Efficiency and Equity in Public Investment in Agriculture: Lessons from Soil Fertility Research in Kenya

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Abstract

Many of Africa's poor live in low-rainfall areas where relatively large investments may be needed to increase agricultural productivity. This paper uses the results from an assessment of expected returns to research on soil fertility management at the Kenya Agricultural Research Institute to explore the extent to which such investments can be justified on efficiency and equity grounds. While results point to large aggregate potential benefits to Kenyan society, these are weighted toward Kenya's high-rainfall areas. However, a significant share of the gains accrue to the country's low-rainfall areas, where population density is increasing rapidly, and where overall levels of investment in rural infrastructure lag behind those in the high-rainfall areas. Targeted investments in low-potential areas thus may be justified on both efficiency and equity grounds.

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1. Introduction

Almost by definition, public investments aimed at increasing agricultural productivity in a country will have differential impacts across regions, favoring some areas more than others. For agricultural economies are diverse. Their diversity stems in part from institutions and policies that affect the degree to which particular regions are integrated into national economies and international markets. But most fundamentally, it is linked to variations in agroecological conditions.

Many of Africa's poor live in low-rainfall areas (Pinstrup-Anderson and Pandya-Lorch, 1994). Relatively large investments may be needed to increase agricultural productivity in these zones as compared to those required in regions with higher rainfall. Can such investments be justified on efficiency grounds, equity grounds, both, or neither?

This paper addresses these important questions through the prism of the particular challenges raised by soil fertility management in Africa. Results from an assessment of expected returns to research on soil fertility management at the Kenya Agricultural Research Institute (KARI) point to large potential benefits to Kenyan society. But the results also reveal an unequal distribution of research benefits between Kenya's high- and low-rainfall areas; the former stand to garner the lion's share. However, because this distribution mirrors patterns of previous public investment it must be interpreted with care.

The next two sections review recent findings on soil nutrient depletion in Africa and Kenya, respectively. The results of KARI's attempt to quantify benefits to its research on soil fertility management are then reported in detail. The implications of these results for public investment in agricultural productivity growth in Kenya and elsewhere in Africa round-out the paper.

