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DISSERTATION

ACCELERATING AGRICULTURAL PRODUCTION IN SAUDI ARABIA

Submitted by

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In partial fulfillment of the requirements

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WE HEREBY RECOMMEND THAT THE DISSERTATION PREPARED UNDER OUR SUPERVISION BY MANSOOR I. AL TURKI ENTITLED <u>ACCELERATING AGRICULTURAL PRODUCTION IN SAUDI ARABIA</u> BE ACCEPTED AS FULFILLING IN PART REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY.

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ABSTRACT OF DISSERTATION

ACCELERATING AGRICULTURAL PRODUCTION IN SAUDI ARABIA

The main purpose of this study was to find a way to accelerate agricultural production in Saudi Arabia. The way suggested should depend on the current state of input utilization and production efficiency. If Saudi farmers are "poor but efficient," then total production cannot be increased from existing resources farmers supply and control. If there is disequilibria within the agricultural sector, however, and farmers are "poor but not efficient," then total production from existing resources could be increased through production economic studies as well as educational programs helping farmers to recognize and remove disequilibria.

Resource allocation efficiency in Saudi's agricultural sector was analyzed by constructing two production functions for wheat and barley (Cobb-Douglas type). The value marginal productivities (VMP) of land and labor were computed and allocation efficiency was investigated.

The results found the VMP for land under barley was higher than that of land under wheat. VMP of land, both under wheat and barley, was much less than the marginal expense of land, however. Thus, Saudi farmers experience net losses. Resources, then, are used

unprofitably. Moreover, the VMP of labor was very low in wheat and negative in barley production, indicating too much labor is used relative to land.

Production function analysis suggests disequilibria, a result of very low land-labor ratio. This ratio must be altered before the agricultural sector increases efficiency.

Three solutions were considered. "Labor squeeze" and land expansion (horizontally) are ruled out; intensive cultivation seemingly became the solution. Fertilizer, as a form of intensive technique, was investigated. A production function for fertilizing wheat was constructed and the marginal rate of substitution, fertilizer for land, was constructed from different input combinations. This function was compared with two functions the U. A. R. produced. The results show how fertilizer can play an important role as a substitute for land.

Moreover, production from existing resources can be increased by removing disequilibria. Removing the "barriers to efficiency" removes disequilibria. Some of these barriers to efficiency were market structural variables, natural factors and government policies.

The study found disequilibria within Saudi's agricultural sector. Thus, total production from the existing resources could be increased through production economics studies and educational programs. Moreover, to alter the existing unfavorable land-labor ratio, more land investment is required, i.e., the "intensification" within the agricultural sector seems the most feasible solution.

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NOMENCLATURE

The measurements and units used in this dissertation are:

4.5 Saudi Riyals	=	$1.00
1 Saudi Riyal	=	20 Qurshs
Ardab	=	140 Kilograms
Hectare	=	2.471 Acres
Acre	=	1.6 Dunum
Hectare	=	3.9536 Dunum

Chapter 1

INTRODUCTION

In recent years, the crucial role of agriculture in earlier stages of economic development has received considerable emphasis by a large number of economists. Part of this emphasis is a reaction against what some authors feel to be an unwarranted stress on industrialization among the prevailing attitudes toward economic growth.

Economists[1] emphasizing industry over agriculture include Leibenstein, Hirschman, Prebisch, Myrdal, Higgins, and Rosen Rosenstein-Rodan. Among those placing a high priority on agriculture are Viner, Rostow, Coal, and Hoover, Kuznets, Nicholls, and Oshima. Others, notably Lewis, Ranis and Fei, and Johnston and Mellor, have emphasized general characteristics of agriculture in today's underdeveloped countries and have drawn attention to the important role agriculture could play in the growth process.

The general feeling is, however, that agriculture and industry are interdependent, and growth in one cannot proceed far while the

[1] All of these researchers are mentioned in Carl Eicher and Lawrence Witt, (Ed.), Agriculture in Economic Development, McGraw-Hill, 1964.

other stagnates. A "balance" of effort is needed -- whatever that may be.[2]

While there is a degree of agreement over the crucial role of agriculture in the early stages of economic development, there remains some controversy concerning policies for securing increased agricultural output and productivity with the factors employed. Opinions differ on behavior of farmers regarding allocation of resources. There is a view that farmers in developing countries have ample opportunities to increase production if they combine resources somewhat differently. In other words, as a result of farmer behavior there is significant disequilibria within the existing agricultural sectors. Economists associated with this view include Desaie,[3] Heady and Dillon,[4] and Randhawa.[5]

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[2]Balanced growth may take three forms: extreme, moderate, or sophisticated. See Michael Lipton, "Balanced and Unbalanced Growth in Underdeveloped Countries," Economic Journal. vol. LXXII, 1962, pp. 641-657. For different objectives of balanced growth see Ashok Mathur, "Balanced vs. Unbalanced Growth--A Reconciliatory View," Oxford Economic Papers, Vol. 18, 1966, pp. 137-157.

[3]D. K. Desai, Increasing Income and Production in Indian Farming, Vora, Bombay, 1963.

[4]Earl O. Heady and John L. Dillon, Agricultural Production Functions, Ames, Iowa, State University Press, 1961.

[5]Norindar S. Randhawa and Earl O. Heady, "An Inter-Regional Programming Model for Agricultural Planning in India," Journal of Farm Economics, Vol. 46, No. 1, February 1964.

The opposite view states that farmers do combine enterprises so the marginal value of products from resources among different enterprises are equal to their costs. In other words, as Schultz puts it, farmers are "poor but efficient." Economists associated with this view are Schultz,[6] Mellor and Moorti,[7] and Tax.[8]

The controversy has critical policy implications for Saudi Arabian agricultural development. Saudi Arabia is a food-deficit country. While demand for food, stimulated mostly by higher incomes, rose at a fast rate during the last twenty years, domestic supply was hampered in its growth by some difficulties. While total imports of food in 1946/47 were valued at Saudi Riyal 22 million, their value has jumped to SR 396 ($88 million) in 1962/63, and to SR 432 ($96 million) in 1964/65. The growth rate in the value of imports at 1961/62 prices was 9.5 per cent per year (based on the time period of 1951/52 to 1961/62). Asfour, et. al., estimated that future food imports will

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[6] T. W. Schultz, Transforming Traditional Agriculture, New Haven and London, Yale University Press, 1964.

[7] John W. Mellor and T. W. Moorti, Farm Business Analysis of 30 Farms, Research Bulletin 1, Balwant Vidyzpeeth, Bickpuri, India (April, 1960).

[8] Sol Tax, Penny Capitalism: A Guatemalan Indian Economy, Smithsonian Institution Pub. No. 16, 1963.

remain stable and will hold about the same proportion in 1975 as in 1961/62.[9] Is this inevitable?

It is not befitting dignity, self-respect, or the balance of payments of a nation to be an importer of foodgrains when its total cropped area is nearly one quarter of a million hectares (over one half of a million acres); a potential to cultivate over twice as many hectares; and a net irrigated area of 82 per cent on the cultivated area (1963).

The government has become aware of the need for production expansion and attempts have been made by the Ministry of Agriculture and Water as well as other autonomous bodies such as the Agricultural Bank to develop programs increasing food production. However, decision-makers are faced with a host of possibilities and paucity of information on which to base their decisions.

