DETERMINATION OF THE PRICE ELASTICITY OF SUNFLOWER SUPPLY IN KENYA

BY

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1995

DECLARATION

I hereby declare that this thesis is my original work and has not been presented for a degree in any other university.

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ABSTRACT

The production of sunflower and other oil crops in Kenya has been low and declining over the years. In order to feed its population, Kenya has over the years been importing vegetable oils and fats in form of crude palm oil and thus utilising its limited reserves of foreign exchange, which could otherwise be used to finance other development projects. This trend is expected to continue as domestic consumption still far outweighs local production. For instance, the consumption of vegetable oils and fats in Kenya is currently estimated to be over 200,000 tonnes per annum while domestic production is only about 20,000 tonnes. The difference has to be imported. The present study aimed at establishing the effects of various factors, especially price changes, on the production of oil crops with particular reference to sunflower. The study was prompted by the present Government policy objective of saving foreign exchange through increased domestic production of the major crops, especially oil crops, as documented in the current National Development Plan (1994-96).

The double logarithmic version of the Nerlovian Partial Adjustment Model was used to estimate the supply responsiveness of sunflower farmers in the major producing districts, namely Meru, Bungoma and Trans-Nzoia districts. The data set used in the analysis range from the years 1970 to 1992. The results revealed that sunflower farmers responded positively to price changes in Meru District but negatively in Bungoma and Trans-Nzoia districts. The first hypothesis, which assumed that sunflower farmers respond positively to price changes, was therefore accepted for Meru District but rejected for Bungoma and Trans-Nzoia districts. The calculated short-run price elasticities of supply range from a value of -0.06 to 0.74. The second hypothesis was tested by means of the Chow test and revealed that the degree of supply responsiveness of sunflower farmers varies from one

district to the other. In general, the results of this study indicate that the supply responsiveness of sunflower farmers in Kenya is diverse and not well defined.

The other factors included in the supply response model were also found to significantly influence the hectarage put under sunflower in any given year. The major factors in this case are the lagged price of the most competitive enterprise, the lagged yield of sunflower, the annual rainfall amounts and the lagged hectarage which reflects the adjustment difficulties facing the farmers.

The results of this study reveal that the pricing policy could only be used to partly achieve increased production of sunflower. This is because, the results of the first hypothesis test reveal that price may not always play a positive role in achieving increased production, especially in Bungoma and Trans-Nzoia districts where the price elasticity is negative. However, the negative price elasticity of supply for Bungoma and Trans-Nzoia districts is not necessarily an indication of the economic irrationality of the farmers. It is probable that the price offered for sunflower seed is so low that farmers in those districts do not consider it in their hectarage allotment decisions. Such a situation would require that a substantial price increase within the framework of market liberalization is given so as to enable the farmers to meet the costs of production. This would allow the setting of a minimum producer price, beyond which the market forces are allowed to operate freely.

The inability of the pricing policy to achieve increased production of sunflower requires that other non-pricing policy measures come into play. This is in agreement with the current policy of market liberalization which emphasizes on the use of other policy measures (other than price) to achieve increased production of sunflower. In this regard, it was found important that the yields of sunflower should be improved through research and that the farmers are assured of a ready market for their seed by providing adequate and easily accessible market outlets. This would help in eliminating some of the difficulties faced by the farmers in adjusting fully to the equilibrium supply.

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DEDICATION

This thesis is dedicated to my son ERIC.

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CHAPTER ONE: INTRODUCTION

1.1 Background Information

1.1.1 The Vegetable Oils and Fats Industry

Vegetable oil crops constitute one of the essential crops as they provide oils and fats which are necessary for the nutrition of man. Further, their by-products could also be used in the manufacture of livestock feeds, soaps, cosmetics and paints.

Kenya's soils and agro-ecological zones permits the production of various types of oil crops. The most popular among these are sunflower, groundnut, coconuts, rapeseed, castorbeans, simsim and soyabeans. These crops can grow between agro-ecological zones 2 and 4 (perhumid and transitional zones respectively). Most of these oil crops are grown in Kenya, but only three of them, namely sunflower, coconut and simsim are specially grown for the manufacture of vegetable oils and fats (Zulberti and Lugogo, 1989). Sunflower is the most extensively grown among all the oil crops as shown in Table 1.1. Others, such as coconut and simsim, are confined to low altitude mainly coastal areas. There are some crops, such as cotton and maize, which are produced for other purposes but where oil and protein are extracted as by-products. Castor, linseed and some varieties of rapeseed are toxic and are therefore grown for industrial oil extraction and used in the manufacture of detergents, cosmetics and paints. Table 1.1 shows the distribution of oil crops by province in Kenya.

Table 1.1: <u>Distribution of Oil Crops Production by Province in Kenya</u>

Type of Oilseed	Main Growing Provinces					
	Rift Valley	Eastern	Western	Nyanza	Coast	Central
Sunflower	X	X	X	X	X	X
Simsim	-	-	X	X	X	-
Groundnut	-	X	X	X	X	-
Coconuts	-	-	-	-	X	-
Soyabeans	X	-	X	-	-	X
Castorbeans	X	X	-	X	-	X
Rapeseed	X	-	-	-	-	-
Cotton	X	X	X	X	X	-
Maize	X	X	X	X	X	X

Key: X = where crop is grown

- = where crop is not grown

SOURCE: Ministry of Agriculture, Annual Reports.

Table 1.1 indicates that virtually every province in Kenya is capable of producing some oil crop. However, this potential has not been fully exploited. Local production of oil crops has not been adequate and the country has only managed to meet 20 % of its annual national requirements of vegetable oils and fats. The remaining 80 % of local demand has had to be met through importation as shown in Table 1.2 for the year 1971 to 1992. The major oil import is palm oil which consumes millions of shillings worth of foreign exchange (Gitu, 1988). For instance, Table 1.2 shows that in 1992, about 190,000 tonnes of vegetable oils and fats valued at about 3 billion Kenyan shillings were imported. Projections on production and consumption indicate that there is an increase in the gap between domestic production and consumption, which, unless some policy measures are instituted to boost domestic production, will increase further the need for importation. An increase in the quantities of vegetable oils and fats imported will mean a further drain on Kenya's limited supply of foreign exchange. This situation contradicts the stated government policy objectives of self-sufficiency in basic foods and the saving of foreign exchange as stipulated in the Food Policy Paper of 1994 and the Sessional Paper No.1 of 1994.

It is important to note that the amount of vegetable oils and fats imported for 1994 exceeds the national demand. This is due to increases in the amounts of vegetable oils and fats imported for other purposes, for example manufacture of soaps, paints and livestock feeds.

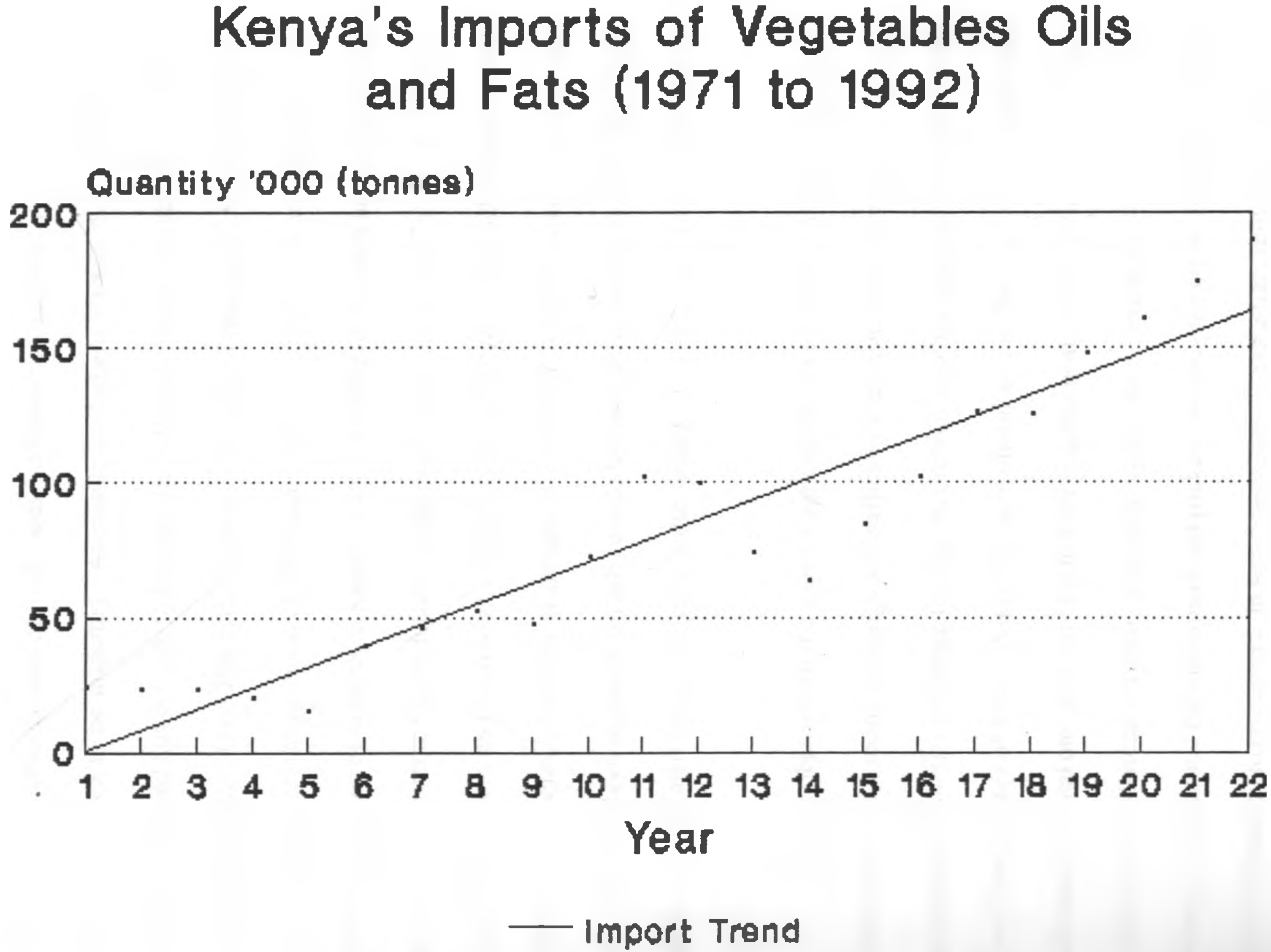
Table 1.2: **Kenya's Imports of Vegetable Oils and Fats (1971 to 1992)**

Year	Vegetable Oils and Fats		
	Quantity(tonnes)	Value (K £'000)	% change in Quantity
1971	23983	2923	
1972	23413	2490	-2.3
1973	23286	3101	-0.5
1974	20056	5070	-13.9
1975	14678	3350	-26.8
1976	39097	7818	166.4
1977	45786	10853	17.1
1978	52398	11541	14.4
1979	47121	12654	-10.1
1980	72381	16973	53.6
1981	102177	18944	41.2
1982	99488	22659	-2.6
1983	74016	43735	-25.6
1984	63165	31240	-14.7
1985	84341	42241	33.5
1986	101724	39470	20.6
1987	125835	37335	23.7
1988	125427	58125	-0.3
1989	147862	64781	17.9
1990	160875	64776	8.8
1991	174676	94710	8.6
1992	189974	148910	8.8
1993	138505	180599	-27.1
1994	296235	247359	113.9

SOURCE: Republic of Kenya (1976, 1980, 1990, 1994)

Table 1.2 indicates that the imports of vegetable oils and fats have been fluctuating from time to time. The percentage change in the quantity of vegetable oils and fats imported has also been fluctuating from time to time. This could be due to changing prices in the highly volatile international market. There is, however, a general increase in the quantities of vegetable oils and fats imported as shown in Figure 1.1.

FIGURE 1.1


Kenya's Imports of Vegetables Oils
and Fats (1971 to 1992)
Quantity '000 (tonnes)
200
150
100
50
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
Year
Import Trend

With the population increase (population growth rate was 3.34% by 1993) and changing feeding patterns towards more of fried foods, additional quantities of vegetable oils and fats are expected to be imported. According to Zulberti (1988), the importation of vegetable oils and fats is likely to increase from 100,000 tonnes in 1987/88 to 320,000 tonnes by the year 2,000. This is due to an increase in both population and per capita oil consumption. The importation of large quantities of vegetable oils and fats is a result of low production of oilseeds in Kenya. This is because the farmers have continued to give more emphasis to the production of other cash crops, namely coffee, tea, pyrethrum, horticultural crops and such food crops as maize and beans, although Kenya has the potential to produce a substantial amount of its oil requirements. It has been said that oil crops "have been neglected partially due to lack of appropriate policies to encourage production and marketing and partially due to lack of facilitating infrastructure" (Gitu, 1988).

A major objective of the Kenya's agricultural sector policy has been to achieve the national food security through self-sufficiency in basic food commodities and the generation of foreign exchange for the importation of other foods as stipulated in the Food Policy Paper of 1994. Within the agricultural sector, the vegetable oils and fats sub-sector is a vital one, as it can help in achieving this goal. The vegetable oils and fats industry can be divided into two main components: the oil extractors who obtain crude oil out of oilseeds and the oil refiners and packers who buy the crude oil, process it and sell the refined oil to consumers. In some cases, the oil extraction, refining and packing activities are integrated within a single firm.

Kenya has been a net importer of edible oils and fats since the beginning of this century (Odhiambo, 1988). The country produces only about 20 % of its local demand for vegetable oils and fats. This situation has worsened to the present time. The country is currently importing over 200,000 tonnes of crude palm oil per year, which is valued at over Kshs. 4 billion in foreign exchange as stated in the Sessional Paper No.1 of 1994. According to Zulberti and Lugogo (1989), the amount of foreign currency used in importing the crude palm oil represents 2.64 % of the total value of imports for home use. It is also the highest of all foreign exchange expenditures on agricultural commodities. The problem existing then is one of an increasing import bill and lack of sufficient local production.

This low level of domestic production and processing of oilseeds not only necessitates importation of palm oil but also results in low availability of protein cake, the co-product of vegetable oil extraction, thus limiting commercial livestock production (mainly poultry, dairy and pigs). It also results in underutilization of the installed oil extracting capacity. Only less than half of the country's installed capacity is utilized. The big question that remains is whether Kenya should continue to spend over Kshs. 4 billion per year in the importation of palm oil, thereby keeping foreign farmers in business while marginalizing local farmers. Such a situation would contradict the theme for the seventh National Development Plan (1994-1996), which is "Resource Mobilization for Sustainable Development". In this case, sustainable development implies "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". In view of this situation, there is an urgent need to raise domestic production of vegetable oils and fats in Kenya so as to reduce the import gap, with the ultimate goal of attaining self-sufficiency. With the population increasing rapidly, and given the limited supply of foreign currency, importation is no longer possible or desirable.

The widespread production of oil crops in all parts of the country as shown in Table 1.1 suggests that with appropriate domestic policy, Kenya could produce adequate edible oils and fats and thus save itself from this excessive dependency on imported edible oil (Oggema, 1988 and Republic of Kenya, 1994). According to the Republic of Kenya (1994), Kenya has suitable agro-ecological zones and soils to grow a variety of oil crops but the area cultivated and the amount harvested remain low. One of the policy measures that can be used to increase the production of any commodity is the pricing policy and hence the aim of the present study. Production of oil crops locally will help in achieving the Government Policy of food self-sufficiency, generation of farm family incomes and saving of foreign exchange, as stated in both the Food Policy Paper of 1994 and the Sessional Paper No.1 of 1994. It is also in agreement with the National Development Plan (1994-1996) which states the need to increase the supply of staple foods, particularly oilseeds, so as to feed Kenya's growing population.

1.1.2 **International and National Importance of Sunflower**

Sunflower was recognized as an oilseed crop in the 19th century and its production has expanded very fast all over the world. The present Commonwealth of Independent States (CIS) (former USSR) has been the world's largest producer of sunflower, followed by Argentina. A lot of efforts have been made in the United States and India in the recent past to promote the crop. Other growing countries include Romania, Yugoslavia, Bulgaria, Hungary and Canada. Since 1976, sunflower oil production in the World has been second to soyabean oil, with groundnut oil taking the third place. However, sunflower seed has advantages over soyabeans since its oil yield is greater and its meal is devoid of any toxic material (Lihanda, 1978).

Sunflower has been grown for many years in Kenya, but it has never achieved much prominence as an oil crop. In the past, production of sunflower has been based on the white variety which was being exported to European and American Countries as bird feed (Lihanda, 1978 and Zulberti and Lugogo, 1989). However, the oil type sunflower (black variety and hybrids) is now gaining emphasis.

In Kenya, sunflower is mainly grown in five provinces, namely, Eastern, Rift Valley, Western, Nyanza and Central provinces as shown in Table 1.3. There is also some limited production in the Coast Province. The Table shows that Eastern, Western and Rift-Valley provinces are the leading provinces in sunflower production. This is in terms of both the hectarage under the crop and the amount harvested.

