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AGRICULTURE AND LIVELIHOOD DIVERSIFICATION IN KENYAN RURAL HOUSEHOLDS

Simon C. Kimenju and David Tschirley

Tegemeo Institute of Agricultural Policy and Development
P.O Box 20498, 00200, Nairobi, Kenya
Tel: +254 20 2717818/76; Fax: +254 20 2717819
E-mail: Egerton@tegemeo.org

Tegemeo Institute

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Kindaruma Lane, off Ngong Road
P.O Box 20498, 00200, Nairobi, Kenya
Tel: +254 20 2717818/76; Fax: +254 20 2717819
E-mail: egerton@tegemeo.org
URL: http://www.tegemeo.org

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Abstract

Governments throughout the developing world have a keen and understandable interest in diversifying their rural economies. Yet to achieve rapid growth in incomes in rural areas and in the economy as a whole, Kenya must go through an agricultural transformation. In this transformation, individual farms shift from highly diversified, subsistence-oriented production towards more specialized production oriented towards the market or other systems of exchange. This paper develops a conceptual model that distinguishes between different types of economic diversification and links these to the process of agricultural transformation; it then uses Tegemeo's 11 year panel (1997 to 2007) of rural smallholder households to search for evidence as to how far Kenya has moved in the agricultural transformation. Within this general research purpose, the paper additionally searches for evidence that households have responded in expected fashion to the liberalization of the maize sector that began in 1994, just prior to the first survey in this panel data set. Analysis suggests that Kenya is at an early stage of the agricultural transformation but that it may be at a key point where it shifts from increasing diversification to increasing specialization. This "change in the direction of change" has important policy implications, which the paper outlines.

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1.0 Introduction

Governments throughout the developing world have for many years had a keen and sustained interest in diversifying their rural economies and the economic activities of rural residents (Delgado and Siamwalla, 1997). In Sub-Saharan Africa, this interest has been accentuated by the wave of liberalization that swept the continent starting in the early 1990s, which has driven concerns that heavy reliance on a few crops for cash income can, in an open market economy with widely fluctuating prices, lead to instability in income that threatens rural livelihoods. It is also true that, for many households that produce primarily for their own consumption with small surpluses for sale, diversifying by adding cash crops (e.g., cotton, tea, coffee, fresh produce) while continuing to produce for their own consumption can lead to greater incomes; diversification into salaried wage labor and remunerative non-farm businesses can also greatly increase (and stabilize) total household incomes. Thus, generally from the perspective of managing risk and associated vulnerability of rural households, and in some cases from a desire to increase incomes, farm diversification makes sense as a policy goal.

Yet it is well recognized by researchers and development practitioners that, to achieve rapid growth in incomes in rural areas and in the economy as a whole, countries must go through an agricultural transformation, and that this process involves more *specialization* by rural households, not more diversification. Resolving this tension between the clear benefits to poor rural households in the short- and medium-term from diversification with the long-term need for greater specialization and trade is a major policy challenge for African governments. Meeting this challenge requires a solid understanding of the process of agricultural transformation and detailed knowledge of where different groups of farmers and different areas of the country lie in this process, so that a proper mix of policies and programs can be executed that drive sustained and equitable income growth.

This paper contributes to this process in three ways. First, it refines the understanding of diversification by identifying and quantifying different types of diversification by rural households, and by showing that diversification can proceed very differently at the level of the individual farm, the broader agricultural sector, and the economy as a whole. Second, it adapts previous conceptual work to link these levels of diversification (farm, agriculture, macro economy) to the process of agricultural transformation. Finally, it empirically

examines diversification trends in rural areas of Kenya over the period 1997 to 2007 and uses this analysis to draw conclusions regarding the progress of agricultural transformation in the country. Specific objectives of the paper are to:

1. Identify trends in rural household livelihood portfolios within and beyond agriculture from 1997 to 2007, and to establish how these trends vary geographically and across types of households;
2. Show whether households have become more diversified or more specialized across crops (crop diversification), across crops and livestock (agricultural diversification), and across farm- and non-farm activities (livelihood diversification), and to identify how these patterns differ geographically and across types of households;
3. Establish whether maize production has responded to the marketing reforms of 1994 by becoming more spatially specialized (concentrated) within agro-ecologically well endowed zones, within villages of given zones, and among well endowed households within villages, and
4. Draw conclusions regarding the policy and programmatic initiatives most appropriate for Kenya at this specific point in the country's development.

The next section discusses the agricultural transformation. Section 3 then lays out a conceptual model that defines diversification in more precise terms and links it to the process of agricultural transformation. Section 4 briefly discusses the economic reforms that have been implemented in Kenya since the early- to mid-1990s, highlights what types of structural changes we might expect in rural areas as a result of these reforms, and generates specific testable hypotheses to be addressed in the rest of the paper. Section 5 describes the data and our measures of diversification, which are used in section 6 to describe general trends in livelihood portfolios among rural Kenyans since 1997, and in section 7 to test the hypotheses developed in section 4. Section 8 concludes.

2.0 The Agricultural Transformation

As stated by Staatz, the agricultural transformation:

> *"... is the process by which individual farms shift from highly diversified, subsistence-oriented production towards more specialized production oriented towards the market or other systems of exchange. The process involves a greater reliance on input and output delivery systems and increased integration of agriculture with other sectors of the domestic and international economies. Agricultural transformation is a necessary part of the broader process of structural transformation, in which an increasing proportion of economic output and employment are generated by sectors other than agriculture." (Staatz, 1998)*

According to Timmer (1988), the agricultural transformation moves through four phases that call for different policy approaches. The process starts with a rise in agricultural productivity, which generates surpluses that can, in the second phase, be tapped to develop the non-agricultural sector. For resources to flow out of agriculture, rural factor and product markets must become better integrated into the rest of the economy. The progressive integration of the agricultural sector and the macro economy, through infrastructure development and better markets, marks the third stage of transformation. A successful third phase will lead to a fourth phase, where the role of agricultural sector in an industrial economy will not be any different from other sectors like manufacturing and services.

Though literature suggests that the economic benefits from agricultural transformation eventually create their own momentum to move the process forward, the process can be derailed or greatly slowed in a number of ways by government policy. Governments can directly slow the process by maintaining tight restrictions on staple food trade, by not allowing land markets to emerge to facilitate the consolidation of farms in response to economies of scale, by failing to invest in the agricultural research and hard- and soft infrastructure that will bring down unit costs throughout the food system, and by economic mismanagement that discourages the kind of large-scale private investment that will help pull labor off the farm and into the industrial and service sectors. Civil strife can of course slow or reverse the process.

Since the mid-1990s, several factors in Kenya have likely promoted its agricultural transformation. Yet other factors have likely held the transformation back; how these

opposing factors have played out in the evolution of Kenya's rural economy is the central empirical question addressed in this paper. The fact that the country has been at peace has preserved and perhaps strengthened its long established role as a center of farm- (e.g., horticultural exports) and non-farm investment in East Africa. High population densities in all but the semi-arid areas tend to reduce the cost of exchange in markets and thus promote a market orientation; the rural populace's relatively high level of education compared to neighboring countries will reinforce this tendency. Long investment in agricultural research through KARI and other centers should increase productivity and facilitate the transformation. Finally, substantial economic liberalization starting around 1994 should have accentuated all these positive factors and spurred further market development and thus agricultural transformation. At the same time, per capita incomes declined through the 1990s, making it difficult for urban and rural non-farm sectors to absorb agricultural labor. Road infrastructure has deteriorated badly in some areas, making it more costly to rely on markets. All these factors hold back the agricultural transformation, as does the periodic civil strife in some areas and, possibly, continuing uncertainty following the post-election violence of 2008.

3.0 Diversification and the Agricultural Transformation: A Conceptual Model

By diversification we mean the number of economic activities an economic unit is involved in and the dispersion of those activities' shares in the total economic activity of the unit; diversified units have many activities with similar shares, while specialized units may have few activities or many activities but with only a few accounting for high shares. An economic unit refers to a household, a village, or any other geographical aggregation up to the national level.

To generate expectations about patterns of diversification in Kenya since 1997, we adapt a model first proposed by Timmer (1997) that relates the process of agricultural transformation to agricultural diversification[1]. Figure 1 depicts the expected relationship between agricultural transformation and two dimensions of agricultural diversification: *economic diversification* by level of the agricultural economy (panel 1a), and *spatial diversification* over spatially distinct units (panel 1b). While agricultural transformation overall implies

[1] See also Pingali (1997), Kurosaki (2003), and Delgado and Siamwalla (1997) for applications. See Timmer (1988) for an earlier full elaboration of the process of agricultural transformation.

greater economic specialization (less economic diversification) of individual farms, we expect farm level diversification to increase in the initial stages of the transformation due to different rates of market development for staple foods and cash crops.

