Population growth has led to increasing clearing of woodlands and wetlands for extra arable land, consequently affecting types of farm enterprises, mainly the type of crops grown and the adoption of new technologies.

A study on land use in Europe by (Grigg, 1980) shows that a rise in population has a strong influence hitherto on cultivation of inferior crops such as potatoes and maize, which were earlier grown only as livestock feed. The study further points at the influence of market demand for the crops in developing nations as key to more distribution of land to crops. Similarly, Omosa, (1994) found that root crops are neglected in Kenya, in spite of being highly ecologically adaptive, mainly because of poor market demand; strengthening the influence of market demand on the allocation of land and patterns of land use.

By focusing on the interdependence between land use and technology, Boserup, (1965) usurped that in the Pre-industrial peasant societies increased output was possible only through expansion of cultivated area or increased frequency of cropping per year. Later on, however, increased output has been mainly realized through a shift towards high yielding crop varieties. These changing patterns influence productivity substantially. In this respect, population pressure though poses a challenge to agricultural growth, it may however, also lead to innovation and higher technological advancement through intensification. Under such conditions, the introduction of the plough can be regarded as a means to prevent a fall in output per man-hour rather than as a means to raise it. Intensification of agriculture then becomes a gradual change towards patterns of land use, which makes it possible to crop a given area of land more frequently than before, in order for productivity to be enhanced.

However, in Western Europe, change to annual cropping is described as a result of the discovery of the possibility of cropping the land without fallow by the use of crop rotations with fodder plants, of which some are leguminous. Rapid growth in population is then considered to be the result rather than the cause of this change. Other evidence however suggests that some of the intensive practices introduced in the fields during the agricultural revolution in Europe had been used in gardens, and were extended to fields, only after the rapid increase in numbers and the need for more output. This suggests that the transition in Europe from short fallow to annual cropping was not the result of contemporary inventions. Instead, it was the spread of various methods of intensive cultivation.

1.2 Land use in Kenya

In Kenya and many parts of Africa, lowland areas and the semi-arid farmers have become specialists in mixed farming and crop-livestock integration. In areas with variable rainfall, income diversification, in the sense of combining farming and non-farm activities within one household, has advantages, particularly by spreading risk. For instance, out of a total land area of 581,679 km^2 only about 17 percent is arable of high to medium potential for agriculture and intensive livestock production. The rest of the land is classified as arid or semi-arid lands and mainly used for extensive livestock rearing and wildlife (Gok, 2001b). This justifies the significance of analyzing arable land use patterns, particularly for basic food crops relative to other crops as food self-sufficiency and security depend on the patterns in question. With the increasing demand of land for various uses, evaluation of land use patterns is crucial for livelihood sustainability (Lovemore, 1999). Studies on land use patterns in Kenya have however not captured its influence on productivity of key food crops. A study undertaken in 1988 in the densely populated Nyeri and Kakamega districts (Migot-Athola and Shem, 1994b), although focused at the relationship between land tenure, agricultural investment and farm productivity, never established the nature of cropping patterns on the productivity.

Besides, Kenya's agricultural sector has registered poor growth over the last decade, with growth falling to negative 2.4 percent in the year 2000 (GoK, 2001a) and percentage value addition to the sector gradually declining from 26.3 % of GDP in 1998 to 16.4% in 2002 (World-Bank, 2004). All these have been blamed on, among other factors, increasing frequency of drought and falling agricultural productivity due to poor land use systems.