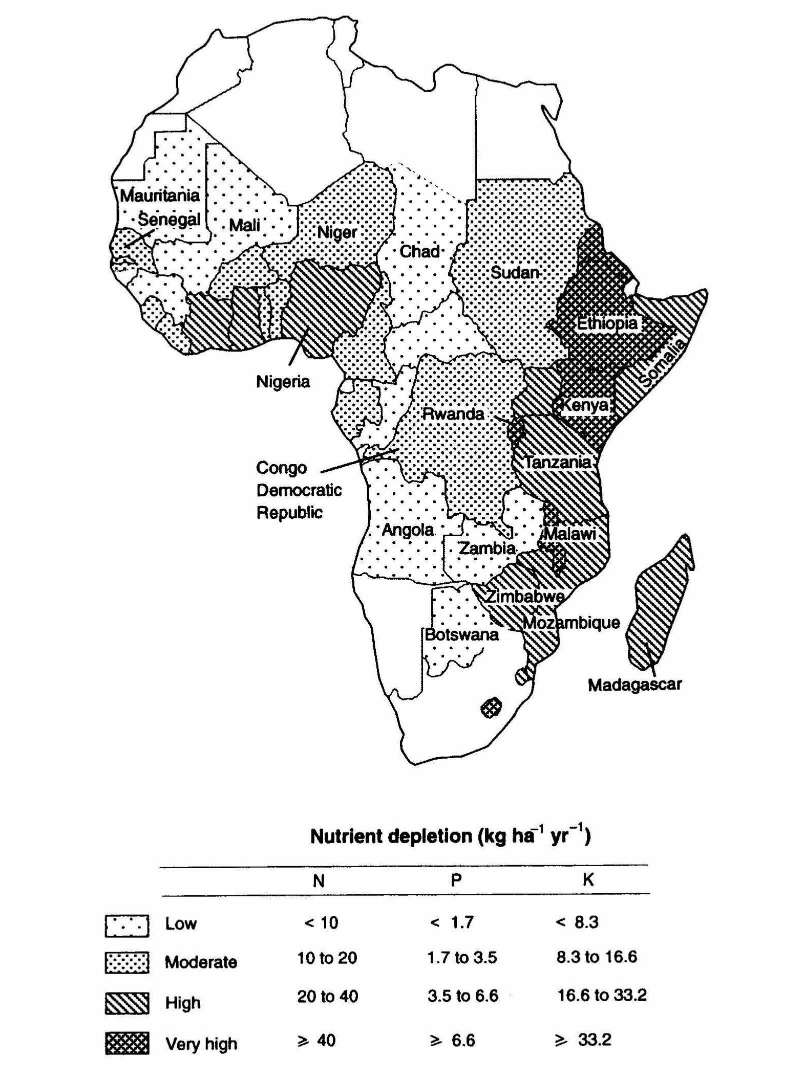
2. Soil Nutrient Depletion in Africa

By 2020, Africa's human population will equal 1.3 billion, more than double its size in 1990 (FAO, 1999). Stagnant agricultural yields alongside steadily growing demand for key staples, point to a food shortage of over 250 million tons in that year (World Bank, 1989). Degradation of the continent's soil resource base has been identified as a major contributor to this threat (Cleaver and Schriefer, 1994), with soil nutrient depletion looming large among degradation forms (Heisey and Mwangi, 1996).

Sanchez et al. (1997) report that between 1960 and 1990, an average of 660 kilograms per hectare (kg/ha) of nitrogen (N), 75 kg/ha of phosphorus (P), and 450 kg/ha of potassium (K) were lost from 200 million hectares of cultivated land in 37 African countries. They put the current rate of nutrient losses at 4.4 million tons of N, 0.5 million tons of P, and 3 million tons of K. These losses swamp additions from fertilizer applications, which equal 0.8, 0.26, and 0.2 million tons of N, P, and K, respectively.

The real story, however, lies in the geographic pattern of nutrient depletion around the continent. Rates of nutrient depletion are highest in east Africa, moderate in coastal west Africa and south Africa, and lowest in the Sahelian belt—from Senegal to Sudan—and in central Africa (Figure 1). At first, this is a puzzling continuum. For inherent soil fertility across the continent follows a similar pattern (Smaling et al., 1997). But a key recognition is that patterns of human settlement typically mirror distributions of natural resources and thus often determine and reflect pressure on natural resources (Pender at el., 1999).

Figure 1: Classification of Soil Nutrient Balances for Arable Land in Sub-Saharan Africa (Source: Smaling et al., 1997)



The steady fall in Africa's stock of soil nutrients appears to be linked to soil fertility management practices—e.g., shifting cultivation and slash-and-burn methods—that are ill-suited to the relatively recent imperative of continuous cultivation under increasing population pressure (Quinones et al., 1997). But with appropriate soil fertility management practices, population pressure need not imply nutrient depletion. Population densities in much of Asia are considerably higher than they are in most African countries. But relatively high adoption and application rates for inorganic fertilizers mean that not only do grain yields in this region average three times those in Africa, they are growing while those in Africa stagnate (Heisey and Mwangi, 1996; FAO, 1999; Mwangi, 1996).

3. Soil Nutrient Depletion in Kenya

Kenya is a remarkably good illustrative case of the causes and consequences of soil nutrient depletion. Countrywide, under increasing land pressure from a still burgeoning population, nutrient losses (e.g., from leaching and erosion) and offtakes from crop harvest removals often exceed additions from biological processes (e.g., nitrogen fixation) and application of organic and inorganic fertilizers (KARI, 1998). Yields of key commodities have stagnated, not only in areas with marginal agricultural potential, but also in regions with relatively good production prospects.

Consider the case of Kisii district, a densely populated area with high agricultural potential in western Kenya. Soils in the area are predominantly well-drained, deep, and, with the exception of phosphorus, rich in key nutrients (Smaling et al., 1997). Mean annual rainfall is high, averaging between 1,350 and 2,050 mm (Jaetzold and Schmidt, 1984). Major food-crops are maize and beans, key cash-crops are tea, coffee, and pyrethrum, and livestock and improved pastures appear on many farms. Most significantly, given the high population density, little land is left fallow during the year. Where fertilizers are used, application rates are well below recommended levels. Annual nutrient depletions in the district have been estimated at 112 kg/ha of N, 2.5 kg/ha of P, and 70 kg/ha of K (Smaling et al., 1997). Similar patterns are reported for Kakamega district, which is similar to Kisii in population density and agroecological potential, and in Embu district, where population densities and agroecological potential are lower (Table 1).