Table 1.3: **Production of Sunflower in Kenya by Province (1972/73 -1991/92)**

Year	Eastern		Western		Rift Valley		Nyanza		Central	
	Area (Ha)	Production (tons)	Area (Ha)	Production (tons)	Area (Ha)	Production (tons)	Area (Ha)	Production (tons)	Area (Ha)	Production (tons)
1972/73	218	109	1774	426	1845	1450	180	90	24	12
1973/74	228	45	3288	668	5597	4043	220	110	26	13
1974/75	2598	403	6422	1857	3677	2988	279	162	74	11
1975/76	5600	1947	7015	1845	6623	5051	591	300	16	11
1976/77	5585	2795	7325	6446	4985	3657	1200	1209	746	304
1977/78	7607	3092	2362	2039	6672	4800	1303	1022	238	189
1978/79	10244	6046	822	157	8943	8634	2591	2071	621	447
1979/80	5551	2568	6788	3250	2418	2556	665	452	332	270
1980/81	5583	5580	5232	6279	1960	1232	850	334	630	504
1981/82	3449	2035	3844	4613	1739	724	1100	425	384	392
1982/83	772	423	5328	7000	2000	1300	1430	550	1185	537
1983/84	1158	532	3550	3720	1300	450	1700	715	809	260
1984/85	6270	1832	7100	5236	4652	1326	1814	850	806	322
1985/86	15140	6543	N/A	N/A	1472	736	1593	907	780	452
1986/87	17390	6740	6660	4698	2475	990	1700	680	432	288
1987/88	19332	10260	8700	9450	2866	1433	1505	620	402	223
1988/89	14677	7232	3400	3357	2699	3533	1200	400	437	279
1989/90	9066	10283	4070	4460	2787	3468	753	300	58	29
1990/91	9084	4757	4525	5475	2751	3918	136	51	346	255
1991/92	7183	3210	4676	5764	2965	4073	115	85	20	6

SOURCE: Ministry of Agriculture, Annual Reports (1973 - 92)

Table 1.3 is an indication that sunflower as a crop can grow almost everywhere in Kenya. This has a further indication of the potential of sunflower in substituting for the imported palm oil.

1.2 <u>The Statement of the Problem</u>

Given the heavy importation of edible oils and fats in Kenya, much research has focused on production of oil crops locally. Recent work has focused on the importance of sunflower for production of oils and protein cake because it is believed that it can contribute positively towards reducing Kenya's dependence on imported essential vegetable oil (Gitu, 1988). This is because sunflower is a major oil crop in the country, but production has not exploited the full potential. The production of sunflower in terms of both hectarage and output between 1970\71 to 1991\92 has been low and fluctuating as shown in Table 1.4 and Figure 1.2.

As can be seen in Figure 1.2, the hectarage devoted to sunflower has fluctuated from year to year. Yield (or output per hectare) has also been fluctuating from year to year and has been below the potential (which can be up to 2.5 tonnes per hectare, as given by Gearside (1975)). The vegetable Oils/Protein System Programme (VOPS) study on sunflower has revealed the following to be the constraints which are associated with its production: low producer prices; lack of coordinated marketing systems; agricultural risks due to operation in marginal rainfall areas and low yield as a result of poor crop husbandry and inadequate production technologies.

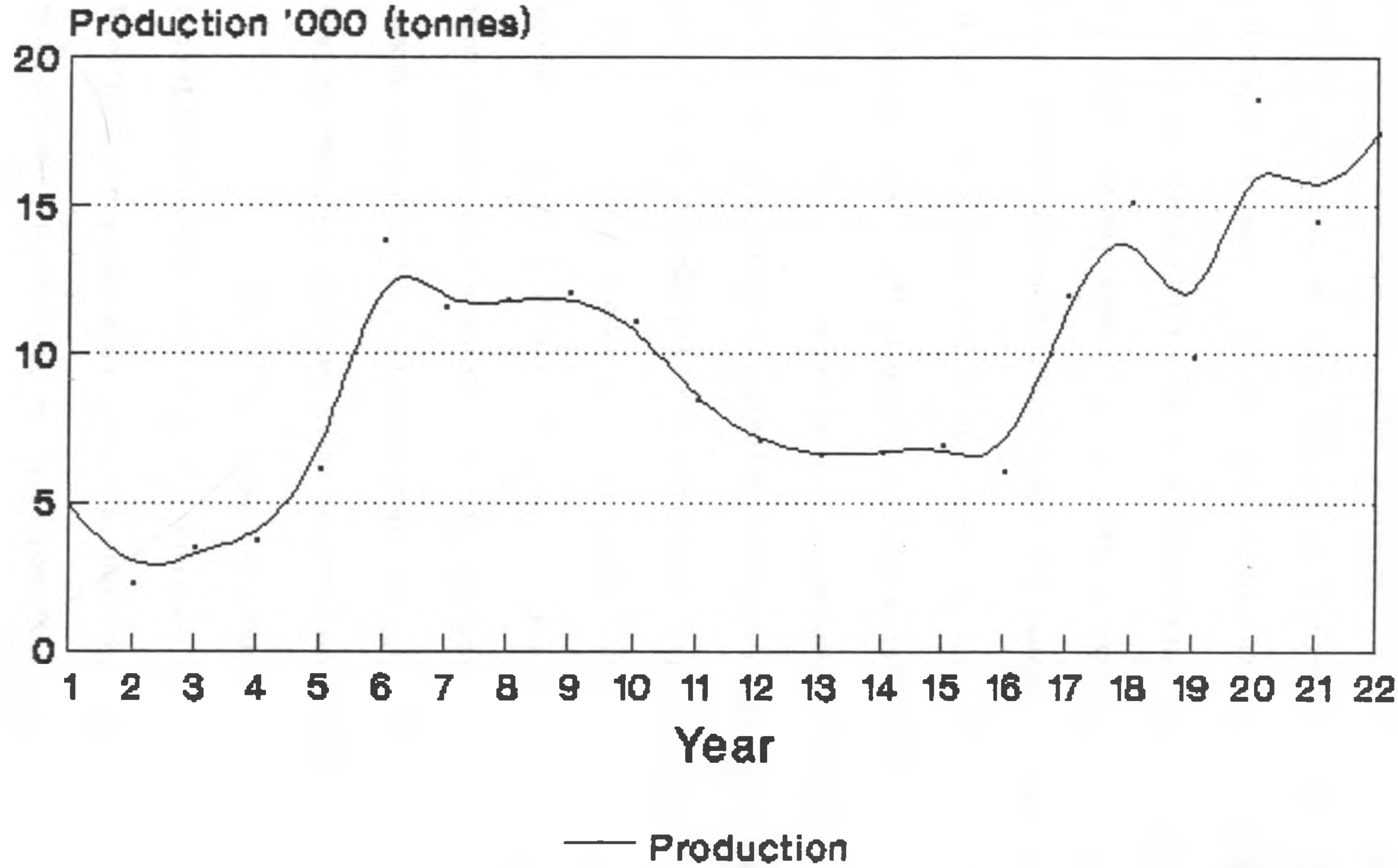
Table 1.4 **Production of Sunflower in Kenya (1971-92)**

Year	Hectarage (ha)	Production (ton)	Yield (kg/ha)
1970/71	10274	4862	473
1971/72	5311	2263	426
1972/73	3224	3410	1058
1973/74	16132	3672	228
1974/75	11422	6073	532
1975/76	18983	13846	729
1976/77	24678	11559	468
1977/78	13141	11795	898
1978/79	17864	12036	674
1979/80	14415	11079	769
1980/81	13237	8462	639
1981/82	8255	7037	852
1982/83	10370	6578	634
1983/84	11928	6693	561
1984/85	18172	6927	381
1985/86	22272	6012	270
1986/87	26245	11989	457
1987/88	29450	15074	512
1988/89	21518	9885	459
1989/90	16734	18539	1110
1990/91	15842	14455	912
1991/92	13440	17436	1300

SOURCE: Ministry of Agriculture, Annual Reports.

FIGURE 1.2

Production of Sunflower in Kenya (1971-1992)



The vegetable Oil and Protein Development Committee created by Kenya government at the end of 1988 gave the main limitation to the development of the vegetable oils and fats sub-sector as the low prices paid for oilseeds to the farmers. Like the VOPS project, the committee attempted to analyze and compare, using time-series data, several policies intended to achieve better sunflower seed price levels for the farmers and better price levels for the oil extractors.

From the above discussion, and the studies discussed under the literature review, it has been suggested that the prices offered for sunflower and other oilseeds have been low. The low prices are believed to have contributed to the low production of sunflower and other oil crops in Kenya. The studies point out the need for an appropriate pricing policy which will ensure higher prices for the oil crops. For such a policy to achieve the desired objective of increasing the production of sunflower, the farmers would have to respond positively to sunflower price changes. In other words, if the pricing policy is to be used to achieve increased production of sunflower, it is vital to have some knowledge of the price elasticity of supply for sunflower. This is indeed the aim of the current study. It complements the earlier studies by determining the likely effects of a change in the price of sunflower. This is because higher prices for sunflower would only affect the quantities supplied or produced in accordance with the respective supply price elasticity. Given that the magnitude of this elasticity is unknown, the impact of price changes can not be properly analyzed. Hence the present study aims at quantifying the influence of changes in prices and other factors on the production of sunflower (i.e. determining the price elasticity of supply and other parameters for sunflower) by estimating a supply response function for sunflower farmers.

In general, the results of this study would be of help to policy makers in their endeavor to formulate appropriate policies and measures to increase production of sunflower and other oil crops in Kenya.

1.3 Justification For The Study

According to the National Development Plan (1994), the government aims at achieving the broad policy objectives of food self-sufficiency and the saving of foreign exchange by increasing the domestic production of most commodities. Of particular importance are those commodities whose domestic supply is inadequate, for example, oil crops. The present study is therefore relevant as it is concerned with ways of increasing sunflower production and hence oil production in Kenya, so as to reduce the import bill and save foreign exchange. Any effort to reduce this import bill would go a long way towards enhancing development in other sectors of the economy.

Production of vegetable oils and fats in Kenya is not only expected to result in reduction on import dependency and foreign exchange consumption, but also the generation of employment and income at the rural level and the improved utilization of the installed oil extracting capacity. It will also result in increased availability of protein cake for commercial livestock feed. There will also be the overall growth of the economy due to improved utilization of underemployed labour and other resources.

The international prices for the imported palm oil have been quite low (Oggema, 1988). However, the low prices of palm oil may not remain so for long and thus there is a danger for continued dependence on this source of oils and fats. This is because, Kenya is only a price taker in the international market for oil, and hence bound to suffer from the high variability of the market. The need for self-sufficiency of Kenya in vegetable oils and fats cannot therefore be overemphasized.

Since the problem at hand is one of insufficient local production of oilseeds which necessitates importation, one way of solving this problem is to try and understand the factors that affect the production hence supply of oil crops and in this case sunflower. By understanding such factors and how they affect supply, then it becomes easier to identify points of intervention in an endeavor to increase the supply of sunflower and other oil crops in general. The current study attempts to analyse and quantify the factors influencing the supply of sunflower in Kenya.

Economic theory dictates that price is one of the major factors that do affect the supply of any commodity. It is therefore important to understand how the price of sunflower and other factors affect its production for policy purposes. The study was initiated and hence most relevant during the pro-liberalization period. However, during this reign of a liberalized market economy, the study is still relevant as it can help to identify other intervention measures that can be used to achieve increased production of sunflower. This would compare to the study done in India whereby lack of improved technology (and not price) appeared to be the major constraint in increasing oilseeds production (Uma, 1990). In this regard, Mungekar (1990) argues that "if technology is raising yields rapidly, even lower product prices may be sufficient". This is because price incentives are necessary but not in themselves sufficient.

Sunflower was chosen for this study because it is the most widely grown annual oil crop in the country as shown in Table 1.1. This is because it has a high potential for expanded production in most parts of Kenya (Gitu, 1988). Of all the oil crops grown in Kenya and apart from coconut and simsim, sunflower seed (hybrid) has the highest oil content (44%) which is also free of toxic materials (Lihanda, 1978) as shown in

Table 1.5.

Table 1.5 shows that coconut has the highest oil content. However, it is so specific in terms of its requirements that it is mainly produced around the coastal regions as shown in Table 1.1. Unlike sunflower, coconut can not be easily adapted to other areas. On the other hand, a study by Odhiambo (1988) noted that most or all of the coconut produced in Kenya was being used in the soap industry. This is because, the mills using copra (the primary product of the coconut industry) do not have complete refining units and those who have find it very expensive to complete the refining process. The crude coconut oil is not fit for cooking purposes.

Groundnuts also have a high oil content but its use in the local oil and fats industry is quite limited due to its high price arising from other competing end-users like direct consumption and manufacture of peanut butter. Likewise, simsim has a high oil content but it is mainly used for food because of its high quality. Soyabeans have a low oil content and a high protein content and are therefore mainly used in the manufacture of animal feeds.

Table 1.5: Oil and Protein Content of Some Selected Oilseeds (Percentage Content on a per Weight Basis)

Seed	Oil Contribution (%)	Cake Contribution (%)	Protein (%) In Cake	Protein (%) In Seed
Groundnut	40	52	50	26
Rapeseed	40	56	52	29
Simsim	44	52	40	22
Soyabean	18	79	46	36
Sunflower	44	37	43	16
Coconut	60	N\A	N\A	N\A

SOURCE: Zulberti (1988)

In addition, sunflower produces edible oil "equal to the finest olive oil in quality, food value, lack of taste, colour and keeping qualities" (Hurt, 1946). According to Gitu (1988), sunflower has the potential to substitute for palm oil. It is also the most important oil crop in Kenya in terms of the area cultivated and the specifity for which it is grown (Mburu, 1991 and Zulberti and Lugogo, 1989). This then explains why sunflower was chosen in this study.

Sunflower has a fairly widespread adoption in Kenya compared to the other oil crops. Weiss (1966) argues that sunflower will "grow on soils which are too dry or too poor for maize land and, provided a suitable variety is chosen, on wheat land". It has good adaptation to local climatic and edaphic variations and has a lower comparative need for capital inputs (Gatere, 1974). In addition, sunflower can and does grow in marginal areas where the opportunity cost of labour is low. Promotion of sunflower in these areas can thus provide gainful employment for labour which could otherwise be idle or unemployed (Gatere, 1974). According to Oggema (1988), sunflower is a possible alternative cash crop, both in the low-potential areas and in the high-potential areas.

1.4 Objectives of the Study

The main objective of the study was to establish the effects of price changes and other factors on the production of sunflower in Kenya. This was done by estimating and analyzing the supply response function for sunflower farmers in the major producing districts.

The specific objectives were:

(I) To estimate the price responsiveness of sunflower farmers in the major producing districts.

(II) To compare how producers respond to the prices of sunflower in the different major growing districts.

(III) To study how the other factors (other than price) affect the production of sunflower in Kenya.

1.5 Hypotheses Tested

The following hypotheses were tested:-

(I) Sunflower farmers in Kenya respond positively to sunflower price changes.

(II) The degree of responsiveness to sunflower price changes is the same for all farmers in the major growing districts.

(III) Factors other than price also significantly influence sunflower production in Kenya.

1.6 Organization of the Study

The text of this thesis is organized into five chapters. The first chapter presents the introduction, which covers the background information, the problem statement, the justification of the study, the objectives and hypotheses and finally, a brief on the organization of the study. In the second chapter, relevant literature on related studies and the methodology are reviewed. The location of the study and the methodology are outlined in Chapter three. Chapter four presents the empirical results of the study and their discussion. Chapter five finally presents the summary, conclusions and policy recommendations of the study.

CHAPTER TWO: LITERATURE REVIEW

2.1 Studies on Oil Crops

There has not been much economic research done on the oil crops industry in Kenya. According to Odhiambo (1988), there exists a wide literature gap in the oils and fats industry which needs to be filled. With full knowledge about the industry, it would be possible to come up with measures to try and revive the industry to self-sustaining growth. The present study aims at reducing the literature gap in the oils and fats industry in Kenya with a particular reference to sunflower production. This is achieved through the estimation of a supply response function for sunflower so as to determine the price elasticity of supply for sunflower. The magnitude of this elasticity is vital in the formulation of appropriate agricultural price policies.

Some of the studies done on the oil crops industry have been fairly general in nature. For example, Thuo (1978) worked on an in-depth analysis of the structure and performance of the edible vegetable oils and fats industry in Kenya. Much of the specific research done on sunflower has focused on its agronomic and cultural aspects (for example, Hurt (1946), Weiss (1966), Ravagan (1969) and Lihanda (1978)). However, there is some detailed but limited information on the economics of sunflower production and marketing in Kenya (for example, the work done by Gatere (1974) and Kavoi (1990)).

The Vegetable Oils/Protein System Programme (VOPS) at Egerton University, has looked into various aspects of the vegetable oils and fats industry in Kenya. Oggema (1988) did a study on the oil crops production in Kenya in which he noted that there was a shift in sunflower production from the high potential areas to marginal areas. This was due to low returns from sunflower in the high potential areas as compared to crops such as wheat and maize. Oggema (1988), therefore, recommended that the prices of oil crops, particularly sunflower and rapeseed be reviewed so as to act as an incentive to the farmers.

Gitu (1988) made an overview of policies and incentives in the Kenya's vegetable oils and fats industry. He found that the existing pricing policies do not encourage increased local oil production and that support policies and subsidization by the government, if implemented, could be an incentive to increased production. Based on the above findings, Gitu (1988) recommended that minimum official prices for all oil crops should be established. The minimum prices should be high enough to act as an incentive to increased production.

Odhiambo (1988) pointed out that the problem in the edible oils and fats industry in Kenya stems from the fact that consumption is already higher than domestic production. He indicated that "between 1976 and 1986, the consumption growth rate was about 13.7% per annum while the overall domestic production growth rate (inclusive of animal and vegetable oils and fats) was around 12% per annum". According to Odhiambo (1988), the animal oils and fats production growth rate during the same period was at an average of 14.5% per annum. However, this was not sufficient to bridge the gap between consumption and production since the vegetable oils and fats registered a negative growth rate. In order to increase the domestic production of vegetable oils and fats in Kenya, Odhiambo (1988) pointed out a need for better pricing of oilseeds. Any price fixed should be such that oilseeds will compete favourably with both food and cash crops such as maize and wheat. Odhiambo (1988) also recommended that the question of a price subsidy to farmers should be looked into as far as oilseeds are concerned.

