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FARM SUPPLY RESPONSE IN KENYA: ACREAGE ALLOCATION MODEL

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FOREWORD

Understanding the nature and dimensions of the world food problem and the policies available to alleviate it has been the focal point of the IIASA Food and Agriculture Program since it began in 1977.

National food systems are highly interdependent, and yet the major policy options exist at the national level. Therefore, to explore these options, it is necessary both to develop policy models for national economies and to link them together by trade and capital transfers. For greater realism the models in this scheme are being kept descriptive, rather than normative. In the end it is proposed to link models to twenty countries, which together account for nearly 80 per cent of such important agricultural attributes as area, production, population, exports, and imports.

A model for Kenya is being developed at IIASA. This model will provide a prototype for African developing countries with growing populations and emerging development problems.

The present report by Narayana and Shah presents the results of work on farm supply response in Kenya. As understanding farmers' behaviour in response to various possible policy instruments is a critical part of much of agricultural policy analysis, this work explicitly considers the small farm - large farm structure of the Kenyan agricultural scene. The study is a significant element of the IIASA agricultural policy model for Kenya.

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Rationality and fairness require that the authors alone should put up with credit or discredit for this work.

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1. Introduction

Agriculture is a major sector of the Kenyan economy. In order to make an appropriate policy analysis towards Kenyan economic development and in particular Kenyan agricultural development it is essential to understand the effects of various policy instruments on the agricultural supply. This implies a detailed study of farmers behaviour in allocating their limited lands to growing various crops, their risk taking enterpreneurship in an uncertain environment of future prices and yields and application of inputs like fertilizer, capital, labour, etc.

In this paper we aim to study the acreage response of Kenyan farmers. All major crops in the small and large farm sector are considered. We believe that Kenyan farmers are rational and they respond to various signals in the economy and formulate their own expectations on the revenue they obtain by growing different crops taking into account rainfall, soil conditions, etc.... The study on application of non-land inputs and the yield response is described in Fischer and Shah (1982).

African farmers are rational. Alibaruho (1974) provides an excellent survey on this issue, and summarizes as: "There has been a "positive" phase in which the issue has been to determine what African farmers do under different economic situations....and a "hypothesis testing" phase in which the issue has been to determine why African farmers do things the way they do".

Many of the "hypothesis testing" studies of African farmers may be divided into three categories, namely:

(1) rational response to price changes

(2) inverse relationship between market surplus and price

(3) institutional constraints prohibiting any price response

We believe that even an institutional constraint like producing for self-consumption is very much a rational response because it represents the farmer's choice in regard to what to sell (to make profits) and what to buy (for own consumption), given the knowledge of taxes, subsidies, trade margins and transport costs.

The rest of this section is devoted to describing the Kenyan agricultural scene providing a brief review of the existing literature in the present context. The present study differs from these past studies in the sense that we have considered all major crops in the small and the large farm sector in an integrated model and also that the whole time series of information to date has been used. In section 2, we briefly present the traditional Nerlovian model for supply response followed by some methodological issues of our model. Details of the data base of the present study are described. In Section 3 the results are given and in Section 4 the policy conclusions and limitations of the study are discussed.

1.1. Kenyan Agricultural Sector

Kenya's agricultural production roughly doubled over the last 20 years. The agricultural sector in Kenya forms the backbone of the Kenya economy in a number of ways. First, more than 80% of the population derives their livelihood from this secctor. Second, this sector accounts for more than 65% of the foreign exchange earnings of Kenya. This foreign exchange is essential for the imports of many non-competitive goods which are crucial for the rapid development of the Kenyan economy. During the period 1961 to 1976, the share of agriculture in total GDP fell from 42% to 38% whereas the share of manufacturing rose from 9% to 12%.

In comparison to most other countries in tropical Africa, Kenya's agricultural sector is perhaps the most developed. For example in this region, Kenya is the only country with land adjudication and registration. The intensity of land use and husbandry are higher than anywhere else in tropical Africa. However, the level of agricultural technology, though relatively sophisticated in comparison to most countries in the region, the intensity of input use is well below what is required for meeting the needs of the future for agricultural products. The food requirements are especially important in the light of the recent estimates of population growth of the order of 3.9% per annum, (Central Bureau of Statistics, (1979)).

Agriculture in Kenya has a dual character. On one hand there are nearly one and a half million small farms, the majority less than 2 ha. and very few more than 5 ha. in size. On the other hand there are some three thousand large farms: 70% of these have an average size of 160 ha. and for the remaining 30% the average size is about 2500 ha. Table 1 shows acreage of the main crops in the small and large farms, for the years 1963 (independence year) and 1975.

Table 1. Small Farm and Large Farm Acreage Under Principal Crops, 1963 and 1975

Crop	Large Farms '000 ha		Small Farms '000 ha	
	1963	1975	1963	1975
Maize	45	68	955	1391
Wheat	113	90	1	21
Rice	-	-	2	6
Sorghum/Millet	1	1	353	281
Barley	18	26	n.a.	n.a.
Pulses	1	2	615	690
Roots	1	1	113	231
Sugarcane	18	32	5	62
Coffee	31	28	49	73
Tea	18	26	4	37
Sisal	109	74	-	-
Pyrethrum	12	4	8	33
Cotton	-	-	58	68

Our approach is to model the supply response for small and large farms separately.* The distinction between small and large farmers is an essential one from the viewpoint of policy analysis. Historically many of the agricultural policies and in particular produce price policies and trade policies were formulated on the basis of the large farms. But these policies could have had an important impact on the acreage response of small farms. The small farm sector has increased its share of marketed production from 18% in 1954 to 51% in 1976. This group accounted for 7% and 28% of total fertilizer use in 1961 and 1976 respectively. However, fertilizer application in the small farms in 1961 and 1976 was 1kg/ha and 13 kg/ha respectively in comparison to 82 kg/ha and 298 kg/ha in the large farm sector. Hence from the pattern of overall resource usage, it is also necessary to differentiate between the supply response of these two farm types. In the early 1970's some of the mixed large farms** were subdivided into small farms; however further subdivision of large farms, especially the plantations, is unlikely at least in the foreseeable future.

1.2. Previous studies on Kenyan Farmer's Response:

Though there are a large number of studies on the African farmers' decision behaviour in the context of allocation of their scarce resources, attitudes towards risk and acreage and output response with respect to price, only a few of them dealt with Kenyan agriculture in particular. For a detailed review of some of these studies, readers may refer to G. Alibaruho (1974). Here, we only discuss briefly some literature available on the Kenyan agriculture.

Maitha (1974) studied maize and wheat production response with respect to price. His study used the data on large farms for the period 1954-1969. He adopted the traditional Nerlovian model, in estimating the acreage of wheat and maize separately, with the difference that farmers' price expectation was specified as a distributed lag model with a known lag. Wheat and maize were treated as mutually competing crops. However, he used ordinary least squares in estimating the final reduced form where acreage under the crop in the previous year, a lagged dependent available, appeared as an explanatory variable. Also possibility for auto correlation was not checked. Maitha's parameter estimates should be considered in the context of these limitations especially with a small sample. The results indicated that Kenyan farmers do respond to price changes and in general the price elasticity is higher for maize compared to wheat.

Maitha's (1974) study on coffee in the Kenyan economy, involved setting up a CES production function and assuming that coffee farmers behave rationally, marginal product of acreage was equated to rental of land. This resulted in a demand equation for land as a function of expected output and ratio of expected land rental to expected output price. While the expected output was speciffed to be merely the last years output, the latter ratio was specified as to follow a Fisher lag scheme. Maitha estimated the demand equation for land for the coffee industry as a whole, for large farms and small farms separately. The price effect was found to be significant for all the three groups. However, apart from not checking for auto-correlation etc...., the inclusion of an expected output variable in the regression is rather unsatisfactory. D.J. Ford (1971) commented rightly, that when the acreage functions are taken together with their yield levels also, a simultaneous equations model might be necessary to derive

* In addition to these two farm types, there are also a small number of "gap" farms; however data for these farms is not available and hence are not considered in the present study.

** Mixed farms are defined as crop and livestock (dairy and meat) farms the appropriate long-run elasticities.

J.M. Wolgin (1975) studied the Kenyan small farmers attitude to resource allocation in the environment of risk. The objective function was to maximize farmers' expected utility (a function of expected income y, and the variance σ_y^2 of it) rather than income, subject to production and resource constraints. The marginal increments to risk of increased production of a crop, were computed, as

$$S_j = \text{marginal increment risk of increased production of crop } j = \frac{\partial(\sigma_y^2)}{\partial Q_j}$$

where

Q_j = production of crop j and y = total income

Now given the production functions of two crops (j = 1, 2 say)

$$g_j = g_j(\text{land}_j, \text{inputs}_j)$$

then, through his model Wolgin derived that

$$\frac{\partial g_1}{\partial(\text{land}_1)} P_1 \geq \frac{\partial g_2}{\partial(\text{land}_2)} P_2 \quad \text{as} \quad S_1 \gtrsim S_2 \ ;$$

g_j were estimated as Cobb Douglas production functions to obtain marginal product of land and other inputs. To obtain S_j Wolgin estimated the following output and price equations:

$$Q_{jt} = a_{0j} + a_{1j}t + a_{2j}P_{j,t-1} + u_{jt}$$

$$P_{jt} = b_{0j} + b_{1j}t + \text{bsub2j}P_{j,t-1} + v_{jt}$$

where $Q_{j,t}$ and $P_{j,t}$ are output and price variables of jth crop and t = time.