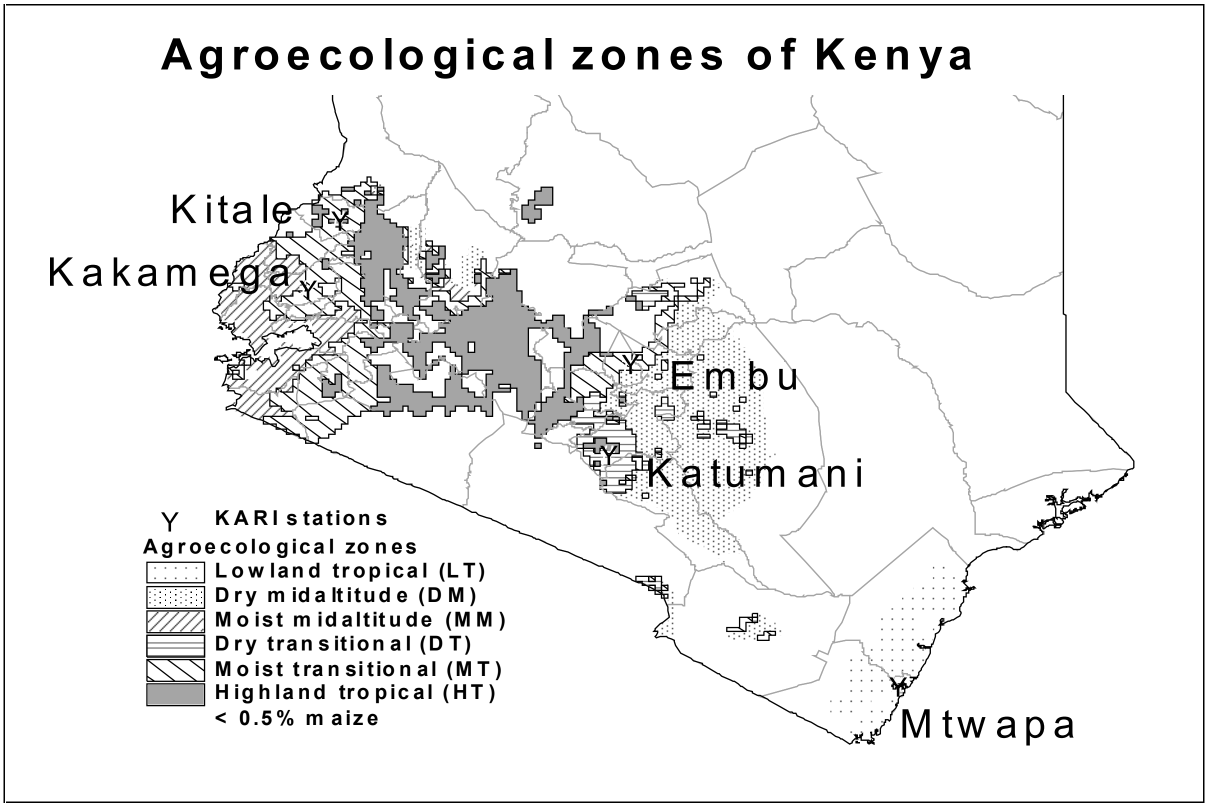
In view of the above, this study had the objectives to compare land use patterns and cropping practices in maize farming systems across all the maize agro-ecological zones in Kenya, to establish (through mapping) the influence of land use patterns on maize productivity, household size and income and, to establish factors that influence area shares in different group of crops across the zones, with final derivation of recommendations targeted at breeders' priority setting for Bt-insertion on available maize varieties in different maize agro-ecologies in Kenya.

2. Methods and Data

2.1 Area of the Study

The areas of study was based on an earlier survey by CIMMYT and KARI (Kenya Agricultural Research Institute) that defined six major maize agro-ecological zones in Kenya in 1992 (Hassan, 1998). Figure 1. is a representation of the zones. The zonation is based on variations in parameters such as elevation, temperature, precipitation, evaporation, radiation, and humidity data [Mwasi, 2001].

Figure 1. Maize Growing Agroecological zones of Kenya



From east to west shows the Lowland Tropics (LT) at the coast, followed by the Dry Mid-altitude (DM) and Dry Transitional zones (DT). In Central and Western Kenya are the Highland Tropics (HT), bordered on the west and east by the Moist Transitional (MT) zone (transitional between mid-altitudes and highlands). As of 1992, the first three zones had average yields under 1.5 t/ha, and although they covered 29% of maize area in Kenya, they produced only 11% of the country's maize. Yields in the Highland Tropics averaged over 2.5 t/ha, and produced 80% of the maize in Kenya. In the moist mid-altitude around Lake Victoria, maize yields averaged 1.34 t/ha (Table 1).

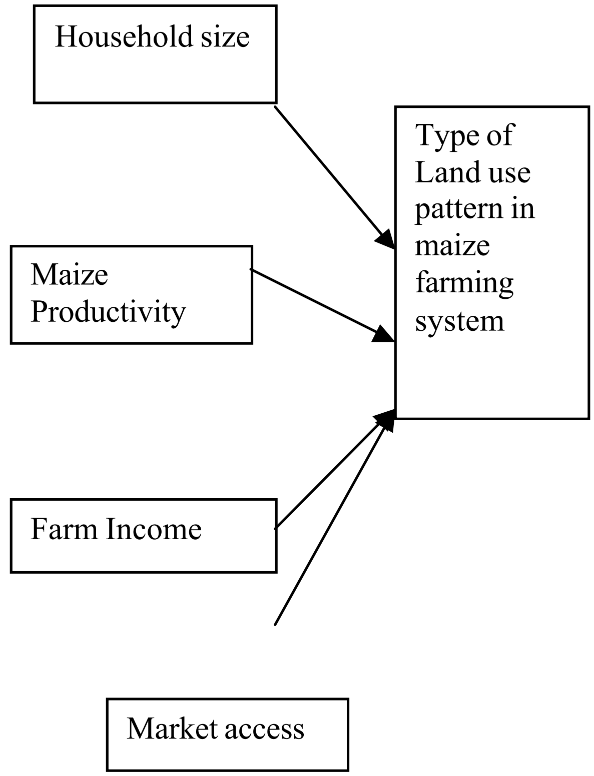
Table 1. Elevation and productivity in Kenya's maize-producing zones.