The studies discussed above under the VOPS project have a basic suggestion, that the prices for oil crops have been low. The low prices have led to the low production of oil crops in the country resulting to foreign exchange drain due to heavy importation of palm oil. The studies clearly point out a need to increase the prices of oilseeds particularly sunflower so as to increase the domestic production of oil crops. Such a pricing policy requires some knowledge of how sunflower farmers respond to price changes. It is necessary to understand how farmers make their decisions based on the prevailing prices. This is because, an increase in the price of sunflower would only result in increased production depending on the supply price elasticity. The above studies give a lot of emphasis on sunflower among other oil crops. Sunflower is the most important oil crop in Kenya as discussed in section 1.3. According to Thuo (1978), expansion of sunflower production in Kenya would improve the foreign exchange position by cutting down on imports of palm oil.

Gatere (1974) looked at some aspects of production and marketing of sunflower in Kenya and found that the profitability of sunflower was relatively low, mainly due to poor yields which were, in turn, due to low levels of input utilization. Another reason for the low profitability was low prices, which is a disincentive to production. This situation, as observed by Gatere (1974) seems to have persisted to the present time.

Kavoi (1990) carried out a study on the economic analysis of factors affecting sunflower production in Kibwezi division of Machakos district. The study was carried out to establish the relationship between sunflower production and other crop enterprises, namely maize and cotton. Maize and Cotton were taken as the most competitive enterprises. The results revealed that both maize production and cotton production do not have any significant influence on sunflower production. There was no correlation between sunflower production and other crop enterprises. This may be so in the marginal areas like Machakos where alternative uses of land are limited and where maize is strictly grown for food. However, this may not be the case in the high potential areas, such as Meru and Trans-Nzoia districts, where land has many alternative uses or where maize is grown for sale. In this study, therefore, it was assumed that the area put under sunflower could be affected by the area put under maize or other competing enterprises. In this respect, therefore, the price of the most competitive enterprise in each region was included in the supply response model. In addition, the results obtained by Kavoi (1990) can not be generalized for the whole country because maize and cotton are not the only competing enterprises for sunflower in every region. The present study attempted to determine the most competitive enterprise for sunflower in any region through regression and correlation analysis as argued out by Msemakweli (1979) and Askari and Cummings (1974).

Kavoi (1990) also did a break-even price analysis for sunflower and found that the prices of sunflower offered to the farmers were different from the break-even price computed. He, therefore, recommended that the price of sunflower should be reviewed frequently and adjusted to be in line with the break-even price. Kavoi (1990) included the price of sunflower lagged one period in his model. However, he used the simple regression model which is applicable only when the coefficient of expectation or adjustment is equal to one. When the coefficient of adjustment is equal to one, it implies that there are no technological or institutional constraints to prevent the farmer from achieving his\her intended hectarage level (Lim, 1975). In other words, the farmer can attain the desired hectarage in one time period. This is indeed not the case. Farmers are faced with many difficulties as they try to adjust their hectarage to the equilibrium level. If the coefficient is less than one (which is mostly the case), the simple supply response model is not only mis-specified in that it omits lagged prices (e.g. P_{t-2}, P_{t-3} and so on), but also the coefficient or elasticity of supply response is underestimated (Yotopoulos and Nugent, 1976). It is therefore important to estimate the supply responsiveness of sunflower farmers using the Nerlovian supply response models which are much more general in that the coefficient of expectation or adjustment is not restricted. This is the reason why the present study employs the Nerlovian Partial Adjustment Model discussed in section 2.2.

The studies reviewed in this section are relevant to the present study in terms of their broad objective of attempting to solve the major problem in the vegetable oils and fats industry in Kenya. This problem is one of low domestic production of oil crops and an increasing import bill. The present study meets this objective by attempting to quantify the farmers responsiveness to sunflower price changes. This information is vital in the formulation of appropriate agricultural price policies necessary to stimulate production. Though the study focuses on sunflower production, it is expected that a similar picture is portrayed by the other oil crops.

2.2 Theoretical Framework

One of the policies that can be used to control the output of a crop, or any other commodity, is the pricing policy. The main objective of the agricultural price policy is to stimulate production, particularly when the technology for that purpose is available (Kahlon and Tyagi, 1989). However, this policy is only relevant where farmers react rationally to price changes. Hence, for an effective agricultural price policy, it is necessary that the authorities have a reliable estimate of the price elasticity of supply. With the knowledge about the magnitude of the elasticity coefficient, the policy maker would have a precise idea as to what level of price support would be necessary. For this reason, supply response studies have an important role in the context of formulation of appropriate agricultural price policies.

The purpose of the supply response studies is to examine how output is related to a number of important factors, such as price, technology and weather (Yotopoulos and Nugent, 1976). However, the relationship between output and price is of special interest. This can be investigated by estimating the partial regression coefficient of the price variable in a multiple regression of output, while holding other relevant variables constant.

The degree of responsiveness of a group of farmers to price changes for a given commodity is measured by the own price elasticity of supply for that commodity (Kenyanito, 1991). The price elasticity of supply for a given commodity can be defined as the proportionate change in quantity supplied as a result of a one percent change in its price. According to economic theory, the price elasticity of supply for any commodity should be a positive number. However, this is not always the case and the sign depends on the commodity in question and the economic rationality of the farmers' behaviour.

A number of supply response studies on Kenya's agricultural crops have been done (for example, Maitha's (1969) study on Kenyan Coffee, Maize and Wheat; Odada's (1975) study on Kenyan Pyrethrum; Msemakweli's (1979) study on cotton; Kere's (1986) study on Kenyan Wheat; Kenyanito's (1991) study on Cotton and Ngugi's (1991) study on Pyrethrum). No comprehensive study has been done on Kenyan sunflower, which is indeed an important oil crop in Kenya and whose supply needs to be increased (Zulberti and Lugogo, 1989). Hence this study aims at filling this gap.

Most of the supply response studies attempt to estimate acreage rather than output response to price changes. Traditionally, "acreage response to price has been interpreted as the output response to price" (Maitha, 1969). This is because the output supplied depends on acreage under the crop in question. In addition, due to great seasonal variability of weather conditions, farmers tend to have little control over actual output due to fluctuations in yield. Yotopoulos and Nugent (1976) state that it is logical to use actual acreage as a proxy for output. This is because acreage is more directly under the farmer's control and, once planted, can not be varied during the production period by factors outside the farmer's control. For this reason, acreage planted to a crop acts like a proxy or is an approximation of the farmers expected output for that period. Nerlove (1956) suggests that the elasticity of acreage is a lower limit to the price elasticity of supply. He gives this as one of the reasons why relatively low estimates of the elasticity of supply have been obtained.

Most of the studies on supply response have used either of the two versions of the Geometric Lag Model developed by Nerlove (1956). The first rationalization of these models is known as the Adaptive Expectations Model, first suggested by Cagan (1956) and later developed by Nerlove (1956). This model is based on the following behavioral hypothesis and developed as discussed below:

According to Nerlove (1956):

> "Farmers react, not to last year's price, but rather to the price they expect, and this expected price depends only to a limited extent on what last year's price was".

The Adaptive Expectations Model is thus based on the reasoning that the hectarage under the crop in year t (H_t) is a linear function of the expected price in year t (P^*_t) (Kmenta, 1971).

The farmers' expectations model then becomes:

$$H_t = b_o + b_1 P^*_t + U_t \quad \ldots\ldots \quad 2\text{-}1$$

where:

H_t = Hectarage under the crop in year t

P^*_t = Expected price in year t

b_o = Constant

b_1 = Structural coefficient of the model

U_t = Random error term in year t

But P^*_t is not directly observable. Hence Nerlove (1956) further made a plausible hypothesis that "each year the farmers revise the price they expect to prevail in the coming year in proportion to the error they made in predicting the price this period".

This hypothesis can be expressed mathematically as follows:

$$P^*_t - P^*_{t-1} = \beta (P_{t-1} - P^*_{t-1}) \quad \text{......} \quad 2\text{-}2$$

Where:

P^*_t = Expected price in year t

P^*_{t-1} = Expected price in year t-1

P_{t-1} = Actual price in year t-1

β = Coefficient of expectation

The above equation is equivalent to one in which the expected price is represented as a weighted moving average of the past prices, where the weights are functions solely of the coefficient of expectation. Such a formation of expectations is based on the idea that the current expectations are derived by modifying previous expectations in the light of current experience (Kmenta, 1971). Mathematically this becomes:

$$P^*_t = \beta P_{t-1} + (1-\beta)\beta P_{t-2} + (1-\beta)^2 \beta P_{t-3} + \ldots\ldots + (1-\beta)^{i-1} \beta P_{t-i} \quad \text{......} \quad 2\text{-}3$$

Where i = 1,..........., infinity.

Since $0 < \beta < 1$, P^*_t is a weighted average of past realized prices, with the weights declining geometrically as we move back into the past. Equations 2-1 and 2-3 can be combined to give:

$$H_t = b_o + b_1 \beta \Sigma (1-\beta)^{i-1} P_{t-i} + U_t \quad \text{......} \quad 2\text{-}4$$

This implies that the more recent prices have a greater influence on the farmers' decisions than the very distant previous prices. However, Kmenta (1971) indicates that an equation such as 2-4 is clearly awkward from the point of view of estimation because of the infinite number of regressors. It can, however, be simplified by the application of Koyck transformation to get:

$$H_t = \alpha_o + \alpha_1 H_{t-1} + \alpha_2 P_{t-1} + V_t \qquad 2\text{-}5$$

Where:

$\alpha_o = b_o ß$

$\alpha_1 = 1\text{-}ß$

$\alpha_2 = b_1 ß$

$V_t = U_t - (1\text{-}ß) U_{t-1}$

Equation 2-5 can now be used to estimate the supply function from which one calculates the farmers' responsiveness to price changes. However, there is a problem in trying to estimate equation 2-5 because the new disturbance term V_t is correlated with H_{t-1}, which is one of the explanatory variables. This means that "the Ordinary Least Squares (OLS) estimates of the coefficients will be inconsistent" (Kmenta, 1971). However, consistent estimates of the coefficients can be obtained in several ways, the simplest being the use of instrumental variables as is the case when dealing with "errors-in-variables" models (Kmenta, 1971).

An alternative rationalization of the Geometric Lag Model is the Partial Adjustment Model or Habit Persistence Model. This model is based on the argument that farmers are always trying to bring the actual level of farm output to some desired level, but such efforts are never completely successful, due to uncontrollable factors, such as weather (Odada, 1975). Other reasons why a complete adjustment of actual output to desired output is not achieved in a simple period are technological constraints, institutional rigidities or persistence of habit (Kmenta, 1971).

The Partial Adjustment Model is given as:

$$H^*_t = b_o + b_1 P_{t-1} + U_t \quad \ldots\ldots \quad 2\text{-}6$$

Here it is assumed that the expected price is equal to the last year's price, but that desired acreage (H^*_t) is not the same as the observed acreage (Nerlove, 1956). Desired hectarage (H^*_t) is not directly observable, but it is assumed that an attempt is being made to bring the actual level of the area to its desired level. Such an attempt is only partially successful during any one crop production period. Since H^*_t is not directly observable, Nerlove (1958) hypothesized that the farmers revise their hectarage expectations each year in proportion to the error they made in predicting last period's hectarage level. Mathematically, this becomes:

$$H_t - H_{t-1} = \mu (H^*_t - H_{t-1}) \text{ and } 0<\mu<1 \quad \ldots\ldots \quad 2\text{-}7$$

where, in equations 2-6 and 2-7:

H_t = Hectarage under crop in year t

H_{t-1} = Hectarage under crop in year t-1

H^*_t = Desired or expected hectarage if there is no difficulty of adjustment in year t

P_{t-1} = Actual price in year t-1

μ = Coefficient of adjustment

b_o = Constant term

b_1 = Structural coefficients of the model

U_t = Error term in year t

By substituting equation 2-6 into equation 2-7, we get:

$$H_t = \beta_o + \beta_1 H_{t-1} + \beta_2 P_{t-1} + V_t \quad \text{.......... 2-8}$$

Where:

$\beta_o = \mu b_o$

$\beta_1 = 1-\mu$

$\beta_2 = \mu b_1$

$V_t = \mu U_t$

It should be observed that equations 2-5 and 2-8 are basically the same, except for the specification of the disturbance or the random error term V_t. In equation 2-5, the problem of serial correlation is severe because V_t is equal to U_t -(1-ß) U_{t-1}. V_t is also correlated with H_{t-1}. Equation 2-8 does not induce additional serial correlation in the disturbances if there was none to start with (Griliches, 1967). This means that, in equation 2-8, V_t is not serially correlated if U_t is serially independent. However, according to Thiel (1971), it is not satisfactory to prefer the Partial Adjustment Model to the Adaptive Expectations Model on the ground that we can allow the disturbances to be uncorrelated and to have constant variances. What matters are the properties of the disturbances of the estimated equation, and this is a matter to be considered in every instance. According to Odada (1975), the Partial Adjustment and the Adaptive Expectations Models are simply special cases of a more general model embodying the conceptual ingredients of both. Nerlove did not specify under which conditions each of the two models would apply. His advice was that "additional empirical evidence must be brought to bear on the problems of how strongly the farmers react to actual prices in altering their expectations, and how rapidly they react to expected prices in the adjustment of actual acreage to desired acreage" (Nerlove, 1956). However, Griliches (1967) gives the most important difference of the two models as being conceptual. He states that:

> "The Adaptive Expectations Model attributes the lags to uncertainty and the discounting of current information. The Partial Adjustment Model attributes the same lags to technological and physiological inertia, and to the rising cost of rapid change. Circumstances (or experiments) are conceivable in which one could discriminate between these two hypotheses. For example, a government guaranteed price for next year's crop should dispose of most of the information uncertainty. If lags still persist, they must be due to other slow adjustment reasons "(Griliches (1967), page 42).

As discussed previously, the major contribution of Nerlove was the explicit introduction of uncertainty in the formulation of supply response models. The Adaptive Expectations Model emphasizes price uncertainty as being responsible for the farmer's adjustment lags while the Partial Adjustment Model emphasizes technological uncertainty as being responsible for these lags. Price uncertainty is the rate of adjustment between expected and actual prices. Technological uncertainty represents the time necessary to change the level of fixed resources employed in production. Whenever there are technical difficulties, full adjustment of supply to the equilibrium level is not possible within one production period and this implies that the coefficient of adjustment (μ) lies between zero and one (that is, $0<\mu<1$). In the absence of technical difficulties, full adjustment occurs within one time period and the coefficient of adjustment has a value of one (that is, $\mu = 1$). Situations do, however, arise when both forms of uncertainty are present. Under such circumstances, "mixed models"[1] are used and these are difficult to estimate.

Besides considering the type of uncertainty prevailing, Krishna (1963) adds that the choice of which of the two Nerlovian models to use in any situation depends, firstly, on whether it is a plausible formalization of the institutional, technological and expectational facts of the sector concerned, and, secondly, on the estimation difficulties posed by the model. Unlike the Adaptive Expectations Model, the Partial Adjustment Model can be easily estimated by the Ordinary Least Squares (OLS) Method and has an error structure which can be subjected to Durbin-Watson test for serial correlation (Koutsoyiannis, 1977). It is on the above discussion that the present study is based on the Partial Adjustment Model

The Partial Adjustment Model can also be formulated in a double logarithmic form. In this case, equations 2-6 and 2-7 becomes 2-9 and 2-10 respectively.

$$H^*_t = b_o P^{b1}_{t-1} e^{Ut} \quad \ldots \quad 2\text{-}9$$

$$H_t / H_{t-1} = (H^*_t / H_{t-1})^{\mu} \quad \ldots \quad 2\text{-}10$$

When equations 2-9 and 2-10 are expressed in natural logarithms (ln), they become 2-11 and 2-12 respectively:-

$$\ln H^*_t = \ln b_O + b_1 \ln P_{t-1} + U_t \quad \ldots \quad 2\text{-}11$$

$$\ln H_t - \ln H_{t-1} = \mu(\ln H^*_t - \ln H_{t-1}) \quad \ldots \quad 2\text{-}12$$

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[1] Combines both the Partial Adjustment Model and the Adaptive Expectations Model concepts.

By substituting equation 2-11 into equation 2-12, and upon rearrangement, we get:

$$\ln H_t = \ln \beta_o + \beta_1 \ln H_{t-1} + \beta_2 \ln P_{t-1} + V_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 2\text{-}13$$

where:

$$\ln \beta_o = \mu \ln b_o$$

$$\beta_1 = 1-\mu$$

$$\beta_2 = \mu b_1$$

$$V_t = \mu U_t$$

Equation 2-13 is the general double logarithmic equation of the Partial Adjustment Model.

Equations 2-8 and 2-13 are basically the same except for the fact that the variables in equation 2-13 are expressed in natural logarithms. The economic interpretation of the coefficient of adjustment (μ) is the same, whichever formulation is adopted (Lim, 1975). The computation of the short-run and the long-run price elasticities of supply in the two formulation are slightly different but the interpretation is the same.