Markets for staple foods develop more slowly than those for cash crops for three reasons. First, staples have a lower value for weight than cash crops, implying a higher relative burden of downstream costs (transport, transformation, transactions costs) and thus more restricted scope for trade. Second, these crops in developing countries are typically traded only domestically or regionally, not internationally, and their processing requirements are more flexible than those of many cash crops[2]. As a result, staples tend not to receive the same level of investment from agribusiness firms, with backward linkages to farmers, which typify many cash crops in Africa such as cotton, tobacco, and sugar, and their markets remain more fragmented. Finally, governments in the developing world are more likely to follow policies that restrict the development of private food staple markets due to concerns that unrestricted trade could lead to food security crises. As a result, food staples tend to have a large wedge between sales and purchase prices, to suffer from very high seasonal price rises, and to become very scarce in more isolated markets whenever supplies fall short. For all three of these reasons, smallholder farmers in the early stages of the agricultural transformation are likely to become *more* diversified as they add cash crops and traded livestock products to their portfolio while attempting still to produce all their staple food needs.[3]

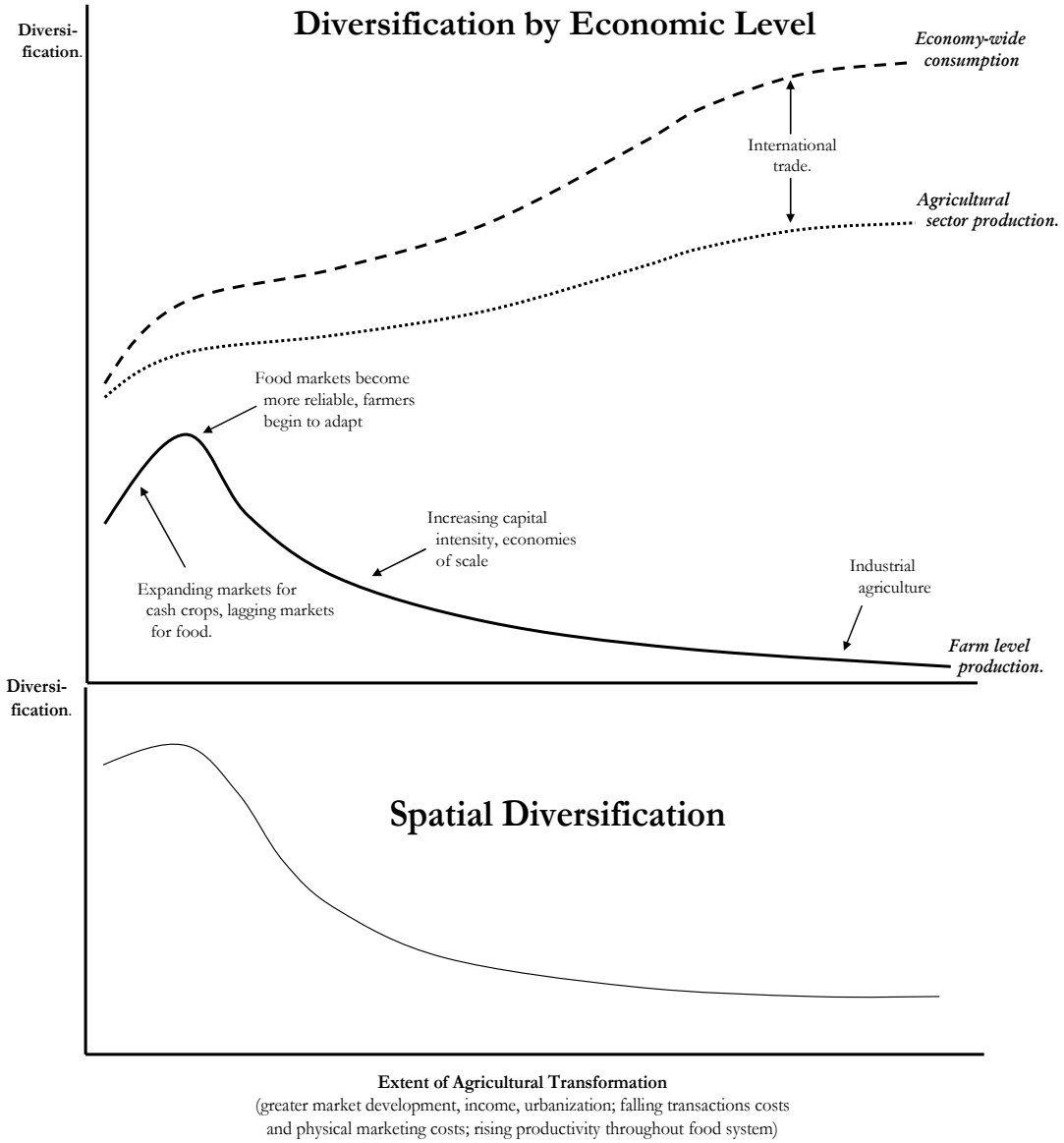
The trend towards greater economic diversification at the farm level eventually peaks and then reverses course for two reasons. First, as trade and (slowly at this stage) increasing productivity drive increases in cash income, and as the broader economy presents more off-farm income earning opportunities, farmers' opportunity cost of labor begins to surpass the high wedge between purchase and sales prices, and they become more willing to purchase their food while pursuing more remunerative activities on- and off the farm. Second, historically throughout the developing world, governments fairly early in the transformation process have moved away from the most comprehensive and restrictive regulation of staple food trade towards a more liberalized policy environment; in most countries of East and Southern Africa, restrictions on the physical movement of food staples began to be lifted in

[2] For example, maize can be milled in an industrial maize mill, or in a small hammer mill, or at home by hand pounding. Crops like cotton, tobacco, and sugar do not present this range of processing options.

[3] See Jayne (1994) for evidence of how high food marketing costs inhibit cash crop adoption among smallholder farmers.

the early 1990s, with major positive effects on staple availability and on lowering prices to consumers (Jayne and Jones, 1997). Together, these factors drive farmers increasingly to specialize in those activities in which they have a comparative advantage (due to agro-ecological and human capacity factors), moving rapidly away from small, diversified farming operations to larger, more capital intensive and specialized operations. The rate of change can be dramatic in some cases; see Pingali (1997) for examples of large, measureable changes over the course of 10 years in Asia.

Figure 1: Diversification and the agricultural transformation



Because agro-ecology and consumer preferences are not homogeneous over space, overall agricultural production will always be more diversified than will production on individual farms. Moreover, diversification at this level will increase as the transformation proceeds, driven by income growth and urbanization that lead consumers to diversify beyond staples into fresh produce, livestock products, and an array of value added products.[4] Thus, the typical pattern over the course of the agricultural transformation is that aggregate agricultural production will become more diverse as production on individual farms becomes more specialized (less diverse). Overall consumption of agricultural products (the top line in Figure 1) will diversify at an even more rapid rate, as traders and food companies draw on regional and international trade to complement national production and meet the demand for more diverse consumption by wealthier consumers.

Production systems tend to show very little spatial specialization in the early phases of the transformation, as limited trade means that each region needs to produce nearly everything it consumes. As markets open and the costs of trade fall, however (both in real terms and as a share of consumer incomes), production of specific crops and livestock will begin to migrate towards areas presenting the best agro-ecology. Timmer (1997) notes that economies of scale in marketing reinforce this tendency; areas that present the right agro-ecology and begin to ramp up production of specific, well adapted crops also see their unit marketing costs fall rapidly, further reinforcing the tendency towards regional specialization.[5]

Looking beyond agriculture, rural households can be expected to follow a broadly similar pattern with regard to livelihood diversification, i.e., economic diversification beyond agriculture. In the early phases, those households with the capacity to do so will diversify into salaried wage employment and profitable off-farm businesses while maintaining their farm operation. Eventually, however, their rising opportunity cost of time and the increasing knowledge- and capital intensity of agriculture will drive them either to leave agriculture

[4] Timmer (1997) notes that diversification at the level of the agricultural sector *decreased* in Asia immediately after the start of the Green Revolution, due to the rapidly falling price of rice; the push towards more diversified consumption from growing incomes was initially swamped by – but eventually overtook -- this price drop. In ESA, production and consumption may initially move away from crops such as cassava, sorghum, and millet in favor of more reliance on maize and wheat.

[5] Highlighting just how far this trend can go, 99% of lettuce production in the U.S. takes place in the Salinas and Imperial Valleys of California and around Yuma, Arizona, each about 3,000 miles from key consumption centers on the east coast (Borris and Brunke, 2005).

entirely or to re-specialize as full-time farmers; a very small share of farm production will remain long-term in the hands of part-time farmers with off-farm income.

4.0 Economic Reforms in Kenya and Expected Specialization

Initial attempts to liberalize the Kenyan economy started as far back as 1980 (Karanja et al, 2003), but accelerated and became more comprehensive in the 1990s (Mwega and Ndung'u, 2002). Structural adjustment policies of the 1980s were followed in the 1990s by more comprehensive reforms including liberalization of foreign exchange and interest rates, deregulation of input and commodity prices, removal of trade barriers, rationalization of the government budget and government divestiture from state-owned corporations (Karanja et al, 2003).

Agricultural sector reforms were geared towards creating market competition through removal of price controls and encouraging more private sector investments and participation. For maize, Nyangito and Ndirangu (1997) note that the earlier controls were based on a strict regulation of private trade in maize and direct government participation in the market through the National Cereals and Produce Board (NCPB). The reform process was expected to reduce costs in the maize marketing system by encouraging more private sector participation in the market (Nyoro et al, 2002). The private sector was allowed to directly purchase maize from farmers, while the role of the National Cereals and Produce Board (NCPB) was in theory confined to management of strategic stocks and buyer of last resort (Karanja et al, 2003). The Kenya government also deregulated maize meal prices, and eliminated subsidies on maize sold to registered millers (FAO, 2003). In turn the large-scale millers swiftly lost a major part of their market to small hammer mills, whose numbers rapidly expanded in urban areas.
In 1992, price controls for all food items and agricultural inputs were abolished. In the same year, milk prices were deregulated and all manner of milk marketing innovations emerged to compete with the Kenya Co-operatives Creameries (KCC) (Karanja et al., 2003).