Wolgin's simple and elegant approach concluded that Kenyan farmers are willing to grow high risk crops only if they get a higher payoff in expected return. However, unfortunately Wolgin did not present the results of production functions and output and price equations mentioned above, so as to judge the specification biases involved on which his results had a bearing.

Etherington's (1973) study on smallholder tea considered a multiperiod production function where the age distribution of the stock of trees and changes in technology were explicitly considered. Unfortunately in this study no price variable figured in and consequently a clear acreage and production response to price variables could not emerge. Also this aspect makes this study unsuitable for studying the affects of price policies.

It may be noted that much of the above literature on Kenyan agricultural response is outdated as their data base ended with the time period just about Kenya's independence in 1963. Wolgin's study was based on cross section data for 1968/69 Small Farm Survey and hence many impacts due to the structural changes since the independence were not reflected. Besides many of the past studies were only with respect to some specific crops and with either of the farm types: large and small.

2. The Model and the Methodology

2.1. Model

The traditional Nerlove model, originally formulated for a study on the dynamics of supply in U.S. agriculture (Nerlove, 1958) is as follows:

$$A_t^* = a_o + a_1 P_t^* + U_t$$

$$P_t^* = \beta P_{t-1} + (1-\beta) P^*_{t-1}, \qquad 0 < \beta \leq 1$$

$$A_t = (1-\gamma) A_{t-1} + \gamma A^*_t, \qquad 0 < \gamma < 1$$

where

* refers to desired or expected long run equilibrium values

t refers to time period

A_t and P_t refer to acreage and price of the crop respectively

β and γ refer to price expectation and acreage adjustment coefficient respectively.

The interpretation of the Nerlove model equations and the associated estimation problems have been much discussed in the literature, (see Nerlove (1958), Askari & Cummings (1976), Narayana and Parikh (1981)) and a repetition is avoided here.

The merit of the Nerlovian framework is that its underlying assumptions suit to a straight forward application of the model to even developing economies. However, Narayana and Parikh (henceforth N-P) (1981) experienced some problems when they applied the Nerlove model to study the farmer's acreage response in India. In their cropwise study such an application was reported to have yielded the estimate of β, the price expectation coefficient, to be always equal to one for all crops. N-P argued "accepting these estimates would have meant that farmers in India have only naive expectations."

It may be noted that N-P (1981) considered revenue, instead of price, as an index for profit because in a dynamic framework changes in yield levels also affect profits. However, according to them, even when price alone was taken to be an index for profit the results were similar. They then formulated the revenue (or price) expectation equation differently arguing that "The presence of a secular trend in the revenues could lead to a result when β would exceed 1. If expectations reflect secular trends in relative revenue it seems reasonable to assume that farmers observe the levels of prices and revenues over time and are also aware of any random shocks (which may be of a short-term nature) to which the variables have been subjected. The future expected price or revenue should adequately account for this process of movement and occasional random shocks.

An ARIMA model seemed to be more satisfactory:

$$P_t^* = P_t - W_t = \varphi_1 P_{t-1} + \varphi_2 P_{t-2} + \varphi_3 P_{t-3} + \ldots + \mu + \vartheta_1 W_{t-1} + \vartheta_2 W_{t-2} + \vartheta_3 W_{t-3} + \cdots +$$

where

P_t^* is the expected price,

P_t is the actual price,

W_t, the difference between actual and expected price, is a white noise

μ is a constant."

Later they also show that Nerlovian formulation of the expectation equation is only a special case of an expectation equation formulated as an ARIMA model.

In view of the above mentioned arguments, we follow the same methodology of the NP model for the present Kenyan study too. We replace the price expectation equation of the Nerlove model as an ARIMA equation. As a first step, this equation has been estimated by Box Jenkins procedure and then, as a second step, the appropriately modified reduced form equation of the Nerlove model is estimated. So the model now looks as follows:

1st step: Revenue§ Expectation

$$\Pi^*_t = \Pi_t - W_t = \Phi_1\Pi_{t-1} + \Phi_2\Pi_{t-2} + \Phi_3\Pi_{t-3} + \cdots \qquad (2.4)$$
$$+ \mu + \vartheta_1 W_{t-1} + \vartheta_2 W_{t-2} + \vartheta_3 W_{t-3} + \ldots..$$

2nd step: Acreage Response

$$A^*_t = a_o + a_1\Pi^*_t + a_2R_t + U_t \qquad (2.5)$$

$$A_t = (1-\gamma)A_{t-1} + \gamma A_t^* \ldots, \qquad 0 < \gamma \leq 1 \qquad (2.6)$$

where

Π^*_t refers to expected revenue

R_t refers to rainfall

U_t refers to random disturbance and the remaining variables being as explained earlier. On substitution, a reduced form equation can be written out as follows:

$$A_t = a_o\gamma + (1-\gamma)A_{t-1} + a_1\gamma\Pi^*_t + a_2\gamma R_1 + \gamma U_t \qquad (2.7)$$

2.2. Estimation

Equation (2.4) has been estimated using Box-Jenkins methodology. The essence of such a formulation of the expectation is to forecast the value of a variable by identifying the stationary and random components of each past value of it. An Auto Regressive Integrated Moving Average Process (ARIMA) can be written for a time series constituting a discrete linear stochastic process (X_t) as:

$$X_t = \Phi_1X_{t-1} + \Phi_2X_{t-2}\,P + \Phi_3X_{t-3} + \ldots. + \kappa + \vartheta_1W_{t-1} + \vartheta_2W_{t-2} + \cdots$$

where

W_t is white noise or random disturbance in period t

k is a constant that determines the mean level of the time series process.

For each crop an appropriate ARIMA scheme constituting p, q and d, where p is the number of lagged dependent variables, q is the number of moving average variables and d is the degree of differencing has been identified and selected which satisfied a diagnostic checking consisting of:*

(a) stationarity conditions of the estimated series implying certain restrictions on the values of parameter estimates, and also

(b) a X^2 (chi-square) test based on the residual auto correlations.

One interesting feature observed during this part of our study was that the finally identified ARIMA scheme, while for most of the crops, turned out to be with reasonable values of p, q and d (ie. p and q < 2 and d < 1), for pulses and coarse grains the scheme, satisfying the diagnostic checking mentioned above

§ For some crops, equivalent expected price (P^*_t) and/or expected yield (Y^*_t) models instead of expected revenue (Π^*_t) model.

* See Box and Jenkins (1970) and Nerlove (1971)

turned out to contain a large value of q (the number of moving average terms).

Results of the selected schemes are given in Table 3 and 4 for the large and small farms respectively. The computed forecast values of the expected revenue (or expected price, or expected yield, as the case may be) over the data period have been used in estimating the equation (2.7), the reduced form of

Table 2. Data Sources: Area*, Production, Price and Rainfall*****

crop	time series period	source
L.F. Wheat	1957-68	Economic Review of Agriculture, 1963, 1968.
L.F. Wheat	1969-76	National Wheat Board
S.F. Wheat	1961-76	National Wheat Board, Economic Reviews of Agriculture 1969-76, Economic Surveys 1974-76
L.F. Maize	1954-67	Economic Review of Agriculture 1963, 1968
L.F. Maize	1968-76	Maize and Produced Board, Food & Marketing Project
S.F. Maize	1961-76	FAO data, Maize and Produce Board, Surveys (1968/9, 1974-77) of small farms, Economic Reviews of Agriculture 1969-76
S.F. and L.F. Coffee	1954-67	Economic Review of Agriculture 1963,1968
S.F. and L.F. Coffee	1968-76	Economic Reviews of Agriculture 1969-76, Economic Surveys 1968-76, and Kenya Coffee Board
L.F. Tea	1954-68	Economic Review of Agriculture 1963, 1968
S.F. Tea	1959-68	Economic Review of Agriculture 1963, 1968
S.F. and L.F. Tea	1969-76	Economic Reviews of Agriculture 1969-76 Economic Surveys 1968-76, and Kenya Tea Board
S.F. Rice	1961-76	National Cereals and Produce Board, Kenya Statistical Abstracts 1968-76
L.F. Sisal	1954-76	Kenya Sisal Board, Economic Reviews of Agriculture, 1963, 1968, 1969-76, Kenya Statistical Abstracts 1968-76
S.F. & L.F. Pyrethrum	1958-76	Kenya Pyrethrum Board, Economic Reviews of Agriculture 1963, 1968, 1969-76
L.F. Barley	1957-76	Kenya Breweries, Economic Reviews of Agriculture 1963, 1968,1969-76, and FAO
S.F. Cotton	1961-76	Cotton Lint and Seed Marketing Board, Economic Reviews of Agriculture 1963, 1968, 1969-76
S.F. Pulses	1961-76	FAO, National Cereals and Produce Board, 1968-69 and 1974-77 Survey of Small Farms, Food & Marketing Project
S.F. and L.F. Sugar	1961-76	Economic Reviews of Agriculture 1968, 1969-76 and Economic Surveys 1968-76

