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FARM LEVEL DERIVED DEMAND RESPONSES FOR FERTILIZER IN KENYA

(A Research Proposal)

by

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ABSTRACT

The primary purpose of this research is to attempt to provide quantitative information at farm level on derived demand for fertilizers.

In this research an attempt will also be made to assess the impact of such policy variables as fertilizer subsidies, product prices, interest rate on demand functions for fertilizer and hence on optimal farm organizations based on representative farms.

In deriving these demand functions the techniques of static and parametric linear programming will be used.

FARM LEVEL DERIVED DEMAND RESPONSES FOR FERTILIZER IN KENYA

Introduction

Kenya, like any other developing country, relies to a great extent on the agricultural sector. It is therefore expected to perform all the roles often cited by development economists -- supply of food, capital formation and supply of labor to the development of the economy at large. In the period 1964-1971, agriculture accounted for some 35-40% of Gross Domestic Product (GDP) compared with 10-12% from manufacturing, 10% from commerce and 13-15% from the Government sector. It is further estimated that up to 90% of the total population is directly dependent on agriculture for their livelihood (1).

The 1974-78 National Development Plan succinctly states the role of agriculture in the economy: "Agriculture will continue for a long time to be the backbone of the country's economy and a vast majority of the population will be dependent upon agriculture for their living. Hence a rapid growth of agricultural production through intensification and increased productivity to ensure adequate and balanced food supplies and the rapid increase in standard of living in the farming community is a fundamental aim of the Government" (1). The plan further states that the "key strategy will be to direct an increasing share of the total resources available to the nation towards developing the smallholder farming areas."

The agricultural sector in Kenya can be divided into two distinct sub-sectors based on size of land: (1) large farms and (2) small farms (smallholders or small-scale farmers).[1] The large farms market most of their output and purchase most of their inputs (See Table 1). The farms in the small farm sub-sector on the other hand are in transition from subsistence forms of agriculture to commercial agriculture. They market approximately 40% of what they produce and purchase 10-20% of their labor inputs. Their purchase of modern inputs (fertilizers, improved seeds;

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1. Smallholders (small farmers) defined as holders owning up to 10 hectares of land.

insecticides, herbicides, fungicides and machinery) is minimal (2). We shall be concerned with this latter sub-sector. This is the sector that is supposed to bear the largest share of responsibility in Kenya's development.

Table 1: KENYA: Gross Marketed Production from Large and Small Farms, 1963-1971

	Large Farms		Small Farms		Total		Percentage Share of Total by Small Farms
Year	K£'000	Annual Percent Change	K£'000	Annual Percent Change	K£'000	Annual Percent Change	Percent
1963	36.5	---	10.3	---	46.8	---	34.6
1964	35.8	-4.0	24.6	16.6	60.4	29.0	40.7
1965	33.3	-7.0	23.8	-3.3	57.1	-5.2	41.7
1966	36.0	8.1	32.8	37.4	68.8	20.3	47.5
1967	32.9	-8.6	34.1	4.3	67.0	2.8	51.0
1968	34.4	4.9	35.8	5.9	70.2	4.9	51.0
1969	37.9	10.2	38.3	7.0	76.2	8.5	50.3
1970	41.2	8.7	45.5	21.4	86.7	13.8	52.5
1971	41.1	-0.2	42.5	-6.5	83.6	-3.6	50.8

Source: Economic Survey, 1968 and 1972.

The Problem

In many respects the smallholder is the key to Kenya's future. Already occupying the bulk of the productive land and producing a growing proportion of the marketed output, smallholders' production will have to increase at an increasing rate if the nation is to grow.

The situation, however, is not all that easy. The capacity for the smallholder sector to meet the objectives of development such as increasing farm income so as to improve the standard of living of rural population as well as meeting the growing demand for food will depend on how fast this sector grows. Already rising prices of food and other agricultural

products indicate that supply is lagging behind demand.

The problem of increasing output and productivity is aggravated by the complex ecology, rapid population growth, complex institutional structures and shortage of good arable land. The population was estimated at 11.2 million in 1970 and 13.4 million in 1975. The current population growth is probably about 3.5% per year (3) a high figure by any standard. Population pressure is greatest in smallholder areas mainly in Western, Nyanza and Central Provinces, overall densities approximate 150 to 200 persons per square kilometer ($PPKM^2$), on holdings averaging three hectares (ha). There are locations such as the Vihiga Division of Kakamega District in Western province with densities of about 500 $PPKM^2$ on holdings of no more than one ha (3). Table II on page 4 shows distribution of agricultural holdings by size in Kiambu district of Central province. If we apply our definition of up to 10 ha for a smallholding, then 99.5% of the holdings fall into this category.