Reforms introduced in 1992 allowed the trading of coffee and tea in US dollars at the Nairobi coffee and Mombasa tea central auctions (Karanja et al, 2003). Farmers were gradually allowed to receive their payments in the same currency with the intention of allowing producers to benefit from currency gains and to participate in foreign exchange dominated

trade, such as importation of farm inputs. The depreciation and floating of the exchange rate and removal of foreign exchange controls that followed in 1993 were also expected to benefit exporters, including agricultural producers. Institutional reforms in the internal marketing systems for coffee and tea were also initiated in the mid-1990s with the purpose of enhancing private sector participation and competition.

The course of these reforms, together with our conceptual model, leads to four hypotheses whose testing will form the analytical core of this paper:

Hypothesis 1: Because of general economic reforms, greater population densities, and rising incomes (at least since 2000), household livelihood specialization will have increased from 1997 to 2007, with some households moving increasingly towards reliance on off-farm incomes[6] while others have prioritized more intensive crop or livestock agriculture.

Hypothesis 2: Due to agricultural reforms since the early- to mid-1990s, especially in the maize and dairy sectors, crop diversification and agricultural diversification will have decreased (specialization will have increased) from 1997 to 2007. For example, some households will have specialized more in maize or wheat or vegetable production, others in dairy or other livestock activities.

Hypothesis 3: Because lifting of movement restrictions 15 years ago on maize has led to more domestic and regional trade in this grain, maize production will have become more concentrated regionally, across villages within regions, and across households within villages.

Hypothesis 4: In all cases, increased specialization will have been more pronounced in areas of higher population density, greater agro-ecological potential, and proximity to large urban markets. Central Highlands and High Potential Maize Zone (HPMZ) thus stand out as primary candidates for greater household level specialization in livelihoods, agriculture, and cropping and greater spatial specialization in maize production.

[6] It is unlikely, however, that many will have abandoned farming altogether.

5.0 Data and Methods

We use the Herfindahl index of diversification, as applied by Kurosaki (2003), to quantify the amount of diversification at the various levels in Kenya's agricultural sector:

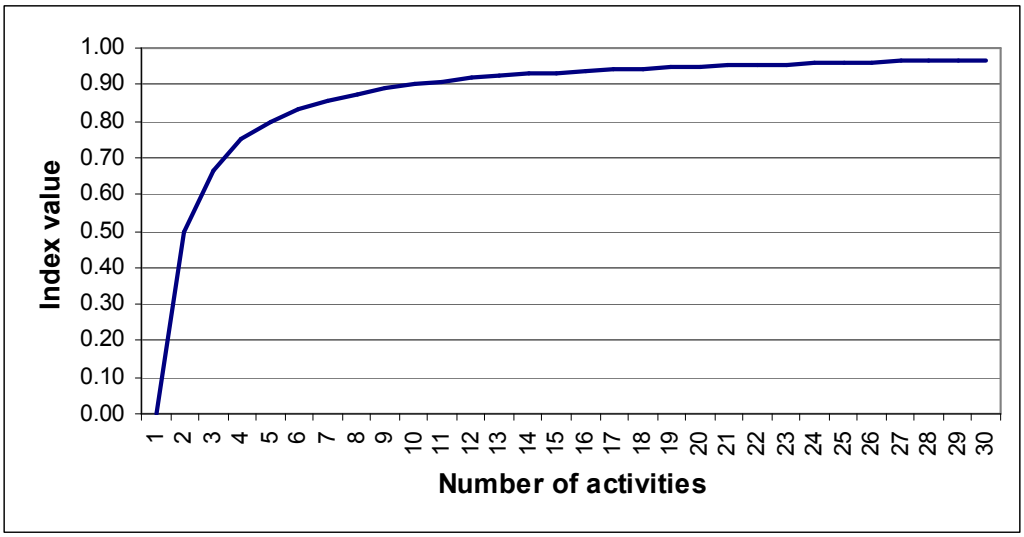
$$D_k = 1 - \sum_{i=1}^{N} \left(s_{i,k}\right)^2$$

where s_i refers to share and $\sum_{i=1}^{N} s_{i,k} = 1.0$. D_k varies from a value of zero, indicating complete economic specialization in one activity or complete spatial specialization into one spatial unit ($s_i = 1$ in each case), to 1.0, indicating that economic output comes from many different activities or spatial units, none with a predominant share.

The interpretation of k, i, and N depends on the type of diversification being computed (see Figure 1). For economic diversification (diversification across economic activities within an economic unit), k refers to the economic unit of interest, i refers to a specific economic activity, and N is the total number of activities being considered. For example, to compute how diversified a household (or region) is across all economic activities, k refers to the household (or region) and i refers to the N different crop, livestock, and off-farm activities in which the household is involved (or which take place in the region). Economic diversification within a sector, e.g. diversification across crops within all cropping activities, can be computed by limiting the computation to that set of activities. When calculating spatial diversification, k refers to the spatially most aggregated unit (e.g., country), i to a less aggregated unit within k (e.g., region), and N to the number of less aggregated units. Figure 2 shows the values the index takes on as a function of the number of activities (i) in which the economic unit is involved, and assuming that each activity has an equal share in overall economic activity.[7]

[7] The index can take on very different values when activities do not have equal shares. For example, a household with five activities having shares of 5%, 15%, 30%, and 50% would have an index value of 0.39, not the value of 0.80.(as in Figure 2) achieved when each activity has an equal share.

Figure 2: Values of Herfindahl concentration index assuming equal shares of each economic activity



We base our crop diversification calculations on five groups of crops: cereals, tubers and pulses, fruit and vegetables, industrial crops, and all other crops. In calculating agricultural diversification we add three livestock categories to these five crop categories: cattle, goats sheep and pigs, and poultry. Livelihood diversification is then calculated by adding four off-farm activity groups to the eight agricultural groups: salaried employment, informal businesses, remittances, and farm kibarua.

Data for this work comes from the TAPRA household panel database collected in four years; 1997, 2000, 2004 and 2007. The panel data were obtained through rural household surveys covering 24 administrative districts, 39 divisions and 120 villages using structured questionnaires. Standard proportional sampling using census data for rural divisions of the country formed the basis of extraction of the sample households. Due to the variation in agro-ecological patterns within the administrative units, the analysis stratifies households into eight agro-ecological zones based on relative homogeneity of agricultural activities within a zone. Out of the 1997 TAMPA (Tegemeo Agricultural Monitoring and Policy Analysis) survey sample of 1,500 households, 1,275 households were interviewed during all four phases.

6.0 General Trends in Livelihood Portfolios among Rural Kenyans

Before presenting results of our analysis using the Herfindahl index, we look at trends in less formalized indicators of diversification that include household income, cultivated acreage, number of crops, cultivated area allocated to different crops, proportion of improved cows, and number of people moving into off-farm activities. We also look at different activities' contribution towards gross revenue within crops, agriculture and overall household livelihood.

6.1 Household Income Sources

Household incomes are categorized as crop, livestock, business and salaries & remittances. Crops' contribution to household income has increased from 40% in 1997 to 44% in 2007. However, the contribution rose to 50% in 2000, before falling gradually to 46% in 2000 and 44% in 2007 (Table 1). In most zones, year 2000 has the highest contribution by crop income. Livestock income on the other hand has decreased on the overall from 21% in 1997 to 16% in 2007, but increased marginally since year 2000 onwards. This is the case for most regions but in Western Transitional and Marginal Rain Shadow it increased consistently since year 2000.

Contribution of business to household income has increased from 13% in 1997 to 21% in 2007. This percentage has risen in all zones, signifying that rural households are diversifying their income sources by engaging in business activities. The contribution of salaries and remittances on the other hand has reduced from 27% to 18% in 2007, and the drop is consistent in all zones. As a result, overall shares from off-farm income have remained stable over the ten year period, though the share of off-farm income has increased marginally since the year 2000 (65% to 61%) while that of on-farm income decreased over the same period (35% to 39%)[8].

Categorizations of business activities show the ones that are increasingly contributing more to household income. Mean incomes from some business categories have increased even though the proportion of households involved in them does not necessarily show an

[8] The mean number of household members receiving off-farm income has however remained relatively constant.

increasing trend. These include small business trading like retail shops and selling clothes; food and beverages businesses such as operating a hotel, butchery and fish trading; and artisan activities like masonry, carpentry, welding, weaving and pottery. For service-related business like tailoring, part time teaching, hair dressing and barber shops, and car washing however, the proportion of households involved in them increased from 2.9% in 2000 to 4.82% in 2007.

6.2 Crop Production Trends

Area Cultivated in Acres: Cultivated acreage per household has decreased from 3.5 acres in 1997 to 3.4 acres in 2007 (Table 2). In most zones, it went up in the year 2000 but then continued with the downward trend (consistent with crop income contribution in Table 1). It is potentially noteworthy that mean area cultivated dropped in every zone from 2004 to 2007, after rising in four of the eight zones from 2000 to 2004. The HPMZ has the highest cultivated acreage while Marginal Rain Shadow has the lowest followed by Central Highlands.