The Objective of This Study

The main purpose of this study is to find a way or ways to accelerate agricultural production in Saudi Arabia. Whatever way is taken should depend on the current state of input utilization and

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[9] Edmond Y. Asfour, et. al., "Saudi Arabia: Long-Term Projections of Supply of and Demand for Agricultural Products, Economic Research Institute, American University of Beirut, Beirut, 1965. Also Saudi Arabian Monetary Agency, Statistical Summary, Vol. III, No. 1, November, 1965, pp. 28-29.

production efficiency. Therefore the problem of resource "allocation efficiency" in the agricultural sector must be tackled. If Saudi farmers are "poor but efficient," then total production cannot be increased from the existing resources farmers supply and control. Increased total production has to come from policies that change the decision-making environment within the agricultural sector. If, however, there is disequilibria within the agricultural sector and if Saudi farmers are "poor but not efficient," then the total production from the existing set of resources can be increased through production economics studies and educational programs helping farmers recognize and remove disequilibria. However, in doing this the existing input-input relationship will be obtained, then a decision must be made as to whether it is favorable or not. If it is not favorable, then some possibilities of altering this relationship has to be investigated and policies which might raise resource productivities would be proposed.

Chapter 2

THE STATE OF AGRICULTURE

The Kingdom of Saudi Arabia covers 865,000 square miles--four-fifths of the Arabian Peninsula, roughly 1.5 per cent of the total surface of the earth. The Red Sea borders Saudi Arabia on most of the west coast and the Arabian Gulf on the east. On a map, it extends northward beyond the latitude of Alexandria; it reaches approximately to Jerusalem. The Southern part of this plateau is the Rub Al-Khali (the empty quarter) (see Figure 1).

Most of Saudi Arabia is arid, averaging less than 4 inches annual precipitation characterized by extreme irregularity. In addition to the sparsity of rainfall, precipitation varies within the year, i.e., it is not uniform, and with some months being virtually rainless, as is shown in Table 2-1.

The best known feature of the Arabian climate is the intense heat of the summer months. Mean monthly temperatures in selected towns are shown in Table 2-2.

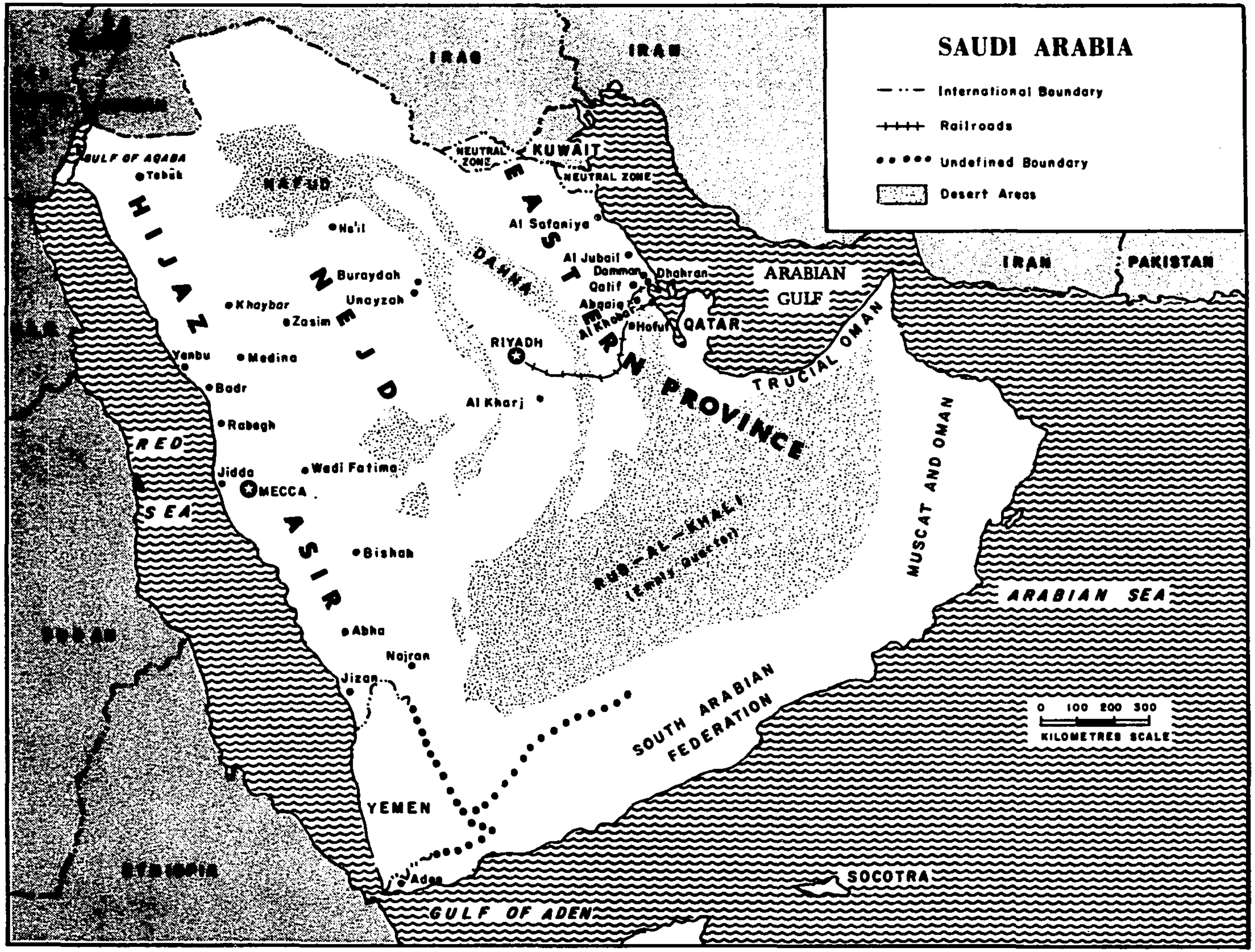

Figure 1. Map of Saudi Arabia.

Table 2-1. Annual rainfall in selected towns of Saudi Arabia, 1957 - 1966 in (mm.). Traces are not included.

Town	1959	1960	1961	1962	1963	1964	1965	1966
Jeddah	46.7 (1, 11, 12)	40.5 (1, 5, 11, 12)	33.0 (1, 7, 12)	96.0 (1, 11, 12)	45.5 (4, 5, 12)	7.0 (2)	48.5 (1, 3, 4, 11)	66.0 (1, 2, 3, 10, 11, 12)
Riyadh	66.0 (1, 3, 5, 11, 12)	49.5 (1, 3, 4, 5, 12)	53.3 (1, 2, 3, 4, 5, 7, 11)	68.0 (3, 4, 11)	96.0 (3, 4, 5, 11)	146.0 (1, 2, 3, 5, 12)	80.5 (1, 2, 3, 4, 11)	13.5 (2, 4)
Medina	40.6 (11, 12)	84.6 (2, 3, 5, 11, 12)	45.3 (1, 4, 5, 7, 11, 12)	11.0 (12)	59.0 (1, 4, 5, 8, 11)	18.0 (3, 12)	15.4 (1, 3, 11)	26.0 (1, 2, 4, 10, 11)
Dhahran	147.8 (1, 3, 4, 5)	--	80.0 (1, 2, 3, 4, 5, 11)	37.0 (4, 11)	42.7 (3, 4, 5, 11, 12)	123.5 (1, 2, 3, 6, 12)	18.0 (1, 2, 3, 4)	39.7 (1, 2, 3, 4)
Ta'if	*	*	132.0 (3, 4, 5, 6, 7, 10, 11, 12)	111.8 (1, 3, 4, 5, 7, 8, 9, 11, 12)	397.5 (1, 2, 4, 5, 8, 9, 11)	109.0 (1, 3, 4, 5, 6, 7,	188.0 (3, 4, 5, 6, 8, 9, 10, 11, 12)	155.0 (1, 3, 4, 5, 8,
Turaif	64.1 (2, 3, 4, 11, 12)	24.9 (1, 3, 4, 11, 12)	27.5 (1, 2, 3, 4, 10, 12)	23.5 (1, 2, 3, 12)	61.0 (2, 3, 4, 5, 10, 11, 12)	19.0 (1, 2, 4, 5, 11, 12)	43.0 (1)	*