Table 1: Farm Level Soil Nutrient Balances in Kenya, 1996 (kg/ha/year)

Soil Nutrient	Kisii District[1,2]	Kakamega District[2]	Embu District[2]	ALL Districts[2]
Nitrogen (N)	-112	-72	-55	-71
Phosphorus (P)	-2.5	-4	9	3
Potassium (K)	-70	18	-15	-9

1. De Jager et al. (1998).
2. Smaling et al. (1997).

Returns to food-crops in these districts tend to be insufficient to cover the costs of fertilizers required to replenish lost nutrients (De Jager, 1998). Farming systems dominated by cash-crops such as tea and coffee thus are less nutrient-mining than are those dominated by food-crops like maize and beans. But Kenya’s agricultural landscape is dominated by these food-crops (Argwings-Kodhek et al., 1998). This implies strong and widespread incentives to mine nutrients and significant obstacles to replenishing them.

4. Potential Economic Benefits of Research on Soil Fertility Management in Kenya[1]

Soil nutrients can be replenished by increasing nutrient inputs into the soil, by reducing nutrient losses, and by increasing nutrient-use efficiency. Research on soil fertility management thus revolves around explorations of ways through which the “natural” biophysical relationships that underlie these processes can be accelerated and intensified (Izac, 1998; Sanchez et al., 1997; TSBF, 1995; Woomer and Swift, 1994).

KARI’s Soil Fertility and Plant Nutrition (SFPN) research program is one of its largest, with a mandate area that spans all agroecosystems in Kenya. Given the scope of this charge, the Program cannot fully address the entire range of soil fertility problems facing its diverse client base, even with its relatively large human resource capacity. Priority research areas must be identified and research resources concentrated accordingly. An ex ante assessment of returns to research investments thus took place in the context of a broad effort to set priorities in the Program (KARI, 1998).

A key recognition is that soil fertility management technologies are embedded within crop and livestock enterprise management practices (Lynam, 1994). Impacts on yields of crops and livestock thus are fundamental to incentives for adoption of soil fertility management technologies and are a logical starting point for assessing the economic impacts of research to develop these technologies. This was a basic underlying assumption in KARI’s efforts to quantify impacts of research on soil fertility management in Kenya.

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[1] This section draws considerably from KARI (1998).

Soil fertility management research is typical of other research on natural resource management in that it relies for its impact on the interplay of intricate biophysical effects in complex farming systems featuring several commodities. Quantifying the economic impacts of research on soil fertility management thus calls for techniques that simultaneously keep track of farm-level yield gains and aggregate supply shifts for a number of commodities. Following Alston et al. (1995), the modeling challenges thus were: to identify and quantify multi-commodity net yield gains at the farm level under different soil fertility management research interventions; to aggregate these farm-level gains to regional and national supply shifts for affected commodities; and to translate these supply shifts into changes in economic surplus.

Data used included spatially disaggregated agroclimatic information, time series on yields, aggregate output levels, and prices of the major commodities produced in most parts of Kenya, background information on farmer constraints, technology adoption, and socioeconomic differentiation, and data on key variables describing the soil resource base—e.g., soil nutrient balances, toxicity, and depth. Using these data, research target zones were identified, research themes specified, zone-specific potentials for technology generation and adoption under each theme and their associated farm-level yield gains estimated, and aggregate economic benefits based on multi-commodity supply shifts computed.

Five research target zones were identified based on altitude, rainfall, and population density as follows (Table 2): zone 1, covering low altitude and relatively high rainfall areas along the Kenyan coast; zone 2, arid and semi-arid lands (ASALs) with low population density; zone 3, ASALs with high population densities; zone 4, mid-altitude, medium rainfall areas with high population density; and zone 5, high altitude, high rainfall regions with both high and low population densities.