The double logarithmic form of the Partial Adjustment Model is based on the assumption that the proportion of the disequilibrium which is eliminated is smaller, the greater the disequilibrium (Lim, 1975). This assumption is more realistic as it is likely that the closer the producers are to equilibrium, the more inclined they are to eliminate the disequilibrium. Hence, the reason for using the double logarithmic version of the Nerlovian Partial Adjustment Model in this study.

For one reason or the other, many of the studies done on supply response in Kenya have used the Partial Adjustment Model. Maitha (1974) used the Partial Adjustment Model and the Fisher Distributed Lag Model to estimate the supply response of Kenyan maize and wheat farmers. The estimated price elasticities suggested that maize acreage has a higher response to price than acreage under wheat. However, for both crops, the elasticities suggest that Kenyan farmers' response to price is quite high as compared to other countries. Maitha (1974) gave two possible reasons for the high price elasticities for the two crops. Firstly, that these two crops are highly competitive and the degree of substitutability of one for the other is quite high and, secondly, lack of shift variables in Kenyan maize and wheat industries during the period under consideration.

Kere (1986) estimated the supply response functions for wheat at district level using the Partial Adjustment Model. In his study, yield of wheat (lagged one period), mean annual rainfall and the time trend variable were included in the model as explanatory variables. The results showed that Kenyan farmers are relatively responsive to wheat prices as compared to the farmers in U.S.A and India. Relatively high price elasticities were obtained, and they indicated competitiveness between wheat and other enterprises, as well as their substitutability. The wheat yield coefficient was positive and significant while the time trend coefficient was significant but negative, and this could be as a result of land sub-division,

Kenyanito (1991) carried out a study on the supply responsiveness of cotton farmers in Central and Eastern Kenya, still using the Nerlovian Partial Adjustment Model. This was done at district level where the hectarage under cotton during any year was assumed to be a function of the previous year's hectarage, lagged seed cotton price, lagged producer price of the most competitive enterprise, current annual rainfall amounts and a time trend variable. The estimated price elasticities varied from a short-run value of 0.92 for Machakos District to a long-run value of 5.79 for Kitui District.

Maitha (1969) and Odada (1975) also estimated the supply response models for coffee and pyrethrum respectively using the Nerlovian Partial Adjustment Models. However, the two crops are perennial with a significant time lag between planting and the first realization of output. Hence they involve more complicated models as compared to the ones used for annual crops.

The models reviewed in this section are important in trying to select the best model to meet the objectives of this study. From this review, and considering the situation in the vegetable oils and fats industry, the double logarithmic version of the Nerlovian Partial Adjustment Model was selected. The choice of this model is justified by the following reasons. Firstly, the model is suitable because it is assumed that during the period covered by the study, sunflower farmers always had a knowledge of the price to prevail in the coming season prior to the planting period. Until 1982, sunflower had been a scheduled crop (one whose minimum price was determined and reviewed by the government). It is indeed the only oilseed crop for which, in the past, a purchase price was set by the government through the Annual Price Reviews (Gitu, 1988). Since 1982, the Oil Crop Development (OCD) Limited has been the promoter and buyer of sunflower which is later supplied to the East African Industries (EAI).There are some other private companies and agents who are also involved in the promotion and buying of sunflower from the farmers. Such companies include Kenya Seed Company, Kitale Industries, Western Seed Company Limited, Arkay Industries and Ufuta Limited among others. These private companies contract farmers before the planting period and inform them of the prices to be offered for the produce. In this case, it is believed that most of the information uncertainty is eliminated. However, there are a few farmers who grow sunflower without being contracted, but their number and the amount of produce they offer may not be very significant. Secondly, the Partial Adjustment Model is widely used than the Adaptive Expectations Model because it has fewer estimation problems (Lim, 1975). More specifically, the Partial Adjustment Model does not suffer from serious serial correlation as the Adaptive Expectations Model. Lastly, the model has the advantage of including the time element without specifying the length of such time, thus enabling the calculation of both the short-run and long-run price elasticities.

CHAPTER THREE: METHODOLOGY

3.1 Location of the Study

The major sunflower producing areas in Kenya are Eastern, Western and Rift-Valley provinces (Oggema, 1988) (See Table 1.3). There is also some sunflower production in Nyanza, Central and Coast provinces, but this is not large enough to warrant their inclusion in the study.

For each of the three main sunflower producing provinces, a major sunflower producing district was selected. The three districts are Meru, Bungoma and Trans-Nzoia districts. Supply response models for each of the three districts were then estimated and analyzed.

3.2 Functional Forms of the Model

The functional forms of the models used in this study are based on the double logarithmic version of the Nerlovian Partial Adjustment Model as discussed in the previous chapter. In this model, it is hypothesized that the current hectarage under sunflower is a function of the last period's price and the hectarage lagged one period as shown in Equation 2-13. However, price is not the only determinant of the area put under sunflower and thus other variables are included in the final model. Nerlove's model provides only "a skeleton" of an acceptable rationale and one, therefore, needs to 'put the flesh' to get a more realistic picture.

In the present study, it was assumed that the hectarage under sunflower (H_t) during any given year in a district is a function of the previous year's hectarage (H_{t-1}), lagged sunflower price (P_{t-1}), lagged yield of sunflower (Y_{t-1}), current annual rainfall amounts (R_t) and a time trend variable (T). The estimated equation was built from the double logarithmic version of the Partial Adjustment Model with the above variables as follows:-

$$H^*_t = b_o P^{b1}_{t-1} Y^{b2}_{t-1} R^{b3}_t T^{b4} e^{Ut} \quad \text{3-1}$$

$$H_t / H_{t-1} = (H^*_t / H_{t-1})^{\mu} \quad \text{3-2}$$

where:

H^*_t = Desired hectarage if there is no difficulty of adjustment in year t

H_t = Hectarage under sunflower in year t

H_{t-1} = Hectarage under sunflower in year t - 1

P_{t-1} = Producer price of sunflower in year t-1

Y_{t-1} = Yield of sunflower in year t - 1

R_t = Annual rainfall in year t

T = Time trend variable

U_t = Disturbance (random error) term

μ = Elasticity of adjustment

By substituting equation 3-1 into equation 3-2, we get:

$$H_t / H_{t-1} = (b_o P^{b1}_{t-1} Y^{b2}_{t-1} R^{b3}_t T^{b4} e^{Ut} / H_{t-1})^{\mu} \quad \text{3-3}$$

As it is, Equation 3-3 can not be estimated using the Ordinary Least Squares (OLS) technique. It must be transformed into the linear form by taking the natural logarithms (ln) of all the variables. When equation 3-3 is expressed in natural logarithms, and upon rearrangement, we get:-

$$\ln H_t = \ln \beta_O + \beta_1 \ln H_{t-1} + \beta_2 \ln P_{t-1} + \beta_3 \ln Y_{t-1} + \beta_4 \ln R_t + \beta_5 \ln T + V_t \quad \text{......} \quad 3\text{-}4$$

where:

$\ln \beta_o = \mu \ln b_o$

$\beta_1 = 1-\mu$

$\beta_2 = \mu b_1$

$\beta_3 = \mu b_2$

$\beta_4 = \mu b_3$

$\beta_5 = \mu b_4$

V_t = New disturbance (random error) term (= μU_t)

μ = Elasticity of adjustment (= $1 - \beta_1$)

β_o = Constant term

β_1 ....β_5 = Structural coefficients of the model.

Equation 3-4 can be rewritten in a more simplified form as shown below:

$$H'_t = \beta'_o + \beta_1 H'_{t-1} + \beta_2 P'_{t-1} + \beta_3 Y'_{t-1} + \beta_4 R'_t + \beta_5 T' + V_t \quad \text{......} \quad 3\text{-}5$$

where:

$\beta'_o = \ln \beta_o$, $H'_{t-1} = \ln H_{t-1}$,

$P'_{t-1} = \ln P_{t-1}, \quad Y'_{t-1} = \ln Y_{t-1},$

$R'_t = \ln R_t$ and $T' = \ln T$

This study, like many other supply response studies (for example, Cummings (1975), Kere (1986) and Kenyanito (1991)), used hectarage rather than output as the dependent variable. Hectarage is used as a proxy variable since planned output (the variable to be explained) can not be observed directly (Ghatak and Ingersent, 1986). It is possible to use realized output as a proxy for planned output but the two could differ significantly due to effects of uncontrollable factors on agricultural output (for example, weather). Hence, it is assumed that the hectarage planted indicates the farmers' planned output (Maitha, 1974). Indeed, Ghatak and Ingersent (1986) argue that the "idea of regressing acreage[2] rather than output on price is not very difficult to understand". However, according to Nerlove (1956), acreage response to price is only one facet for the much more complicated problem of obtaining a comprehensive supply function. But almost certainly, the area response function underestimate the total output response to changes in price (Kahlon and Tyagi, 1989).

According to Dean (1966), the use of output as the dependent variable would be unsuitable for agricultural commodities which may be consumed at the farm level. Sunflower seed is an example here since it is sometimes fed to birds or used for domestic oil extraction at the farm level. In such a situation, the amount of produce harvested and sold could differ from the actual output because some of it could have been consumed when

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t is important to note that both acres and hectares are units of measuring land area (1 hectare 471 acres) the crop was in the farm. On the other hand, for a minor crop such as sunflower, the farmer's responsiveness is likely to be reflected in his acreage allotment decisions (Stevens, 1977).

The inclusion of the lagged dependent variable (i.e hectarage under sunflower in year t-l) as an explanatory variable in the model was based on the assumption that its coefficient contributes significantly to an explanation of the level of the current area put under sunflower. Hill (1971), in an attempt to explain the economic meaning of this parameter, described it as a "catch-all" variable, picking up the effects of all manner of factors contributing to a supply trend. It could also be used to indicate and measure unexplained shifts in the supply curve and describe the way in which supply is adjusted towards the long-run equilibrium supply. The coefficient of the lagged dependent variable is expected to be positive, indicating that the current area put under sunflower is positively influenced by the area put under the crop during the previous season. Negative values of the coefficient could be caused by alternate rises and falls in supply brought about by chance or some third agent (Hill, 1971). A zero value for the coefficient may suggest that the supply curve is constant, indicating that there is no relationship between the area put under the crop during this period and last period. In such a case, the lagged dependent variable would be irrelevant in the model. Values of the coefficient close to unity indicate very slow adjustment on the part of farmers (Jhala, 1979). This would mean that there are some technical, institutional and subjective factors that seem to greatly influence the decision-making of the farmers.

Griliches (1967) points out that one should be careful in the interpretation of the coefficient of the lagged dependent variable. This is because, introducing an irrelevant lagged dependent variable into the estimating equation will usually lead to significant and sensible coefficients even though the true equation is static with serially correlated residuals. In such a case, the Partial Adjustment Model will produce sensible results even though it is wrong.

Related to the coefficient of the lagged dependent variable is the coefficient of adjustment (μ) which represents the proportion of the adjustment towards equilibrium which occurs in one time period. A zero coefficient for the lagged dependent variable suggests that the coefficient of adjustment in the Nerlovian model is approximately one ($\mu=1$) (Bateman, 1965). Since the coefficient of adjustment gives the time necessary to change the fixed factors of production, a value of one implies that there are no technical barriers to full adjustment in one time period. In other words, a value of one indicates a rate of adjustment of a hundred per cent (100%) per period (year in this case). Thus, there occurs full adjustment to supply within one year.

Like the Nerlovian formulation of the Partial Adjustment Model, this study used lagged price of sunflower as one of the independent variables. The inclusion of the price variable in the supply response functions is an indication of its importance in decision making at the farm level. Nerlove (1979), commenting on this importance, states that:

> ".......responses to changing prices for outputs and inputs, whether made visible by markets, must be a key element in our attempt to understand the agricultural production and food supply problems in the low income and developing economies, as well as in the highly efficient and productive agricultural sectors of the developed and high income countries of the world" (Nerlove, 1979 page 874).

The use of undeflated prices was based on the assumption that farmers attempt to maximize profits without regard to their real value. According to Hill (1971), this may be reasonable when considering the immobility of farmers in spite of relatively low incomes in agriculture. However, Nerlove (1979) states that despite their importance, "visible" prices may not convey all of the information to which farmers find it necessary to respond to particularly in a highly developed economy.

Economic theory dictates that the coefficient of the price variable in a supply response model be positive. The assumption here is that as the producer price of a crop is increased, more of that crop is produced by increasing the area put under the crop. This implies a positive relationship between the price of a crop and the area allocated to such a crop. The same relationship was expected in this study where it was assumed that as the price of sunflower increases, more land is allocated to sunflower and vice versa. However, it is important to note that it is possible to get a negative price response, depending on the type of the crop in question and the economic rationality of the farmers. Jhala (1979) points out that the idea of a negative supply response is not an uncommon feature in the literature on supply response. Cummings (1975) study on supply response for major cereals and cash crops in India, found that wheat had uniformly positive price response in all the wheat areas at the state level but nearly half of the districts analyzed had a negative price response. However, according to Cummings (1975), the districts with negative price response are those where wheat generally accounts for less than five per cent of the total cultivated acreage. This is an indication that wheat was a minor crop in these districts and the farmers were giving priority to other enterprises. A study done by Kere (1986) also obtained a negative price response for wheat production in Narok district. This could have been due to a shift away from wheat growing to other crop enterprises (Kere, 1986).

From the studies done in India and other developing countries, it is clear that the farmers are rational in economic decision-making, meaning that they allocate the limited resources at their disposal in a highly efficient manner (Nervole, 1979). But, except for a few cash crops, the supply responses have been found to be much weaker than those of the farmers in the developed countries. In some instances, the farmer's response to economic incentives is not clear or well defined. Kahlon and Tyagi (1989) point out that such findings have an obvious policy implication that price, as an instrument for achieving increased production, may have only a limited role to play. A study on oil seeds in India by Uma (1990) concludes that the long-term strategy for making India self-sufficient in edible oils should lay emphasis on technological upgradation and not price alone.

Since the main objective of most supply response models is the identification of the farmer's response to market influences, a concise statement of the price variable has been a major concern. Askari and Cummings (1974) point out that the question of what price variable to use in the supply model confronts all researchers since no single pattern has emerged as the most preferable. However, according to Askari and Cummings (1974), most of the studies have used either of the following four price series: the price received by farmers for the crop; the ratio of the price received by farmers for the crop to some consumer price index; the ratio of the price received by farmers for the crop to some index of the prices of the farmers' inputs and finally the ratio of the price received by farmers for the crop to some index of the prices of competitive crops (or the price of the most competitive crop).

As discussed previously, the use of the price received by farmers for the crop is based on the assumption that farmers take no regard of the real value of profits. However, this is not always the case. Bateman (1965), in his study of aggregate and regional supply functions for Ghanaian cocoa, suggests that the primary factor which causes a change in the farmer's price expectations from one year to the next is the change in real producer prices. The biggest problem remains on how to choose an appropriate and relevant deflator, and this is frequently determined by data availability. It is, however, important to note that the use of deflated prices introduces problems in assuming that the farmers used this same deflator in arriving at their expectations as to price (King, 1956).

A few studies have used the ratio of the price received by farmers for the crop to some Consumer Price Index (CPI). An example is Kenyanito (1991) who used the Consumer Price Index for the Nairobi lower-income earners to deflate the producer prices of cotton and those of the competing enterprises to obtain real producer prices. Other studies, for example, Cummings (1975) deflated the prices by a Cost of Living Index taken from the nearest urban centre for which such index was available. The use of urban centres was due to insufficient information on the changes in the rural areas. However, Askari and Cummings (1974) argue that deflating the price by some Consumer Price Index may not be of much value, especially in the rural areas where farmers buy only a very select basket of goods. On the other hand, data on the CPI in Kenya is only available for Nairobi, Mombasa and Kisumu. The CPI for these three towns may not provide an exact picture of what is happening in the other towns especially in the rural areas. The study by Kenyanito (1991) using real producer prices may have posed a limitation in that the consumer basket in the study area may be significantly different from the consumer basket in Nairobi. The current study did not use the CPI as a deflator because the data available would not have been a proper representation of the study area.

Ideally, the producer price of sunflower should be deflated either by some index of the prices of the inputs of production or by the prices of alternative enterprises. Since it is difficult to obtain some index of prices of the inputs of production because some inputs cannot be valued directly, the ratio of the price of the crop to the price of the most competitive enterprise (or crop) could be used. Alternatively, the price of the most competitive enterprise could be included as an independent variable in the model. This study adopted the latter approach. The use of the most competitive enterprise has been supported by earlier studies on sunflower which reveal competition between sunflower and other crop enterprises (especially food crops) for the available land and other resources.

Since it is not possible to know a priori the most competitive enterprise to sunflower in each district, and since it is not the same in all the districts, the first stage of the analysis involved the determination of the most competitive enterprise in each district. This involved running a regression with the lagged prices of all the competing enterprises as additional independent variables in the model for each district. The regression equation was of the form:

$$H_t = a_o + a_1 H_{t-1} + a_2 P_{t-1} + a_3 Y_{t-1} + a_4 R_t + a_5 T + a_6 P^1_{t-1} + a_7 P^2_{t-1}$$

$$+ \ldots\ldots\ldots\ldots + a_{k+5} P^k_{t-1} + Z_t \ldots\ldots\ldots\ldots\ldots\ldots \quad 3\text{-}6$$

where:

$a_0, \ldots, a_{k+5}$ are the structural coefficients of the model

$P^1_{t-1}, \ldots, P^k_{t-1}$ are the prices of k competing enterprises in year t-1

Z_t is the error term

Other variables are as in Equation 3-1 and 3-2.