Notes: Numbers in parentheses indicate months
* information not known
-- No rain except traces

Source: Calculated from Statistical Yearbooks, 1965, 1966, 1967

Table 2-2. Mean monthly temperatures in selected towns (centigrade).

Town	J	F	M	A	M	J	J	A	S	O	N	D	Years of Period
Jeddah	23.8	23.6	24.7	24.3	29.5	31.7	32.1	32.0	31.1	27.7	26.8	24.8	8
Riyadh	14.7	17.0	20.2	25.0	29.8	33.3	34.3	34.6	31.5	25.5	19.2	14.2	8
Medina	18.4	19.7	23.1	27.4	31.0	35.6	34.7	25.5	24.1	30.5	22.8	18.6	8
Dhahran	16.4	18.0	22.1	28.0	31.0	34.5	36.0	35.7	32.5	26.5	23.2	17.1	8
Ta'if	15.3	18.0	20.0	22.1	25.5	28.1	28.3	28.5	27.1	22.3	17.2	17.2	6
Turaif	9.0	8.6	13.6	19.4	21.6	28.3	28.5	30.3	24.7	21.5	14.0	10.7	7

Source: Calculated from the Statistical Yearbooks, 1965, 1966, 1967

2-1. Population

A partial government census conducted in 1962/63 estimated a population of about 3. 3 million.[10] The rate of population growth is a broad approximation. A United World Health Organization survey team estimated in 1962/63 that the rate of increase in Saudi Arabia is at least 1. 5 per cent per annum. This was based on sample surveys which indicated a death rate at about 2.4 per cent with birth rates in two villages ranging between 4. 24 per cent and 5. 17 per cent. The rate of increase will range from 1. 8 per cent to 2. 8 per cent.[11]

While the death rate in Saudi Arabia (2. 4 per cent per annum) may be considered reasonably realistic, there is no reliable indication of the birth rate. However, at the time of the 1962/63 census, almost 72 per cent of the population was 30 years of age or under, over 40 per cent of the population was under 15 years of age, and approximately 36 per cent of the total population was under 10.[12] One could infer then, the rate of birth is high -- say about 5 per cent.

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[10] Kingdom of Saudi Arabia, Ministry of Finance and National Economy, Census of population and Establishments, The Island Press Company, Riyad, 1963.

[11] World Health Organization, Report on a Health Survey of Saudi Arabia, from 10 November 1962 to 31 January 1963, (EM/PHA/110), Saudi Arabia, July 1963.

[12] Asfour, op. cit., p. 40, and United States Department of Labor, Labor Law and Practice in Saudi Arabia, BLS Report No. 269, April 1964, p. 19.

This would yield a rate of increase of about 2.5 per cent yielding the following increase in relation to the base year 1962 (Table 2-3).

Table 2-3. Index of size of population (1962 = 100).

Year	Index of Size of Population
1950	73.78
1957	88.12
1962	100.00
1965	107.00

About 20 per cent of the population is settled in urban areas, 20 per cent is nomadic, and the remainder live in villages.

2-2. Recent History of Saudi Arabian Economy

Until the 1940's, when the development of the oil industry started to exert an impact, the economy of Saudi Arabia was based almost completely on agriculture. Dates and live sheep were important export commodities in trade with other Middle Eastern countries during the pre-oil industry period.

The development of the oil industry has had profound effect upon the traditional, almost self-sufficient, but low per capita income economic pattern of Saudi Arabia. This industry has provided an important stimulus to the nation's economic growth, primarily by providing a large flow of foreign exchange giving Saudi Arabia an extraordinary capacity for foreign payments. The economic structure of the country, in many respects, has been drastically changed in a relatively short period of time.

The oil industry has increased income, both total and per capita (Table 2-4), although this increase was not distributed to a large proportion of the total population. This increased purchasing power could not be supplied by the other sectors of the economy. Therefore, as would be expected, there was a large import increase of consumer goods to meet the demand. Also, the large fiscal income of the government brought a drastic re-orientation to traditional government services formerly limited to minor road-building and national safety. Government services were increased in fields of economic development, public health and education, and national public work.

Table 2-4. The rate of change of per capita GDP at factor cost (1962/63-1966/67).

	GDP (million dollars)	Population (thousands)	Per Capita (dollars)	% Change
1962/63	1978	3200	618	
1963/64	2126	3280	648	4.8
1964/65	2276	3362	677	4.4
1965/66	2552	3445	741	9.4
1966/67	2912	3531	825	11.3

Source: Tables 2-3 and 2-5

Although the remarkable increase in the product of the Saudi Arabian economy brought about an increase in per capita income, this increase has not been sufficient to provide an improvement in the general welfare. In real terms, the distribution of income is such that certain sectors of the population, especially farmers and nomads, receive relatively slight improvement while other sectors receive extraordinary benefits. Agricultural productivity has shown some improvement but is still far behind other sectors of the economy.[13]

2-3. The Position of Agriculture in the Economy

The important position of agriculture is shown in the estimates of the gross domestic product, GDP. These figures need, of course, cautious interpreting. The collection of production figures in the agricultural sector is based on an "intelligent assumption" rather than on systematic inquiry. They are of value insofar as they convey some idea of the relative importance of this sector. The GDP for 1966/67 is estimated at SR 13102.3 million, or roughly $825 per capita of population. SR 1007 million, or 7.7 per cent comes from agriculture--livestock, forestry, and fishing are included (Table 2-5).

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[13] The 1965 Economic Report of the Central Planning Organization of Saudi Arabia estimates the annual output per worker in the oil industry at SR 143, 000, in government at SR 6690, in private non-agricultural employment at SR 3240, in the agricultural sector at SR 1580, and among nomads at SR 510. See Saudi Arabia, Central Planning Organization, Economic Report, 1965, Riyadh, 1965.

Table 2-5. GNP by industrial origin--at current market prices, Saudi Arabia, 1962/63-1966/67 (SR million).