Zone	Population Density (pers.km-2)	Elevation (meter)	Major season			Minor season			Total		
			Area '000 ha	Yield T/ha	Prod. '000 ton	Area '000 ha	Yield t/ha	Prodn. '000 ton	Yield T/ha	Prod. '000 ton	Prod. %
Highlands	238	1600-2900	307	2.91	893	9	1.73	16	2.88	909	34
Moist-transition	331	1200-2000	424	2.76	1,170	42	1.5	64	2.65	1234	46
Moist Mid-altitude	310	1110-1500	118	1.44	170	55	1.11	62	1.34	231	9
Dry-Transition	398	1100-1700	37	1.21	45	29	1.08	32	1.15	76	3
Dry Mid-altitude	210	700-1400	118	1.03	122	48	0.83	40	0.98	162	6
Lowland Tropics	121	0-700	33	1.36	45	8	0.99	8	1.29	53	2
Total			1037	2.31	2,395	207	1.33	276	2.15	2,671	100

2.2 Sampling and Sample Design

Variables were constructed using data from both community and household surveys. A stratified sampling design was used to select sub-locations (herein referred to as communities or villages) in each maize agro-ecological zone. The zones formed the strata and sub-locations the sampling population. A total sample of 1800 households was made. Personal interviews were conducted using semi-structured questionnaires capturing area shares in both cash and food crops. The optimization of sample design (De Groote, 1996) was accomplished with parameters drawn from the 1992 Kenya Maize Data Base (KMDB), with a precision of 5-10 % Root Mean Square Error (RMSE) for each zone. The parameters used were maize area, yield, household size and acres under the three most widely grown varieties during the 1991/1992-survey year.

Figure 2. Conceptual Framework



The framework (Figure 2) hypothesizes that the type of cropping systems used is influenced by variations in agro-ecological climate, which dictate productivity of maize, productivity of other crops, general farm income, market access, price and household size. Therefore, higher incomes and higher levels of maize productivity determine decisions to change cropping patterns and to seek new technologies such as Bt maize technology.

2.3 Analytical Approach

To address the influence of land use patterns on productivity and on farm income and then on new technologies, we used GIS-based Decision Support System (DSS) in Arc-View as used by (Mwasi, 2001) to map area shares by crops and relate with that of maize productivity and general farm income mapping. Further, we developed a simple ordinary least squares model to measure factors that influence area shares in each group of crops, with dependent variable being the area share in a given crop or group of crops as follows:

$$\%croparea = f(AEZ, householdsize, Marketaccess, Price, Income, Maize\ productivity)$$