Number of Crops: Number of crops cultivated per household went up from 12.2 in 2000 to 13.3 in 2004, but then declined to 11.0 in 2007 (Table 3)

Table 1: Contribution to household income

Income Category	Year	Zone								
		Coastal Low-lands	Eastern Low-lands	Western Low-lands	Western Tran-sitional	High Potential Maize Zone	Western High-lands	Central High-lands	Marginal Rain Shadow	Total
Crop	1997	10	22	41	47	49	46	44	13	40
	2000	39	43	50	62	41	59	65	23	50
	2004	24	34	37	56	51	49	53	33	46
	2007	29	40	40	48	38	55	55	36	44
Livestock	1997	5	16	18	24	24	22	19	35	21
	2000	3	12	15	10	24	15	9	10	15
	2004	4	11	13	15	21	18	17	23	16
	2007	2	13	7	17	26	11	16	26	16
Business	1997	39	13	13	14	10	11	10	15	13
	2000	37	20	17	16	19	8	12	34	17
	2004	42	24	24	15	13	11	12	16	17
	2007	49	21	30	23	20	16	13	16	21
Salary and remittance	1997	46	49	28	15	18	22	27	37	27
	2000	21	25	18	12	16	18	15	33	18
	2004	30	30	26	14	16	22	18	28	21
	2007	21	26	23	12	16	18	16	22	18

Table 2: Mean cultivated area in acres

Agro-regional zones	1997	2000	2004	2007
Coastal Lowlands	2.81	4.33	4.07	3.39
Eastern Lowlands	3.09	3.88	4.38	4.04
Western Lowlands	2.25	2.77	3.23	2.29
Western Transitional	4.28	4.70	4.21	4.08
High Potential Maize Zone	5.93	7.07	5.10	5.07
Western Highlands	1.68	2.10	2.06	2.01
Central Highlands	2.21	2.36	2.48	1.98
Marginal Rain Shadow	1.91	1.85	1.88	1.75
Overall	**3.54**	**4.21**	**3.73**	**3.41**

Table 3: Mean number of crops cultivated by zone

Agro-regional zones	2000	2004	2007
Coastal Lowlands	14.2	10.5	9.8
Eastern Lowlands	14.8	14.8	11.6
Western Lowlands	8.6	11.8	11.5
Western Transitional	12.1	12.3	9.8
High Potential Maize Zone	11.1	11.2	8.6
Western Highlands	11.6	14.6	13.5
Central Highlands	15.0	17.6	14.2
Marginal Rain Shadow	7.5	10.5	8.2
Overall	**12.2**	**13.3**	**11.0**

A consistent trend appears for years 2004 and 2007, when looking at both cultivated land and the number of crops: in both cases, the mean of these variables fell in every zone between 2004 and 2007 after rising in several zones from 2000 to 2004. This finding suggests a trend towards greater cropping specialization as land areas fall, and may also be associated with diversification into more off-farm activities (since cultivated acreage is a conscious decision unlike land owned). We will return to this issue later in the paper.

Cultivated Area Allocated to Different Crop Categories: Cultivated area allocated to maize has declined slightly from 58% in 1997 to 54% in 2007 on the overall as shown in Table 4. However, maize's share has increased in HPMZ from 64% in 1997 to 69% in 2007 and in Western Transitional from 40% to 42%. Though intercropped, maize still takes the highest proportion of cropped land among Kenyan rural households. Area allocated to vegetables,

which are high value crops, fell slightly nationally from 25% in 2000 to 22% in both 2004 and 2007[9], but the pattern is quite diverse across zones. For the HPMZ, Western Transitional and Costal Lowlands, this area declined consistently from the year 2000 to 2007 (27% to 13% in HPMZ) while it rose substantially in Eastern and Western Lowlands and to some extent in Marginal Rain Shadow.

Proportion of area allocated to industrial crops such as tea, coffee, and sugarcane reduced marginally from 18% in 1997 to 17% in 2007. Marginal increases are observed for Western Transitional (40% to 42%) and Central Highlands (32% to 35%). Decreases are observed for Eastern Lowlands, Western Lowlands, Western Highlands and MRS. In HPMZ, the proportion has remained steady.

[9] We exclude 1997 for vegetables because the questionnaire design likely led to undercounting of these crops; the national mean for that year was only 8%.

Table 4: Cultivated area allocated to different crop categories (%)

Crop	Zone	1997	2000	2004	2007
Maize	Coastal Lowlands	0.64	0.59	0.63	0.61
	Eastern Lowlands	0.73	0.63	0.59	0.72
	Western Lowlands	0.66	0.65	0.6	0.5
	Western Transitional	0.4	0.41	0.44	0.42
	High Potential Maize Zone	0.64	0.65	0.63	0.69
	Western Highlands	0.59	0.59	0.53	0.42
	Central Highlands	0.41	0.38	0.35	0.35
	Marginal Rain Shadow	0.75	0.67	0.7	0.75
	Overall	0.58	0.56	0.54	0.54
Vegetables	Coastal Lowlands	--	0.43	0.34	0.29
	Eastern Lowlands	--	0.33	0.35	0.42
	Western Lowlands	--	0.07	0.09	0.19
	Western Transitional	--	0.20	0.11	0.08
	High Potential Maize Zone	--	0.27	0.23	0.13
	Western Highlands	--	0.21	0.16	0.25
	Central Highlands	--	0.29	0.29	0.26
	Marginal Rain Shadow	--	0.37	0.54	0.43
	Overall	--	0.25	0.23	0.22
Industrial	Coastal Lowlands	0.00	0.01	0.01	0.00
	Eastern Lowlands	0.07	0.09	0.04	0.05
	Western Lowlands	0.16	0.09	0.11	0.09
	Western Transitional	0.40	0.37	0.38	0.42
	High Potential Maize Zone	0.07	0.06	0.06	0.07
	Western Highlands	0.25	0.30	0.18	0.19
	Central Highlands	0.32	0.34	0.33	0.35
	Marginal Rain Shadow	0.03	0.03	0.02	0.00
	Total	0.18	0.18	0.16	0.17
Fodder	Coastal Lowlands	0.00	0.00	0.00	0.00
	Eastern Lowlands	0.02	0.06	0.09	0.23
	Western Lowlands	0.00	0.00	0.00	0.01
	Western Transitional	0.01	0.02	0.01	0.05
	High Potential Maize Zone	0.02	0.03	0.05	0.09
	Western Highlands	0.04	0.12	0.12	0.11
	Central Highlands	0.09	0.17	0.15	0.22
	Marginal Rain Shadow	0.01	0.11	0.10	0.34
	Overall	0.03	0.06	0.07	0.12

Note: Numbers across crop categories for a given zone during a given year may sum to more than 100 due to intercropping.

The proportion allocated to fodder, which includes nappier, oats and lucern has increased from 3% in 1997 to 12% in 2007. This rise is observed in all zones except Coastal Lowlands.

To further investigate why there are different trends in allocation to industrial crops, we look at area allocated to tea, coffee and sugarcane (Table 5). Nationally, the trend in each crop is remarkably stable from 1997 to 2007. Tea's share has also been stable in every region, while coffee's share remained stable in Central Highlands (the primary area where it is grown) but

fell in Western Highlands and Eastern Lowlands. Sugarcane was stable in Western Transitional (its main production zone) but fell slightly in Western Lowlands.

Table 5: Area allocated to tea, coffee, and sugarcane by zone and year (%)

Zone	1997	2000	2004	2007
Tea				
High Potential Maize Zone	0.05	0.04	0.04	0.05
Western Highlands	0.08	0.07	0.08	0.08
Central Highlands	0.16	0.17	0.17	0.17
Total	0.05	0.05	0.05	0.05
Coffee				
Eastern Lowlands	0.06	0.04	0.04	0.03
High Potential Maize Zone	0.00	0.01	0.01	0.01
Western Highlands	0.17	0.22	0.11	0.10
Central Highlands	0.16	0.17	0.16	0.17
Total	0.06	0.06	0.05	0.05
Sugarcane				
Western Lowlands	0.10	0.09	0.09	0.07
Western Transitional	0.40	0.36	0.37	0.41
Total	**0.06**	**0.05**	**0.05**	**0.06**

6.3 Livestock Production Trends

In this section we seek to find more evidence on whether households are moving more into dairy farming, as suggested by the increase in area allocated to fodder crops in 2007. The mean number of cows owned has decreased from 4.85 in 1997 to 4.34 in 2007. However, the proportion of improved cows (grade and cross) has increased (Table 6). The proportion has increased from 52% to 61% on the overall, with an increase in almost all zones apart from Western Lowlands. This proportion is highest in Central Highlands, followed by HPMZ and Marginal Rain Shadow. The increase has been marginal in Central Highlands (94% to 95%) due to the already very high levels in 1997, but is significant in Western Transitional (18% to 27%), HPMZ (70% to 82%), Western Highlands (29% to 67%) and Marginal Rain Shadow (58% to 79%). Increases in the share of improved cows have occurred throughout the income distribution, with the greatest proportional increases in the bottom two income quintiles (Table 7).

6.4 Crop and Livestock Contributions to Household Gross Revenue

As defined earlier, diversified households derive their income sources (in this case gross revenues) from more sources with none being dominant, unlike specialized households. The

decision to diversify is a conscious household decision and may be driven by factors like prices, new technology, or even new markets. The contribution of gross income from a certain activity is another indicator of household diversification into or out of a certain economic activity. Gross revenue is also a proxy for time and effort allocated by a household to a certain activity hence may be a better indicator of diversification than net incomes.