Sectors	1962/63	1963/64	1964/65	1965/66	1966/67	Arithmetic average of index rise yearly
Agriculture & Livestock	782.0	804.0	856.0	913.0	1007.0	7.2%
Petroleum	4741.0	4951.0	5153.0	5863.0	6876.0	11.2
Mining & Quarrying	34.0	37.0	41.0	45.5	50.0	11.7
Manufacturing	171.0	188.0	207.0	227.5	250.0	11.5
Construction	365.0	402.0	442.0	486.0	535.0	11.6
Electricity, Gas, Water & Sanitary Services	172.0	189.0	208.0	229.0	252.0	11.6
Transportation, Storage and Communication	580.0	650.0	720.0	805.0	900.0	13.8
Wholesale & Retail Trade	558.0	598.0	714.0	832.0	932.0	16.7

Table 2-5. (continued)

Sectors	1962/63	1963/64	1964/65	1965/66	1966/67	Arithmetic average of index rise yearly
Banking, Insurance & Real Estate	35.0	38.0	42.0	46.0	50.0	10.7%
Ownership of Dwelling	382.0	405.0	430.0	462.0	494.0	7.3
Public Admin. & Defense	694.0	847.0	911.0	1027.0	1113.0	15.1
Education	187.0	236.7	270.5	300.5	340.3	20.5
Medical & Health	72.1	85.7	98.0	111.1	120.0	16.6
Other Services	125.0	137.0	151.0	166.0	183.0	11.6
GNP	6887.1	7332.9	8308.5	9069.0	9891.3	10.6
GDP	8898.1	9568.9	10243.5	11513.6	13102.3	

Source: Ministry of Finance and National Economy, Central Statistical Dept., Estimates of Gross Domestic Product, Gross National Product and National Income of Saudi Arabia during the period 1382/83-1386/87 AH. Feb. 1969.

Estimates indicate this 7.7 per cent was produced by some 60 per cent of the population. This fact explains why fluctuation in agricultural production may have a considerable repercussion on 60 per cent of the population. Moreover, the figures again indicate an unequal distribution of income arising from the underdevelopment of agriculture.

In recent years, the importance of agriculture tended to diminish in its relative contribution to the GDP.

The study of Table 2-6 reveals that while all sectors of the economy show absolute increase in production during the period 1962/63 - 1966/67, the agricultural sector has the lowest rate of growth in relative contribution to GDP. As a result, the agricultural sector has moved back to the third position in regards to relative contribution GDP.

2-4. Trends in Output and Productivity

The rate of growth in crop production was well ahead of the rate of population growth during the period 1950-63. While the population increased by 38.9 per cent, crop production increased by 260 per cent during the same period (Table 2-7).

The trends in foodgrain production vis-a-vis the increase in population can be seen from the figures of per capita availability of food grains from 1950 to 1963. In the year 1950/51, per capita availability of cereal and vegetables (produced in the country) was 2.9

Table 2-6. Changes in the relative industrial structure of Saudi Arabia -- 1962/63 and 1966/67.

Sector	Contributions to GDP (%) 1962/63	Contributions to GDP (%) 1966/67	Percentage of population engaged in sector*
Agriculture and Livestock	8.8	7.1	60
Petroleum	53.3	52.3	less than 2
Mining and Quarrying	0.4	0.4	less than 4
Manufacturing	1.9	1.9	less than 1
Construction	4.1	4.1	less than 2
Electricity, Gas, Water, Etc.	1.9	1.9	unknown
Transportation, Etc.	6.5	6.9	unknown
Wholesale and Retail Trade	6.3	7.1	10
Banking, Etc.	0.4	0.4	unknown
Ownership of Dwelling	4.3	3.8	unknown
Public Admin. and Defense	7.8	8.6	7
Education	2.1	2.6	unknown
Medical and Health	0.8	0.9	unknown
Other Services	1.4	1.4	unknown
Total	100.0	100.0	

*Approximation

Source: Table 2-5

and 0.9 ounces per day respectively. In 1962/63 the per capita availability of cereals and vegetables was 7.0 and 10.2 ounces per day. Thus, against a total availability of all foodgrains of 14.4 ounces per day in 1950/51, the availability in 1962/63 was 27.4 ounces per day.

Although production of crops has increased rather rapidly, the country has yet to be self-sufficient. Before this is discussed, the causes for the large increase in ouput should be investigated.

The growth in output of all crops was brought about by the extension of cultivation rather than the use of productivity-raising factors. While output of all crops increased by 260 per cent during the period 1950 to 1963, area under all crops increased by 255 per cent. (Acreages are shown in Table 2-8).

Table 2-7. Indexes of total crops output and population in Saudi Arabia for selected years.

Year	Total crops output	Index	Population Index
1950	355, 657	100	100.0
1957	437, 805	123	119.4
1963	925, 326	260	138.9

Sources: Tables 2-4 and 2-8

To find the trend via productivity, i.e., yield per hectare, Table 2-8 is utilized. Figures for the intervening years were derived by arithmetic extrapolation. (i.e., A constant growth per year in

Table 2-8. Trends of output and area under cultivation in Saudi Arabia (area in hectares, output in tons).

Crop	1950		1957		1963	
	Area	Output	Area	Output	Area	Output
All field crop	67838	71300	155400	168815	175929	236235
Wheat	21800	20200	43800	42836	89890	129201
Barley	17163	15268	23800	23800	29182	48244
Vegetalbes	4128	29226	3000	21240	33132	345485
Dates	21752	150000	43900	23500	22281	257606
All Crops	95316	355657	207400	547805	242829	925326

Source: G. S. Medawar, A Report to the Ministry of Agriculture on Agriculture in Saudi Arabia. (Unpublished report January 1965).

absolute terms was found and added to, or subtracted from 1950, and 1957, to get 1951 and 1958; and so on.) The yields per hectare were computed from the acreage and production information (Tables A, B, C, D, and E in the Appendix).

Since one is interested more in relative growth rather than absolute growth, the index numbers of yield per hectare have been used with 1950 as the base period.

Among the various known methods of measuring the annual rate of change is the linear regression,

$$Y = a + bT,$$

where Y stands for index of yield and T for time measured in years with reference to 1950 as origin.

The linear regression was fitted to the index number of yield. In the regression equation, this determined the coefficient of T (i. e., b represents the annual rate of change over the period). It should be noted, however, that b does not represent the per cent rate of growth per annum; b must be adjusted before it represents the growth rate in per cent per annum, (i. e., the time rate of change of Y is defined as $\dot{Y}$; and $\dot{Y} = dy/dt = b$. When the percentage rate of growth, γ is considered, the ratio $\dot{Y}/Y$ is relevant. That is,

$\gamma = \dot{Y}/Y = dy/dt \times 1/Y = b \times 1/Y$, (i.e., γ is obtained when b is divided by the mean of Y).[14]

The linear trend equation

$$Y = a + bT,$$

however, gives us an approximation of the relative increase per unit of time and would be a rough estimate of γ. The growth rates of different crops with respect to productivity are shown in the following table (Table 2-9).

Table 2-9. Growth rate of productivity in Saudi Arabia (1950-1963).

Crop	Equation	Annual Productivity Rate
Wheat	$Q = .00826 + 5.07033\ T$	5.1
Barley	$Q = .00781 + 6.75385\ T$	6.8
Vegetables	$Q = .00849 + 3.92088\ T$	3.9
Dates	$Q = 70.9780 - .178022\ T$	-0.18
All Crops	$Q = .00744 + .59121\ T$	0.6

Source: Calculated by the author

[14] One assertion is γ is obtained when b is divided by the harmonic mean. For a proof see B. S. Minhas, Rapporteur's Report on Measurement of Agricultural Growth, Indian Journal of Agricultural Economics, October - December 1966, Vol. XXI, No. 4, p. 168.