Table 2: Research Target Zones for KARI's SFPNRP

Zone	Elevation (meters)	Rainfall (mm/year)	Population Density (people/km^2)
Zone 1: Coast	< 400	> 900	> 20
Zone 2: ASAL* - Low Population Density	400 - 900	200 - 900	20 - 80
Zone 3: ASAL - High Population Density	400 - 1200	200 - 900	> 80
Zone 4: Medium Rainfall - High Population Density	400 – 1800	> 900	> 80
Zone 5: High Rainfall - Low and High Population Density	1800 - 3000	> 900	> 20

Districts containing areas covered by the target zones are as follows:
Zone 1: Kwale, Kilifi, Lamu
Zone 2: Kitui, Machakos, Laikipia, Nakuru, West Pokot
Zone 3: Machakos, Meru, Kitui, Nakuru, Kiambu, Embu
Zone 4: S. Nyanza, Siaya, Kakamega, Kisumu, Busia, Bungoma, Trans Nzoia, Muranga, Nyeri, Kirinyaga, Meru
Zone 5: Kericho, Nakuru, Uasin Gishu, Nyandarua

Based on secondary data sources and scientists' specialized knowledge of Kenyan agriculture, 33 major production systems with 35 different commodities in the five zones were identified in the five zones. In general, the higher the production potential of a zone, the larger the number of commodities produced and the greater the number and complexity of extant production systems. For instance, in zone 4—covering mid-altitude, medium rainfall areas—17 different commodities occupy significant areas (Table 3). Given the importance of small-scale producers in the region, maize and beans are produced in almost all production systems, dominating the most important one, PS-1. However, systems in which cash-crops like coffee, tea, and sugarcane are prominent account for almost one-half of the zone. Compared to the other zones, milk and horticultural production are significant, as, too, is potato production. Kenya's sugar belt falls in the western portion of the zone.

Based on data sources ranging from formal household surveys, rapid rural appraisals, participatory rural appraisals, and soil surveys, detailed zone-specific constraint identification and analysis were completed. From this exercise emerged a number of clear-cut research activities (or projects). Related research activities were then grouped into four research themes: Problem Soils Management; Inorganic Fertilizer Management; Soil Organic Matter Management; and Technology Transfer.

Table 3: Principal Production Systems in Zone 4: Medium Rainfall - High Population Density

Production System (PS)	Share of Production System in Target Zone (%)	Commodities (and % shares) in Production Systems
PS-1	30	maize (45), beans (15), tea (10), bananas (8), dairy (7), horticulture (5), cassava (5), millet (5)
PS-2	20	coffee (50), maize (20), dairy (15), beans (8), bananas (5), Irish potato (2)
PS-3	15	tea (60), Irish potato (15), dairy (10), horticulture (10), maize (5)
PS-4	10	sugarcane (45), maize (30), dairy (8), beans (8), bananas (4), groundnut (3) soybean (2)
PS-5	8	sorghum (25), cassava (20), maize (15), livestock (11), millet (8), beans (8), sweet potato (5), groundnut (4), sunflower (2), horticulture (2)
PS-6	7	horticulture (50), dairy (20), Irish potato (20), flowers (10)
PS-7	7	dairy (80), horticulture (20)
PS-8	2	coffee (90), flowers (10),
PS-9	1	sugarcane (100)

The Problem Soils Management (PSM) theme addresses several soil quality difficulties—such as acidity and alkalinity, salinity, sodicity, hard-setting, crusting, leaching, aluminum and manganese toxicity, and phosphorus fixation—that, either in isolation or in combination, militate against agricultural productivity growth. These problem soils are location-specific but not location-unique. They thus are ubiquitous countrywide, in some cases accounting for large portions of extant soils.

The second theme—Inorganic Fertilizer Management, IFM—seeks to raise agricultural productivity in target zones by increasing the efficiency of fertilizer use on farmers' fields. Problems associated with IFM are linked to problem soils and thus are specific to zones.

Improved soil organic matter management is important not only in its own right but also in a mutually reinforcing role with enhanced nutrient use efficiency (Palm et al., 1997); this is the rationale behind the third theme—Soil Organic Matter Management, SOMM. Under this theme, improved management of the quantity and quality of soil organic matter is an important issue in all target zones.

The final theme—Technology Transfer (TT)—aims to identify and address enduring constraints on adoption of existing technologies. Difficulties in technology transfer often hinge on socioeconomic constraints faced by farmers—such as poor access to key input and output markets and lack of appropriate information. These factors likely vary across zones. Thus while the Technology Transfer theme clearly straddles the other three, it was viewed to be of sufficient importance to warrant separate treatment.