S.F. Roots	1961-76	FAO, 1968/9, and 1974-77 Surveys ofSmall Farm
S.F. Sorghum/Millet	1961-76	FAO, 1968/9, and 1974-77 Surveys of Small Farm Economic Reviews of Agriculture 1969-76
S.F. Fruits	1961-76	FAO
L.F. Pineapples	1958-76	Economic Review of Agriculture, 1963,1968 Horticulture Development Study, Ministry of Agriculture
S.F./L.F. Wattle	1961-76	Kenya Statistical Abstract 1968-76 Economic Reviews of Agriculture 1968, 1969-76
S.F./L.F. Vege. Oils	1961-76	FAO

* Large Farm Area: Agricultural Census of Large Farms 1962-76. The 1962-64 issues also gives data on commodity wise revenue (and production).

** Price information from Kenya Statistical Abstracts 1961-76, various commodity Boards as mentioned above and FAO

*** A first approximation derived on the basis of annual rainfall by main stations, Kenya Statistical Abstract 1966-76. Large Farms: The Agricultural Census of Large Farms gives commodity-wise acreage in each district. The main rainfall time series for each main station in these districts was weighted by the commodity acreage to arrive at a commodity wise rainfall series. For the small farms district-wise time series on acreage is not available. District level information from 1968/69 small farm survey and the province level information from 1974/5 IRS Survey was used to derive acreage weights for main stations in the small farm areas. The procedure adopted here is approximate and will be modified when the analysis of Kenya rainfall time series data from the Ministry of Agriculture, Nairobi, becomes available.

L.F. Large Farms
S.F. Small Farms

Table 3. LARGE FARMS

	ARIMA SCHEME	φ_1	φ_2	φ_3	μ	ϑ_1	ϑ_2	ω_{1974}	ω_{1975}	ω_{1976}	χ^2	d.f*
												23
WHEAT												
Price	111	1.8455	-0.8455			0.3303		111.835	-12.507	0.0	4.972	20
Yield	110	0.9191			0.1066	0.4699		0.304	0.058	-0.013	6.893	20
Revenue	111	0.5179	0.4821			-0.7585		196.266	172.811	0.0	8.551	20
MAIZE												23
Price	210	0.7090	0.0615		89.2510	-1.0475		89.926	161.832	-16.007	4.935	19
Yield	120	0.8199			0.3824	-0.0034	-0.2630	-0.048	0.042	0.229	5.919	19
Revenue	121	1.1048	-0.1048			-0.1513	-1.1058	463.010	-1.295	0.0	3.873	19
COFFEE												23
Price	101	1.3524	-0.3524					301.052	14337.735	0.0	2.378	21
Yield	200	0.5301	0.3880		0.0732			-0.094	-0.020	0.353	9.152	20
Revenue	101	1.0679	-0.0679					917.428	24237.057	0.0	1.521	21
TEA												19
Price	120	-0.0424			76.364	-1.2272	-1.1863	7.8870	6.5990	15.3070	3.171	15
Yield	110	0.9126			0.1109	0.2524		-0.028	-0.010	0.054	4.919	16
Revenue	101	0.8213	0.1787					13.9110	44.6400	0.0	7.785	17
Expt.Price	211	1.2834	0.2643	-0.5476		-0.2693		3.7720	9.6040	0.0	5.620	15
PYRETHRUM												19
Price	210	1.2726	-0.7203		17.2405	-0.1176		14.733	24.381	58.717	5.705	15
Yield	120	0.6078			2.2363	0.1548	-0.8433	0.498	-0.057	0.874	3.690	15
Revenue	110	0.9082			203.2782	-0.2916		190.546	-66.746	849.922	3.679	16
SISAL												23
Price	210	1.5388	-0.8457		472.8668	0.7690		1977.362	-717.026	62.078	4.184	19
Yield	200	0.6494	-0.3286		0.3814			-0.004	0.021	-0.103	4.393	20
Revenue	100	0.6394			321.8295			1763.604	-239.637	-473.505	1.586	20
BARLEY												20
Price	101	1.8362	-0.8362					34.7624	69.7275	0.0	7.741	18
Yield	211	0.9824	-0.6001	0.6177		0.2893		0.182	0.360	0.0	7.867	16
Revenue	201	1.6883	-0.4491	-0.2391				53.758	274.284	0.0	3.127	17
SUGAR												16
Price	200	1.7991	-0.8885		4.574			8.458	19.666	-6.004	1.844	13
Yield	100	0.7796			6.9593			3.260	5.394	1.179	5.462	14
Revenue	101	1.4761	-0.4761					1207.886	-184.488	0.0	4.054	13
PINEAPPLES												19
Price	101	1.9838	-0.9838					26.070	75.475	0.0	4.010	17
Yield	200	0.7216	-0.0325		4.6036			-0.002	-0.002	-0.002	4.308	16
Revenue	101	1.9838	-0.9838					385.860	1116.945	0.0	4.007	17

* Underlined numbers refer to number of observations

** Oats "Revenue": $\vartheta_3 = 0.0057$

Table 4. SMALL FARMS

	ARIMA SCHEME	φ_1	φ_2	φ_3	μ	ϑ_1	ϑ_2	ω_{1974}	ω_{1975}	ω_{1976}	χ^2	d.f
MAIZE												16
Price	110	0.7905			83.8821	-1.0554		99.788	142.013	-19.526	1.256	13
Yield	200	0.5940	0.3167		0.1103			-0.129	0.471	0.145	6.173	13
Revenue	120	0.6923			159.0831	-1.1716	-1.7688	75.166	148.558	-20.777	1.580	12
COFFEE												23
Price	101	1.3524	-0.3524					301.052	14337.735	0.0	2.378	21
Yield	120	0.4192			0.2385	-0.4038	0.3399	0.075	0.004	0.068	6.655	19
Revenue	101	0.6170	0.3830					-347.494	6815.191	0.0	4.999	21
TEA												19
Price	120	-0.0424			76.3641	-1.2272	-1.1863	7.8870	6.5910	15.3070	3.171	15
Yield	110	0.8605			0.0688	0.1129		-0.170	-0.050	0.041	5.727	16
Revenue	120	0.9416			2.0672	-0.1644	0.4031	-4.1890	3.6620	15.6190	7.455	15
Expt. Price	211	1.2834	0.2643	-0.5476		-0.2693		3.7720	9.6040	0.0	5.620	15
PYRETHRUM												19
Price	210	1.2726	-0.7203		17.2405	-0.1176		14.733	24.381	58.717	5.705	15
Yield	120	0.1409			3.8448	-0.2279	-0.0861	0.762	1.952	0.168	4.571	15
Revenue	200	0.6355	-0.0102		65.1257			411.394	880.501	162.284	5.263	16
WHEAT												16
Price	101	1.8185	-0.8185					53.118	-42.885	0.0	1.72	14
Yield	121	-0.2150	1.2150		0.0	-1.5555	-1.1025	0.034	-0.017	0.0	4.10	12
Revenue	110	0.8807			51.9878	-0.2903		152.458	432.996	-136.470	1.47	13
RICE												16
Price	111	0.8812	0.1188			-0.8711		364.190	61.112	0.0	1.519	13
Yield	110	0.8255			0.9078	0.5660		-0.591	-0.630	0.260	1.835	13
Revenue	101	1.7670	-0.7670					1807.358	1005.479	0.0	3.866	14
PULSES												16
Price*	151	1.6780	0.6780			-0.0210	-0.8673	7.999	7.418	0.0	0.722	9
Yield	200	0.0530	-0.4837		0.6934			0.061	0.018	-0.019	5.294	13
Revenue	201	1.5339	-0.3463	-0.1876				-1.677	2.034	0.0	3.729	13
ROOTS												16
Price	101	1.7936	-0.7936					26.668	58.383	0.0	6.429	14
Yield	100	0.4436			3.8128			0.238	-0.128	0.068	3.773	14
Revenue	101	1.5190	-0.5190					158.378	581.516	0.0	5.209	14
COTTON												18
Price	200	1.8018	-0.9519		177.6095			286.725	98.260	-72.665	5.622	15
Yield	120	0.2055		0.1769	-0.1726	-0.0204	0.041	-0.002	-0.005	3.596	5.209	14
Revenue	110	-0.3368			320.7541	-1.0202		34.751	31.957	86.251	3.832	15
COARSE GRAINS												16
Price**	151	1.6788	-0.6788			-0.0231	-0.8751	3.844	3.668	0.0	0.726	9
Yield	110	0.6452			0.3139	0.2690		-0.057	0.048	-0.051	1.987	13
Revenue	200	1.6686	-0.8156		47.7830			58.522	113.103	10.475	2.947	13
SUGAR												16
Price	200	1.7991	-0.8885		4.5740			8.458	19.666	-6.004	1.844	13
Yield	110	0.8962			3.2297	0.3824		7.230	6.999	2.381	3.930	13
Revenue	120	0.9981			3.1801	-0.3475	-0.9866	343.842	546.410	-26.461	2.520	12

* Pulses "Price": $\vartheta_3 = 1.0559$, $\vartheta_4 = -0.4140$, $\vartheta_5 = -0.5654$.