The most competitive enterprise to sunflower was identified as the one with the largest negative coefficient. It is also possible to identify the most competitive enterprise for any crop for a given region by using simple correlations. The enterprise whose price is most negatively correlated with the current hectarage of the crop whose supply response is being estimated is chosen as the most competitive enterprise for that crop. The present study applied the two methods in determining the most competitive enterprise.

The estimation of the simple correlation matrices for all the variables given above plus the estimation of the regression equation 3-6 constituted the first stage of the analysis. Having determined the most competitive enterprise in each district, and after including it as an additional independent variable in the model, Equation 3-5 becomes:

$$H'_t = \beta_0 + \beta_1 H'_{t-1} + \beta_2 P'_{t-1} + \beta_3 P^{ic}_{t-1} + \beta_4 Y'_{t-1} + \beta_5 R'_t + \beta_6 T' + V_t \ldots \quad 3\text{-}7$$

Where:

P^{ic}_{t-1} = Price of the most competitive enterprise in year t-1

Other variables are as in Equation 3-1

The prices of sunflower and those of the most competitive enterprise were considered a priori to be relevant to the farmers' decision-making process. The coefficient of the price of the most competitive enterprise is expected to be negative. This implies that as the price of the most competitive enterprise increases, the area put under sunflower decreases as more of the competitive crop is grown. Besides the problem of identifying the correct price specification to use in the model, it should be noted that the proper price formulation itself is likely to change over time. As a result, Askari and Cummings (1974) suggest that the use of an inappropriate price series casts some doubt on the empirical results and may also account for some of the response differences observed in various studies.

Yield of sunflower is also included in the model to determine its influence (if any) on the supply of sunflower. According to Gearside (1975), the yield of sunflower could be up to 2.5 tonnes per hectare, but this is far from being achieved as shown in Table 1.4. Also, Zulberti and Lugogo (1989) state that the yields obtained by Kenyan farmers are well below the international standards, even when compared with the yields in countries where little fertilizer is used. King (1956) suggests that one of the important factors affecting the difference between what a farmer expected for a price and what he received is unusual yields. He argues that acreage planted is influenced by expected price, assuming normal conditions. It is, therefore, important to determine how yields influences the acreage planted through the expected price.

In this study, it is the yield lagged one period that is expected to affect the current area under sunflower. According to Askari and Cummings (1974), there is no scientifically satisfactory way of expressing the yield concept, but the incorporation of past yield (in the guise of yield expectations) involves recognition of prior climatological experience. The coefficient of the yield variable was expected to be positive. The positive relationship implies that if the last period's yield of sunflower was high, then the farmers will put more land under the crop during the current period. However, it is also possible to get a negative yield coefficient. Jhala (1979), commenting on the negative coefficient of yield, suggested that there could be some inferior land being brought under cultivation. In such a case, yield could be declining as more area is put under the crop. A negative yield coefficient could also be a result of mismanagement whereby as more land is put under sunflower, management difficulties arise resulting in a decrease in yield.

Some studies have focused on yield response rather than hectarage response to price changes. However, according to Stevens (1977), small scale farmers are caught up in a low technical and economic equilibrium trap. In his study of tradition and dynamics in small-farm agriculture, he found that in the short-run, farmers respond to price increases through increases in hectarage rather than yield improvement. That is, when prices go up, the immediate increased output realized is due to increased acreage rather than due to technical improvement. This then justifies the use of acreage response. An alternative version of the model excluding the yield variable was also fitted and analyzed. This was done in order to reduce any likely multicollinearity in the estimated equations, especially between yield and price. Without the yield variable, equations 3-5 and 3-7 becomes equations 3-8 and 3-9 respectively:-

$$H'_t = \beta_o + \beta_1 H'_{t-1} + \beta_2 P'_{t-1} + \beta_3 R'_t + \beta_4 T' + V_t \quad \text{3-8}$$

$$H'_t = \beta_o + \beta_1 H'_{t-1} + \beta_2 P'_{t-1} + \beta_3 P^{\prime c}_{t-1} + \beta_4 R'_t + \beta_5 T' + V_t \quad \text{3-9}$$

Some studies on supply response have also excluded the yield variable (for example, Cummings (1975), who rejected the yield variable due to its unreliability and little statistical significance).

Yotopoulos and Nugent (1976) indicate that the most important factors of agricultural supply are price, technology and weather. Weather is a broad term encompassing rainfall, temperature, humidity and wind. The above elements of weather cannot enter directly in the model formulation of supply response studies. This is because the collection of data would be tedious, plus the twin problems of multicollinearity and serial correlation.

It is, therefore, important to identify one element to use as a proxy for weather. In this study, annual rainfall amount was taken as a proxy for weather because the study areas include some semi-arid areas where rainfall is not guaranteed and could fluctuate from year to year. Sunflower does well both in the high and low-potential areas. However, according to Oggema (1988), there has been a shift in sunflower production from the high-potential areas to the marginal areas. This means that rainfall is a relevant variable and is expected to influence the area put under sunflower, depending on whether we have a normal rainfall, flood or drought. Ghatak and Ingersent (1986) argue that the impact of rainfall on crop production has been particularly significant in the arid and semi-arid regions of India and Pakistan. Krishna (1963) in his study on cotton in the Punjab region showed that annual rainfall does significantly influence the farmer's decision on area planted. The rainfall coefficient is expected to be positive in the marginal areas. However, in the high potential areas, the coefficient could be negative. This is because too much rain could destroy the crop.

The yield of any crop is greatly influenced by weather or rainfall, among other things, so that yield is sometimes used as a proxy for weather. But in the first version of this study, both yield and rainfall are included as explanatory variables, assuming that the last period's yield is not correlated to current period's rainfall. However, their relationship was determined by using the simple correlation matrix and the best form of the model chosen on the basis of the R^2 values and the significance of the coefficients.

The time trend variable is included in the model to capture other variables that could influence acreage response but are omitted in the model. Such variables include technological and political changes, among others. The coefficient of the trend term could be positive or negative, depending on whether the area put under sunflower is increasing or decreasing with time. Askari and Cummings (1974) indicate that the inclusion of the simple time trend variable is intended to represent the effects of monotonic changes in both technology and in the supporting infrastructure. According to Koutsoyiannis (1977), the coefficient of time is interpreted as a measure of autonomous growth, i.e. the constant term in the equation increases or decreases steadily.

The second stage of the analysis involved the estimation of the supply response models for sunflower in the three districts. Four different equations (3-5, 3-7, 3-8, and 3-9) were estimated for each of the three districts.

3.3 **Multicollinearity in the Estimated Models**

The problem of multicollinearity arises in multiple regressions when the independent variables are collinear or highly correlated (Wonnacott and Wonnnacott, 1979). In other words, multicollinearity is the presence of any fixed relation between independent variables. Multicollinearity is characterized by large variances of estimators, large standard errors, insignificant (or indiscernible) coefficients and high R^2. As a result, structural questions cannot be answered (for example, the influence of a single independent variable on the dependent variable). The estimating procedure also becomes very unstable and very sensitive to random errors. Although the problem of multicollinearity is very common in multiple regressions, Rao and Miller (1971) claim that it is largely a theoretical nightmare rather than an empirical reality.

In this study, the standard rule involving inspection of the simple correlations among independent variables was used to scan for multicollinearity. According to Klein (1977), "so long as the simple correlation between any two explanatory variables X and Y is less than the multiple correlation R, there is no serious collinearity between them". This rule of thumb was used to scan for multicollinearity in this study. However, according to Rao and Miller (1971), the simple correlations are only elements of the entire correlation matrix and hence may or may not contribute to the problems of multicollinearity. They conclude that one should not, a priori, rule out estimation of any regression equation because of high simple correlations between any two independent variables.

3.4 Testing for Serial Correlation in the Estimated Model

The application of the Ordinary Least Squares method used in this study requires that the successive values of the random error term be independent. This means that the value which the error term assumes in any one period is independent from the value it assumed in any previous period (Koutsoyiannis, 1977). In some econometric studies, the above assumption is not satisfied and hence the problem of serial correlation. Serial correlation occurs in econometric studies when the errors in one period are dependent on the errors in the previous periods (Rao and Miller, 1971). According to Nerlove (1956), most economic time-series data are known to exhibit a great deal of serial correlation. However,the analysis of time-series data using the Ordinary Least Squares regression method is recommended on the assumption that the errors in the model are not serially correlated. Durbin[2](1970) points out that when this assumption does not hold, the least-squares estimates of the coefficients can be biased. Nerlove and Addison (1958) urge econometricians to take serial correlation as a `fact of life', but indicate that its prevalence in economic time-series data leads to a serious difficulty in the interpretation of statistical regressions among economic variables.

For the above reasons, a test of serial correlation should form part of the least-squares analysis of time-series data. One of the tests for first order serial correlation is the Durbin-Watson test. However, the Durbin-Watson test will only work well in regressions where we do not have a lagged dependent variable as an explanatory variable. When lagged endogenous variables are included in an equation estimated by OLS method, the Durbin-Watson statistic (d) is asymptotically biased towards 2, (the value it should have if no serial correlation is present) indicating the absence of serial correlation (Nerlove and

Wallis, 1966 and Griliches, 1967). It is therefore doubtful that the test should be used to test for serial correlation or to provide any indication of the extent of such correlation when the equation contains lagged values of any endogenous variable. In most cases, the addition of the lagged dependent variables leads to a reduction in the serial correlation of the residuals and hence increased values of the Durbin-Watson statistic (Griliches, 1961).

In situations where we have a lagged dependent variable as an independent variable, Durbin[1] (1970) suggested an alternative `h' statistic (known with the acronym Durbin's h-test). The test statistic `h' is defined by Rao and Miller (1971) as:

$$h = (1-1/2d)\sqrt{n/1-n.V(\beta_1)} \quad \text{3-10}$$

where:

d = the Durbin-Watson d statistic

n = sample size

$V(\beta_1)$ = estimated variance of the coefficient of the lagged dependent variable in the OLS regression.

The h statistic is normally distributed with mean zero and variance unity in large samples (Rao and Miller, 1971). Thus, the standard normal distribution tables were used to test for the null hypothesis of no serial correlation in the errors. If the absolute value of h is greater than 1.645 at the 5 percent level of significance (or the 95 percent confidence level), the null hypothesis of no serial correlation is rejected and vice versa.

According to Kenkel (1974), the 'h' test proposed by Durbin for testing the hypothesis of no serial correlation is a large sample test and not much is known about its properties in small samples. If the Durbin's 'h'- test is to be used in testing for serially correlated errors in small samples, it should at least be the case that the h-test performs better than the Durbin-Watson d test. In the present study, the h-statistic was calculated and used to test for serial correlation despite the small sample limitation. The Durbin-Watson d statistic was also computed and the two tests compared in testing for the presence of serial correlation in the errors. However, it must be noted that many researchers have continued to use the Durbin-Watson d statistic in those cases in which the test is invalid, probably due to lack of a better test, especially in small samples (Kenkel, 1974).

3.5 Computation of the Elasticity of Supply and the Time Required for Full Adjustment of Supply

The third stage of the analysis involved computation of the price elasticity of supply for sunflower and the time required for full adjustment of supply for each district from the results of the second stage. As defined previously, the price elasticity of supply gives the percentage change in the quantity supplied of a commodity as a result of a one percent change in its own price. However, since hectarage (rather than output) is used as the dependent variable, the price elasticity computed will be that of hectarage and not total supply. According to Askari and Cummings (1974), the two elasticities may differ, as rising prices first induce planting on the best land and then expansion occurs on the less suitable land.

The short-run and the long-run price elasticities of supply were computed. The distinction between the short-run and the long-run elasticities of supply is based on the assumption about the supply of certain factors to the farm or industry. It is assumed that in the short-run, most or all factors of production are fixed while, as time passes, more of these restrictions are removed and in the long run, most or all factors of production can change (Nerlove, 1958). It must be noted here that one advantage of the double logarithmic function is that the coefficient of the independent variable is an elasticity by itself. In this case, the short-run price elasticity of supply ($\cap s$) was obtained from equations 3-5, 3-7, 3-8 and 3-9 as shown below:

$$\cap s = \beta_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 3\text{-}11$$

where:

$\cap s$ = short-run price elasticity of supply

β_2 = coefficient of lagged price of sunflower

On the other hand, the long-run price elasticity of supply ($\cap l$) for sunflower was given by:

$$\cap l = \frac{\cap s}{\mu} = \frac{\beta_2}{1 - \beta_1} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 3\text{-}12$$

where:

$\cap l$ = Long-run price elasticity of supply

μ = Elasticity of adjustment (= $1-\beta_1$)

Other variables are as in Equation 3-11

Economic theory dictates that the price elasticity of supply for any commodity be positive, but some studies have produced negative values for the elasticity of supply. The magnitude of the elasticities also differs from one study to another, and from one commodity to another. This is because farmers react differently to price changes for different crops, and a high supply elasticity for one crop does not necessarily mean that the farmers will react in the same way for all agricultural crops in general (Ghatak and Ingersent, 1986). Generally, price elasticities in agriculture have been found to be low. Maitha (1974) attributes this to shift variables which tend to hide the true relationship between price and supply.

It was also necessary to calculate the time required for full adjustment of supply. The formula used to compute the number of years or seasons required to attain 95% of adjustments to price changes is given below.

$$(1-\mu)^n = 0.05 \quad \text{.......} \quad 3\text{-}13$$

where:

μ = Elasticity of adjustment

n = Number of years (or seasons) required for full adjustment of supply.

It is assumed that 95% statistically represents full adjustment of supply to the equilibrium level (Jhala, 1979). Large values of n indicate very slow adjustment on the part of farmers. It signals the presence of difficulties faced by farmers in adjusting the hectarage of sunflower to some desired level. Small values of n indicate quick adjustment on the part of farmers.

3.6 Hypothesis Testing

Hypothesis testing is a tool used in empirical investigation to distinguish one theory from the other. In this study, statistical procedures were used to test the hypotheses. The first hypothesis was tested by means of a one-sided upper bound student t-test. The rule for rejecting or not rejecting a null hypothesis on the basis of empirical research is normally based on some test statistic computed from the data (Rao and Miller, 1971). In the present study, if the estimated β_2 (the coefficient of the price variable) in equations 3-5, 3-7, 3-8 and 3-9 was positive and statistically significant at the specified level of significance, then the null hypothesis was accepted. In other words, if the calculated t value is greater than the critical value at some specified significance level, then the null hypothesis was rejected. This would mean that farmers in that district do not respond positively to sunflower price changes or the results would be inconclusive.

When linear regressions are used to represent an economic relationship, the question that arises often is whether the same relationship holds for two different groups of economic units (Chow, 1960). Often, there is no economic rationale in assuming that two relationships are completely the same. In this study, the second hypothesis was tested by means of the Chow test (as developed by Chow (1960)). This test is computed by means of an F-distributed random variable expressed as below:

$$F(k, n_1 + n_2 + n_3 - 3k) = \frac{(Q - Q_1)/k}{Q_1/(n_1 + n_2 + n_3 - 3k)} \qquad \text{3-14}$$

where:

Q = the sum of the squares of residuals with the three data sets pooled.

Q_1 = the combined sum of squares of residuals from the three separate regressions.

k = the number of parameters that were estimated.

n_1, n_2 and n_3 = the number of observations for each of the three regressions for the three districts, namely Meru, Bungoma and Trans-Nzoia respectively.

To carry out the above test, the regression was run for each district and the sum of squares of the residuals taken. Then the data sets were pooled and the sum of squares of the residuals taken. If the coefficients of the regression differ, then the value ($Q - Q_1$) will be relatively large and the value of the calculated F - statistic would exceed the critical value for the test (Kenyanito, 1991). If this was the case, then the null hypothesis that the degree of supply responsiveness for sunflower farmers is the same for all the districts was rejected.

The third hypothesis was also tested by means of a one-sided upper bound student's t-test. The t-values for each of the coefficients of the other variables were computed and compared with the critical t values. If the calculated t value exceeded the critical value, then the null hypothesis was rejected.

3.7 **Data Sources and Data Collection.**

This study relied heavily on secondary data. However, for better understanding of how sunflower is grown in Kenya, personal interviews were held with the sunflower farmers and the extension agents of the Ministry of Agriculture in the three study districts. Ten farmers from every district were interviewed on general information about sunflower growing. The farmers and the extension agents were selected by purposeful sampling whereby only the farmers and the extension agents with the required information were selected. Time-series data on the area put under sunflower, prices of sunflower, prices of competing enterprises and yield of sunflower were mainly obtained from the District Annual Reports for Meru, Bungoma and Trans Nzoia districts. Where such data were missing from the District Annual Reports, the Provincial Annual Reports for Eastern, Western and Rift Valley provinces were used.

The prices of sunflower and those of the competing enterprises were obtained either directly as quoted in the Annual Reports or by dividing the value of the crop concerned with its output in any specified year. It was not possible to include all the possible alternative enterprises to sunflower in each district due to lack of data. The prices of some of the competing enterprises were not available in the Annual Reports. In such cases, the prices were obtained from the respective marketing boards or companies (for example, Cotton Board, National Cereals and Produce Board, Kenya Sugar Authority and the Kenya Seed Company). The yield of sunflower was obtained by dividing the output of sunflower by the hectarage put under the crop for a given year. The figure for the yield was sometimes given directly in the Annual Reports. Other official sources of the time-series data on the variables included publications of the Ministries of Agriculture, Finance and Planning and National Development, Economic Reviews and statistical Abstracts.