Table II: Distribution of Agricultural Holdings by Size-Kiambu District 1968/1969

Size of Holding (Hectares)		Number of Holdings	Hectares	Cumulative % of Holdings	Cumulative % of Hectares
	0.5	10407	2352	19.46	1.41
0.5	1.0	7646	3991	33.76	3.80
1.0	2.0	12424	13525	56.99	11.90
2.0	3.0	10194	18307	76.05	22.87
3.0	5.0	7858	22182	90.75	36.16
5	10	3823	19222	97.90	47.67
10	20	868	17837	99.51	58.35
20	50	65	1351	99.65	59.16
50	100	84	4912	99.80	62.10
100	200	38	5805	99.87	65.58
200	300	26	4972	99.92	68.56
300	400	15	4263	99.95	71.11
400	500	9	4247	99.96	73.66
500	1000	7	5046	99.98	76.68
1000	2000	6	5534	99.99	79.99
2000	4000	5	14629	100.00	87.76
400	11000	3	18718	100.00	100.00
		53478	166893		

Source: Strategies for Improving Rural Welfare: Occasional Paper No. 4, IDS, University of Nairobi, 1971.

This situation points to the need to develop and promote use of technologies and farming systems that are land saving, and which at the same time will increase productivity and output of these smallholders.

We contend that this technology lies in modern inputs. As noted earlier smallholder agriculture uses minimal amounts of these inputs. Input-output price relationships have been viewed as the major vehicle through which the use of modern inputs can be expanded so as to increase output in the rural areas. This would appear to be the rationale behind the fertilizer subsidy program in Kenya. However, public policy makers' ability to determine input-output price relationships is seriously handicapped by lack of quantitative information at farm level on demand for these inputs. The primary purpose of this research is to provide this needed information with respect to fertilizers.

Our emphasis on fertilizers reflects the realization both by agricultural scientists, economists and governments of the significant role fertilizers can play in agricultural development and hence the improvement of the welfare of the rural people. Of course, it is recognized that large increases ascribed to fertilizer are made possible only through simultaneous application of a number of other inputs -- so-called "package" approach.

Goldsworthy (4) and Watson (5) in Nigeria contend that the use of fertilizer is one of the most important factors capable of bringing about significant short-run increase in agricultural production. In the United States, Heady et al. estimated that 45% of the average annual increase in yields for all crops over the past several decades came from fertilizers. Of the remainder 6% came from irrigation, 10% from introduction of hybrid maize and the remainder from the improved seeds, improved cropping practices and other innovations. Ibach (7) concluded that from the mid-fifties to the early sixties about 36% of the change in crop production per acre could be attributed solely to the increased rates of fertilizer application. In Kenya the government realizes the significance of fertilizer use in contributing to the farmers' income and to the total value of the agricultural output. The government is using fertilizer subsidy to encourage its use. Fertilizer subsidy schemes have been in operation since 1963 and they are bound to continue. Table III on page 6 shows

the trend of fertilizer subsidies between 1964-73. Currently fertilizer subsidy is 30% of the price per 50 kgs.

TABLE III: FERTILIZER SUBSIDIES: RATES AND TOTAL COST, 1964-73

	P_2O_5	N	Total Cost
	K£ per long ton		K£ Thousand
1963-64 (July 1, 1963)	375	-	166
1964-64	375	-	189
1965-66 (March 1, 1965)	410	-	325
1966-67	410	-	350
1967-68	410	-	356
1968-69 (July 1, 1968)	387.5	-	
(January 1, 1969)		200	563
1969-70	500	200	809
1970-71	500	200	778
1971-72	500	200	973
1972-73 (September 1, 1972)	300	120	750 1/

1/ Estimated

Source: Ministry of Agriculture

Fertilizer use in Kenya is shown by Table IV on page 6. Fertilizer use has increased significantly but it is difficult to tell whether the increase has been due to fertilizer subsidy or relatively higher product prices. The use is also not disaggregated by large and small farms.

The International Labor Organization report to Kenya (ILO, 8) notes that the use of fertilizers is likely to be in general employment augmenting since they increase the yield of existing crops and thereby either increase output or release land for other uses. It further contends that given the population pressure on land and the increasing demand for foodstuffs, fertilizer use should be encouraged.

The use of fertilizers has been concentrated in commercial crops[1] as compared to subsistence[2] (food) crops. Table V below shows allocation of fertilizers among crops by large and small farms.