The four themes exhibit distinct adoption profiles and adoption rates (Table 4). Research lags range from 1 year (Technology Transfer) to 8 years (Problem Soils), while years to maximum adoption have a low of 9 years (IFM) and a high of 15 years (Problem Soils). Yet cumulative lengths of time to the onset of disadoption of technologies and to complete disadoption are quite similar. These profiles, along with those for maximum adoption rates, point to much greater potential for technology generation and adoption under the IFM, SOMM, and TT themes than under the PS theme. However, potential research benefits depend not only on the potential for technology generation and adoption but also on the potential yield gains from resulting research interventions.

Table 4: Adoption Profiles for Research Themes

Research Theme	**Research Lag (years)**	**Years to Adoption (cumulative)**	**Maximum Adoption Rate (%)**	**Begin Dis-adoption (cumulative years)**	**Complete Dis-adoption (cumulative years)**
Problem Soils	8	15	35	20	50
Inorganic Fertilizer Management	3	9	54	15	30
Soil Organic Matter Management	4	10	52	20	50
Technology Transfer	1	11	15	15	50

Zonal averages of commodity-specific expected net yield gains were summed to give national net yield gains for the four themes (Table 5). Technologies generated under the Soil Organic Matter Management (SOMM) and Technology Transfer (TT) themes had higher probabilities of exceeding dissemination thresholds and somewhat higher conditional net yield gains than did those developed under the other two themes (Table 5). Estimates of research benefits across zones and themes thus were the combined effect of theme-specific conditional net yield gains and adoption profiles, the spatial distribution of commodity production, and commodity prices.

Insofar as this aggregation procedure did not allow for variations in research impact across zones via differences in estimated net yield gains—and instead attributed all such variation to differences in quantities of affected commodities produced in the five zones—it was analogous to a simplistic congruence methodology and was not entirely satisfactory. However, the results of this cruder approach proved to be reasonable.

Table 5: Potential for Technology Generation for Each Research Theme Across all Zones

Theme	**Estimated Net Yield Gain (%)***			**Estimated Dissemination Threshold**	**Probability of Exceeding Threshold**	**Conditional Net Yield Gain (%)**
	Minimum	**Most Likely**	**Maximum**			
PSM	3.11	6.88	11.91	10.00	0.08	10.56
IFM	3.90	8.34	14.03	10.00	0.11	10.59
SOMM	4.34	7.76	13.18	10.00	0.28	11.18
TT	3.85	7.67	12.00	8.00	0.21	10.93

The estimated present discounted value of potential economic benefits from research on soil fertility management at KARI totals 63 billion Kenya shillings over a 30 year horizon. Comparable estimates for KARI’s cassava, maize, sorghum, and wheat research programs are 12, 89, 2.4, and 17 billion shillings. The cost of running KARI’s soil fertility and plant nutrition research program over this 30-year period is estimated to be 1 billion shillings. Every shilling invested in the Program thus potentially yields 63 shillings of social benefit. The benefits translate into roughly 2,100 shillings per person, or 8 percent of average agricultural household income in

Kenya in the 1997-98 crop year (Argwings-Kodhek et al, 1998). The overall magnitude of these benefits is important but less informative than are distributions of the estimated gains across research themes and target zones.

Estimated potential benefits to the four themes differ significantly (Table 6). Over 86 percent of all potential gains fall under the IFM and SOMM themes, with the former accounting for nearly half of all Program benefits. Returns to the PSM and TT themes each account for roughly 6 percent of total gains. These differences across themes are driven mainly by distinct adoption profiles and maximum adoption rates (Table 4) and to a smaller extent by different conditional net yield gains (Table 5).

Table 6: Distribution of Estimated Benefits Across Research Themes

Research Theme	Estimated Benefits (Kshs billion)	Share of Total (%)
Problem Soils Management (PSM)	4.22	6.70
Inorganic Fertilizer Management (IFM)	30.59	48.56
Soil Organic Matter Management (SOMM)	24.50	38.89
Technology Transfer (TT)	3.69	5.85
TOTAL	**63.00**	**100**

The distribution of potential benefits across research target zones also varies considerably (Table 7). The greatest gains fall in zones 4, 5, and 2. But whereas high-potential zones 4 and 5 register large benefits because of the large number of commodities in the zones whose yields can potentially be impacted by research on improved soil fertility, zone 2—an ASAL zone with fewer commodities and production systems—accrues large gains because of its great expanse. The smallest gains fall in zones 1 and 3, the former due to the relatively low value of many of the commodities produced there, and the latter due to its small area.