Table 6: Proportion of improved cows in total cows, by agro-ecological zone (%)

Zone	1997	2000	2004	2007
Coastal Lowlands	0.00	0.00	0.17	0.13
Eastern Lowlands	0.23	0.28	0.45	0.36
Western Lowlands	0.02	0.03	0.01	0.00
Western Transitional	0.18	0.23	0.24	0.27
High Potential Maize Zone	0.70	0.81	0.81	0.82
Western Highlands	0.29	0.61	0.62	0.67
Central Highlands	0.94	0.96	0.95	0.95
Marginal Rain Shadow	0.58	0.72	0.71	0.79
Total	**0.52**	**0.61**	**0.62**	**0.61**

Table 7: Proportion of improved cows in total cows, by income quintile

Income Quintile	1997	2000	2004	2007
Lowest	0.26	0.32	0.36	0.33
2	0.41	0.51	0.53	0.55
3	0.53	0.66	0.68	0.57
4	0.61	0.69	0.67	0.74
Highest	0.70	0.76	0.78	0.79
Overall	**0.52**	**0.61**	**0.62**	**0.61**

Diversification within agriculture considers revenues from both crops and livestock. In this case, the categories have been combined. Maize contribution to agriculture gross revenue is 23% on the overall (Table 8) but at least 30% every year in HPMZ. However, in this zone, revenue from cattle increased consistently from 27% in 1997 to 35% in 2007. For the Marginal Rain Shadow, revenue from cattle now becomes the highest contributor of farm income, overtaking fruit and vegetables (fresh produce). Though the importance of maize to total income is increasing in the Coastal Lowlands (24% to 33%), fruits are of equal

importance. In comparison, we see that Coastal Lowlands, Marginal Rain Shadow and HPMZ are more specialized, deriving their agricultural revenue from largely two sources, as opposed to other zones like Central Highlands, Eastern Lowlands and Western Highlands which are more spread out.

Table 8: Crop and livestock contribution to gross revenue (%)

Zone	Year	Maize	Tubers and pulses	Fresh produce	Industrial	Cattle	Shoats and pigs	Poultry
Coastal Lowlands	1997	24	14	26	0	7	5	17
	2000	27	16	48	0	4	0	3
	2004	24	19	38	0	10	0	5
	2007	33	19	36	0	5	4	2
Eastern Lowlands	1997	19	17	22	1	27	3	9
	2000	23	21	32	2	16	0	2
	2004	22	21	26	1	23	0	3
	2007	25	18	23	1	22	3	2
Western Lowlands	1997	26	22	2	9	23	3	5
	2000	26	17	18	8	15	0	2
	2004	18	16	26	7	25	0	0
	2007	27	14	21	5	17	3	2
Western Transitional	1997	19	15	12	21	24	1	7
	2000	15	10	15	41	15	0	1
	2004	25	10	14	21	23	0	2
	2007	23	10	14	25	24	1	1
High Potential Maize Zone	1997	34	9	5	6	27	1	5
	2000	31	8	11	5	29	0	6
	2004	31	8	11	5	31	0	2
	2007	30	7	9	6	35	2	3
Western Highlands	1997	26	7	22	10	28	1	4
	2000	20	8	28	16	19	0	2
	2004	22	7	22	8	32	0	1
	2007	20	7	24	17	22	1	1
Central Highlands	1997	8	12	17	26	31	2	3
	2000	8	12	17	35	24	0	1
	2004	8	13	20	24	28	0	2
	2007	8	12	19	28	25	1	1
Marginal Rain Shadow	1997	6	21	15	0	35	10	12
	2000	2	14	24	0	45	0	8
	2004	11	19	16	0	37	0	8
	2007	13	17	20	0	32	9	2
Overall sample	1997	23	13	13	11	26	2	6
	2000	21	12	20	16	21	0	3
	2004	22	13	19	10	27	0	2
	2007	23	11	18	12	25	2	2

7.0 Examining Trends in Diversification for Evidence of Agricultural Transformation

In this section we begin to examine the hypotheses put forth in section 4. We use the Herfindahl index of diversification first to examine economic diversification (crop, agricultural, and livelihood) by households and draw preliminary insights regarding the process of agricultural transformation in response to general economic reforms. We then focus on spatial diversification in maize production in response to the extensive maize market reforms of the mid-1990s.

7.1 Household Economic Diversification

Table 9 presents results for the diversification index at crop, agricultural, and livelihood levels. Several results stand out. First, crop diversification increased over the period but at a rapidly decreasing rate, and actually fell slightly (meaning that specialization began to occur) from 2004 to 2007. Second, agricultural diversification may have stabilized, though the trend in this case is not as clear. Finally, livelihood diversification increased in linear fashion throughout the period, showing no signs of slowing. Together, these results suggest that households are beginning to respond to the changing policy and economic environment by slowing or even reversing their crop and broader agricultural diversification – by beginning slowly to specialize in these areas -- but are continuing to diversify their broader livelihoods by adding off-farm activities while maintaining most of their agricultural activities. This suggests that the country as a whole remains at quite an early stage of the agricultural transformation.

Table 9: Crop, agricultural, and livelihood diversification indices in Kenya, 1997 to 2007

Year	Type of Diversification		
	Crop	Agricultural	Livelihood
1997	0.49	0.60	0.59
2000	0.57	0.60	0.62
2004	0.60	0.65	0.63
2007	0.59	0.65	0.66

Figure 3 shows that crop specialization has begun to take place in HPMZ, Eastern Lowlands, Central Highlands, and Western Transitional zones, while Coastal Lowlands and Western Lowlands remain in a diversification phase. Western Highlands may have reached its

maximum in diversification and could begin to specialize from this point forward. Figure 4 shows that agricultural diversification follows a broadly similar path, though generally with more continued diversification than at the crop level. HPMZ, Central Highlands, and Western Transitional all saw increased specialization from 2004 to 2007, while all other areas (including Eastern Lowlands, which saw crop specialization begin to occur) continue to diversify. Overall, these results provide support for our fourth hypothesis, suggesting that areas of greater population density and agro-ecological potential and closer to urban centers would have seen more specialization than other areas.

Figure 3: Crop diversification indices by zone in Kenya, 1997-2007

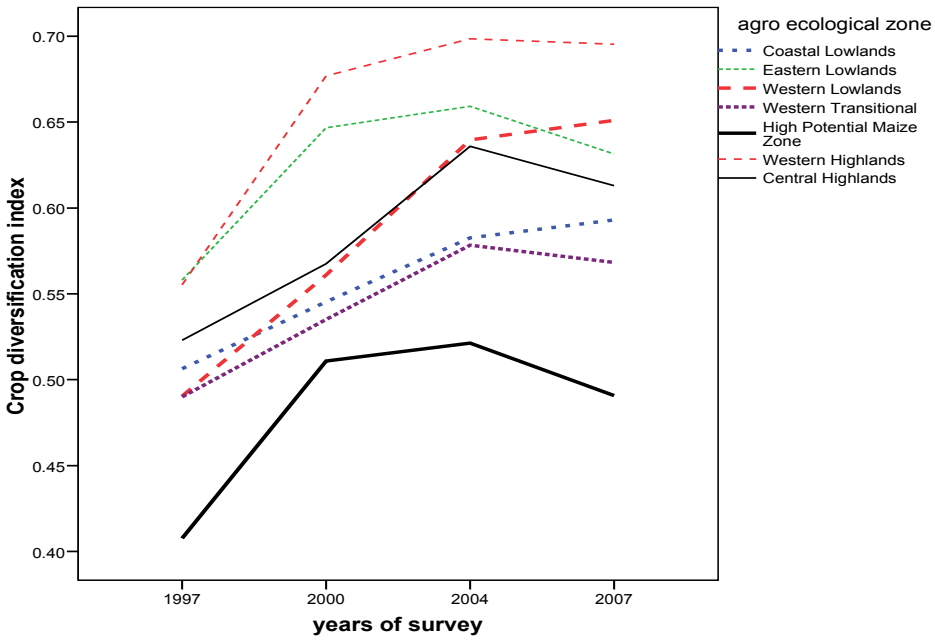
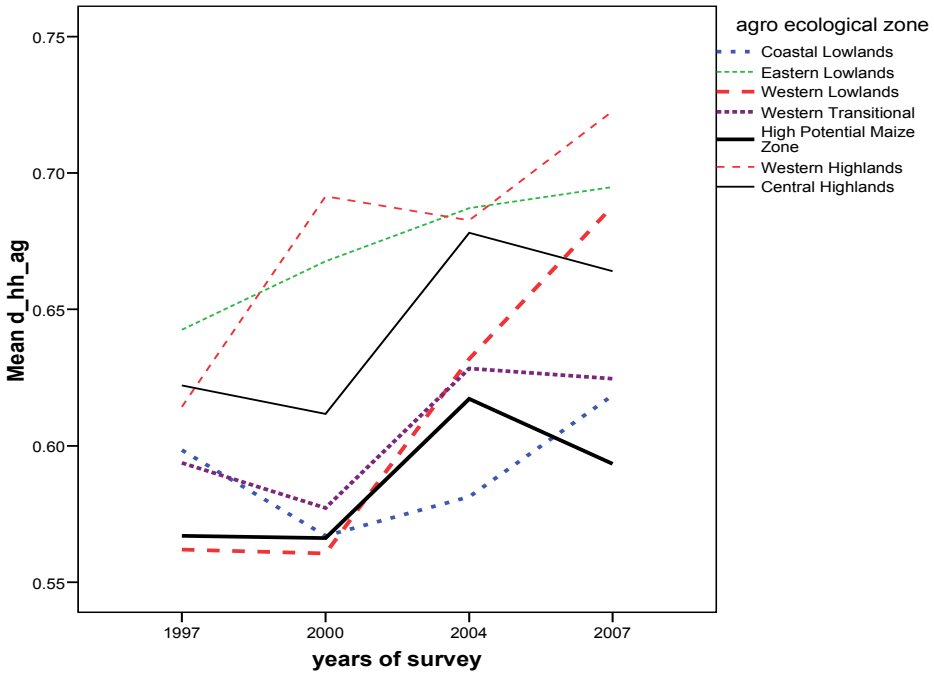


Figure 4: Agricultural diversification indices by zone in Kenya, 1997-2007



Though we present no graph for it, livelihood diversification has continued to increase in every region through 2007 with the exception of Coastal Lowlands, where it fell sharply in 2004 and rose only slightly in 2007. In this zone, the pattern on livelihood diversification reflects primarily the effects of difficulties in the early 2000s in the tourism sector, which pushed people out of salaried employment before recovery later in the decade, and not any dynamic process of broader agricultural and rural transformation.