2-5. Crop Pattern

It is worthwhile to examine any recent changes in crop pattern in the country, and if so, the extent of changes. Table 2-10 presents the area distribution under different classes of land during the period 1950 to 1963.

Table 2-10. Crop pattern in Saudi Arabia (1950-1963).

Items	1950		1957		1963	
	Area (Ha)	% of Total	Area (Ha)	% of Total	Area (Ha)	% of Total
Field Crops	67838	71.2	155400	74.9	175929	72.4
Vegetables	4128	4.0	3000	1.4	33132	13.6
Dates	21752	22.8	43900	21.5	22281	9.0
Fruits	2226	2.0	5100	2.5	11487	5.0

Notes: Field Crops include wheat, barley, dura, dukhun, rice, and others. Vegetables include onions, tomatoes, watermelons, and others.

Source: Table 2-8

The area under field crops here expressed as a percentage of area under all crops showed a relative constancy over the period. Field crops ends up with 72.4 per cent of the total area as against the 71.2 per cent from the beginning of the period. The changes in crop pattern of vegetables shows a significant favorable shift from 3.0 per cent to 13.6 per cent. Fruits shifted from 2.0 per cent to 5.0 per cent. This seems to have occurred at the expense of dates. Thus, apart from a constancy of field crops, there seems to have been a change in the pattern of cropping in Saudi agriculture during the 1950 to 1963 period.

The cropping pattern in Saudi Arabia is basically oriented to the production of food crops. Cultivation of fruits and vegetables occupies only a secondary place. Crop production in Saudi Arabia is characterized by low yields per hectare. Moreover, as can be seen from Table 2-9, productivity for all crops has shown no significant tendency to rise over the years.

These very low yields per hectare for almost all important food crops coupled with the fact that about 60 per cent of the country's population engages in agriculture, reflects another significant feature of Saudi Arabian agriculture--its subsistence nature.

2-6. Food-Deficit Country

In spite of an increase in output, a large portion of the agricultural products consumed in Saudi Arabia are imported. Moreover, the import rate of food has been increasing rather rapidly in recent years. While imported food represented less than one-tenth of total food supply in 1946/47, the ratio rose quickly to about 36 per cent in 1961/62. In money terms, the value of food imports has jumped to SR 432 in 1964/65 from SR 22 in 1946/47.

It is disheartening. No single import has been completely eliminated. Instead, more items, at one time exports, are now added to the import list. Before 1949, Saudi Arabia was a net exporter of live animals, now it has become a heavy net importer. Estimates of live animal import and total meat quantity import show a steadily rising trend. It is estimated that about one quarter of total meat consumption in Saudi Arabia was met by imports in 1960/61.

However, Saudi Arabia will not likely face the severe food crisis that is facing some heavily poplulated areas of the world. Saudi Arabia is endowed with an extraordinary capacity to import food as the demand requires. In a longer range period, some critical food supply problems may develop should Saudi Arabia's agricultural potential lag too far behind population needs (especially if the high-value oil exports become exhausted). This means supply and demand for food must be known before the country plans its agricultural development.

2-7. Potential Demand and Supply of Food

<u>A - Potential Supply</u>. The 1965-1975 projected annual growth rate of supply for meat is estimated to be 1.8 per cent; 7.2 per cent for cereal; 5.3 per cent for fruits. Vegetables are estimated at 7.7

per cent and 6.4 per cent for the periods 1965-1970 and 1970-1975 respectively.[15]

B - Potential Demand. The main assumptions are: (1) closed economy in the sense that only home demand is considered; (2) factors other than income and population growth have no influence on the demand for food; and (3) individual peculiarities of taste and habit cancel each other, and average behavior more or less represents normal behavior.

The elasticity coefficients of demand were estimated by Al-Kaylani; 0.2 for cereal, 0.4 for meat, 0.6 for fruits, and 0.6 for vegetables.[16] Considering the population[17] and per capita income effects,[18] the annual increase in demand for meat is estimated to be 4.9 per cent, 3.7 per cent for cereal, 6.1 per cent for vegetables, and 6.1 per cent for fruits.

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[15] Lyle E. Moe, Saudi Arabia: Supply and Demand Projections for Farm Production to 1975, With Implications for U. S. Exports USDA, ERS-Foreign 168, December 1966, Washington, D. C.

[16] H. M. Al-Kaylani, Sample Survey of Household Food Consumption in Riyadh, Saudi Arabia, September 1963, Economic Research Institute, American University of Beirut, Beirut, 1964 (Unpublished Memo). Also 0.5 for fats and oil, 1.2 for dairy products, 1.5 for sugar, and -0.5 for dates.

[17] Annual population growth is 2.5%, see section 2-1.

[18] Annual per capita income growth is assumed to be 6%, see section 2-2.

The supply rate of growth for meat and fruits is going to be less than the rate of growth of demand. Therefore, a deficit is going to exist. Supply and demand for vegetables and cereal, at some point of time, will match each other and the country will be self-sufficient concerning these two commodities. This indicates the agricultural sector in Saudi Arabia needs planning for development. Before development plans can be drawn, some information on existing resource allocation and production efficiency is needed. This is the point of the coming chapter.

Chapter 3

ALLOCATION EFFICIENCY

"How well are Saudi Arabian farmers presently allocating their resources?" The question is not easy to answer because the answer must remain inside the limits of the data. Before an answer is derived, the following must be known: first, the production functions underlying the traditional village production; second, the actual allocation of resources farmers made among their production alternatives; and third, the prices of factors and products.

This chapter attempts to construct two production functions. The first production function is for wheat and the second for barley. From these production functions the marginal productivities of inputs and production elasticities are derived. After these economic relationships are derived, farmers resource allocation is examined.

3-1. General Framework

The more generally accepted types of functions fall into three main categories:

a. Exponentials

b. Polynomials

c. The Power Function

This chapter uses the power function of Cobb-Douglas. i.e.,

$$Y = aA^{b_1}L^{b_2} \tag{3-1}$$

where Y is output, a is constant, A and L are land and labor respectively and exponents or b coefficients are the regression coefficients.

Given the function in equation (3-1), various economic relationships can be specified.

<u>A - The Marginal Physical Productivity of Inputs</u>. The marginal product of a factor indicates the increase in total product by adding one more unit of input. The marginal physical product is the slope of the individual input-ouput curve. Thus, it is derived by taking the first derivative of the production function with respect to the variable resource as:

$$\frac{\partial Y}{\partial A} = ab_1 A^{b_1 - 1} L^{b_2} \tag{3-2}$$

$$\frac{\partial Y}{\partial L} = ab_2 A^{b_1} L^{b_2 - 1} \tag{3-3}$$

The value in equation 3-2 and 3-3 can be derived from

$$\frac{\partial Y}{\partial A} = b_1 \frac{Y}{A} \tag{3-4}$$

and

$$\frac{\partial Y}{\partial L} = b_2 \frac{Y}{L} \tag{3-5}$$

Heady and Dillon say the most reliable estimate of marginal productivity is obtained by taking A and L at their geometric means. Also, Y should be the estimated level of output when each input is held at its geometric mean.[19]

B - The Production Elasticities. Other quantities of some importance in this study are the production elasticities of the individual resources. The elasticity of production indicates the change in output relative to the change in input. The regression coefficients, b_1 and b_2 derived with the observations in logarithms, are the production elasticities of the individual resources.