** Coarse Grain "Price": $\vartheta_3 = -1.0324$, $\vartheta_4 = -0.4141$, $\vartheta_5 = -0.5392$.

In estimating the acreage response models for the small and large farms, substitutability between crops competing for the same land has to be taken into account. Such substitution pattern varies from district to district and province to province in Kenya due to ecological, agro-climatic and social conditions. However, the present study being an aggregate study at the national level, an overall substitution pattern at the national level had to be arrived at. This pattern, in the context of the present study, was formulated by considering the nature of the soil, sowing and harvesting seasons of various crops grown in different provinces of Kenya and the importance of these provinces with regard to each crop at the national level. Essential information and data from which the substitution/competition patterns were derived, is given in Appendix A1. A separate study which arrives at an "optimal" substitution pattern based on ecological and agro-climatic considerations is underway, see (Shah and Fischer (1982)).

Before we go on to the results part, let us point out one aspect of the acreage under the two types of farms. There were instances in the past where some of the large farms were purchased by the Government and Cooperatives and subdivided into small farms. This process automatically would show a decrease in the large farms acreage data and a corresponding increase in the small farms data. In the present study this aspect was not explicity considered because the available data on such shifts are not reliable and the overall situation, (see Table 5), seems to suggest that such shifts did not significantly affect the acreage in the two farm types.

Table 5. Large Farms Holdings: Kenya 1961-1976
1963 = 100

Year	No. of holdings	Total Area	Area under temporary and permanent crops
1961	99	106	107
1962	98	105	104
1963	100	100	100
1964	81	93	94
1965	84	93	112
1966	83	89	101
1967	82	91	105
1968	81	90	100
1969	83	90	101
1970	86	91	101
1971	86	91	98
1972	86	91	98
1973	86	90	96
1974	88	90	101
1975	89	90	103
1976	89	90	109

3. Results

The estimated model equations for large and small farms given in Table 6 and 7 respectively, are discussed below.

3.1. Large Farms

3.1.1. Wheat

Most of the wheat in Kenya is grown on high and medium potential land by large scale farmers using mechanical equipment for cultivation, harvesting and handling. There is considerable ongoing research into the possibilities of small scale wheat production. At the present time the new "wheat lands" in the Narok district are being opened up for smallholder wheat production.

Data on wheat acreage show that during the sixties the acreage increased at about 6% annually, whereas during the early seventies it declined almost at the same rate. It may be noted that maize is a major competitive crop for wheat. In explaining wheat acreage, rainfall and expected price of wheat relative to that of maize have been included in the regression equation along with the previous year's acreage. All the coefficients except that of rainfall turned out to be significant. Also, the estimate obtained for area-adjustment parameter (γ) implies that though farmers could not achieve their desired levels of acreage, they could adjust in the desired direction.

3.1.2. Maize

Maize is the staple food in Kenya and about 5% of the total national maize area is under large farm cultivation. Most of the large farm production of maize is marketed through the Maize and Produce Board and in the past this has been a significant (about 50%) proportion of the official marketed maize because most of the maize produced in small farms is retained for self-consumption.

In explaining maize acreage, again competition between maize and wheat has been considered, and expected price of maize relative to that of wheat has been included as the explanatory variable, along with the previous year's acreage. Here the $\bar{R}^2$ obtained is rather low and even the t-coefficient for the relative price coefficient is significant only at 10%. When the relative price of maize has been replaced by only the expected price of maize the $\bar{R}^2$ improved a little and the t-coefficient for the expected price turned out to be significant at 5%. In explaining maize acreage in large farms, its own price rather than the competition between maize and wheat seems to be more relevant.

3.1.3. Barley

Large farms have been the major suppliers of barley for brewing of beer and barley has not traditionally been a staple food in Kenya. The small farms have recently begun to participate in barley production through contracts with the breweries.

In explaining barley acreage two estimated equations are reported. In the first equation the explanatory variables consisted of the previous year's acreage, expected price and expected yield of barley separately. Due to possible multicollinearity between yield variable and rainfall, the rainfall term has not been included. Results show that expected yield is a significant variable whereas expected price is not significant (but only a relevant variable in the sense of the corresponding t-coefficient is greater than one). Somewhat preplexing result is the low value of the estimate of the area-adjustment parameter (γ = 0.3024), though data show considerable variation over time in barley acreage.

In the second equation the explanatory variables were the expected relative price and expected relative yield with respect to wheat. The coefficient of the former is significant at 5% and latter is not significant. As in the first equation the value of area adjustment parameter suggests that the farmers were not able to acheive the desired barley acreage.

3.1.4. Sugarcane

Factory estates and large farms have been the main producers of sugarcane in Kenya in the past, though during the last five years or so smallholders and cooperative societies have also become important producers. Government policy on sugarcane producer prices was such that there was only a little variation in sugar price over time upto 1973, though there has been a steep rise later. But acreage data show certainly a trend in it over time. Besides, it may also be noted that, in some parts of Kenya, (e.g. Nyanza and Coast Provinces which are two main large farm sugar producing areas) there has been competition between maize and sugarcane. In view of this, a time variable to explain trend part and relative expected price of sugar with respect to maize have been included as explanatory variables along with the previous year acreage. Both these variables turned out to be significantly positive whereas the coefficient of the previous year acreage turned out to be insignificant. The latter implies that farmers could almost adjust their acreage towards the desired levels.

3.1.5. Coffee

Coffee is by far the most important export crop in Kenya; in 1964 and 1976 coffee accounted for 51% and 68% of export earnings from agriculture. The structure of the coffee production in Kenya is such that there is direct competition between small and large farms. A detailed study of the coffee sector in Kenya and a two-stage least square estimation model for large and small farmers coffee acreage response is reported elsewhere, Shah and Narayana (1982a).

3.1.6. Tea

After coffee, tea is the second most important export crop in Kenya. In 1976, tea exports amounted to about 23% of agricultural export earnings and about 10% of all export earnings. The quality of tea produced on the large estates has contributed to the premium price of Kenyan tea on the world market. Area under tea in the large farm sector increased at an annual rate of 6.08% during 1954-70 and 1-02% during 1970-76. The reduced rate of growth in the latter half is due partly to the government policies on increasing smallholder participation in tea production.

Two equations for tea are reported in Table 6. In the first equation, the explanatory variables were expected export price and previous years acreage. The coefficient is significant at 5% and value of the area adjustment parameter (γ) suggests that the large farmers were not able to achieve the desired acreage. The second equation considered expected producer price and the difference of expected export and expected producer prices as explanatory variables. The coefficients are significant at 10% and 5% respectively. This suggests that large farmers do respond to expected producer price but also take account of the expected export price. This response is in line with the Kenyan Government Tea Board's policy to adjust (after allowance for operating costs of the Board) the producer prices in line with export prices.

3.1.7. Sisal

Sisal is basically a plantation crop produced on the lowlands below 900 meters (e.g. Voi) and on the highlands above 1800 meters (e.g. Thika). Though prior to 1964 large farms gradually increased the acreage under sisal, later however, the acreage showed only an overall declining trend. Government policy has been to encourage producers to maintain production so as to meet the local industrial demand and also in view of export possibilities

During the last two decades there have been large fluctuations in the world market price. Farmers have tended to shift away to other enterprises such as selling the land to new housing complexes (as in Thika, for example) and to industrial complexes (as in Voi, for example) and to a small extent (about 5000 hectares) to cultivate alternative crops (pineapple). Furthermore there are some derelict sisal plantations which are being brought under production (1974-76) as sisal prices become attractive.

In estimating the acreage under sisal, a time trend, expected price and the previous year acreage have been included as explanatory variables. The price coefficient is significant at 10% level whereas the time trend coefficient is significant at 5% level. The estimate of the area adjustment coefficient (γ) implies that farmers have not been able to achieve the desired acreage. The results of the equation suggest that further decline in the sisal acreage will continue, unless in future the government provides incentives for sisal production to at least meet the demand of the domestic processing industry.