3. Results

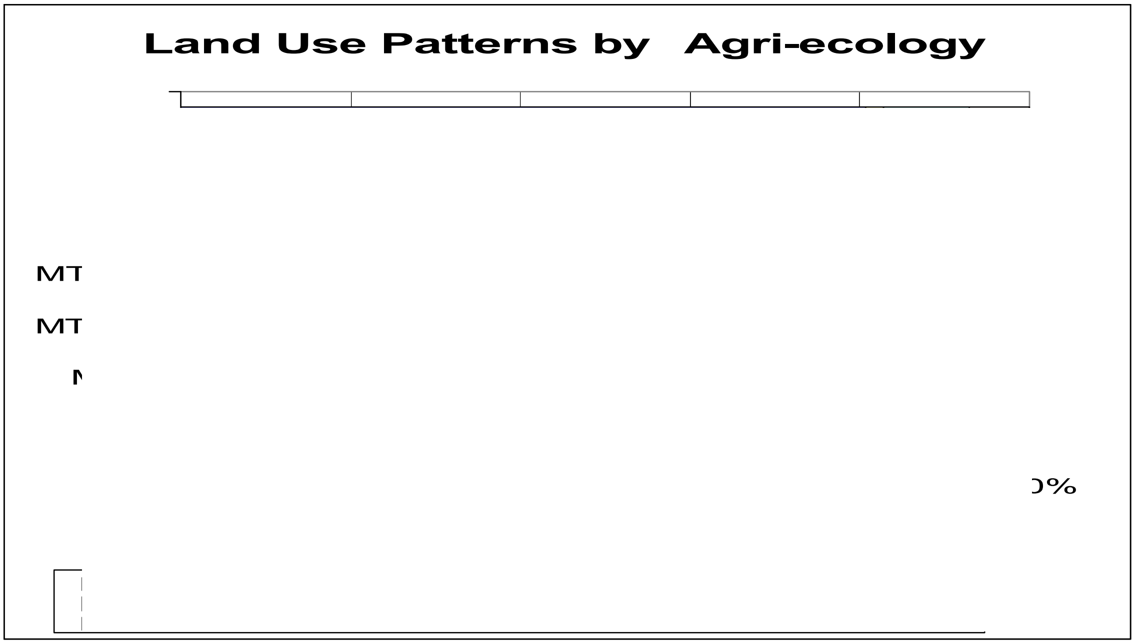
3.1 Importance of Land holdings

In the areas surveyed, land remains the main source of production and reproduction, and for this, its ownership is economically, socially, politically, and emotionally driven. In general, land holdings range from as low as a quarter of an acre to over 50. But, some households in the medium-large scale areas around Kitale in the High tropics and marginal areas in the Dry-mid-altitude zones have as much as 100 acres of land.

In addition, households augment their holdings by hiring in land, particularly in the high potential areas, where land is quite scarce due to high productivity and high population densities. Renting land is, however, a recent phenomenon among small holders; few households (less than 10 per cent per region) hire land.

3.2 Area Shares by Crops and cropping patterns

Most of the agricultural land is under crops, with maize taking precedence in land allocation against all other crops (Figures 2 and 3). In the low tropics, where food deficits are more prevalent, maize is grown in larger areas than all other zones, followed by the dry areas and then the transitional zone in Kisii. In most zones, beans are the second in land allocation, with exception of the coast (where other legumes such as pigeon pea and soybean are popular, followed by root tubers).



LT= low tropics, DT=dry transition, MM=Moist midaltitde, MTSW=

In the Mount Kenya region, cash crops such as coffee and tea compete for the second place in land use with beans, indicating the economic importance of such crops here. Vegetables also claim relatively appreciable land sizes. In the high tropics and moist transition North West around Kitale, the bedrock of maize farming, maize and beans are definitely major crops covering almost all the farmland (Figure 3).