The sum of b_1 and b_2 indicates the nature of returns to scale, provided A and L are the only relevant inputs. A sum of elasticities equal to one indicates constant return to scale, i.e., output increases by the same rate as input. A sum less than one indicates diminishing return to scale, i.e., the percentage increase in output is less than the percentage increase in input. A sum greater than one indicates increasing return to scale, i.e., output increases by a greater percentage than input.

C - The Elasticity of Substitution of Resources. By deriving the elasticities of production of the variable inputs, the elasticity of substitution of resource A for resource L is easily derived. The elasticity of substitution of resource A for resource L is defined as the

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[19] Heady and Dillon, op. cit., p. 231.

percentage change in A associated with a 1 per cent change in L, and mathematically is expressed as

$$E_{A,L} = \frac{dA}{dL} \frac{L}{A} \tag{3-6}$$

or $$E_{A,L} = -\frac{b_1}{b_2} \tag{3-7}$$

i.e., the elasticity of substitution of A for L is $(E_{A,L})$, the ratio of production elasticities. If the ratio of production elasticities is greater than one, more should be spent on the input A than on input L. The ratio indicates that L's marginal productivity is low relative to that of input A. Also, it indicates that too much of input L is used relative to the other input A.

3-2. Secification and Measurement of Variables

The variables used in this study are: (1) farm output, namely wheat and barley, (2) land, and (3) labor. Capital and management inputs could not be included. They are excluded due certain gaps in the available data on these items. In fact, most studies on agricultural production functions have not been able to include "management" input owing to the problems of measurement.

Estimates are based on input-output data relating to a single production year in seven Saudi Arabia regions. These data were calculated during the course of a survey on agricultural production sponsored by the Saudi Arabian Ministry of Agriculture.

The procedure followed in this study for standardizing and measuring the variables is given below:

A - Output. This variable consists of the value of output, wheat and barley, less the value of seed used. The value is given in Saudi Riyals ($1 = 4.5 Saudi Riyals).

B - Land. Since land is a heterogeneous unit, it was necessary to standardize it by some index of productivity. Land rent is assumed to represent land productivity and it is used as an index to adjust acreage. Current fallow land is also included because part of these fallowed acres are rotational. Thus cultivation of other lands which might have been left fallow in previous years is possible. Land is recorded in acres.

C - Labor. Information on labor input is available for all farms; but since production functions for wheat and barley are being constructed, an assumption has to be made. It is assumed that 10 per cent of the total agricultural labor input is used on wheat and 3 per cent on barley production.[20] Also, there are 300 days per man-year.[21]

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[20] Wheat covered about 33 per cent of the total cropped area and barley covered about 11 per cent in 1962/63.

[21] The Arabic year is about 354 days a year. Fasting month (30 days), two holidays (i.e., 12 days), and 12 days for sickness are eliminated.

Labor input -- total of hired and family -- is included in the form of number of work-days in the year.

3-3. Some Simple Measures of Input-Output Relationships

The objective of this section is bring out the levels of output per unit of labor and land, and the inputs of labor per unit of land in different regions.

Data for the average output-input (man-day) per acre in the seven regions are presented in Table 3-1. This table indicates that the southern region has the highest output per acre compared to all regions. It yields 595 Saudi Riyals and SR 316 for wheat and barley respectively. The per acre labor input is relatively higher in Medina (i. e., in wheat). Thus in Medina, where output per acre is the lowest, larger labor input per acre resulted in a much lower output per unit of labor. The comparatively lower productivity of land in all regions relative to the southern region may be explained largely by topographical and climative factors. The combination of these factors along with the quality of soils accounts for these significant regional disparities in productivity.

Moreover, Table 3-1 indicates that output per man-day is very low and labor input per acre is very high. For, example, in Medina, output per man-day is 0.01 Saudi Riyal, while 694 man-day is spent on each acre in Medina. Actually a laborer does not spend 694 man-days

Table 3-1. Output per unit of labor and land and labor input per unit of land in Saudi Arabia, 1962/63 (output in Saudi Riyals).

	North	Medina	Jedda	Ta'if	Qaseem	Central	South
Wheat							
Output per labor (man-day)	4.0	0.01	0.2	5.0	21.0	21.0	6.0
Output per acre	57.0	71.0	89.0	82.0	71.0	74.0	595.0
Labor input per acre (man-day)	14.0	694.0	330.0	14.0	3.3	2.8	9.9
Barley							
Output per labor (man-day)	3.2	0.5	0.4	0.8	3.2	1.3	70.0
Output per acre	135.0	47.0	59.0	41.0	51.0	30.0	316.0
Labor input per acre (man-day)	41.0	91.0	140.0	20.0	60.0	17.0	4.5

Source: Calculated from Statistical Year Book, 1967, p. 134.

a year on each acre of wheat, but it does indicate that too much labor is underutilized or unutilized in Medina.

3-4. Production Functions for Wheat and Barley

The production functions are derived by fitting the data to a Cobb-Douglas production function of the type in equation (3-1). The results were:

Wheat:

$$\log Y = 1.309 + 0.948 \log A + 0.119 \log L$$

Barley:

$$\log Y = 1.99016 + 0.80087 \log A - 0.36663 \log L$$

where Y it output, wheat or barley; A is land in acres and L is labor input in days.

3-5. Production Elasticities and Return to Scale

The results obtained by fitting the Cobb-Doublas function are shown in Table 3-2 and need to be interpreted with a considerable degree of caution.

Land elasticities, that is the regression coefficients, are less than unity both for wheat and barley, and therefore indicate diminishing marginal return to land used under wheat or barley. Labor elasticity is less than unity in the case of wheat, but it is negative in the case of barley. The negative elasticity indicates negative marginal return to labor. That is to say, increasing labor while holding land constant would decrease output. The very low, or negative elasticity of labor suggests that too much labor is used relative to land in the existing input-output relationships.

Table 3-2. Cobb-Douglas function results for Saudi Arabia, selected areas combined, 1962/63.

	Wheat	Barley
Production Elasticities:		
land*	0.9482	0.80087
labor**	0.1191	-0.36663
Sum of elasticities	1.067	0.434
Coefficient of multiple determination	0.995	0.74
Coefficient of multiple correlation	0.997	0.86
Standard error of estimates	0.0972	0.5633
Standard error of elasticities:		
land	0.03807	0.34356
labor	0.14914	1.04436

*Land is significant at any level of probability for wheat and at 0.5 per cent probability for barley.

**Is not significant at 0.5 per cent probability level.

3-6. Marginal Physical Products

The marginal product of a factor is the return which might be expected, on the average, from a unit addition to the factor-input concerned while other inputs are held constant.

Marginal productivities of inputs taken in conjunction with their prevailing market or opportunity costs throw some light on the efficiency of resource-use. If marginal productivity is less than market costs its resource use is unprofitable. At the same time, a greater than market cost indicates output profitably through an increased use of resource inputs.