3.1.8. Pyrethrum

Kenya produced over 65% of the world's supply of pyrethrum. During the early sixties, most of the pyrethrum production was from the large farms; but at present over 90% of the production is in the smallholder sector. From 1964-1976 the area under pyrethrum in the large farms declined at an annual rate of about 15%.

In view of the changing structure of pyrethrum production in Kenya, previous year share of small farms acreage to the total acreage under pyrethrum in the country, has been considered to be an explanatory variable. Other expalantory variables have been expected revenue and the previous year acreage under large farms. While the share variable turned out to be significantly negative as expected, the coefficient of the expected revenue could be positively significant at only 20% level. The coefficient of the lagged area, is significant, and implies that farmers could not fully achieve the desired acreage levels.

3.1.9. Pineapples

Pineapples are produced under irrigation and the large farm area has increased from about 700 ha in 1961 to 5600 ha in 1976. Although this is a relatively minor crop in terms of crop acreage, large expansions of pineapple acreage in Kenya are expected due to rapidly increasing demand of domestic pineapple processing industry (canned fruit and juice) for exports. For example, the exports of tinned pineapples increased from about 4000 mt to 30000 mt during the period 1961-76.

Here, the crop being only a minor one, the previous year price was itself considered as the expected price. The yield, under irrigation, being fairly without variation, was not included in the equation. The coefficients of the price variable is significant at 5% level and the coefficient of $A_{i,t-1}$ implies that farmers could not achieve the desired acreage, possibly due to limitations of irrigation expansion.

3.2. Small Farms

Results for small farms have been presented in Table 7. In discussing these results, we leave out the self-explanatory ones and also be brief in view of the already provided details under the large farm results.

Table 6. Large Farm Results

Large Farms	$A_{i,t-1}$	Exp. Revenue	Exp. Price	Exp. Yield	Time	Constant	Rainfall	Other Variables	Degree of Freedom	$\bar{R}^2$/(D.W.)	Rho
Sisal	0.7004	--	0.0031**	--	-0.9939*	34.6237	--	--	17	80.27	-0.45
	(8.0658)	--	(1.7232)	--	(-4.6907)	(3.4788)	--	--	--	(1.8134)	--
Wheat	0.4529	--	--	--	--	-26.3603	0.0084	9.7002*[1]	17	76.09	0.95
	(2.6505)	--	--	--	--	(2.7610)	1.3490	(1.9237)	--	(1.3272)	--
Maize	0.4654	--	0.0364*	--	--	17.5202	--	--	18	59.33	0.45
	(2.7556)	--	(2.1887)	--	--	(1.7521)	--	--	--	(1.4491)	--
	0.5306	--	--	--	--	16.1489	--	18.0513**[2]	18	55.95	0.45
	(3.1261)	--	--	--	--	1.4668	--	(1.7439)	--	(1.6689)	--
Barley	0.6976	--	0.0067***	5.3920	--	-6.0605	--	--	14	82.63	0.25
	3.7854	--	(1.0460)	(2.0726)	--	(1.5927)	--	--	--	1.4267	--
	0.8334	--	†16.0299*	†3.9090***	--	10.8585	--	--	14	82.07	0.60
	(3.9455)	--	(2.0960)	(1.2760)	--	(-2.1468)	--	--	--	(1.5967)	
Tea	0.9870	--	--	--	--	-1.0338	--	0.0279*[4]	14	98.36	-0.52
	(46.7388)	--	--	--	--	(-0.9200)	--	(2.1943)	--	(2.4171)	--
	0.9833	--	0.0243**	--	--	-0.7162	--	0.0368*[3]	13	98.31	-0.52
	(43.8041)	--	(1.7533)	--	--	(-0.5835)	--	(2.0524)	--	(2.3939)	--
Pyrethrum	0.4014	0.0215***	--	--	--	5.6632	--	10.2011*[5]	13	90.18	0.60
	(2.2671)	(1.2630)	--	--	--	2.0251	--	(-2.1363)	--	(1.0689)	--
Pineapples	0.9831	--	0.0027*[6]	--	--	-0.3268	--	--	13	89.95	-0.50
	(7.7884)	--	(2.9696)	--	--	(-2.1445)	--	--	--	(2.1804)	--
Sugar	0.0614	--	--	--	0.9319	7.7368	--	56.8115**[7]	10	87.84	-0.05
	(0.1835)	--	--	--	(2.6443)	(1.9970)	--	(1.7187)	--	(1.8498)	--

* 5%
** 15%
*** 20%

† Barley/Wheat relative expected price and relative expected yield

1. Ratio of Expected Wheat/Expected Maize Price
2. Ratio of Expected Maize/Expected Wheat Price
3. Difference between Expected Export Price and Expected Producer Price
4. Expected Export Price
5. Small Farms Share of Total Pyrethrum Acreage (lagged)
6. Actual Price lagged 1 year
7. Ratio of Expected Sugar to Expected Maize Price

Table 7. Small Farm Results

Small Farms	$A_{i,t-1}$	Exp. Revenue	Exp. Price	Exp. Yield	Time	Constant	Rainfall	Other Variables	Degree of Freedom	$\bar{R}^2$/(D.W.)	Rho
Maize	0.0818	--	0.3365***	634.1080	--	-45.0138	0.1383	--	9	74.22	--
	(0.1844)	--	(1.5974)	(2.0611)	--	(0.3429)	(1.2538)	--	--	(2.4722)	--
Tea †	0.4858	--	--	--	--	-2.3998	--	0.1016[1]	13	67.85	0.04
	(2.6817)	--	--	--	--	(-1.8594)	--	(2.4696)	--	(1.9866)	--
Pyrethrum	0.4411	0.1021*	--	--	--	19.5239	0.0067	--	13	79.90	0.00
	(2.6686)	(2.5811)	--	--	--	(-2.4888)	(3.1474)	--	--	(2.2905)	--
	0.3501	--	0.4928**	6.9627*	--	-48.4440	0.0059	--	12	78.29	0.15
	(1.9148)	--	(1.7388)	(2.2685)	--	(-2.7458)	(2.5401)	--	(2.3481)	--	--
Rice	0.4274	--	--	3.6421*	0.4732	-20.3990	--	--	10	97.98	-0.05
	(2.4504)	--	--	(2.6499)	(3.4400)	(-2.6106)	--	--	--	(1.3669)	--
Coarse Grain	0.2528	--	--	199.1975*	--	24.9221	--	--	11	75.29	0.70
	(1.4036)	--	--	(3.8728)	--	(1.0078)	--	--	--	(1.7141)	--
Pulses	0.2719	--	0.0632*	886.7684*	--	-53.4017	--	0.1256*[2]	9	92.80	-0.35
	(1.2299)	--	(3.2507)	(2.7649)	--	(-1.7255)	--	(4.5652)	--	(2.0115)	--
Roots	0.8978	--	0.0487*	--	0.8423	6.1866	--	--	10	98.33	-0.20
	(11.9718)	--	(2.7699)	--	4.6118	(0.5366)	--	--	--	2.0930	--
Cotton	0.4183	--	0.0064***[3]	51.0417[3]	--	2.2837	0.0094	--	10	62.96	-0.65
	(2.4431)	--	(1.3540)	(2.7064)	--	(0.2148)	(1.4540)	--	--	(2.0016)	--
Wheat	0.6980	0.1115*	--	--	0.4307*	-4.3138	--	--	10	98.72	-0.50
	(3.7525)	(4.8211)	--	--	(1.9234)	-3.2046	--	--	--	(2.3636)	--
Sugar	0.4916	--	--	0.5735*	--	-10.5676	--	--	11	76.44	0.15
	(1.8856)	--	--	(1.9329)	--	(-1.4897)	--	--	--	(1.6309)	--

* 5%
** 15%
*** 20%

† For tea the model is estimated in the following form:

$$ardf_t = \alpha_1 \cdot ardf_{t-1} + \alpha_2 \cdot revn_{t-1} + C$$

where $ardt_t = area_t - area_{t-1}$

$ardt_{t-1} = area_{t-1} - area_{t-2}$

and α_1, α_2 are estimated coefficients

1. Actual revenue lagged one year
2. Small Farm Current Maize Area
3. Actual price and yield, lagged one year

3.2.1. Maize

A large portion of the maize produced in small farms is for self consumption and only the surplus is marketed mainly through local markets and to a lesser extent through the formal marketing channel, namely, Maize and Produce Board. The latter enforces producer and consumer prices and has a legal monopoly over all purchases.

During the period 1961-76 maize area as a percentage of the total cultivated area in the small farm sector has averaged about 40% and during this period, the annual rate of increase in maize area has been about 1.6%. At the same time there has been a substantial increase in the corresponding yield levels (an average of 3% per year). During the last decade there has been a marked change in the technology of production and at present about 30% of the maize area in the small farm sector is of the hybrid variety.