Data on annual rainfall was obtained from the Data Bank of the Meteorological Services Department of the Ministry of Transport and Communication in Nairobi. The rainfall data used in the analysis were from meteorological or rainfall stations that fell in the sunflower growing regions of the district and for which the required data were available. This is because, some stations which would have been chosen had not been operational in the 1970's, while others had been closed before 1992, meaning that all the required data could not be available. In such a case, the station with the required data was chosen.

Getting all the data used in this study was a difficult task that involved comparisons of many publications, and hence requiring some reconciliations. For example, in some cases, there were conflicts or discrepancies between the figures, say for hectarage or output of sunflower given in the District Annual Report and that given in the Provincial Annual Report. However, many studies based on time-series data have been known to suffer from this drawback. For this reason, the results of this study should be viewed and interpreted with respect to the data limitations mentioned above.

The methodology outlined in this chapter has various limitations, particularly with regards to the formulation and application of the Nerlovian model. However, even with these limitations, the value of the model as an analytical tool must certainly be recognised. For example, although the model gives just an estimate of the supply elasticity, Askari and Cummings (1974) argue that such knowledge is of undeniable importance to agricultural policy makers. In this respect, therefore, the model outlined here only attempts to reconcile the conflicting goal of presenting a realistic picture of the situation facing sunflower production while maintaining simplicity in order to ensure manageability. After all, the importance of theory is not to reflect reality but to simplify by abstracting from reality (Friedman, 1953).

It is also important to mention that the Ordinary Least Squares (OLS) estimation procedure used in this study is not the 'best' when lagged dependent variables are included as independent variables in the model. This is because, in small samples, (less than 30 observations) the least squares estimates are biased but consistent when errors are serially independent (Rao and Miller, 1971). However, the problems associated with least squares estimation do not mean that it is an inappropriate procedure. No other estimation procedure has been shown to be 'better' in small samples when lagged dependent variables appear in the equation as explanatory variables. Hence, the use of the Ordinary Least Squares (OLS) method in the current study.

CHAPTER FOUR: EMPIRICAL RESULTS AND DISCUSSION

4.1 Determination of the Most Competitive Enterprise

The first stage of the analysis involved the determination of the most competitive enterprise to sunflower. This was achieved by estimating the regression equation 3-6 outlined in the methodology. The results of this first stage of the analysis were as given hereafter. The most competitive enterprise to sunflower in Meru District was identified as millet, while in Bungoma District it was sugarcane. In Trans-Nzoia District, commercial maize was given as the most competitive enterprise to sunflower.

4.2 The Estimated Supply Response Models

The second stage of the analysis involved the estimation of the supply response models for sunflower in the three study districts. The supply response models used in this study were estimated using the Ordinary Least Squares (OLS) estimation method. The double logarithmic version of the Partial Adjustment Model was fitted onto the data and analyzed. The basic equations used for the estimation are Equations 3-5, 3-7, 3-8, and 3-9 as given in the methodology chapter. Other forms of the model, especially the linear formulation was also tried out but the double logarithmic version was found to give better results in terms of the R^2 values and the magnitude and significance of the coefficients. The results of this second stage of analysis are given in Tables 4.1, 4.2, 4.3 and 4.4. The variables in the tables are abbreviated as below:-

H'_{t-1} = Natural logarithm of the lagged hectarage under sunflower

P'_{t-1} = Natural logarithm of the lagged price of sunflower

P'^{c}_{t-1} = Natural logarithm of the lagged price of the most competitive enterprise

Y'_{t-1} = Natural logarithm of the lagged yield of sunflower

R'_{t} = Natural logarithm of the current annual rainfall amount

T' = Natural logarithm of the time trend variable

From the results in Table 4.1, the coefficient of the lagged dependent variable was positive in the three study districts, indicating that the current hectarage under sunflower is positively influenced by the area put under the crop in the previous season. The coefficient of the lagged dependent variable was significant at 5% for Meru and Bungoma districts. The results indicate that the lagged dependent variable significantly affected the farmers' hectarage allotment decisions in Meru and Bungoma districts. The insignificance of the coefficient of the lagged dependent variable at 5% for Trans-Nzoia district is an indication that farmers in this district are faced with relatively less difficulties as they try to adjust the hectarage under sunflower production to the desired level. The coefficient of the lagged dependent variable was fairly large for Meru District (0.654), and this indicates very slow adjustment on the part of farmers, while that for Bungoma District indicates moderate rate of adjustment.

Tables 4.1 and 4.2 give the regression results when the price of the most competitive enterprise is excluded.

Table 4.1: **Regression Results when the Price of the Most Competitive Enterprise is Excluded (with the Yield Variable Excluded)**

			Regression coefficients		
District	Constant	H'_{t-1}	P'_{t-1}	R'_t	T'
Meru	16.552 (3.271) ****	0.654 (3.328) ****	0.737 (1.391)	-1.870 (-2.569) ****	-0.334 (-0.755)
Bungoma	5.915 (0.761)	0.409 (1.902) ***	-0.792 (-1.500)	-0.513 (-0.472)	1.178 (1.790) ***
Trans-Nzoia	0.858 (0.171)	0.361 (1.521)	-0.223 (-0.426)	0.598 (1.007)	-0.0009 (-0.022)

SOURCE : Author's Study, 1995

Note:

Figures in parenthesis are t-ratios and the asterisks below them indicate significance levels

**** = Significant at 1%

*** = Significant at 5%

The coefficient of the lagged dependent variable for Trans-Nzoia District was small (0.361), indicating quick adjustment on the part of farmers.

The inclusion of the lagged dependent variable was based on the grounds that difficulties often arise when farmers attempt to adjust their present output to some desired output level. Large and significant values of the coefficients of the lagged dependent variable indicate the presence of some difficulties faced by farmers in trying to adjust the hectarage under sunflower to some desired level. It is an indication of the presence of various technical and institutional factors that influence the decision-making of the farmers.

The coefficient of the lagged price of sunflower was insignificant at 5% in the three study districts. However, this coefficient was positive for Meru District but negative for Bungoma and Trans-Nzoia districts. The positive value of the coefficient of the price variable is consistent with economic theory. However, negative values of the coefficient of the price variable, as in Bungoma and Trans-Nzoia districts, is common in many supply response studies (Jhala, 1979; Kere, 1986; Cummings, 1975 and Krishna, 1963). The sign of the coefficient of the price variable depends on the crop in question and the economic rationality of the farmers. In Bungoma District, sunflower is grown during the short rains where it competes with other enterprises. Trans-Nzoia District has only one season implying that sunflower competes with many other enterprises for the available resources. In this district, much of the sunflower is grown after the main crop or is intercropped with grass. In such a case, the farmers would not care so much about the price of sunflower in their hectarage allotment decisions. The area put under sunflower would depend on the area put under the previous main crop. Such a situation indicates that price would only play a limited role in achieving increased production, which is consistent with the findings of Kahlon and Tyagi (1989).

The rainfall coefficient was negative and significant at 1% level in Meru District, meaning that rainfall in this district is a relevant factor in sunflower production. The negative coefficient of the rainfall variable indicates the possibility of too much rain being harmful to the crop. Sunflower as a crop is sensitive to rainfall, especially during the harvesting period when too much rain could destroy the whole crop. Meru District is a high potential area with quite a high amount of rainfall per year. The coefficient of the rainfall variable was positive but insignificant at 5% in Trans-Nzoia District indicating that as rainfall increases, the area put under sunflower increases, although the increase is not significant. This suggests that in this district, rainfall is not a major determinant of the area put under sunflower production. In other words, there are rare cases of too little or too much rainfall in the regions where sunflower is grown.

The coefficient for the trend term was positive and significant at 5% level for Bungoma District. The significance of the coefficient of the trend term for Bungoma District implies that there has been improvement in the technological and institutional conditions of the district. The coefficient for the trend term was negative and insignificant at 5% for Meru and Trans-Nzoia districts, indicating that the supply shift variables had been more or less constant during the period under the study. The negative coefficient of the trend term for Meru and Trans-Nzoia districts indicates that the area put under sunflower production in these districts has been declining with time. There could be a shift from sunflower production to other enterprises.

Table 4.2: **Regression Results when the Price of the Competitive Enterprise is Excluded (with the Yield Variable Included)**

	Regression coefficients					
District	Constant	H'_{t-1}	P'_{t-1}	Y'_{t-1}	R'_t	T'
Meru	11.272	0.557	0.012	-0.815	-1.258	0.380
	(1.822)	(2.747) ****	(0.017)	(-1.395)	(-1.515)	(0.570)
Bungoma	3.774	0.369	-0.469	-0.471	-0.198	1.116
	(0.515)	(1.832) ***	(-0.901)	(-1.898) ***	(-0.193)	(1.819) ***
Trans-Nzoia	2.447	0.644	-0.437	0.335	0.034	0.184
	(0.524)	(2.498) ****	(-0.888)	(2.051) ***	(0.055)	(0.480)

SOURCE: Author's Study, 1995

Note:

Figures in parenthesis are t-ratios and the asterisks below them indicate significance levels

**** = Significant at 1%

*** = Significant at 5%

Table 4.2 gives the regression results when the price of the most competitive enterprise was excluded but with the yield variable included in the model. This analysis was done so as to asses the effect of the yield variable on sunflower production. The results indicate that the yield variable significantly affected sunflower production in Bungoma and Trans-Nzoia districts but not in Meru District. The coefficient of the yield variable was positive and significant at 5% for Trans-Nzoia District. The positive coefficient of the yield variable was in line with earlier expectations that last period's yields have a positive influence on the area put under sunflower in the current period. The coefficient of the yield variable was negative and significant at 5% for Bungoma District. The negative coefficient of the yield variable for Meru and Bungoma districts was not expected. However, this could be due to poor land being put under sunflower such that, as more land is put under sunflower, the output per unit decreases.

It is important to note that the inclusion of the yield variable in the model for Trans-Nzoia District increases the magnitude of the coefficient of the lagged dependent variable as shown in Table 4.2. This implies that the yield variable introduces more difficulties in trying to adjust supply to the equilibrium level. The low yields of sunflower in this District represent difficulties in the form of technical barriers which prevent the farmers from achieving an increase in yield which could further increase the area put under sunflower. In other words, technical barriers in achieving the potential yield of sunflower (e.g. inadequate fertilizer usage) are represented as difficulties preventing the farmers from adjusting fully to the equilibrium supply. This situation occurs in Trans-Nzoia District where the coefficient of the yield variable is positive and significant at 5%. The results indicate the relevance of the yield variable in this district. On the other hand, the inclusion of the yield variable in the model for Meru District reduces the magnitude of the coefficient of the rainfall variable (thus rendering it insignificant) as shown in Table 4.2. This could be due to existence of some collinearity between yield and rainfall although the correlation matrix does not prove this. In such a case, the yield variable would not be a major factor in determining sunflower production in this district.

The results in Table 4.3 indicate that the coefficient of the lagged dependent variable was positive in all the three districts, even when the price of the most competitive enterprise was included in the model. This means that the farmers base their hectarage allotment decisions in the current period on how the situation was in the previous period. The coefficient of the lagged dependent variable was significant at 1% in Meru District and 5% in Bungoma District, indicating the magnitude of the difficulties facing the farmers as they try to adjust the hectarage under sunflower to some desired level. These difficulties were more in Meru District and least in Trans-Nzoia District as evidenced by the size of the coefficients of the lagged dependent variable.

Table 4.3: **<u>Regression Results when the Price of the Most Competitive Enterprise is Included (with the Yield Variable Excluded)</u>**

	Regression coefficients					
District	Constant	H'_{t-1}	P'_{t-1}	P'^{c}_{t-1}	R'_{t}	T'
Meru	15.188	0.759	0.355	0.256	-1.715	-0.521
	(2.654) ****	(2.768) ****	(0.409)	(0.564)	(-2.157) ***	(-0.927)
Bungoma	7.422	0.347	-0.062	-1.745	-1.407	2.015
	(1.173)	(1.977) ***	(-0.128)	(-3.131) ****	(-1.515)	(3.373) ***
Trans-Nzoia	0.791	0.344	-0.121	-0.107	0.617	-0.0002
	(0.153)	(1.366)	(-0.167)	(-0.210)	(0.998)	(-0.00)

SOURCE: Author's Study, 1995

<u>Note:</u>

Figures in parenthesis are t-ratios and the asterisks below them indicate significance levels

**** = Significant at 1%

*** = Significant at 5%

The coefficient of the lagged price of sunflower was insignificant at 5% in all the three study districts. However, this coefficient was positive for Meru District, indicating that the area put under sunflower increases as the price of sunflower increases, though the increase is not significant. The insignificance and the negative sign of the coefficients of the price variable for Bungoma and Trans-Nzoia districts are an indication that price may not always play a positive role in achieving increased production of sunflower.

The coefficient of the lagged price of the most competitive enterprise was negative and significant at 1% in Bungoma District. The negative coefficient of the most competitive enterprise is consistent with economic theory and earlier expectations. This is because, as the price of the most competitive enterprise increases relative to that of sunflower, farmers tend to increase the area put under that crop at the expense of sunflower, thereby reducing the area put under sunflower. This implies a negative relationship between the price of the most competitive enterprise and the area put under sunflower. The significance of the coefficient of the price of the most competitive enterprise at 1% in Bungoma District was an indication of the relevance of the included variable in the specified model. The insignificance of the coefficient of the price of the most competitive enterprise at 5% in Meru and Trans-Nzoia districts could be an indication of incorrect identification of the most competitive enterprise to sunflower in these districts.

As in the earlier case, the rainfall coefficient was negative and significant at 5% in Meru District. This is an indication that too much rainfall in this district could destroy the crop, especially during harvesting. The rainfall coefficient was positive and insignificant at 5% in Trans-Nzoia District implying the absence of the risk of too much rainfall and the farmers' expectations of normal rainfall every year.

The trend term in this case behaved in the same manner as when the price of the most competitive enterprise was excluded. The coefficient of the trend term was positive and significant at 1% in Bungoma District. The significance of the coefficient of the trend term is an indication of improvement in the technological and institutional conditions in Bungoma District. The coefficient of the trend term was negative and insignificant at 5% for Meru and Trans-Nzoia districts, indicating a decline in sunflower production in these districts during the study period.

Table 4.4: **<u>Regression Results when the Price of the Most Competitive Enterprise is included (with the Yield Variable Included)</u>**

	Regression coefficients						
District	Constant	H'_{t-1}	P'_{t-1}	P^{kc}_{t-1}	Y'_{t-1}	R'_{t}	T'
Meru	11.276	0.555	0.015	-0.0003	-0.816	-1.258	0.383
	(1.739)	(1.748)	(0.017)	(-0.005)	(-1.211)	(-1.450)	(0.413)
Bungoma	6.097	0.335	0.0003	-1.499	-0.245	-1.117	1.865
	(0.947)	(1.909) ***	(0.006)	(-2.487) ****	(-1.047)	(-1.157)	(3.045) ****
Trans-Nzoia	2.552	0.631	0.136	-0.677	0.447	-0.038	0.304
	(0.560)	(2.508) ****	(0.213)	(-1.357)	(2.492) ****	(-0.063)	(0.792)

SOURCE : Author's Study, 1995.

<u>Note:</u>

Figures in parenthesis are t-ratios and the asterisks below them indicate significance levels

**** = Significant at 1%

*** = Significant at 5%

Table 4.4 gives the regression results when the price of the most competitive enterprise and the yield variable were included in the model. The results indicate that the yield variable significantly affected sunflower production in Trans-Nzoia District but not in Meru and Bungoma districts. The coefficient of the yield variable was positive and significant at 1% for Trans-Nzoia District and this is in line with earlier expectations. The coefficient of the yield variable was negative and insignificant at 5% for Meru and Bungoma districts and this could be a result of expansion of the area put under sunflower to unsuitable areas. As discussed under Table 4.2, the inclusion of the yield variable in the model results in an increase in the coefficient of the lagged dependent variable in Trans-Nzoia District and a reduction of the rainfall coefficient in Meru District.

4.3: Computed Price Elasticities of Supply and Other Summary Statistics

Based on the results given in Tables 4.1, 4.2, 4.3 and 4.4 and applying Equations 3-11 and 3-12 in the methodology chapter, the short-run and the long-run price elasticities of supply for sunflower in the three districts were computed. The elasticity of adjustment was also obtained from the same Tables and the time required for full adjustment of supply computed using Equation 3-13. The Durbin's h statistic used to test for serial correlation when lagged dependent variable appears as an independent variable in the model was also computed using equation 3-10. All these results plus other summary statistics are presented in Tables 4.5 and 4.6.

Table 4.5: <u>Computed Price Elasticities of Supply and other Summary Statistics when the Price of the Most Competitive Enterprise is Excluded</u>

District	Short-Run Price Elasticity	Long-Run Price Elasticity	Elasticity of Adjustment	Time Period for Full Adjustment	R^2	$\bar{R}^2$	F	D-W	h
Meru	0.74	2.13	0.35	7.05	0.745	0.672	10.206	2.178	-0.757
Bungoma	-0.79	-1.34	0.59	3.35	0.532	0.422	4.831	2.155	-2.792
Trans-Nzoia	-0.22	-0.35	0.64	2.94	0.345	0.191	2.241	1.860	0.662

SOURCE: Author's Study, 1995

<u>**Note:**</u>

The statistics are calculated from the regression results when the yield variable was excluded from the model.