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1. Commercial crops (tea, coffee, maize, pyrethrum) are produced mainly for the market.

2. Subsistence crops (maize, pulses, sorghum, millet, bananas, English potatoes, and sweet potatoes).

NOTE: Maize falls in both categories.

TABLE IV: FERTILIZER CONSUMPTION IN KENYA

(in 000 m.t. of material)

Year	Straight N fert.	Straight P fert.	Straight K fert	Compound fert	Toal
1958	5.5	15.0	-	0.9	21.4
1959	8.1	14.3	0.1	1.8	24.3
1960	15.0	13.2	0.1	10.9	39.2
1961	15.9	12.8	-	6.9	35.7
1962	17.4	11.9	-	4,4	33.7
1963	17.9	14.2	0.4	6.2	38.7
1964	32.2	12.7	0.2	10.6	55.6
1965	48.0	28.0	0.3	10.5	86.7
1966	30.1	46.1	0.8	18.0	94.9
1967	29.3	32.3	0.8	18.8	81.1
1968	37.3	31.5	2.2	11.1	82.1
1969	31.1	37.0	2.5	32.0	102.6
(1969)	(30.1)	(35.1)	(2.5)	(39.7)	(107.5)
1969 (')					106.484 (')
1970 (')					142.744 (')
1971 (')					132.216 (')

Source: "Fertilisers and development of Agriculture in East Africa", for 1958-1969: East African Customs and Excise Department Annual Trade Report of Tanzania, Uganda and Kenya, and for (1969): estimation by Smith and Aldington based on the importers' figures for the obtention of subsidies. As there is no subsidy on K fertiliser, there is no alternative information concerning this nutrient.

(') According to K.W. von Buckersroda, International Potash Institute (Nairobi).

This situation has occurred due to pricing policy and extension service that has tended to emphasize commercial crops to the exclusion of subsistence crops culminating in rising food prices. The situation is further dramatized by apparent decline in percentage of area planted under various food crops (See Table VI).

Fertilizers and improved seeds are complements. Consequently, it can be argued that as small farmers adopt the use of these seeds, the use of fertilizers can be expected to increase. However, this increase cannot be expected to be dramtic in Kenya where the emphasis has been on hybrid maize which small farms have adopted significantly (See Table VII on page 8).

TABLE V: KENYA: Estimated Utilization of Fertilizers and N and P_2O_2 Nutrient in 1969 Metric tons.

Crop	Total Tonnage	Total N Nutrient			Total P_2O_2 Nutrient		
		Large Farms	Small Farms	Total	Large Farms	Small Farms	Total
Tea	15,845	3,663	275	3,944	935	55	1,008
Coffee	11,256	1,688	862	2,550	825	---	825
Wheat	19,923	2,284	*	2,284	9,222	*	9,223
Maize	41,706	3,373	*	3,373	5,966	3,784	9,750
Rice	1,265	---	214	214	---	105	105
Other Cereals	1,500	---	---	---	645	---	645
Sugar	6,383	1,264	----	1,264	216	---	216
Pineapples	750	216	---	216	86	---	86
Other Horticulture	810	43	42	85	45	45	90
Pyrethrum	919	---	---	---	---	248	248
Mixtures Exported	2,327	N.A.	N.A.	354	N.A.	N.A.	781
Others Unaccounted for	2,288	N.A.	N.A.	456	N.A.	N.A.	430
Total +	104,972	12,537	1,393	14,740	17,959	4,237	23,407

Source: Report of the Working Party on Agricultural Inputs (Havelock Report) Ministry of Finance and Economic Planning, Kenya, 1971.

NOTES: * According to evidence received by the Working Party, it appears that a number of small scale farmers especially in the settlement schemes used a moderate quantity of fertilizer in 1969, but we have been unable to obtain a precise estimate of the quantities involved.

+ These are column totals only. The total of columns 2 and 3 is less than the total of column 4 by the amount of fertilizer exported or unaccounted for.

TABLE VI: Percentage of Area Planted to Ten Major Food Crops Grown in the Small Farm Sector, 1960 and 1970.