Expected price, expected yield, rainfall and the lagged acreage under maize in small farms have been considered as explanatory variables to estimate maize acreage. While the coefficient of the expected yield has been significant at 5% level, that of the expected price has been significant only at 20%. Also, the coefficient of the lagged acreage, which turned out to be insignificant, implies that farmers could almost adjust their maize acreage towards their desired levels.

3.2.2. Wheat

Only in recent years, there have been efforts to promote smallholder wheat production in certain districts (e.g. Narok) of Kenya. Maize is a possible competing crop although this point could not be considered since the present level of wheat acreage is less than 3% of the maize acreage in the small farms.

Expected revenue and a trend variable have been included as explanatory variables along with the previous year wheat acreage. All these gave significant coefficients at 5% level.

3.2.3. Coarse Grains

Sorghum and millet, considered as coarse grains in Kenya, are produced mainly in small farm sector. The acreage under these two crops put together decreased from about 353,000 ha in 1973 to 281,000 ha in 1975. This decline in acreage may be the response to the changing consumption patterns i.e. shift away from these "inferior" cereals.

The expected price of coarse grains relative to that of maize was included as an explanatory variable. However, the results did not look satisfactory.* Similarly the response to expected price of coarse grains also was not significant. Only when the expected yield of coarse grains along with the lagged acreage were included as variables, the results looked better. The coefficient of yield is significant at 5% and the coefficient of $A_{i,t-1}$ suggests that farmers are able to achieve the desired coarse grain acreage.

3.2.4. Pulses

The main pulse in Kenya is the bean and is an important source of protein in the diet of the small farm population. Most of the pulses production is on the basis of intercropping with maize and the method of broadcasting is often practiced. This aspect was introduced in the model equation by introducing the

* The parameter estimate is considered to be "satisfactory" if the estimate is of expected sign and the t-coefficients are significant

current area of maize as one of the explanatory variables.

The results show that the coefficients of expected price, expected yield and current maize area are all significant at 5% level.

3.2.5. Sugarcane

Smallholders, especially cooperatives, have increasingly participated over time in sugar production. Though in the beginning the production was mainly from large farms, by 1976 the smallholder production was in fact higher than that of the large farms. With the large investments and capacity of the sugar processing industry in Kenya, government policy is aimed at making Kenya self-sufficient and exporting the surplus. Again as expected, the coefficient of the price variable was not significant (see large farm results) and only the expected yield (coefficient significant at 5% level) along with the lagged acreage gave a satisfactroy result.

3.2.6. Coffee

Details of the small farmers coffee acreage response are reported elsewhere, (Naryana and Shah (1982)).

3.2.7. Tea

Apart from the importance of tea as an export crop, it is also attractive in terms of profitability and labour intensiveness. These aspects are a major thrust of the government pclicy to encourage smallholder tea production. This is important in terms of creating employment opportunities as well as increasing income levels.

As in the case of coffee, smallholders did not participate in tea production prior to independence in 1963. During the period 1963-75, small farms tea acreage increased from 4000 ha to 37000 ha, i.e. an annual increase of 19.5%. The yield in the small farm sector increased at a corresponding rate of 10.3%. Although the average yield in 1975 is only about a third of those achieved in the large farm sector, this has been achieved with a much lower rate of fertilizer application and there is considerable scope for future productivity increases, (Fischer and Shah (1982)).

In explaining the tea acreage, the model was formulated in terms of area differences.§ The explanatory variable (previous years actual revenue) is significant at 5% level and the coefficient of lagged area difference term suggest that though small farmers could not achieve the desired increment in acreage, they could adjust in the desired direction.

3.2.8. Pyrethrum

In the past government policy has been aimed at encouraging smallholder production of this crop. The smallholder acreage increased from 8000 ha to 33000 ha during the period 1963-75. At present small farm production accounts for almost 90% of the national production. Kenya is a price maker for pyrethrum in the world market and if demand continues to rise (especially if synthetic alternatives are not available, and international environmental concern for synthetic insecticides increases) then small farm acreage will continue to grow. Another aspect of this crop is that it is labour intensive and the

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§ Estimation in the undifferenced form showed up unsatisfactory parameter estimates involving wrong signs and out of bound value of γ, indicating essentially multicollinearity, see footnote under Table 7.

harvesting period does not really conflict with the other staple crop production activities.

Results of two equations are reported in Table 7. In the first equation the coefficients of expected revenue and rainfall are both significant at the 5% level. The second equation includes expected yield, expected price and rainfall. The corresponding coefficients are significant at 10%, 5% and 5% respectively.** In the two estimated equations the $\bar{R}^2$ are 78.3% and 79.9%. The coefficients of $A_{i,t-1}$ in the two cases suggest that to some extent small farmers are able to achieve the desired pyrethrum acreage.

3.2.9. Rice

In the past there was some rice production under rainfed conditions in the Nyanza and Coast provinces. However at present this area is negligible and the most of the production is under irrigation in the government financed and operated Mwea, Ahero, Bunyala and West Kano Irrigation Schemes. Mwea is by far the most important scheme and in 1976/7 accounted for 82.4% of irrigated production. Rice also occupies 87.8% of the total area under these irrigation schemes.

The results of the estimated equation show that the coefficient of the expected yield and time variable are both significant at the 5% level. The time variable in a sense represents the area expansion and development of the irrigations schemes. Data on annual investments for these irrigation schemes is not available; we have assumed that time is a good proxy at least in the initial development of the irrigation schemes. The coefficient of the $A_{i,t-1}$ shows the farmers are not able to achieve the desired acreage. This is to be expected since demand in Kenya is almost double the present production levels and also there are limitations on the rapid expansion of the irrigations schemes. The $\bar{R}^2$ is 98.0.

3.2.10. Roots

Most roots in Kenya are produced in the small farms and the main types are cassava, sweet potato and english potato. During the period 1970-75 there was a marked reduction (about 50%) in the area under cassava whereas for english potatoes there has been an almost eight-fold increase in acreage. The root crop production is very much regionalized in the sense that the production of english potatoes is concentrated in Central and Eastern provinces whereas sweet potatoes and cassava are more common in Nyanza and Western Provinces. The policy of cassava production for use as feed stuff and for exports is presently under consideration by the government. The demand particularly for english potatoes is rapidly rising and with the possibility of cassava production (especially in marginal areas) for feedstuffs, root crops acreage is likely to increase significantly.

The estimated equation is significant at the 5% level for the expected price and time variables. The coefficient $A_{i,t-1}$ suggests that farmers could not achieve the desired acreage.

** As a check against the possible multicollinearity, correlation between expected yield and expected price was computed which turned out to be only 0.18.

3.2.11. Cotton

Cotton is produced under rainfed conditions in the small farm sector. Since 1961/62 there have been some efforts to produce cotton under the Tana River Irrigation Scheme; from 1961 to 1976 the irrigated acreage increased from 162 ha to 856 ha. During the same period irrigated production rose from 176 mt to 2507 mt. In comparison the rainfed acreage increased from about 45,000 ha in 1961 to 70,000 in 1976.

In the past cotton from Uganda supplemented the demand of the local textile industries. However due to the break in this source of supply, government policy is now aimed at increased smallholder production. The cotton yields have tended to be rather low due to the low level of husbandry and shortage of chemical supplies (pest and disease control). Furthermore cotton is a labour intensive crop and the conflict in labour requirements of the crops such as maize has led to the slow growth of cotton production. However, with the increasing level of demand, acreage expansion as well as yield increases are expected. This will occur if producer prices are attractive and if the availability of inputs and marketing infrastructure is ensured.

The cotton acreage allocation first considered expected price and expected yield as variables. The results were found to be significant. These expectation terms were replaced by one year lagged (price and yeild) variables. The results show that the coefficients of yield is significant at the 5% level variable whereas price and rainfall terms are significant at 20% level.

The $\bar{R}^2$ value of 63% is lowest of all small farm crops considered in the study. The coefficent $A_{i,t-1}$ implies the farmers are to some extent able to adjust their acreage to desired levels.

Table 8: Summary of Results

Crop	Large Farms				Small Farms				Relative Yields Large Farms/ Small Farms	
	$\hat{\gamma}$	Price Term	Yield Term	Revenue Term	$\hat{\gamma}$	Price Term	Yield Term	Revenue Term	1961	1976
NON COMMERCIAL										
Maize	0.5346	S*			0.9182	S***	S*		1.17	2.00
Wheat	0.5471	S*			0.3020			S*	2.63	1.67
Rice					0.5726		S*			
Coarse Grains					0.7472		S*			
COMMERCIAL										
Tea	0.0177	S**			0.5142			S*	6.57	3.44
Sugarcane	0.9386	S**	S***		0.5084		S*	S*	1.00	1.00
Barley	0.1666	S*								
Pyrethrum	0.5986			S***	0.5589			S*	1.55	1.35
Sisal	0.2996	S**								
Cotton					0.5817	S***	S*			

Note:
1. S*, S**, S*** denote the significance levels 5%, 10%, 20% respectively, as obtained in the results shown in Tables 5 and 6.
2. For the actual specification of the price, yield and revenue terms see Section..... and Tables 5 and 6.
3. $\hat{\gamma} = 1$. (the coefficient of $A_{i,t-1}$ of the regressions in Tables 5 and 6).