Table 7: Distribution of Estimated Benefits Across Research Target Zones

Research Target Zone	Estimated Benefits (Kshs billion)	Share of Total (%)
Zone 1: Coast	1.49	2.36
Zone 2: ASAL, Low Population Density	16.53	26.24
Zone 3: ASAL, High Population Density	6.45	10.23
Zone 4: Mid-Altitude, High Population Density	20.26	32.16
Zone 5: High Altitude, Low and High Population Density	18.28	29.01
TOTAL	**63.00**	**100**

5. Implications for Public Investment

The results suggest that the investment pattern that will result in the largest increase in aggregate social welfare—i.e., the most efficient strategy—should weigh heavily toward the high-rainfall zones 4 and 5, where over 60 percent of all potential gains fall. But a more subtle interpretation is required. For the spatial configuration of agricultural production—on which the estimated benefits are based—depends not just on agroecological conditions but also on a number of factors that reinforce agroecological disparities.

Consider, for instance, the density of roads in the country. Poor rural infrastructure raises farm-to-market transaction costs and lowers farm income by increasing costs of using markets to acquire and dispose of goods and services (Omamo, 1998a and 1998b). The lower are farm incomes, the lower is the demand for, and use of, improved inputs, the lower are associated incomes, and so on in a self-reinforcing downward spiral.

In India—a country at the heart of Asia's Green Revolution—road density is 90 km/100 km^2 (Heisey and Mwangi, 1996). In Kenya, it is just above 11 km/100 km^2 (MTC, 1998). The expenditure currently required to bring Kenya's road density to India's level is at least 450 billion shillings—assuming gravel roads only—and could be as high as 5,600 billion shillings—assuming paved roads. But, again, the important story lies in the geographic distribution of roads within the country, which is highly skewed. Across districts, only one, Kiambu, has India's road density (Table 8). A district such as Kitui requires an investment of at least 24.5 billion shillings to bring it to a comparable level.

Table 8: Road Lengths and Densities in Selected Districts in Kenya

District	**Relevant KARI Research Target Zone**	**Road Length (kms)**	**Road Density (kms/100 km^2)**
Kwale	1	1,546	18.7
Kitui	2 and 3	1,967	6.7
Machakos	2 and 3	1,579	11.1
Kiambu	4	2,296	93.8
Muranga	4	1,520	61.4
Uasin Gishu	5	1,243	32.8

Source: MTC (1998).

The key point is that the pattern of road density mirrors that of agroecological potential. It is highest in districts with relatively high rainfall and agroecological potential (e.g., Muranga and Kiambu) and lowest in those with low rainfall and potential (e.g., Kitui and Machakos). Road networks take years to build. This spread thus is not accidental. It has its roots in the Swynnerton Plan pursued by the Colonial government (IBRD, 1963) and in policies embedded in successive National Development Plans in independent Kenya that, on efficiency grounds, favored commodities produced in Kenya's high-rainfall areas.

These differences in road densities across regions are important in themselves, but more so as signals of deeper differences in the quality of rural infrastructure in the country—differences that appear to lower returns to agriculture in the country (Omamo et al., Forthcoming; Omamo, 1998b). In the current analysis, the disparities are most significant in light of the distribution of estimated research benefits across research themes (Table 6). Almost half of the potential gains fall under the inorganic fertilizer management theme. These gains hinge on greater and better use of inorganic fertilizers. A well-functioning fertilizer distribution system thus is crucial to full realization of the potential impacts of research on soil fertility management.

In 1990, the Kenya government liberalized international and domestic trade in fertilizer by abolishing import quotas and licenses and decontrolling prices. Following liberalization, numerous private traders—ranging from specialized large-scale importer-distributors sited in major urban areas to diversified small-scale retailers in relatively isolated rural trading centers—entered the fertilizer trade, displacing the once-dominant parastatal Kenya Farmers Association in most parts of the country (Argwings-Kodhek, 1997; Omamo, 1996). However, in an analysis of factors influencing trade in inorganic fertilizers in Kenya, Omamo and Mose (1997) found that while the vigorous response to liberalization from the private sector points to important efficiency gains to the agricultural sector, liberalization is not sufficient to override several structural constraints on expanded trade in fertilizer. More strongly, their analysis suggests that the post-liberalization market-based fertilizer distribution system is inherently biased against low-potential agroecological zones. Demand-side factors—e.g., agroecological conditions and food prices—and supply-side factors—e.g., duration in fertilizer trading and access to credit—have mutually-reinforcing dampening effects on trade in these areas.