Again, there are limitations arising from the method of estimation itself. Since marginal productivities are derived from elasticities, and since the estimated elasticities are biased due to the omission of certain explanatory variables from the functions (i.e., capital, etc); the estimated marginal products are also biased in the same direction as elasticities.

The estimated marginal physical productivities of land (per standard acre) and labor (per man-day) taken at the geometric mean of the input factors used in the two functions are given in Table 3-3. The marginal product of land used in wheat production is relatively higher than that of land used in barley production. Marginal productivities of labor are negative, and MP of land is positive.

3-7. The Allocation Efficiency

If a farmer has allocated his inputs among his production alternatives efficiently, while at the same time he operates under conditions of competition in product and factor markets, the following equilibrium condition will prevail:

$$P_W \frac{\partial Y_W}{\partial A} = P_B \frac{\partial Y_B}{\partial L} = P_A = P_L$$

where

P_W and P_B are market prices of wheat and barley respectively.

P_L and P_A are prices of labor and land respectively.

Table 3-3. Geometric mean of the input factors and marginal productivities of inputs, Saudi Arabia, 1962/63.

	Wheat	Barley
Geometric mean		
Land (acres)	4.27	3.97
Labor (man-days)	5.64	5.17
Output (expected yield in Saudi Riyals)*	96.0	155.95
Marginal physical products		
Land (Saudi Riyals)	21.4	29.2
Labor (Saudi Riyals)	2.04	-10.97

*Taken at the geometric mean of the input factors.

So far as the marginal product of labor is concerned the marginal product of hired labor should be relevant for comparison with the market wage rate, not the marginal product of composite labor input, made up from both family and hired labor. Therefore, these estimates cannot be compared with the market prices of factors concerned with analyzing resource-use efficiency. Moreover, further discussion is required because marginal productivity of labor was found to be very low in wheat and negative in barley.

Since the dependent variable, output, consists of output value, then the marginal productivity is equal to the value marginal productivity. However, the marginal expense of the input, i.e., land rent, is necessary. The average land rent for land under wheat is 96 Saudi Riyals per acre, for land under barley, SR 80.

Table 3-4 gives the value marginal products of land under wheat and barley and also gives marginal expense of land.

Table 3-4. Value marginal products of land under wheat and barley and marginal expense of land in Saudi Arabia, 1962/63.

	Wheat	Barley
Value marginal products of land (in Saudi Riyals)	21.4	29.2
Land Rents (in Saudi Riyals)	96.0	80.0

The value marginal product of land under barley is higher than that of land under wheat. This indicates that shifting land from wheat production to barley production would definitely increase farmers' income. Thus, farm production is below its potential maximum because resources are not correctly allocated.

However, looking again at Table 3-4, value marginal products of land, both under wheat and barley, are much less than marginal expenses of land. This suggests disequilibria and unprofitable resource-use in the agricultural sector in Saudi Arabia.

The results derived from this production function analysis confirms the studies that have been made on the relative costs and returns of wheat and barley in Saudi Arabia. The agricultural survey for Ta'if, Jedda, North, and Qaseem have reported some rough estimates of return and cost for rice, wheat and barley. A summary of these estimates is shown in Table 3-5.

Table 3-5. Average returns and cost of wheat and barley per dunum in Saudi Riyals, 1962/63.

	Estimated Production Cost	Estimated Return	Loss (-) or Profit (+)
Wheat (Qaseem)	144	104	-40
Wheat (North)	166	133	-28
Wheat (Ta'if)	159	140	-19
Wheat (Central)	235	240	+ 5
Wheat (Average)	193	154	-39
Rice (Eastern)	171	228	+57
Barley (Ta'if)*	0.85	0.68	- 0.17

*Saudi Riyals per Kjm.

Sources: (1) Ministry of Agriculture, Statistics and Agricultural Economics Paper, No. 3, March 31, 1966, pp. 17-20 (in Arabic).

(2) E. Asfour, Saudi Arabia, p. 63.

Note: For more on this table see Tables F and G in the Appendix.

3-8. More on Labor Productivity

An interesting result emerging from the present study is the marginal physical product of labor is very low in wheat production and negative in barley production -- a serious finding. Therefore, another look into labor utilization is necessary.

The data presented in Table 3-6 show total labor (family and hired) and per cent hired. Apparently, the marginal product of family labor must be positive, otherwise it would not make sense to hire outside workers. Some economists would interpret the existence of hired labor as proof, per se, that disguised unemployment is not present.[22] But as Wonnacatt argues, although it is "difficult to see why an individual employer would hire workers whose marginal product is zero," one should "open the door to the possibility of disguised unemployment by assuming that the 'typical' employer is persuaded by social and political pressures to hire his share of the labor force whether he wants to hire this number or not."[23] It should be

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[22]For example, Adam A. Pelelasis and Pon A. Yatopoulos, Surplus Labor in Greek Agriculture, 1952-60, Center of Economic Research, Research Mono, Ser. 2, Athens, 1962, pp. 33-34. Jacob Viner, Some Reflections on the Concept of Disguised Unemployment, Indian Journal of Economics, July, 1957, p. 38; and Ragnar Nurkse, Problems of Capital Formation in Underdeveloped Countries, Oxford, 1955, p. 33.

[23]Paul Wonnacatt, "Disguised and Overt Unemployment in Underdeveloped Economies," Quarterly Journal of Economics, May 1962, 76, p. 284.

recognized that for Saudi Arabia, the existence of hired labor does not mean that every farm uses hired labor.

Table 3-6. Distribution of cultivators in Saudi Arabia, 1962/63.

Item		Percentage of Total
1. Farm labor (total)	155,906	
2. Hired labor	17,138	10.9
3. Family labor	138,768	89.1
4. Land (total) in acres	600,030	
5. Owned	552,028	92.0
6. Rented	48,002	8.0
7. Land per Capita (4 ÷ 1)	3.8	
8. Landless cultivation (6 ÷ 7)	12,632	8.1
9. Land-owner cultivators (1-8)	143,274	91.9

Sources: Calculated from George S. Medawar, A Report to the Ministry of Agriculture on Agriculture in Saudi Arabia, Ryadh, January 1965 (Unpublished Report) and the Saudi Arabian Statistical Year Books, 1967.

In most underdeveloped countries, the term "normal working hours" is very difficult to define precisely. However, for this study a certain number of work-hours during one man-year is assumed. As previously discussed, 300 days a year and 8 hours a day have been assumed for this analysis, i. e., 2, 400 is the number of hours available per man-year. One more assumption, however, should be made, i. e., the average number of hours required per cropped acre per year. This would be assumed to be 500 hours per acre.[24]

Before the unutilized farm labor is estimated, the reader is reminded that the analysis now deals with all agriculture and not only for wheat and barley as previously discussed.

In Table 3-7, unutilized farm labor is estimated to be 32, 584 workers. This estimate indicates too much labor is used relative to land in the existing input-input relationship in Saudi Arabia. The estimate confirms results reached from the production functions analysis and the conclusion, zero marginal productivity of labor exists in the Saudi Arabian agricultural sector.[25]

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[24] The 500 hours is taken arbitrarily. However, some area studies on cropping pattern, intensities, and other relevant factors in East and West Pakistan showed that one acre requires 600 hours and 300 hours in East and West Pakistan, resectively. Since irrigated areas in Saudi Arabia (percentage-wise) is much higher than in East Pakistan and lower than that in West Pakistan, the 500 hours is assumed.