Crop	1960 % of Total	1970 % of Total
Maize	44.0	51.4
Pulses	25.7	25.8
Sorghum	7.3	6.8
Millet	5.8	2.9
Cassava	4.4	4.2
Finger Millet	4.2	1.8
Bananas	2.7	3.7
English Potatoes	2.0	1.5
Sweet Potatoes	2.5	1.3
Yams	1.1	0.3

Source: Kenya Statistical Digest 1966 (1960 figures) Economic Survey 1973 (1970 figures)

TABLE VII: KENYA: Acreage of Hybrid Maize

Year	Large Farms	Small Farms
1964	28,100	1,750
1965	50,470	20,040
1966	63,900	37,730
1967	137,140	115,250
1968	90,195	126,600
1969	97,605	158,850
1970	113,409	239,448
1971	158,669	370,316
1972	173,299	511,013

Source: Kenya Seed Company

The effort should then be concentrated in developing improved seeds for the other food crops if this complementarity between fertilizers and improved seeds is to be exploited. However, Dalrymple (9) has argued that farmers could still increase output by using improved seeds without using the recommended levels of fertilizer use.

Importance of Study

Fertilizer studies in Kenya as shown by literature review below have concentrated on various aspects of marketing or distribution of fertilizers.

Cayler (10) has indicated that no fertilizers are manufactured in Kenya, although several companies maintain storage, blending and bagging facilities designed to package a wide range of fertilizer types with a comparatively small tonnage of fertilizers each. Zschernitz (11), in discussing marketing of fertilizers through local stocks in Kenya, has concluded that this is the most successful method for a country at Kenya's level of development.

Chege and Ascroft (12) have indicated the problem of marketing fertilizers in 50 kg and 100 kg units which makes them difficult to transport in areas where roads are poor and distances to a stockist are far. They have called for packaging in smaller and more manageable units.

United Nations (FAO, 13) studies have been concerned mainly with demonstrations of fertilizer applications, especially in Western Kenya.

Zschernitz and Okalo (14) have discussed FAO fertilizer programs in respect to soil fertility. Louis (15) in his brief study of diffusion of the use of fertilizers and development in Ethiopia, Kenya and Madagascar, contends that FAO-sponsored fertilizer programs have boosted the sale of fertilizers, but it is the large farms which invest most in fertilizers.

Muthee (16) concludes that the possible prerequisites for a successful non-farm input distribution by an agricultural cooperative are timely estimates, timely procurement of adequate quantities supported by provision of adequate storage, transport facilities, a reasonable credit and pricing policy.

The pricing of fertilizer is left to the fertilizer companies which sell their fertilizers to three agents appointed by the government viz. Kenya Farmers' Association (KFA), Mackenzie (K) Ltd. and Kenya National Federation of Cooperatives (KNFC). KNFC serves coffee unions only.

Government has been concerned with the pricing of fertilizers as well as the level of fertilizer subsidy. The studies undertaken on behalf of the government on these two issues have not been unanimous. ILO (8) opposed fertilizer subsidy on equity grounds while the other two select committees (2, 17) recommended it be continued and increased. The Parliamentary Committee (17) further charged fertilizer companies of forming a cartel with parent companies in Europe which prevented them from buying from the cheaper Persian Gulf sources. From above studies we can see that fertilizer studies in Kenya have been fairly general and descriptive. They have mainly focused on the problems of marketing and distribution of fertilizers.

There is a wide gap of knowledge between the farmer and public policy makers who fix product price as well as fertilizer subsidy. Similar gap exists between the farmer, fertilizer companies and credit institutions.

This study, by attempting to derive fertilizer demand at farm level, hopes to contribute some of the quantitative information needed to close this gap. Ogunfowora and Norman (18, 19), using data collected in 1966 from Northern Nigeria have provided similar information. However, the lack of information on fertilizer demand at farm level is not unique to Kenya. Dalrymple (9) has observed that astonishingly little seems to have been written about the nature of demand for fertilizer at the farm level.

Objectives

1) To identify the major constraints for fertilizer use on the farm level as perceived by farmers.

2) To generate farm plans for a set of representative farms which will maximize gross margins within a set of objective and subjective constraints.

3) To derive a series of demand responses for fertilizers under various policy alternatives. These policy alternatives include price support, fertilizer subsidy, interest rate on seasonal credit and a combination of price support and fertilizer subsidy.

4) To evaluate the potential of various policy alternatives (See 3) on fertilizer which could be used to close the gap between what farmers are doing and the potential production and thus provide the framework for policy manipulations desired to achieve expanded food production and farm incomes.

Area of Study

The study area will be the central province of Kenya. Central province covers 13,176 sq. kilometres of Kenya's 582,646 sq. kilometres (20). It consists of five districts viz. Kiambu, Murang'a, Nyeri, Kirinyaga, and Nyandarua (See Appendix I). The primary reasons for choosing this province include:

1) Acute land shortage and high population densities thus reflecting the problems confronting smallholders and indicating the need for land-saving technology.