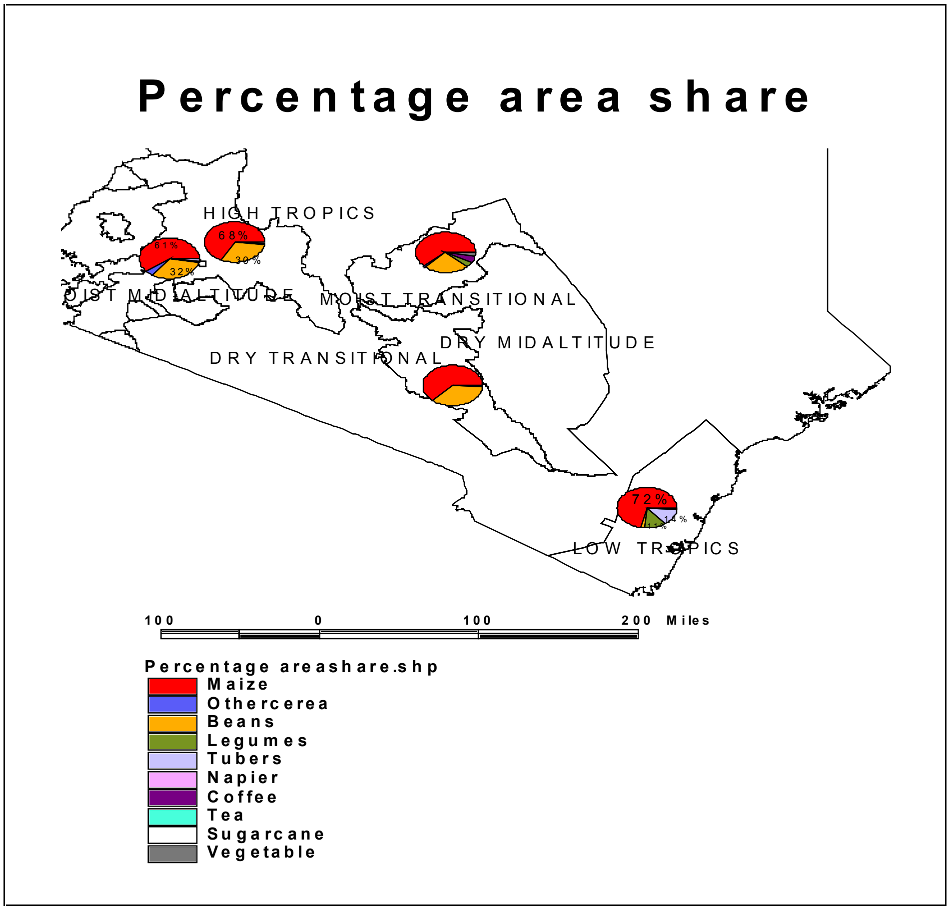


Figure 3 : Percentage Area Allocation to crop enterprises in Maize farming Systems

The overall limitation of land is however more obvious when we look at area under tree crops, root crops and even Napier with a maximum of 1.3 acres as compared to food crops such as maize and even legumes that occupy up to 0.80 acres per season (Figure 3).

3.3 Productivity across maize growing agri-ecologies

Consistent with Hassan (1998), findings (Table 2) the parameters of yield distributions elicited from farmers shows that the maize yields in the high potential zones are almost twice those of the lower potential zones in the main growing season. This indicates that high potential areas area surplus zones most likely because of reliability in rainfall, but maize stiffly competes for land with high value cash crops such as tea and coffee, unlike the lower potential zones, where due to prevalence of drought, farmers allocate much more land to maize followed by other legumes such as cowpeas and soybeans in addition to root crops such as cassava and sweet potatoes (which are fairly drought tolerant), possibly as a risk management strategy.

Table 2 Maize Yield Variations Across-Agro-ecologies in Kenya

	Agro-ecological Zones					
Variable	High Tropics	Moist Transition	Moist Midaltitude	Dry Transition	Dry-Midaltitude	Low Tropics
Mean	1,915.69	1,082.43	277.88	832.73	956.20	729.39
Minimum	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	18,000.00	9,000.00	1,800.00	5,933.33	9,000.00	5,010.00
StdDev	2,134.21	1,480.82	298.50	1,201.38	1,221.54	601.93

3.4 Factors Influencing land use patterns in Maize Farming Systems

Model results (Table 3) show that other cereals, beans, tubers, Napier and coffee area shares significantly reduce the area share in maize, depicting the competition that maize faces against these crops in land allocation. The abundance in family labour also leads to more area allocation to maize. However, education of head, market access measured in time to market and income do not significantly influence area allocation to maize. Area in excellent fertility, also had positive effect, but insignificant. On the other hand, output from maize had a negative sign, probably an indicator of intensification.

Table 3: Factors Influencing Cropping patterns in maize farming systems

N=1800

Variable	Coefficient	Standard Error
Constant	0.389***	0.002
other cereals share	-0.939***	0.041
area share beans	-0.933***	0.012
area share other legumes	-0.928***	0.022
area share tuders	-0.928***	0.024
area share napier	-0.934***	0.134
area share coffee	-0.966***	0.073
area share tea	-0.933***	0.081
maize production	0.0008	0.000
education of head	0.000351**	0.000
area excellent fertility	0.0005	0.001
family labour	0.0011	0.000
Total minutes to the nearest market	-0.0002	0.000
Total annual expenditure in ksh	0.0002	0.000

N/B ***= significant at 0.01%, **= significant at 0.05%, *= significant at 0.1%

4. Conclusion and Recommendation

Land use patterns and maize productivity in maize farming systems differ between agro ecological zones. The variation point at variability in rainfall or production potential, thus the high potential areas experience high maize yields, and thus more comfortable with maize and other cash crops. Here production are high and returns higher too, but maize area quite small, a sign of increased intensification due to competition for land by many high value crops (tea and coffee) and livestock enterprises.

In contrast, the lowland areas around the coastal strip and areas around Lake Victoria tend to grow drought tolerant tuber crops (such as cassava and sweet potatoes) besides maize in appreciable land sizes. Similar practices apply to the dry areas for other legumes such as pigeon pea. These latter regions peg much of their cropping systems to meet their food subsistence needs, because they are characterized by rampant food deficiency. Food self-sufficiency reasons are thus their main priority and land use patterns here hinge around risk management strategies against drought and pests such as stem borer. On the contrary, high potential areas exhibit surplus productions, with land use patterns pegged on high value cash crops (with commercial orientation) as opposed to subsistence maize production.

In view of the above, breeders should consider insertion of Bt-genes in maize varieties that would achieve high production and which are also capable of safely growing side by side with crops that meet different food security conditions in different agro-ecological zones in Kenya.

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