4. Policy Considerations and Conclusions.

The essence of the results reported in the previous section is summarized in Table 8. Except in the case of barley, sisal and tea under large farms and wheat under small farms, the results show that farmers in general were able to adjust their acreage towards desired levels.

In general the small farms are able to adjust the acreage under food crops towards the desired acreage much more than in the case of acreage under non-food crops (γ is generally higher for food crops). This could be in response to the increasing self-consumption in the small farms caused by the rapid increase in population; in 1975 over 75% of the total population in Kenya was in the small farm sector and recent estimates, (Central Bureau of Statistics (1979)), suggest that the national population is growing at the rate of 3.9% annually.

For the large farms, the farmers are able to adjust the acreage under sugar towards the desired acreage and to a lesser extent this is also the case for maize, wheat and pyrethrum. For the remaining crops (tea, barley, and sisal) the rate of adjustment towards the desired levels is lower.

There is one important difference between the two types of farms. It cannot be denied that, from the point of view of economic rationality, both the type of farmers ultimately react to revenue (or profit) incentive. However, the large farms being already "technically" advanced in farming further increases in their yield levels could be more difficult. In contrast, for the small farms which are "technically" not as advanced, there is a possibility of increasing the yields considerably. This implies that for large farms, increases in revenue would basically come from price changes whereas for the small farms, increases in revenue would come from both price as well as yield changes. This aspect could be the main reason why yield terms resulted in significant coefficients for the small farms whereas the price terms resulted in significant coefficients for the large farms

Table 8 shows the movement of relative yields for some important crops between 1961 and 1976. While small farms could increase their yield levels relative to large farms particularly in the case of tea, wheat and pyrethrum, this relative gap widened in the case of maize.

The overall results suggest that a produce price policy alone would be inadequate to influence the small farmers' cropped acreage. In addition a compatible and integrated policy regarding provision of input subsidies and credits is necessary to affect the small farmers crop yields and hence the cropped acreage. The integration of a simultaneous price and input policy in relation to specific crops is essential to ensure desired supply. In the past, policymakers in Kenya have tended to concentrate on produce price policies especially for basic food commodities. This raises one important issue, namely, are the present price policies "reasonable". This is not an irrelevant question to ask especially when the data, though somewhat scanty they are, suggest that Kenya exported cereals (maize in particular) in the year when per capita availability domestically was as low as 277 gms per day in the year (1968) and imported in the year when the domestic availabiltiy was relatively as high as 453 gms per day in the year (1971). It may seem at the outset that availability was low because of exports and high because of imports. However, a deeper understanding suggests that apart from policy regarding producer price,consumer price and trade, a whole lot of issues relating to institutional structure seems to dictate the pace of Kenyan agricultural development. These aspects are discussed in detail elsewhere, Narayana and Shah (1982b).

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Appendix A1: Crop Substitution and Crop Competition in the Small and Large farms in Kenya

Kenya is a country of enormous contrasts in topography, climate and soils. Within the country's 575,000 sq. km of land, conditions range from a limited Afro-Alpine zone in the center south, to the tropical coastal strip and from near desert in the north, to high rainfall forest in the south western highlands. The country is administratively divided into seven provinces, namely, Central, Coast, Eastern, Nyanza, Rift Valley, Western and Nairobi. The first six provinces are further subdivided into districts.

Due to the very wide range of agro"-ecological conditions in the country, there are large differences in agro-climatic suitability for various crops in different parts of the country, Shah and Fischer (1982). In the context of the present paper, our aim is to identify crop substitution and crop competition at the national level for large and small farmers.

Table A1 shows the percentage distribution of crop-wise acreage across the six provinces in 1975. Table A2 shows the relative importance (in terms of share of acreage) of the various crops in the six provinces in 1961 and 1975. From the information in Table A1 and Table A2, we have identified the important districts in terms of crop-wise acreage for the large and small farms, Table A3. Using this information and the crop calendar for Kenya, Central Bureau of Statistics (1972), we derived the approximate national level planting and harvesting seasons of the various crops for small and large farms separately, Table A4.

The above information together with information on crop competition between the two farm types was used to work out the crop substitution and crop competition for large and small farms, Table A5 and Table A6 respectively. Note that the assumptions on crop substitution is general. This aspect will be improved when district-wise data on agro-climatic suitability and cropping patterns become available from the FAO/IIASA/KENYA, Agro-ecological zone study, Shah and Fischer (1982).

Table A1: Percentage Distribution of Crop Acreage in the Small and Large Farms in Kenya, 1975

LARGE FARMS

Crop	Central %	Coast %	Eastern %	Nyanza %	Rift Valley %	Western %	Total '000 ha
Wheat	7.1	—	—	—	82.7	10.2	89.9
Maize	1.9	—	0.9	0.4	96.5	0.1	68.1
Barley	12.9	—	9.0	—	78.0	—	13.5
Sugar	—	15.2	0.8	43.6	28.0	12.3	31.5
Pineapples	99.4	0.4	—	—	0.2	—	4.7
Pyrethrum	5.7	—	0.3	0.7	93.2	—	4.2
Sisal*	10.0	40.9	20.4	—	27.1	—	73.8
Coffee*	68.0	—	10.0	—	16.4	—	28.3
Tea	13.6	—	—	3.6	82.8	—	26.0

* Nairobi Province accounting for the remaining share

SMALL FARMS

Crop	Central %	Coast %	Eastern %	Nyanza %	Rift Valley %	Western %	Total '000 ha
Local Maize	21.6	9.3	36.6	24.3	2.0	6.2	1194.6
Hybrid Maize	20.2	1.9	11.6	10.3	20.2	35.8	500.8
Wheat	—	—	—	—	100.0	—	21.0
Sorghum/ Millet	—	—	8.7	69.9	5.1	16.3	284.3
Beans	30.4	2.3	37.3	9.6	0.9	19.4	763.5
Cow Peas	2.9	14.3	76.8	1.1	—	4.9	271.2
Pigeon Peas	3.6	5.6	90.6	—	—	—	115.3
English Potatoes	45.8	—	53.4	—	0.7	—	261.2
Cassava	2.3	7.0	1.1	38.9	1.9	49.6	69.9
Sweet Potatoes	41.4	0.6	5.8	43.5	4.0	4.9	32.6
Bananas	45.4	1.4	34.7	7.8	—	10.7	130.4
Cashew nuts	—	100.0	—	—	—	—	53.5
Oil seeds	—	13.5	7.3	—	—	79.2	24.5
Coconuts	—	100.0	—	—	—	—	51.3
Sugarcane	5.0	1.9	14.9	65.1	1.4	11.5	63.7
Pyrethrum	46.9	—	5.2	36.5	11.8	—	27.1
Cotton	0.1	1.8	31.7	35.9	1.6	28.9	70.1
Coffee	31.9	0.3	52.5	12.4	—	1.1	111.3
Tea	66.0	—	17.0	8.5	5.7	2.9	64.8

Source: Derived from 1976 Agricultural Census of Large Farms and IRS 1974/75 Survey of Small Farms

Table A2: Relative importance of various crops in the six provinces of Kenya, and percentage changes in share of various crops in 1961 and 1975, Small and Large Farms

Crop		Central	Coast	Eastern	Nyanza	Rift Valley Valley	Western	Nairobi	1961 % Area Share	1975 % Area Share
Wheat	LF	x		xx		xxx			100	75
	SF					✓✓✓			-	25
Maize	LF					xxx			6	5
	SF	✓✓✓	✓✓	✓✓✓	✓✓✓	✓✓	✓✓		94	95
Barley	LF	x		xx		xxx			100	100*
Sugarcane	LF	xx			xxx	xx	x		94	50
	SF	✓✓		✓✓	✓✓✓		✓		6	50
Pyrethrum	LF					xxx			65	8
	SF	✓✓✓			✓✓✓	✓	✓		35	92
Oilseeds	LF					xxx				5
	SF		✓	✓			✓✓✓		n.a.	95
Sisal	LF	xx	xxx	xx		xxx		x	100	100
	SF								n.a.	n.a.
Tea	LF	xx			x	xxx			90	39
	SF	✓✓✓		✓✓	✓	✓			10	61
Coffee	LF	xxx		x		xx		x	82	31
	SF	✓✓✓		✓✓✓	✓				18	69
Sorghum/						x			-	-
Millet	SF			✓	✓✓✓	✓	✓✓		+99	+99
Pulses	LF	xx				xxx			-	-
	SF	✓✓	✓	✓✓✓	✓		✓✓		+99	+99
Roots	LF	xx				xxx	x		-	-
	SF	✓✓✓		✓✓✓	✓✓		✓✓		+99	+99
Fruits	LF	xxx	x			x			-	2
	SF	✓✓✓	✓	✓✓✓	✓		✓		+99	98
Vegetable	LF	xx		xx		xxx				
	SF	✓✓✓	✓	✓			✓✓		+99	+99
Cotton	SF			✓✓✓	✓✓✓		✓✓✓		100	100
Rice	SF			✓✓✓					100	100