2) The land holdings are consolidated and individually owned.

3) Smallholder development has been undertaken for over twenty years.

4) The researcher comes from this area, knows it well and would have no language problem.

Methodology

In this study, to achieve our stated objectives, we shall make use of a farm sample survey, static linear programming and parametric linear programming. The discussion that follows shows how these techniques will be used to achieve our objectives.

a) Farm Survey:

In order to achieve our first objective of identifying the major constraints for fertilizer use on the farm level as perceived by farmers, we shall undertake a farm survey.

A census of the 250-300 households contained in the national sample (See below) for the central province will be undertaken. The data collected here will be mainly attitudinal data pertaining to farmers' perceptions of or level of understanding of profitability of fertilizer use, reliability of fertilizer delivery system, their view of extension service, availability of credit and attitudes towards risk.

The information gathered from farm survey will be of help in our construction of constraints for use in our static linear programming.

b) Static Linear Programming

Our second objective will be achieved through the use of static linear programming techniques.

The linear programming model will be of the form:

$$\begin{aligned} &\text{Maximize} && G = CX \\ &\text{Subject to:} && AX \leq B \\ &\text{and} && B \geq 0 \\ & && X \geq 0 \end{aligned}$$

Where G = objective function to be maximized
X = set of decision variables
C = vector of activity prices
B = vector of resources availabilities

The input-output data, input prices and output prices to be used in the above model will be obtained from the Integrated Rural Survey (IRS) of Central Bureau of Statistics (CBS). The CBS national sample consists of 1656 households in 138 sub-locations equally distributed among the six major provinces. The sample is stratified into 12 cropping zones. As mentioned above, our interest will be in all the households from the central province. The data of interest will be that of 1975-76 crop year.

The CBS data is gathered over a continuous basis with monthly visits to each farm in the sample. Certain entries such as capital stock, inventories, livestock numbers are filled in the questionnaire at the beginning of the period and at the end of the period. Observations are made for each enterprise viz. hybrid maize, local maize, coffee, cotton, pyrethrum, tea, improved and unimproved dairy cattle. For each enterprise labor inputs and all quantities of other inputs used, all output produced, the cash value of these outputs and the distribution of the outputs between home use and market, debt obligations and sources are all recorded. Labor inputs are differentiated into family and hired labor. Demographic characteristics and other socio-economic variables are included.

These data will be supplemented where necessary by data from such institutions as experiment stations, major fertilizer distributors appointed by the Kenya Government, namely Kenya Farmers' Association, Mackenzie (K) Ltd., Kenya National Federation of Cooperatives, fertilizer companies and through discussion with agriculturalists familiar with smallholder agriculture in Kenya.

As mentioned earlier our model constraints will be constructed with the help of the information gathered from farm survey.

The objective function to be maximized in the programming model is "gross margin" which is defined as total receipts less variable production costs. The concept of gross margin is preferred over other indicators because smallholders own most of their resources and relatively few inputs are purchased. Also, the CBS data, which will provide the empirical basis for this study, uses gross margins.

For programming purposes we shall stratify the farms into ecological zones such as star-grass zone, the cofee-banana zone and high bracken zone of central province. We shall then program the representative farm. The debate on the choice of representative farm is unsettled. Clayton (21), using Kenyan experience, has contended that ecology and the land/labor ratio are the two most important factors in defining group homogeneity. Heady et al. (22) used the means and modes of several characteristics for constructing representative

farm. Thus, resource restraints used in programming optimal plans can be determined from averages of characteristics of sampled farms in each stratum.

Clayton's and Heady's approach will be employed in this study. Our stratification of farms using ecological zones as above is useful in that our results can be generalized to other parts of Kenya having similar ecological zones and agricultural enterprises.

c) Parametric Linear Programming:

Our third and fourth objectives will be attained through use of parametric linear programming. Through this technique we hope to determine various demand responses for fertilizer under:

1) Varying fertilizer subsidy levels holding all other prices constant.
2) Varying product prices holding all other prices constant.
3) Varying interest rate for seasonal credit holding all other prices constant.
4) A combination of various subsidy levels and product prices holding interest rate for seasonal credit constant.

This technique gives us "stepped" demand functions. Those demand responses are normative, since they indicate farmers' potential responses under assumptions of gross margin maximization and perfect knowledge in respect to prices and technological changes. However, these demand responses can indicate sufficient guidance to the expected fertilizer demand given levels of fertilizer subsidies, product prices, and interest rates for seasonal credit.

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APPENDIX I:

Administrative map of Kenya

CENTRAL PROVINCE.