The results in Table 4.5 indicate that the short-run price elasticity of supply for Meru District is positive, which is in line with economic theory. This means that farmers in this district respond positively to sunflower price changes. The calculated price elasticity for this district, though insignificant at 5% level[3] is moderately large (0.74) indicating the degree of market responsiveness on the part of the farmers. However, the short-run price elasticities for Bungoma and Trans-Nzoia districts are negative, which, as mentioned earlier, is common in most supply response studies. This is particularly so for a minor crop. Sunflower is a minor cash crop, especially in Bungoma and Trans-Nzoia districts where there is sugarcane,

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This elasticity was however significant at 10% level.

maize, wheat, cotton and tobacco as cash crops among others. In such cases, if the prices of these other crops increase as sunflower price increases, the end result could be a decrease or an increase in sunflower hectarage depending on the relative increment of each crop. On the other hand, the price of sunflower could increase together with the cost of inputs such that the net effect is negative, hence resulting in a reduction in the area put under sunflower. The short-run price elasticity of supply was highest for Meru District and lowest for Trans-Nzoia District (0.22). This is in agreement with the results of earlier supply response studies which reveal that the price elasticity of supply differs in sign and magnitude from one crop to another and from one region to the next. This is an indication of the economic rationality of the farmers and the importance of the crop in question to the farmer. The elasticities of supply obtained in this study are generally low, and this is in agreement with Kahlon and Tyagi (1989) who argue that low estimates of the elasticity of supply have been obtained in the agricultural sectors of the less developed economies. The price elasticities of supply obtained when the price of the most competitive enterprise was included in the model are generally lower than when it was excluded as shown in Table 4.6. This is an indication that the farmers do consider the price of the most competitive enterprise as they decide on how much land to put under sunflower. In such a situation, the inclusion of the price of the most competitive enterprise as an explanatory variable in the model reduces the effect of the price of sunflower on the area put under the crop. It is important to note that when both the price of the most competitive enterprise and the yield variables were included in the estimating equations for Bungoma and Trans-Nzoia districts, the short-run price elasticities for the two districts became positive but were very small and with very low significance levels.

The elasticity of adjustment, which gives the proportion of the adjustment towards equilibrium which occurs in one time period was also computed. It was generally higher when the price of the most competitive enterprise was included than when it was excluded as shown in Tables 4.5 and 4.6. This means that the inclusion of the price of the most competitive enterprise eliminated some difficulties in moving to full adjustment of supply. The elasticity of adjustment was highest for Trans-Nzoia District, followed by Bungoma District. Meru District had the least.

Table 4.6: **Computed Price Elasticities of Supply and other Summary Statistics when the Price of the Most Competitive Enterprise is Included**

District	Short-Run Price Elasticity	Long-Run Price Elasticity	Elasticity of Adjustment	Time Period for Full Adjustment	R^2	$\bar{R}^2$	F	D-W	h
Meru	0.36	1.47	0.24	10.86	0.751	0.655	7.831	2.119	-0.397
Bungoma	-0.06	-0.10	0.65	2.83	0.710	0.619	7.826	2.249	-1.035
Trans-Nzoia	-0.12	-0.184	0.66	2.81	0.347	0.143	1.701	1.848	0.523

SOURCE: Author's Study, 1995

Note:

The statistics are calculated from the regression results when the yield variable was excluded from the model.

Closely related to the elasticity of adjustment was the time period required for full adjustment of supply. The higher the elasticity of adjustment, the less the period (in years) required for full adjustment of supply. Trans-Nzoia District required the least number of years (less than 3) to adjust its supply to the equilibrium level. This is due to less difficulties that face the farmers in trying to adjust their supply to an equilibrium level. Farmers in Trans-Nzoia District have large farms, meaning that land as a factor of production may not be limiting sunflower production. Meru District required the longest period (over seven years) to adjust its supply to equilibrium. Land is very scarce in Meru District, and increasing the area put under any crop implies reducing the area put under another crop. This in itself presents a major difficulty in trying to adjust fully to the equilibrium supply. The results of the study also indicate that there are cases of too much rainfall which destroys the sunflower crop especially during harvesting in Meru District unlike in Trans-Nzoia District. Such cases do also present some difficulty in adjusting fully to the equilibrium supply.

Interviews with the sunflower farmers in the three study districts revealed that transportation of sunflower seed to the buying company is cheaper and easier in Trans-Nzoia District than in Meru and Bungoma districts. There are many private companies that buy sunflower seed from farmers in Trans-Nzoia District (for example, Kitale Industries, Kenya Seed Company, Western Seed and Grain Company and Arkay Industry, among others). All of these companies, except for Arkay Industry in Eldoret are situated in Kitale Town, thus making it easier for the farmers in Trans-Nzoia District to market their seed. This is not the case for Bungoma and Meru districts. At times, sunflower seed has to be transported from

Bungoma to Eldoret (or Kitale), or from Meru to Nakuru and this is quite expensive. This, too presents a source of difficulty to the farmers in trying to adjust their supply to the equilibrium level.

Except for Trans-Nzoia District, most of the estimated supply response models explained over fifty percent of the variation in the dependent variable based on the magnitude of the coefficient of determination (R^2) as shown in Tables 4.5 and 4.6. The adjusted coefficient of determination (R^{-2}) was also moderate, except for Trans-Nzoia District. The R^2 and the R^{-2} for the models used for Trans-Nzoia District were less than 0.5, indicating that the models used explained less than fifty percent of the variation in the dependent variable. This could be due to the fact that this district has only one main season when all the crop enterprises, including sunflower, are grown. Hence there is very high competition between the crop enterprises. In such a case, it is possible that the farmers base their hectarage allotment decisions on many factors. In Meru and Bungoma districts, sunflower is only grown during the short-rains and hence not many factors come into play. It is also important to mention here that it was not possible to get time-series data on all the enterprises that compete with sunflower in Trans-Nzoia District. Hence, only a few were included in the model and there is a possibility that the price of the most competitive enterprise in this district was not correctly identified. The F-Statistics in all the estimated models for Trans-Nzoia District were not significant at 5% level when the yield variable was excluded. However, when the yield was included, the F-statistic in all the estimated models became significant at 5% level, implying that the explanatory variables as a group have a significant influence on the dependent variable. This factor reinforces further the relevance of the yield variable in the model for Trans-Nzoia District. The F-statistics for all the estimated models for Meru and Bungoma districts are all highly significant (at 1% level).

All the estimated models, when tested for serial correlation using the Durbin-Watson (D-W) d-test, indicated the absence of serial correlation. When serial correlation was tested for using the Durbin's h'-test, the results indicated no serial correlation in the models, except for the one for Bungoma District when the price of the most competitive enterprise was excluded. However, when the price of the most competitive enterprise was included, the problem of serial correlation was eliminated as shown in Table 4.6.

The problem of multicollinearity in the estimated models was scanned using Klein's rule of thumb as explained in section 3.3 of the methodology chapter. In most of the estimated models in the three study districts, multicollinearity was not found to be a serious problem. The simple correlation matrices of the variables used in the models are presented in the Appendix A2.

4.4 Results of Hypothesis Testing

From the results of the analysis, the supply responsiveness of sunflower farmers in Meru District was positive while that for Bungoma and Trans-Nzoia districts was negative. This is as shown by the signs of the elasticities of supply given in Tables 4.5 and 4.6 for the three study districts In other words, the null hypothesis that sunflower farmers respond positively to price changes was accepted for Meru District, but was rejected for Bungoma and Trans-Nzoia districts. This means that an increase in the price of sunflower would achieve increased production in Meru District but not in Bungoma and Trans-Nzoia districts.

This is an indication that price may not be the only tool required to achieve increased production of sunflower.

The second null hypothesis, that the degree of responsiveness to sunflower price changes is the same for all farmers in the major growing districts, was tested by means of the Chow test. Here, the data set on annual sunflower hectarage, lagged sunflower hectarage, lagged price of sunflower, lagged yield of sunflower, annual rainfall amounts and a time trend variable for the three districts were pooled and analyzed. The price of the most competitive enterprise was not included in this analysis due to the non-uniformity of the most competitive enterprises.

Using Equation 3-14 as outlined in the methodology, the results of the test were obtained as given below:

(i) with the yield variable included:

$Q = 25.586 \quad Q_1 = 17.016$

$n_1 = 19 \quad n_2 = 22 \quad n_3 = 22 \quad k = 6$

$$F(6,45) = \frac{(25.586 - 17.016)/6}{17.016/45} = 3.78$$

The tabulated F value at 5% level (F 0.95 (6,45)) = 2.31. Since the calculated F value exceeds the critical value, (3.78>2.31), the null hypothesis that the degree of supply responsiveness for sunflower farmers is the same for all the districts was rejected in favour of the alternative. This means that the degree of supply responsiveness for sunflower farmers varies from one district to the other. This is logical, owing to differences in the climatological, sociological, educational and cultural aspects of each district and its people.

(ii) with the yield variable excluded:

$Q = 26.177 \quad Q_1 = 20.489$

$n_1 = 19 \quad n_2 = 22 \quad n_3 = 22 \quad k = 5$

$$F(5,48) = \frac{(26.177 - 20.489)/5}{20.489/48} = 2.67$$

The tabulated F value at 5% level (F 0.95 (5,48)) = 2.41. Since the calculated F value is larger than the tabulated one, the null hypothesis was again rejected in favour of its alternative. In general, we conclude that the degree of supply responsiveness for sunflower farmers in Kenya varies from zone to zone.

From the results of the analysis, the third hypothesis was also accepted. This implies that there are some factors other than price that do significantly influence sunflower production in Kenya. Such factors include lagged sunflower hectarage, lagged price of the most competitive enterprise, annual rainfall amount and, to a lesser extent, lagged yield of sunflower and the time trend variable.

The results of this study indicate that the supply responsiveness of sunflower farmers in Kenya is quite diverse and varies from one zone to the other. The results of the study further indicate that there are other factors that do significantly affect sunflower production.

CHAPTER FIVE: SUMMARY, CONCLUSIONS AND POLICY RECOMMENDATIONS

5.1: Summary and Conclusions

The production of sunflower and other oil crops in Kenya has been low and declining over the years. This situation has led to heavy importation of edible oils and fats in Kenya, thus draining the country's supply of foreign exchange. In the recent past, the amount of foreign exchange used to import vegetable oils and fats has been quite high (about 4 billion Kenyan shillings per year). This has caused some concern to the policy makers as evidenced by the emphasis given to the oils and fats sub-sector in the Sessional Paper No.1 of 1994, the Food Policy Paper of 1994 and the current National Development Plan (1994-1996). It is in this interest also that the Oilseed Development Council is to be established to formulate policies and strategies to promote oil crops in Kenya. The main objective of this study was to establish the effects of changes in price and other factors on the production of sunflower in Kenya. The study is important as it looks for ways of increasing sunflower production, hence lifting domestic production of vegetable oils and fats and thus reducing imports of palm oil.

The results of the study indicate that the supply responsiveness of sunflower farmers was positive for Meru District. This positive coefficient of the price variable (though without much significance) is an indication that the price of sunflower does influence to some level[4]

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[4] The coefficient was significant at 10% level

the decision-making of the farmers as to how much land to allocate to the crop in this district. The response was negative for Bungoma and Trans-Nzoia districts. This means that the first hypothesis was accepted for Meru District but rejected for Bungoma and Trans-Nzoia districts. This is an indication that price is not the only tool required to achieve increased production of sunflower.

The negative price response, though contradictory to economic theory, is common in most of the supply response studies. The sign and magnitude of the coefficient of the price variable depends on the importance of the crop in question and the economic rationality of the farmers. This could be the case for sunflower which is a minor crop especially in Bungoma and Trans-Nzoia districts where we have many other cash crops. In Trans-Nzoia District, much of the sunflower is grown after the main season as a relay crop and hence, the area allocated to sunflower would be mostly dependent on the area allocated to the previous main crop. It is also possible that the price offered for sunflower seed is so low that a minor price increase may not affect the farmers decision as to how much land to allocate to sunflower. This would mean that the decline in the area put under sunflower is not the result of a direct response to sunflower price changes, but a response to other factors, such as the price of the most competitive enterprise. According to economic theory, if the price of the most competitive enterprise increases,then the area put under sunflower decreases. In such a situation, only a substantial price increase that fully covers the farmer's costs would result in increased production of sunflower.

The calculated short-run price elasticities for the three districts range from -0.22 to 0.74 when the price of the most competitive enterprise is excluded. When the price of the most competitive enterprise is included, the short-run price elasticities range from -0.06 to 0.36. The difference is due to the effects of the added explanatory variable which tends to reduce the influence of sunflower price on its production. However, in general, the results of this study show that the Kenyan sunflower farmer's response to economic incentives is not very much clear and well defined. The price elasticity of supply for Meru District, though positive is without much significance and those for Bungoma and Trans-Nzoia districts are negative. Such a situation indicate that price as an instrument for achieving increased production may have only a limited role to play as pointed out by Mungekar (1990) and Kahlon and Tyagi (1989).

The coefficient of the lagged hectarage under sunflower is positive and significant at 5 percent level for Meru and Bungoma districts. The significance of the coefficient of the lagged dependent variable is an indication of the presence of adjustment difficulties on the part of the farmers. This means that there are technological or physical difficulties that have to be eliminated before a farmer can fully adjust his/her supply to the equilibrium level in response to price changes. The insignificance of the coefficient of the lagged dependent variable for Trans-Nzoia District at 5 percent indicate that farmers in this district are faced with relatively less difficulties as they try to adjust the area under sunflower to some desired level. The intensity and magnitude of these difficulties are measured by the elasticity of adjustment which gives the proportion of adjustment that occurs in one time period. The elasticity of adjustment is highest for Trans-Nzoia District (over 60 percent) and lowest for Meru District (below 40 percent) indicating that the difficulties are greatest in Meru District, followed by Bungoma, and least in Trans-Nzoia District. Meru District required a long period (over seven years) to adjust its supply to the equilibrium level, while Trans-Nzoia District required the least number of years (less than 3) as shown in Tables 4.5 and 4.6. A possible explanation for this situation could be the existence of large areas of land in Trans-Nzoia District, as compared to Meru and Bungoma districts. The existence of land for expansion allows a farmer to quickly adjust his/her supply in response to price changes. On the other hand, information gathered during data collection indicate that there is ready market for sunflower seed in Trans-Nzoia District as compared to Meru and Bungoma districts. There are many companies that buy sunflower seed from farmers in Trans-Nzoia District. This means that transportation costs to the buying company are less here as compared to those incurred when sunflower seed has to be transported from Bungoma to Kitale, or from Meru to Nakuru. Hence, lack of a ready and easily accessible market for sunflower seed as is the case in Bungoma and Meru districts also present a major difficulty in trying to adjust the supply of sunflower to the equilibrium level.

The results of this study indicate that the coefficient of the lagged price of the most competitive enterprise is negative in the three study districts and this is in line with economic theory. The coefficient was significant at 1 percent for Bungoma District and this indicates the relevance of this variable in determining sunflower production in the district.

The coefficient of the yield variable was found to be significant at 5 percent for Bungoma and Trans-Nzoia districts. The coefficient was positive for Trans-Nzoia District but negative for Meru and Bungoma districts. The negative coefficient of the yield variable could be due to poor land being put under sunflower in the two districts such that as more land is put under sunflower, the output per unit decreases. This may be so in Meru and

Bungoma districts where land is very scarce such that any additional land for sunflower production could only be in the low-potential areas. It is also possible that as more land is put under sunflower, management problems increase resulting in a decrease in yield. It is important to note that the inclusion of the yield variable in the model for Trans-Nzoia District increases the magnitude of the coefficient of the lagged dependent variable. This could be due to technical barriers in realising the potential yield which are represented as supply adjustment difficulties facing the farmers.

The results of this study indicate that the coefficient for the rainfall variable was negative and significant at 5 percent for Meru District. The negative coefficient of the rainfall variable for Meru and Bungoma districts imply that rainfall is not a limiting factor to sunflower production in these districts. Thus, the problem occurs when there is too much rain which destroys the crop, and hence the negative effect. This is particularly the case for Meru District which has a significant coefficient. Sunflower is known to be particularly sensitive to too much rain, especially during the harvesting period. The rainfall coefficient was positive but insignificant at 5 percent in Trans-Nzoia District. These results indicate the presence of sufficient rainfall in the regions where sunflower is grown in this district. In other words, there are rare cases of too much rainfall in these regions.

The results of the second hypothesis test indicate that the degree of supply responsiveness for sunflower farmers in Kenya varies from one district to the next. This was shown by means of the Chow test, which was used to test the null hypothesis that the degree of supply responsiveness for sunflower farmers is the same for the three districts studied. This could be a result of differences in soil types, rainfall patterns, competing enterprises, supporting infrastructure and marketing channels in the three districts. This difference in the supply responsiveness of sunflower farmers would create some scope for policy in price discrimination as a means for increasing sunflower production if the price elasticities were positive and significant.

The results of this study have also revealed that there are other factors which do significantly influence sunflower production. As discussed, these factors include rainfall amounts, adjustment difficulties, the price of the most competitive enterprise, and, to a lesser extent, the yield and the time trend variables.

5.2: **Policy Recommendations**

There are a number of policy recommendations that can be drawn from the results of this study. The estimated price elasticities of sunflower supply for Meru District, though not very high, are an indication that there exists some scope for using the pricing policy to increase the area, and hence the supply of sunflower in this district. For example, the results in Table 4.5 indicate that a 10 percent increase in the price of sunflower would result to a 7.4 percent increase in the area put under sunflower. Since the objective is to reduce imports of vegetable oils and fats with the ultimate goal of attaining self-sufficiency, the results of this study indicate that the pricing policy can be used to partly achieve this goal.