Figures 5 and 6 identify which types of households, by their position in the distribution of per capita income, have begun to specialize within crop production and broader agriculture. Two results stand out. First, higher income households (quartile 4) are consistently less diversified – more specialized – than lower income households. Second, the highest income households have shown a sharp turn towards specialization both in crops and more broadly in agriculture between 2004 and 2007; lower income households either show a mixed pattern (for crop diversification) or are clearly continuing to diversify (agricultural diversification). These

patterns are consistent with the conceptual model we laid out, in which greater specialization eventually is associated with higher and growing incomes.

Figure 5: Crop diversification indices by quartiles of per capita income in Kenya, 1997-2007

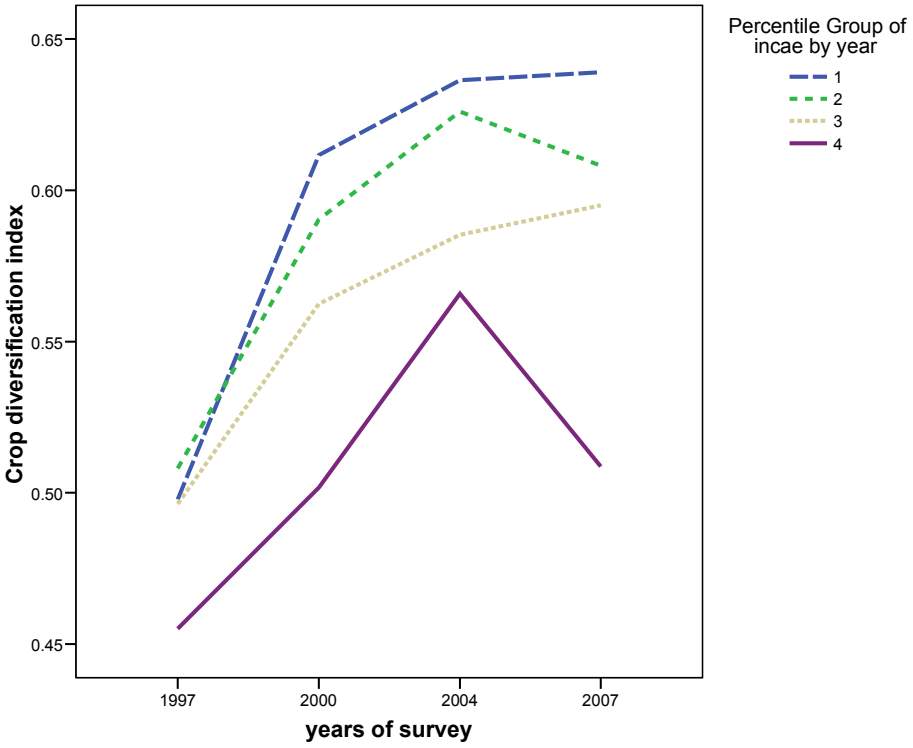
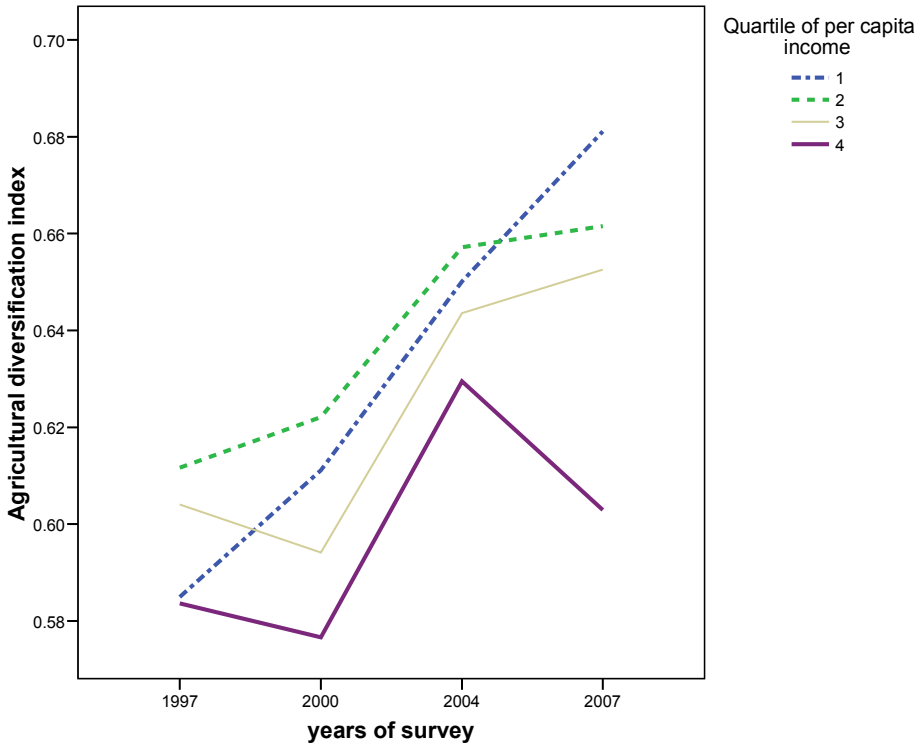


Figure 6: Agricultural diversification indices by quartile of per capita income in Kenya, 1997-2007



7.2 Effect of Maize Market Reforms: Spatial Diversification of Maize Production

In this subsection we test whether production of maize over different regions has responded to maize marketing reform. In the early stages of agricultural transformation, we expect diversification to be high over space, with each region producing the crops it consumes and thus producing many different crops. With increased market development, production of certain crops would be concentrated in areas of comparative advantage. Table 10 shows the contribution of regions to national maize gross revenue over the four years of the TAPRA surveys. The high potential maize zone contributes highest, but this has decreased from 71% in 1997 to 57% in 2007. In contrast, contribution from other zones has increased, from 6% to 10% for Western Transitional, and 5% to 8% for Eastern Lowlands. This trend is collaborated by the regional diversification index (last row of table, also Figure 7), showing diversification across regions within the country. Against expectations, diversification has increased over the

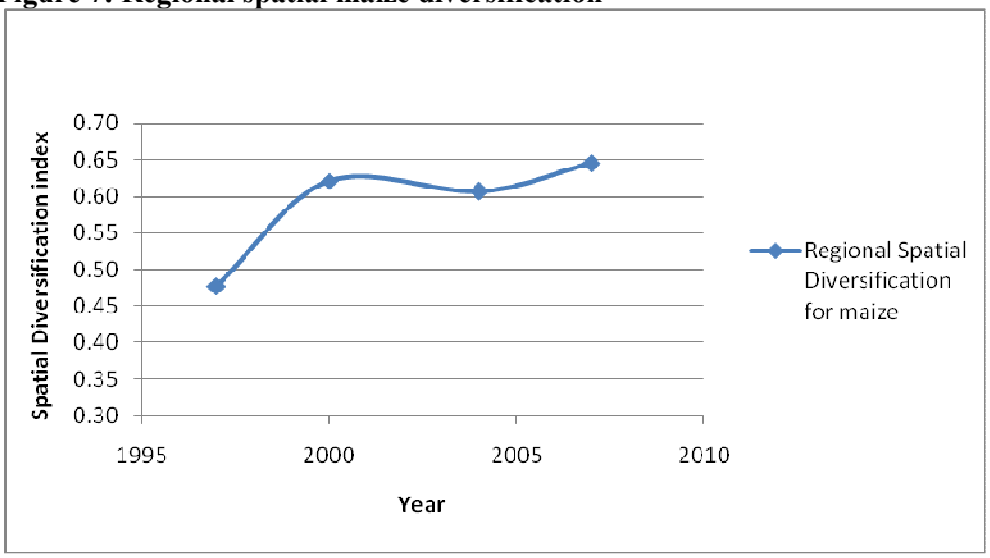
period, from 0.48 in 1997 to 0.65 in 2007, though the rate of increase slowed substantially after 2000.

In fact, there is no evidence of spatial specialization in maize production at any level: diversification indices for households within villages and villages within regions (not shown here) all show steady or rising diversification, regardless of zone. Clearly, these results suggest that the maize market reforms of 1994, while they have had substantial positive effects in reducing real maize and maize meal prices (and especially in reducing the margin between maize grain and maize meal; Jayne and Chapoto, 2006), have had no discernable effect on households' propensity to produce maize; nearly all households attempt to produce maize for their own consumption, though many are unable to do so and become net buyers of maize.

Table 10: Regional contribution to national maize gross revenue

Zone	1997	2000	2004	2007
Coastal Lowlands	2	6	2	4
Eastern Lowlands	5	7	7	8
Western Lowlands	3	3	4	5
Western Transitional	6	8	11	10
High Potential Maize Zone	71	59	60	57
Western Highlands	5	6	7	7
Central Highlands	8	11	7	8
Marginal Rain Shadow	0	0	1	1
Regional Spatial Maize Diversification	**0.48**	**0.62**	**0.61**	**0.65**

Figure 7: Regional spatial maize diversification



8.0 Identifying the Drivers of Specialization

The analysis thus far identifies patterns of diversification and specialization and allows some conclusions regarding how advanced the process of agricultural transformation is in Kenya and where within the country the process may have proceeded furthest. It does not, however, allow us to isolate factors that may be driving these changes. To do this, we estimate three different panel econometric models for crop and livelihood diversification, using the four years of Tampa panel data; these models differ primarily in what they assume about the nature of unobserved variables that are fixed over time but that vary across households (this is often referred to simply as unobserved heterogeneity).