LF = Large Farm; SF = Small Farm

Nomenclature

xxx	most important	Large Farms:
xx	next most important	Importance of province in
x	important	terms of crop acreage
✓✓✓	most important	Small Farms
✓✓	next most important	Importance of province in
✓	important	terms of crop acreage

* 1975 Barley acreage in small farms not available

Table A3: Relative importance of various provinces and districts in terms of crop acreage, Large and Small Farms 1961 and 1975

SMALL FARMS (1961 acreage)

Crop	Important Provinces	Important Districts
Local Maize	Eastern	Machakos,Kitui, Meru, Embu
	Nyanza	S. Nyanza,Siaya, Kisumu, Kisii
	Central	Muranga, Kirinyanga, Kiambu, Nyeri
Hybrid Maize	Western	Kakamega, Bungoma
	Rift Valley	Kericho, Nandi
	Central	Muranga, Kirinyaga
Millet and Sorghum	Nyanz	S. Nyanza, Siaya, Kisumu
	Western	Kakamega, Busia, Bungoma
Beans	Eastern	Machakos, Kitui, Meru
	Central	Muranga, Kirinyaga, Kiambu, Nyeri
	Western	Kakamega, Bungoma, Busia
Cow Peas	Eastern	Kitui, Machakos
	Coast	Taita
Pigeon Peas	Eastern	Machakos, Kitui
English Potatoes	Eastern	Meru, Machakos
	Central	Nyandarua, Kiambu
Cassava	Nyanza	S. Nyanza, Siaya, Kisumu
	Western	Busia, Kakemega, Bungoma
S. Potatoes	Nyanza	Kisii, Kisumu, S. Nyanza
	Central	Nyeri, Kiambu
Bananas	Central	Muranga,Kirinyaga Kiambu
	Eastern	Meru, Machakos, Kitui
Oilseeds	Western	Bungoma, Busia, Kakamega
Cashewnuts	Coast	Kilifi, Kwale
Coconuts	Coast	Kilifi, Kwale
Sugarcane	Nyanza	S. Nyanza, Kisumu, Kisii
	Eastern	Meru, Machakos
	Western	Kakamega, Bungoma
Pyrethrum	Central	Nyandarua, Kiambu, Nyeri
	Nyanza	Kisii
Cotton	Nyanza	S. Nyanza, Kisumu, Siaya
	Eastern	Kitui, Machakos, Embu
	Western	Busia, Bungoma
Coffee	Eastern	Meru, Machakos, Embu
	Central	Muranga, Kirinyaga, Kiambu, Nyeri
Tea	Central	Embu, Meru
	Eastern	Nyeri, Kiambu

* For the small farm sector, the data from 1975 on the basis of individual districts is not available. According to the 1974/75 Integrated Rural Survey of Small Farms, in 1975 relative importance of various provinces is the same as in 1961, except for cassava where Western province followed by Nyanza are the most important provinces

Table A3: Relative importance of various provinces and districts in terms of crop acreage, Large and Small Farms, 1961* and 1975

LARGE FARMS (1975 acreage)

Crop	Important Provinces	Important Districts
Wheat	Rift Valley	Uasin Gishu, Nakuru, Meru
Maize	Rift Valley	Uasin Gishu, Trans Nzoia, Nakuru
Barley	Rift Valley	Nakuru
Sugar	Nyanza	Kisumu
	Rift Valley	Nandi (1)
	Coast	Kwale
Pineapples	Central	Kiambu
Pyrethrum	Rift Valley	Nakuru, Uasin Gishu
Sisal (2)	Coast	Taita, Kilifi
	Rift Valley	Nakuru
	Eastern	Machakos
Coffee	Central	Kiambu, Muranga
	Rift Valley	Nakuru, Trans Nzoia
Tea	Rift Valley	Kericho, Nandi
	Central	Kiambu

* In 1961, in the large farms, the crop distribution pattern among provinces and districts was similar except for:

(1) Sugar for which no production in Nandi and

(2) Sisal for which Thika district in Central Province was the most important

Table A4: Planting and harvesting dates for major* crops in Small and Large Farms of Kenya

(LR) = long rains
(SR) = short rains

Crop	Large Farms		Small Farms	
	Planting	Harvesting	Planting	Harvesting
Wheat	May/July (LR)	Oct/Jan (LR)	Mar/Apr (LR)	Sept/Nov (LR)
Maize	Mar/Apr (LR)	Nov/Dec (LR)	Mar/Apr (LR)	Aug/Sept (LR)
Barley	May/July (LR)	Sept/Jan (LR)	--	--
Sugarcane	Mar/Apr (LR)	18 months after planting	Mar/Apr (LR)	18 months after planting
Pineapple	March (LR)	18 months after planting	--	--
Pineapple	Oct (SR)	18 months after planting	--	--
Pyrethrum	May/June (LR)	Twice monthly, 6 months after planting	Mar/Apr (LR) Oct/Nov (SR)	Twice monthly, 6 months after planting
Coffee	April (LR)	Oct/Nov (3 to 4 years after planting)	Mar (LR) Oct (SR)	Oct/Jan Mar/Aug } 3 to 4 years after planting
Tea	April/May (LR)	Continuously 2-3 years after planting	Mar (LR)	Continuously 2-3 years after planting
Sorghum	--	--	Mar/Apr (LR) Jul/Aug (SR)	Jul/Aug (LR) Nov/Dec (SR)
Millet	--	--	Mar/Apr (LR) Aug (SR)	May/June (LR) Nov (SR)
Cotton	--	--	Mar/Apr (LR) Oct/Nov (SR)	Jul/Oct (LR) Jul/Sept (SR)
Pulses	--	--	Mar/Apr (LR) Oct/Nov (SR)	Jun/Jul (LR) Jan/Feb (SR)

* Crop calendar for sisal is not reported in Central Bureau of statistics (1972), rice is produced under irrigation

Table A5: Large Farms--Crop Substitution and Competition

Crop	Crop Sub- stitution	Crop Com- petition	Explanation
Wheat	Maize	--	Uasin Gishu District-land suitable for both wheat and maize
Maize	Wheat	--	Uasin Gishu District-land suitable for both maize and wheat
Barley	Wheat	--	Nakuru District-land suitable for both wheat and barley
Coffee	--	Small Farm coffee	(See Table A6)
Sugarcane	Maize	Time	Kisumu and Nandi Districts-some competition with maize. Time trend for the increasing sugar demand in Kenya (per capita consumption increased from 12 kg to 20 kg during 1961-1976)
Sisal	Pineapple	Time	Some derelict estates being utilized for housing complex (Thika/Voi) Pineapple as alternative crop (irrigated) in Thika and Voi
Tea	--	Small Farm tea	(See Table A6)
Pyrethrum	--	Small Farm pyrethrum	(See Table A6)
Pineapples	--	Time	Rapid development of processing industry and exports of canned products

Table A6: Small Farms: Crop Substitution and Competition

Crop	Crop Substitution	Crop Competition	Explanation
Maize	Pulses: Intercropping	--	Intercropping and also maize/beans/maize ...rotation attractive in terms of improving soil fertility.
Wheat	--	Time	"New"lands being opened in Narok for wheat production by small farmers
Coarse grain	--	Time	Changing consumption patterns
Pulses	Maize: Intercropping	--	As for maize above
Sugarcane	--	Large Farms in future	Upto 1976 production in Kenya was less than demand. At present there is excess production and competition expected in future. Note that small farmers increased share of production from 6% to 44% during 1961-76
Coffee	--	Large Farm coffee	National Products Quota, and government policy to encourage small farm participation, Narayana and Shah (1982)
Tea	--	Large Farm Tea	Government Policy to ecnourage small farm participation and access to new tea areas
Pyrethrum	--	Large Farm Pyrethrum	Government policy in the past to allocate some production quotas to small and large farms
Rice	--	Time	No competition--government schemes for irrigated rice production. Time explains expansion of irrigation schemes.
Roots	--	Time	Increasing demand for potatoes.
Cotton	Sugarcane/ Maize	--	Sugarcane as competing in Nyanza/Western provinces and Maize in Central Province