The negative price elasticity of supply for Bungoma and Trans-Nzoia districts is not necessarily an indication of the economic irrationality of sunflower farmers. It is probable that the price offered for sunflower is so low that the farmers do not take into account any slight increase in price. This would mean that farmers make their decisions as to how much land to allocate to sunflower production based on other factors, for example the price of the most competitive enterprise. In such a situation, if the government is to achieve its goal of increasing the domestic production of sunflower, it is necessary that a substantial price increase is given so as to set the farmers in a position to be able to respond to any future sunflower price changes. Such a price increase should take account of the prices of competing enterprises to sunflower. This is because the results of this study reveal some competition between sunflower and other enterprises for the available resources.

Due to market liberalization as a result of the Structural Adjustment Programmes (SAP), it may not be possible for the government to intervene through the pricing policy. However, in order to boost sunflower production, it may be necessary to give a substantial price increase which will set a minimum producer price, beyond which the market forces are allowed to operate freely. One way of effecting a price increase for sunflower and other oilseeds in general within the framework of market liberalization is through the policies that affect imports of edible oils and fats. The import duties of edible oils and fats should be increased so as to discourage importation and encourage local oil processors to buy domestic oilseeds. The increase in import duty should be such that the landing price of the imports especially oilseeds is equal to or higher than the price that can keep local producers in business (i.e. between Kshs. 15 to 20 per kilogram of seed in case of sunflower). The import duties for the refined and crude oils and fats should be raised even higher to discourage their importation completely especially the refined oils and fats.

Research on local oil millers indicate a lot of inefficiencies in production which is passed on to the farmers in terms of low prices for their oilseeds. Some of these inefficiencies result from using old machines which breakdown and are out of work so often. If these inefficiencies are removed or at least reduced, the oil millers could afford to offer at least higher prices for oilseeds. In this regard therefore, another way of improving the price of sunflower and other oilseeds in general could be to reduce duty on machinery and equipment to allow importation of modern machines which are more efficient.

The government could also reduce taxes and licensing fees for the local oil millers so as to reduce their cost of production.

The negative price elasticity of supply for Bungoma and Trans-Nzoia districts could also be an indication that price may not always play a positive role in achieving increased production. This is because, in such a case, an increase in the price of sunflower results in a decrease in the area put under the crop. This is a case of perverse supply response which is common in traditional agriculture as explained by Ghatak and Ingersent (1986). Such a situation would render the pricing policy ineffective.

The results of this study reveal that the pricing policy discussed above would only play a limited role in achieving increased production of sunflower. Hence the need for the use of other policy measures.

There is need to improve on the yields of sunflower through the use of high-yielding varieties. This is because the yields have been so low when compared to the potential of 2.5 tonnes per hectare. Improvements in the yield of sunflower could be achieved through research. The government can assist by providing research funds so as to come up with high yielding varieties. The Kenya Agricultural Research Institute (K.A.R.I.) has been doing research on this but the potential yield has not been reached. If the output per hectare (yield) increases, the farmers' income will increase. This compares to the arguement by Mungekar (1990) that with high yields, lower product prices may be sufficient. The results of this study indicate that the yield variable does significantly influence sunflower production. An increase in the yields of sunflower would result in expanded area under the crop in Trans-Nzoia District. In Meru and Bungoma districts, there is need for the extension service department of the Ministry of Agriculture to encourage the farmers to improve the quality of land put under sunflower through the use of fertilizers. In this case, the influence of yield on sunflower production would be positive.

Low yields of sunflower in Meru and Bungoma districts could also be due to too much rainfall which destroys the crop during and prior to the harvesting period. In this case, the farmers should be encouraged to plant early so as to avoid the incidence of too much rain during harvesting.

It is also necessary that sunflower farmers have a ready market for their seed. In the past, there has not been adequate market outlets for sunflower seed, especially in Meru and Bungoma districts, and this has been acting as a disincentive to increased production. However,the issue is not really one of lack of market outlet (because the oil millers also complain of inadequate seeds), but it is a question of quantity. The farmers produce small quantities of oilseeds which are widely scattered hence making it uneconomical for the millers to buy such seeds due to high transport costs. If the regions that grow sunflower produced large quantities of oilseeds, then the millers would provide the market. However, if lack of market emerged to be a problem, the government could assist by reducing taxes, licensing fees and the procedure involved in registering new firms and private agents. This is because lack of a ready and easily accessible market for sunflower seed presents a major difficulty in adjusting fully to the equilibrium supply.

The farmers should also be well educated and informed through the extension arm of the Ministry of Agriculture so as to avoid exploitation by private agents.

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APPENDICES

Appendix A1: The Data Set Used in The Analysis

Table A1.1: Hectarage, Producer Price and Yield of Sunflower for Meru District

Year/Season	Hectarage (Ha)	Producer Price (Kshs\kg)	Yield Tonnes\ha)
1972/73	30	0.63	0.33
1973/74	150	0.67	0.16
1974/75	1,080	1.13	0.33
1975/76	4,800	1.27	0.38
1976/77	7,000	2.50	0.38
1977/78	955	1.00	1.00
1978/79	1,200	0.77	1.08
1979/80	1,500	1.43	0.80
1980/81	1,725	1.38	0.80
1981/82	2,498	1.38	0.61
1982/83	2,520	1.14	0.87
1983/84	778	2.95	0.44
1984/85	3,385	2.95	0.44
1985/86	10,500	1.41	0.50
1986/87	16,060	2.80	0.37
1987/88	18,000	2.36	0.50
1988/89	12,722	2.46	0.50
1989/90	7,349	3.50	0.50
1990/91	8,500	3.52	0.50
1991/92	3,200	4.50	0.50

SOURCE: Ministry of Agriculture, Meru District and Eastern Province Annual Reports (1972 to 1992)

Table A1.2: **Producer Prices of Enterprises Competing with Sunflower in Meru District (Kshs/kg)**

Year/ Season	Maize	Beans	Sorghum	Millet	Cotton	Tobacco	Pigeon peas	Cow peas
1972/73	0.38	0.56	0.50	0.60	1.30	4.51	1.72	0.36
1973/74	0.49	0.85	0.32	0.42	1.82	5.99	1.21	0.59
1974/75	0.72	1.67	0.32	0.42	1.90	6.61	1.21	1.73
1975/76	0.90	1.89	0.35	0.51	2.38	5.67	1.20	1.45
1976/77	0.90	1.65	0.35	0.35	2.88	7.47	1.46	1.45
1977/78	1.56	1.65	0.35	0.35	3.16	10.00	1.32	2.85
1978/79	0.90	1.66	0.33	0.33	3.21	10.00	1.24	2.78
1979/80	1.48	2.97	1.00	1.00	3.55	10.50	5.50	6.60
1980/81	1.00	3.33	0.89	0.89	3.33	13.83	3.35	2.03
1981/82	1.33	3.33	0.92	0.92	3.67	13.81	3.28	2.93
1982/83	1.30	3.15	1.00	1.00	3.39	13.46	3.34	2.04
1983/84	4.00	8.56	6.18	6.18	3.12	15.07	3.38	2.66
1984/85	2.50	3.30	6.18	2.22	4.74	15.07	3.38	2.66
1985/86	2.00	4.00	5.51	1.45	4.66	17.80	5.00	1.90
1986/87	2.70	4.00	5.51	1.99	4.69	19.85	4.00	1.90
1987/88	2.20	5.00	9.00	1.18	5.08	14.98	6.00	12.00
1988/89	1.11	8.03	4.99	1.75	5.47	14.98	12.58	9.00
1989/90	2.50	7.90	3.77	3.83	5.76	19.85	9.09	6.67
1990/91	3.61	5.83	3.50	7.00	8.59	18.23	9.50	6.44
1991/92	7.30	4.91	3.50	6.40	10.90	18.24	6.67	6.70

SOURCE: Ministry of Agriculture, Meru District and Eastern Province Annual Reports (1972 to 1992)

Table A1.3: Hectarage, Producer Price and Yield of Sunflower for Bungoma District

Year/Season	Hectarage (Ha)	Producer Price (Kshs\kg)	Yield (Tonnes\ha)
1969/70	267	0.22	0.58
1970/71	180	0.30	0.94
1971/72	300	0.24	0.39
1972/73	1.030	0.40	0.15
1973/74	2,473	0.42	0.21
1974/75	2,900	0.64	0.09
1975/76	3,460	1.53	0.50
1976/77	3,094	1.50	1.19
1977/78	980	1.41	0.53
1978/79	413	1.80	0.38
1979/80	5,317	1.80	0.40
1980/81	4,798	0.80	1.20
1981/82	3,500	1.63	1.20
1982/83	5,000	1.63	1.20
1983/84	9,040	2.50	1.35
1984/85	6,500	2.65	0.98
1985/86	4,060	2.70	1.60
1986/87	725	3.20	0.80
1987/88	2,200	3.20	1.20
1988/89	1,580	2.80	1.17
1989/90	1,600	4.00	1.20
1990/91	2,690	4.50	1.46
1991/92	2,414	5.00	1.30

SOURCE: Ministry of Agriculture, Bungoma District and Western Province Annual Reports (1970 to 1992)

Table A1.4: **Producer Prices of Enterprises Competing with Sunflower in Bungoma District (Kshs/kg)**

Year/ Season	Maize	Millet	Cotton	Tobacco	Sugarcane	Beans
1969/70	0.22	0.64	1.05	2.19	0.04	0.60
1970/71	0.29	0.64	1.02	2.22	0.03	0.64
1971/72	0.25	0.29	1.31	2.22	0.04	0.44
1972/73	0.39	0.44	1.25	4.51	0.05	0.78
1973/74	0.56	0.78	2.00	5.99	0.06	0.68
1974/75	0.56	0.93	2.00	6.61	0.09	1.00
1975/76	0.89	0.86	2.00	7.56	0.10	1.56
1976/77	0.89	1.77	3.20	9.00	0.13	1.89
1977/78	0.91	2.22	3.45	9.51	0.13	1.89
1978/79	1.00	2.78	3.40	10.27	0.10	1.89
1979/80	1.00	1.88	3.60	10.75	0.11	2.78
1980/81	1.06	1.88	3.60	11.00	0.15	2.78
1981/82	1.44	1.65	3.42	12.38	0.17	2.22
1982/83	1.44	2.22	4.28	11.53	0.16	3.66
1983/84	1.76	2.22	4.80	14.69	0.19	4.22
1984/85	1.94	2.78	4.80	14.81	0.19	4.67
1985/86	1.94	1.37	5.00	16.88	0.30	3.33
1986/87	2.08	1.60	5.00	17.00	0.34	3.85
1987/88	2.08	1.91	5.00	16.00	0.37	3.85
1988/89	2.46	3.33	6.00	17.00	0.37	5.76
1989/90	3.03	7.50	10.03	18.00	0.41	5.22
1990/91	3.61	6.68	8.36	15.00	0.52	5.56
1991/92	6.66	10.00	12.00	20.27	0.63	8.00

SOURCE: Ministry of Agriculture, Bungoma District and Western Province Annual Reports (1970 to 1992)

Table A1.5: **Hectarage, Producer Price and Yield of Sunflower for Trans-Nzoia District**

Year/Season	Hectarage (Ha)	Producer Price (Kshs\kg)	Yield (Tonnes\ha)
1969/70	6,000	0.55	0.80
1970/71	3,200	0.70	0.50
1971/72	3,500	0.70	0.34
1972/73	3,000	0.70	0.80
1973/74	4,500	1.25	0.70
1974/75	2,500	1.23	0.79
1975/76	3,000	1.13	0.72
1976/77	3,250	1.65	0.70
1977/78	5,121	1.75	0.86
1978/79	7,500	2.00	0.04
1979/80	1,550	2.00	1.13
1980/81	1,500	1.75	0.72
1981/82	2,491	1.61	1.54
1982/83	1,673	2.42	0.79
1983/84	1,200	2.50	1.14
1984/85	1,974	2.65	0.61
1985/86	2,113	2.65	0.62
1986/87	956	3.20	1.20
1987/88	1,370	3.20	1.15
1988/89	1,755	3.20	1.50
1989/90	2,472	4.00	1.30
1990/91	2,474	4.50	1.50
1991/92	2,600	5.50	1.46

SOURCE: Ministry of Agriculture, Trans-Nzoia District and Rift Valley Province Annual Reports (1970 to 1992)

Table A1.6: **Producer Prices of Enterprises Competing with Sunflower in Trans-Nzoia District (Kshs/kg)**

Year/Season	Commercial Maize	Commercial Wheat	Beans	Seed Maize
1969/70	0.33	0.44	0.56	0.97
1970/71	0.39	0.56	0.84	0.97
1971/72	0.39	0.46	0.94	1.24
1972/73	0.39	0.46	0.72	1.20
1973/74	0.56	0.88	1.33	1.33
1974/75	0.56	0.88	1.67	1.34
1975/76	0.89	1.33	2.22	1.81
1976/77	0.83	1.28	2.00	1.91
1977/78	0.89	1.18	1.89	1.98
1978/79	0.72	1.34	1.89	1.64
1979/80	1.00	1.51	2.11	2.63
1980/81	1.06	1.67	3.67	3.50
1981/82	1.44	1.67	6.00	2.50
1982/83	1.60	2.79	5.00	3.17
1983/84	1.58	2.69	12.83	2.88
1984/85	2.25	2.78	6.00	5.00
1985/86	2.09	2.76	4.64	5.04
1986/87	2.09	3.02	3.39	5.56
1987/88	2.23	3.24	3.77	5.56
1988/89	2.45	4.29	5.75	5.10
1989/90	2.78	5.12	5.72	5.76
1990/91	3.30	6.12	5.23	6.80
1991/92	6.67	7.18	6.50	-

SOURCE: Ministry of Agriculture, Trans-Nzoia District and Rift Valley Province Annual Reports (1970 to 1992)

Table A1. 7: **Annual Rainfall Amounts (mm) for Specific Rainfall Stations in Meru, Bungoma and Trans-Nzoia Districts (1970 to 1992)**

Year	Meru Meteorological station	Bungoma Water supply	Kitale Meteorological Station
1970	930.0	1740.7	1006.8
1971	1371.0	1482.5	1225.5
1972	1468.4	1695.6	1163.9
1973	692.9	1600.2	1045.8
1974	1174.4	1480.2	1057.0
1975	884.3	1601.2	1168.4
1976	869.5	1421.8	954.5
1977	1568.1	1995.2	1451.2
1978	1904.8	1824.9	1365.9
1979	1447.2	1576.5	1280.7
1980	891.8	1336.4	947.3
1981	1278.4	1719.5	1619.2
1982	1527.4	1789.2	1534.3
1983	941.4	1539.6	1572.3
1984	1186.8	1448.9	888.5
1985	1021.5	1860.5	1331.5
1986	1138.6	1282.0	952.2
1987	669.1	1633.7	1172.3
1988	1502.2	1677.1	1267.6
1989	1523.5	1277.2	1313.8
1990	1653.3	1584.1	1189.5
1991	1176.0	1179.9	1264.8
1992	1431.4	919.0	1269.8

SOURCE: Meteorological Department, Nairobi.

Appendix A2: **Simple Correlation Matrices of the Variables in the Estimated Models**

Table A2.1: **Simple Correlation Matrix of the Variables Used in the Supply Model for Meru District**

Variable	H'_t	H'_{t-1}	P'_{t-1}	P'^{c}_{t-1}	Y'_{t-1}	R'_t	T'
H'_t	1.0000						
H'_{t-1}	0.7848	1.0000					
P'_{t-1}	0.6286	0.7289	1.0000				
P'^{c}_{t-1}	0.4629	0.3907	0.7790	1.0000			
Y'_{t-1}	-.0708	0.2116	-.0195	-.0214	1.0000		
R'_t	-.0183	0.3424	0.3991	0.0302	0.1065	1.0000	
T'	0.6869	0.8237	0.7726	0.6976	0.4267	0.1530	1.0000

SOURCE: Author's study, 1995

Table A2.2: Simple Correlation Matrix of the Variables Used in the Supply Model for Bungoma District

Variable	$H`_t$	$H`_{t-1}$	$P`_{t-1}$	$P`^c_{t-1}$	$Y`_{t-1}$	$R`_t$	$T`$
$H`_t$	1.0000						
$H`_{t-1}$	0.6511	1.0000					
$P`_{t-1}$	0.4313	0.5457	1.0000				
$P`^c_{t-1}$	0.3361	0.5145	0.9353	1.0000			
$Y`_{t-1}$	-.0552	0.2462	0.5730	0.6074	1.0000		
$R`_t$	-.0933	0.0659	-.3181	-.3978	-.0816	1.0000	
$T`$	0.5780	0.6428	0.9362	0.9269	0.5064	-.2811	1.0000

SOURCE: Author's study, 1995

Table A2.3: **Simple Correlation Matrix of the Variables Used in the Supply Model for Trans-Nzoia District**

Variable	H'_t	H'_{t-1}	P'_{t-1}	P'^c_{t-1}	Y'_{t-1}	R'_t	T'
H'_t	1.0000						
H'_{t-1}	0.4947	1.0000					
P'_{t-1}	-.4791	0.5509	1.0000				
P'^c_{t-1}	-.4930	-.6234	0.9545	1.0000			
Y'_{t-1}	0.0561	-.5826	0.2789	0.4237	1.0000		
R'_t	0.0698	-.2635	0.1140	0.1770	0.4868	1.0000	
T'	0.4808	-.6130	0.9509	0.9292	0.2777	0.1614	1.0000

SOURCE: Author's study, 1995