- The random effects (RE) model assumes that all such unobserved variables are uncorrelated with our independent variables, and therefore controls only for that type of heterogeneity; any unobserved variables that vary across households and are correlated with our independent variables could be biasing these results;
- The partial fixed effects model (PFE) partially corrects this problem by purging the error term of correlation with unobserved variables that are correlated with the time means of all our independent variables; to the extent that the unobserved variables are correlated with each year's values of the independent variables, this correlation could bias results;

- The full fixed effects approach controls for any correlation between the unobserved variables and each year's values of the independent variables. This approach provides the best control for unobserved heterogeneity of any of the models, but comes with two costs. First, because the method uses demeaned independent variables as the regressors, variation in those regressors can be greatly reduced, making it more difficult to obtain statistically significant results. Second, the same demeaning makes it impossible to include time constant variables among the regressors, such as zone dummies or other variables such as population density and travel time to major cities, that are hypothesized to be associated with the progress of the agricultural transformation but for which we have observations at only one point in time.

We also note with Wooldridge (2001) that, when a panel data set has many time periods, the RE model converges to FE; with the TAMPA data set's four time periods, the RE and FE estimates should be close but not identical. Combining these three approaches – RE, PFE, and FE -- thus provides a robust test of our model specification and findings; similar results across the three would suggest strong statistical confidence in the results.

Table 11 provides the list of variables, their description, mean, and standard deviation. Our conceptual model makes it clear that expectations regarding the sign of these variables depend on the stage of agricultural transformation in which the country finds itself. In the early stages, factors favorable to the transformation will tend to increase diversification; later, after households' opportunity cost of time rises and they develop more confidence in improving food markets, they will begin to move away from self provisioning behavior and specialize, first within agriculture. As cropping behavior first begins to specialize, livelihood diversification is likely to continue increasing, as successful households add off-farm activities to their portfolio. Like cropping specialization, livelihood specialization eventually follows, but later. For these reasons, we will reason from the results of the regression models to conclusions about the status of Kenya's agricultural transformation, rather than forming apriori expectations.

Results across these models are quite robust (Table 12). Among variables that were significant in at least one of the three cropping regressions, four maintain both their sign and their significance across all three approaches: income per adult equivalence, distance to an

extension agent, population density of the village, and travel time to a city of 250,000. Cultivated area, distance to a tarmac road, and three year dummies maintain their sign but not always their significance. The only statistically significant variable (in at least one regression) that changes its sign is distance to a fertilizer dealer, which is positive and significant in FE and negative (but insignificant) in RE and PFE. In nearly all cases, coefficients that are significant in one regression see little change in their magnitude in other regressions.

Making the same comparison in the set of livelihood regressions, three variables maintain both sign and significance: income per adult equivalence cultivated area, and access to credit. Seven variables maintain their sign but not always their significance: gender and age of the household head, distance to an extension agent, distance to a motorable road, maize yield, travel time to a city of 250,000, and the year 2007 variable. Only the year 2000 and 2004 dummies change sign across the three livelihoods regressions, but only one sign is ever significant (positive for year 2000 in FE, and positive for year 2004 in RE and PFE).

Overall, results reinforce conclusions from previous sections of the paper that Kenya is at an early stage of the agricultural transformation, while providing useful insights about the drivers of that process. Among the demographic variables, male headed households tend to be more specialized in their broad livelihood activities. Because the regression controls for household income, this result may suggest greater risk aversion among female household heads (who diversify to spread risk), which could be considered a rational reaction to the absence of a key income earner.

Higher income households are clearly more specialized, both in cropping and their broader livelihoods[10]. This is consistent with a broad array of research (see Delgado and Siamwala, 1997) that shows the poorest households to be the most diversified, as a risk management strategy. The income result also suggests that, even in the early stages of the agricultural transformation, households that are able to specialize tend to benefit from it. Land area cultivated has opposite effects on cropping and livelihood diversification (though its effect on cropping diversification is statistically significant only in the RE model). Larger farmers tend

[10] Income is an endogenous variable in this regression and so its coefficient should be interpreted with care. We include it because results on other variables are robust to its inclusion (all three models run without income as an independent variable give nearly identical results to those in Table 12) and because it reinforces findings earlier in the paper showing that higher income households are more specialized.

to be more specialized in their cropping activities but more diversified in their livelihoods. Again, this result echoes a wide array of research in Africa showing that farms specialize as they grow larger and that households with the highest off-farm earnings tend also to have the highest agricultural incomes (Reardon, Crawford, and Kelly, 1994; Reardon et al. 2000; Tschirley and Benfica 2001). This pattern – specialization within cropping activities coupled with diversification into non-farm – is also consistent with the pattern explained above, in which livelihood specialization begins later than cropping specialization during the agricultural transformation.

We include the population density within villages in our local infrastructure variables as a proxy for the likely density of roads, commercial outlets, and other infrastructure. All these variables (with the partial exception of distance to a fertilizer dealer in the cropping FE model) paint a consistent picture: better infrastructure, as indicated by lesser distances to various commercial outlets and higher population density, leads to greater diversification. These results strongly suggest, consistent with other results, that Kenya remains in the early stages of the transformation, where factors that are positive for development lead to more diversification for most households, not more specialization.

We proxy the productivity of local agriculture with district average maize yield. A basic tenet of the agricultural transformation and of the vast literature on agricultural growth linkages (see especially Haggblade, Hazell and Brown, 1988 on the latter) is that a more productive local agriculture is needed to drive the off-farm economy. Our results echo this contention, showing that, higher agricultural strongly drives diversification of livelihoods, implying diversification into non-farm activities.

Travel time to a city of 250,000 captures access to major markets by summarizing information on travel distance and road quality. Access to markets is a key driver of specialization under any circumstance, and the positive coefficient on the travel time variable reinforces that idea: lower travel times lead to greater specialization in both cropping (by RE and PFE models) and livelihoods (by RE model).

Zonal dummy variables capture characteristics of the agro-ecological zones not captured in the other independent variables (such as population density and agricultural productivity) and so must not be interpreted as direct indicators of which areas are more or less specialized.

Results in the RE and PFE models for year dummies reflect findings in the earlier descriptive section in two ways: cropping diversification rose through 2004 then leveled-off (FE shows only that it was higher in 2007 than in 1997), while livelihood diversification continued to increase through 2007 (according to the RE and PFE models).

Table 11: Description and means of variables in Random Effects Regression

Variable	Description	Obs	Mean	Std. Dev
Dep. Vars				
dindexcrop	Crop diversification index	5077	0.484	0.1902388
dindexliv	Livelihood diversification index	5099	0.602	0.1666643
Demographics				
age	Age of head of household	5100	55	13.88091
gender	Gender of head of hh (1=male, 0=female)	5100	0.82	0.3814238
educ	Years of education of head of hh	5027	5.8	4.269278
Income, assets, services				
income_ae	Real hh income per adult equiv.	5100	18415	22936.9
cultacres	Acres cultivated	5100	3.7	5.873919
credit	Household did/did not receive credit (1/0)	5100	0.41	0.4920954
Local infrastructure				
fertskm	distance to fertilizer seller	4932	5.25	8.500579
dextn	distance to extension provider	5028	5.15	5.525472
dmtroad	distance to motorable road	5041	1.0	1.689298
dtmroad	distance to tarmac road	5045	7.8	8.208388
	-mean for district	5100	735	451.7382
pop_km2	village population density	4932	327	250.1465
Access to major market				
ttom250k	travel time to city of 250,000	5100	220	106.0816
Local ag prod'ty				
mz_yield	maize yield-kg/acre			
Zone dummies				
coast	Coastal lowland dummy	5100	0.058	0.2353172
easternl	Eastern lowland dummy	5100	0.113	0.3175087
westernlow	Western lowland dummy	5100	0.12	0.3249934
westerntra	Western transitional dummy	5100	0.116	0.3203504
hpmz	High pot. Maize zone (excluded)	5100	0.271	0.4447114
westernhigh	Western highlands dummy	5100	0.101	0.3015918
central	Central highlands dummy	5100	0.189	0.3921843
mrs	Marginal rain shadow dummy	5100	0.029	0.1678779
Year dummies				
yr1997	Excluded	5100	0.25	0.4330552
yr2000	Year 2000 dummy	5100	0.25	0.4330552
yr2004	Year 2004 dummy	5100	0.25	0.4330552
yr2007	Year 2007 dummy	5100	0.25	0.4330552

Table 12: Regression results for cropping and livelihoods diversification: Random Effects, Partial Fixed Effects, and Fixed Effects