Recent initiatives by KARI and a number of its partners to “recapitalize” soils in Kenya’s high-potential, densely populated areas have been justified mainly on efficiency grounds; they are expected to lead to significant gains in regional and aggregate welfare (Sanchez et al., 1997). But if market-based fertilizer procurement and distribution is biased toward high-potential areas, should public funds be allocated to the search for solutions to soil fertility depletion in these areas, where fertilizer adoption rates—along with rates of use of improved seed and the overall degree of commercialization and intensification of production enterprises—already swamp those in the low-potential areas (Argwings-Kodhek et al, 1998)? If public investment is supposed to overcome or correct market failures, are these not more severe in the low-potential areas? Are public funds spent on soil fertility research in high-potential areas unnecessary substitutions for private investments in fertilizer procurement and distribution networks?

Thus the need for caution in interpreting the estimated spatial distribution of potential benefits to research on soil fertility management in Kenya. For even as yield declines and poverty linked to soil nutrient depletion in Kenya’s high-rainfall areas deepen, similar processes are occurring—and perhaps more rapidly—in low-rainfall areas (Okwach and Siambi, 1998). The finding that over one-third of potential benefits to KARI's research on soil fertility management falls in the ASALs is crucial, particularly given the relatively high rates of population growth in low-rainfall areas (CBS, 1995)—growth that is due in part to in-migration from high-rainfall areas. Given these trends, efforts to overcome constraints on improved soil fertility management in the ASALs may not only pass the efficiency test, they also may brighten prospects for improving rural equity—by blunting the growth of poverty in these zones—and stemming land degradation. As population densities in the ASALs increase, these potential positive effects on rural income distribution and natural resource conservation are likely to become even more important.

6. Conclusions

Johnston and Kilby (1975) argued that, "Because of their structure and demographic characteristics, late-developing countries face a fundamental choice between a strategy aimed at the progressive modernization of the entire agricultural sector and a crash modernization strategy that concentrates resources in a highly commercialized subsector." (p. 127). Referring to the first alternative as a "unimodal" strategy and to the latter as a "bimodal" one, they concluded that a unimodal strategy was superior to a bimodal approach because it better mobilized land and labor resources, particularly in the pivotal non-agricultural segment of the rural economy.

Be it by design or by default, Kenya's agricultural sector currently exhibits many of the features that Johnston and Kilby cautioned against (Argwings-Kodhek et al, 1998). So, it appears, do those in a number of other African countries. For where there is "good news" from African agriculture, it usually comes from its higher-rainfall areas (Eicher and Kupfuma, 1997; Schioler, 1998). This paper has presented results that suggest that this split not only reflects past public investments in rural areas, it also influences returns to future investments. At the very least, such future investments should not reinforce dichotomies. At best, they should aim to bridge the gaps. But that is the nub of the problem. Any solution is going to lie in the domain of the second-best.

The results of the KARI evaluation exercise confirm Johnston and Kilby's observation that any efficient and equitable strategy for agricultural development must embrace some combination of investments to strengthen and improve institutions and policies related to such activities as agricultural research and extension, rural infrastructure development, and input and product pricing, procurement, and distribution. But with twenty-five years of experience to draw upon, the results can be more boldly interpreted. Specifically, they suggest how combinations of investments might differ across regions in a country. In some countries—such as Kenya—to correct bimodal structures in rural economies, major reversals in regional emphases in public investment may be warranted. In previously favored areas—which will usually be the high-potential, high-rainfall areas—investments to facilitate a greater role for markets and private institutions are likely to be more efficient than are those involving direct intervention. Areas less favored in the past will most likely be the low-potential, low-rainfall areas ones. To the extent that pressures toward greater population in these areas continue, and to the extent that market failures of the kind in Kenya's fertilizer sector persist, direct interventions to alter incentives and input-output relations may be justified on both efficiency and equity grounds.

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