	Cropping Agriculture						Livelihoods					
	Random Effects (RE)		Partial Fixed Effects (PFE)		Fixed Effects (RE)		Random Effects (RE)		Partial Fixed Effects (PFE)		Fixed Effects (RE)	
Variables	**Coef**	**P**	**Coef**	**P**	**Coef**	**P**	**Coef**	**P**	**Coef**	**P**	**Coef**	**P**
Demographics												
Gender of head	-0.01054	0.180	0.0029159	0.829	-0.01199	0.299	-0.0151	0.032 **	-0.0134363	0.283	-1.97E-02	0.099 *
Age of head	0.000088	0.715	-0.0004799	0.339	-0.00041	0.324	0.000735	0.001 ***	0.000197	0.672	0.000305	0.481
Educ. of head	0.000309	0.694	-0.000033	0.678	-0.00027	0.795	0.00073	0.313	-0.0000369	0.616	0.000702	0.510
Income, assets, services												
Income/ae	-5.6E-07	0.000 ***	-5.4E-07	0.000 ***	-5.9E-07	0.000 ***	-1.16E-06	0 ***	-1.19E-06	0.000 ***	-1.25E-06	0.000 ***
Value of assets	-3.8E-09	0.691	2.2E-08	0.117	2.15E-08	0.062 *	-1.07E-08	0.232	8.89E-09	0.494	7.62E-09	0.522
Cult. Area	-0.0019	0.000 ***	-0.0004951	0.434	-0.00048	0.358	0.001293	0.003 ***	1.03E-03	0.081 *	9.35E-04	0.081 *
Rec'd credit	-0.00728	0.168	0.002583	0.717	-0.00319	0.592	0.011719	0.021	1.35E-02	0.040 **	1.12E-02	0.069 *
Local infrastructure												
Dist to fert. dealer	-0.0005	0.216	-0.0004314	0.393	0.000935	0.054 **	5.74E-07	0.999	0.0000374	0.936	3.09E-05	0.951
Dist to ext. agent	-0.00087	0.113	-0.0016121	0.034 **	-0.00211	0.001 ***	-0.00058	0.263	-1.25E-03	0.078 *	-0.00095	0.148
Dist to motorable rd.	-0.00059	0.686	-0.0008631	0.642	0.000158	0.920	-0.00149	0.297	-3.14E-03	0.068	-0.00159	0.328
Dist to tarmac rd.	-0.00095	0.028 **	-0.0012489	0.114	-0.00106	0.129	0.000151	0.697	-0.000533	0.466	-0.00058	0.422
Pop density	0.000065	0.001 ***	0.000059	0.000 ***	-------	-------	1.42E-05	0.374	2.41E-05	0.079 *	-------	-------
Local ag prod'ty												
Maize yield	-9.4E-06	0.185	-0.0000026	0.773	5.16E-06	0.631	3.28E-05	0 ***	2.49E-05	0.003 ***	3.64E-06	0.743
Access to major market												
Travel time (250k)	0.000153	0.011 ***	0.0001905	0.000 ***	-------	-------	0.000128	0.011 ***	0.0000699	0.126	-------	-------
Zone dummies												
Eastern low.	0.022609	0.251	0.0092464	0.586	-------	-------	0.10632	0 ***	0.1180865	0.000 ***	-------	-------
Western low.	-0.09492	0.000 ***	-0.1208691	0.000 ***	-------	-------	0.012029	0.56	0.0325997	0.082	-------	-------
Western trans.	-0.05116	0.044 **	-0.0441512	0.030 ***	-------	-------	0.059958	0.004 ***	0.0595894	0.002 ***	-------	-------
High pot maize	-0.14182	0.000 ***	-0.1292931	0.000 ***	-------	-------	0.046443	0.012	0.0342223	0.058	-------	-------
Western high	0.020488	0.430	0.0164376	0.445	-------	-------	0.110446	0 ***	0.1095745	0.000 ***	-------	-------
Central	0.024059	0.213	0.0378342	0.048	-------	-------	0.116906	0 ***	0.1065426	0.000 ***	-------	-------
Marg rain shad	-0.12151	0.000 ***	-0.1401927	0.000 ***	-------	-------	0.025963	0.225	0.0474161	0.014 **	-------	-------
Year dummies												
yr2000	0.069325	0.000 ***	0.0707663	0.000 ***	0.011571	0.698	-0.004	0.568	0.0027563	0.732	7.81E-02	0.012 ***

	Cropping Agriculture						Livelihoods					
	Random Effects (RE)		Partial Fixed Effects (PFE)		Fixed Effects (RE)		Random Effects (RE)		Partial Fixed Effects (PFE)		Fixed Effects (RE)	
Variables	**Coef**	**P**	**Coef**	**P**	**Coef**	**P**	**Coef**	**P**	**Coef**	**P**	**Coef**	**P**
yr2004	0.103245	0.000 ***	0.1094833	0.000 ***	0.048574	0.115	0.01264	0.085	2.01E-02	0.023 **	-0.04888	0.126
yr2007	0.099641	0.000 ***	0.1030194	0.000 ***	0.101758	0.001 ***	0.042714	0 ***	4.92E-02	0.000 ***	0.047088	0.146
_cons	0.457283	0.000 ***	0.4607346	0.000 ***	0.469012	0.000 ***	0.453909	0 ***	0.3943285	0.000 ***	0.605936	0.000
Adj. R-square			0.2609						0.1252			
R-sq: within	0.1123				0.1669		0.0639				0.1006	
R-sq: between	0.3523				0.0001		0.2077				0.0267	
R-sq: overall	0.2526				0.0349		0.1261				0.0537	

9.0 Conclusions

The big picture that emerges from this research is that Kenya is in an early stage of the agricultural transformation; earlier, in fact, than hypothesized at the outset of this paper. On the one hand, the graphical and tabular results and the RE and PFE regressions show a flattening out of the crop diversification trend, suggesting that the country may have reached the point in its development in which increasing numbers of rural households will soon begin to specialize in their cropping and agricultural activities, gradually abandoning a self-provisioning attitude to dedicate their time to a limited number of activities in which they can develop expertise and economies of scale. The same set of bivariate and regression results suggest that the rate of livelihood diversification increased between 2004 and 2007 and thus is likely to continue increasing for at least the next several years. Both of these results are consistent with the relative timing of the move towards specialization in cropping and livelihoods hypothesized in our conceptual framework, with livelihoods at first diversifying as households add non-farm activities to their farming portfolio. In both the cropping and livelihood regressions, however, the FE models give opposite results, suggesting that the trend towards crop diversification may have increased in 2007, rather than slowing, while livelihoods may have become less diverse between 2000 and 2007. We suggest that the balance of the evidence favors the conclusion that households have begun to specialize in their cropping activities and increasingly complement these with non-farm activities.

At the outset of this paper we laid out four hypotheses to drive our analysis:

1. That livelihoods would have begun to specialize in Kenya in response to economic reforms, increased population densities, and rising incomes since 2000;
2. That crop and broader agricultural diversification will have decreased due to general reforms in the agricultural sector;
3. That maize production will have become more spatially concentrated (specialized) across regions, villages, and households within villages, due to the lifting of movement restrictions 15 years ago; and

4. In all cases, increased specialization will have been more pronounced in areas of higher population density, greater agro-ecological potential, and proximity to large urban markets. Central Highlands and High Potential Maize Zone (HPMZ) thus stood out as primary candidates for greater specialization.

Our analysis suggests a rejection of hypothesis 1: most households in Kenya are still diversifying their livelihoods, adding non-farm activities as they maintain their farming portfolio. We can also clearly reject hypothesis 3. In fact, maize production has become less spatially concentrated, not more, despite demonstrably more fluid domestic trade in the crop. Together with the findings on hypothesis 1, this suggests either that the transformation of Kenya's economy over the past 15 years has been modest, or that much of the rural economy was heavily subsistence oriented at that time.

On balance, our analysis supports hypothesis 4: Central Highlands and High Potential Maize Zone saw cropping agriculture and also broader crop plus livestock agriculture become more specialized in 2007. Our regression analysis also shows that areas closer to sizeable urban areas tend to be more specialized than comparable areas further away.

Finally, our analysis supports hypothesis 2, that crop and broader agricultural diversification will have decreased over the period, though this trend showed itself only in the final period. If this conclusion stands up to further analysis, it has important policy implications for the country, because it indicates that Kenya is facing a *change in the direction of change*. From increasing diversification of household activities, it will soon be seeing increasing specialization. Perhaps more accurately, while increased diversification has been associated with higher welfare of rural households in the past, increased specialization will be needed to improve welfare in the future. This suggests that policies and programs that may have previously been well adapted to the country's circumstances will quickly become outmoded and even counter-productive. Policies must therefore shift their relative balance from promoting broad diversification to facilitating specialization among the increasing number of households likely to want to do this. Balance is needed; the shift in policy will not be absolute, but it is important that the relative emphasis change in a fundamental way. Key aspects of this change include:

- More room will need to be made in the technical research portfolio for high yielding crop and livestock packages, even if they imply more risk; while not all farmers will demand such technologies, an increasing numbers of them will;
- It will be more important than ever for farmers to have access to the right inputs at the right time. While government input programs (e.g. for fertilizer) can provide wide access to some inputs for many farmers, private systems are likely to be better at providing the range of differentiated inputs needed by the new technologies, and to provide them on a reliable basis. It is thus important that any government input programs that do exist be modest in scope, well targeted, and that they do not interfere with the growth of private input channels.
- The country will need more investment in supply chain efficiencies, including improved extension, market information, physical market places, and cold chains for perishable items like fresh produce, dairy, and meat. Many of these investments will need to be facilitated by government, but they must be conceived and implemented in a highly collaborative fashion with private sector;
- Increased attention will need to be paid to negative environmental externalities from agriculture; though these negative externalities might be modest now, they could grow very rapidly in the absence of an appropriate policy framework, as input use grows rapidly with increased agricultural specialization;
- Specialization will drive less efficient farmers out of agriculture. For the agricultural transformation to proceed, broader macroeconomic and investment policy must be reviewed to ensure that they encourage free investment throughout the economy so that those leaving the farm will be able to find gainful employment elsewhere;
- Finally, the government's decision to offer free primary and now secondary education appears very well timed, as greater education will be needed to drive the growth of the non-farm economy and ensure that people are not just pushed off the farm by specialization but pulled off it by attractive income earning opportunities. As access to education increases, however, attention must continue to be paid to its quality.

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