[25] Actually one should consider also, the average number of hours required per livestock unit per year and add them to the number of hours of actual working per worker. But the total farm labor force that is considered here is only males of working age and, in fact, women also work on the farm. So we consider the number of hours available per woman-year is equivalent to the average number of hours required per livestock unit per year.

Table 3-7. Estimating unutilized labor in Saudi Arabia, 1962/63.

1.	Total cropped area in acres	600,030
2.	Total farm labor force	155,906
3.	Cropped area per labor (1 ÷ 2)	3.8
4.	Number of hours available per man-year	2,400
5.	Average number of hours required per cropped acre per year	500
6.	Number of hours of actual working per worker (3 x 5)	1,900
7.	Percentage of actual work to available hours per man-year (6:4)	79.1%
8.	Percentage of unutilized hours per man-year (100 - 79.1)	20.9%
9.	Total available hours (2 x 4)	374,174,400
10.	Total unutilized hours (9 x 8)	78,202,450
11.	Unutilized laborers (10 ÷ 4)	32,584

Sources: Table 3-2 and this text.

Note: The idea is taken from M. H. Khan, The Role of Agriculture in Economic Development: A Case Study of Pakistan, Center for Agricultural Publication and Documentation, Wagening 1966.

3-9. Conclusion

Clearly, the substantial differences between value marginal products, marginal cost of land and negative marginal physical product of labor in the agricultural sector suggest disequilibria. Better utilization of labor and land, therefore, could increase production and efficiency. In other words, farmers are inefficient and production from the existing set of resources can be increased through production economics studies and educational programs. Moreover, availability of labor in agriculture is much more than the amount of labor required in the agricultural sector. A way is needed to increase labor requirements or to decrease labor availability. There are two problems: farmers must be helped to recognize and remove disequilibria through marketing information, eliminating risk and uncertainty, making production more profitable, etc.; and on the other hand, the gap between labor availability and labor requirements must be eliminated.

In general, production economics studies and educational programs would aid in solving both problems, i.e., they increase efficiency, make production more profitable, and increase labor requirements per acre of land. Saudi Arabia's unique situation, i.e., under-utilization of resources and the existence of too much unoccupied labor, demands more than production economics studies and educational programs. That is to say, altering the unfavorable land--labor ratio existing in the agricultural sector. This is the point of departure for the next chapter.

Chapter 4

SOLUTION TO THE INPUT-INPUT RELATIONSHIPS

In the previous chapter it was seen that there are 32,584 unoccupied laborers in the agricultural sector. Why?--a very low land-labor ratio, namely 3.8 acres per laborer. In other words, the labor availability exceeds labor requirements. Thus, any program for agricultural development has to find a way to change this unfavorable ratio.

There are two ways to change the land-labor ratio: one is transfer labor from the agricultural sector to any other sector of the economy, i.e., transfer the 32,584 unoccupied or underemployed laborers to say, the industrial sector. The second solution is increase land and thereby the land-labor ratio. Either solution would aid the problem of unoccupied labor.

To choose either solution, one has to look into the unique characteristics of the country. In Johnston's terminology, "A critical dimension of an efficient strategy of agricultural development is to generate new production possibilities characterized by much more favorable input-output relationships than those obtainable with existing techologies."[26] Here the applicability of the first solution, which is here called the "labor squeeze" solution, is investigated and the feasibility of the second is tackled, i. e., the expansion of land; the extensive cultivation solution.

4-1. The "Labor Squeeze" Solution

We have seen from the production functions analysis that the agricultural sector has some negative marginal productivity of labor. Because of the non-significance of the correlation between labor and output and the biased output elasticities, the number of laborers that are unoccupied were estimated. The estimate in Table (3-8) indicates only the total volume (as a percentage of the total hours per man-year available) of the unutilized labor force (unoccupied labor force), citerius paribus given the norms. These data do not really show the proportion of under-employed workers over the year. No exact conclusion can be drawn about the existence of surplus labor either in seasonal or in permanent form. Even if there is some zero marginal productivity of labor, as is the case in the Saudi agricultural sector, it would not by any means indicate that a surplus of labor exists. Desai and Mozumdar showed that surplus labor exists only if the supply of labor (measured on labor hours) is assumed to be

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[26] Kaczushi Ohkawa, et. al. (ed.), Agriculture and Economic Growth: Japan's Experience, University of Tokyo Press, 1969, p. 86.

horizontal.[27] A zero marginal product of labor is neither a necessary nor a sufficient condition for the existence of surplus labor. The phenomena of horizontal labor supply, regardless of the value of marginal productivity of labor, exists if, and only if "leisure" is an inferior good. That is to say, the "inferiority of leisure" is a necessary and sufficient condition for the existence of surplus labor.[28] It is debatable whether the "inferiority of leisure" phenomenon exists among Saudi farmers. Transferring the 32, 584 unoccupied labor with families from agriculture to other sectors is not an easy task. Socio-cultural barriers to occupational and geographical mobility are more pronounced in Saudi Arabia. Any attempt to transfer the unoccupied laborers from agriculture will have to be accompanied by some structural changes. The structural changes will have to be supplemented by institutional changes before the released surplus is available for the labor market. These changes require energy and over all organization throughout the economy. Furthermore, before these laborers are transferred, one has to be sure the other sectors have employment opportunities for them. It is doubtful that these opportunities will come from private business. Therefore, the public sector might

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[27] M. Desai and D. Mozumdar, "A Test of the Hypothesis of Disguised Unemployment," Economica, Vol. XXXVII, 145, 1970, p. 41.

[28] A. L. Berry and R. Saligo, "Rural-Urban Migration, Agricultural Output, and the Supply of Labor in a Labor-Surplus Economy," Oxford Economic Papers, Vol. 20, July 1968, No. 2, pp. 230-249.

be the only solution. The government, however, now tied-up in a huge nomad settlement project, is in no position to help transfer farmers to other sectors. Thus, the "labor squeeze" solution is ruled out; it is not useful for Saudi Arabia. In other words, this solution cannot be used to change the land-labor ratio. Another solution must be found.

4-2. The Land Expansion Solution

The cultivated land in Saudi Arabia is only 30 per cent of the total cultivable land; over twice as many hectare of land are potentially cultivable but have not been cultivated. Land, therefore, is in abundance. But in Warriner's terminology, " . . . land without water is a meaningless abstraction."[29] That is to say, land expansion depends on the potential increase in water resources and on the cost of bringing them into use. This necessitates a look into the country's water resources and its potential use.

A - Water Resources. In a country where there are no rivers and where rainfall does not generally exceed four inches a year, there should be a lack of water. There are, however, favorable conditions for the development of ground water. Vast aquifers -- water-bearing formations -- underlie many sections of the country. Aquifers

[29]Doreen Warriner, "Employment and Income Aspects of Recent Agrarian Reforms in the Middle East," International Laborer Review, Vol. 101. No. 6, June 1970, p. 606.

are mainly sandstone formations (but there are also limestone formations) separated by water barriers or acquicludes which are shales and marls.[30]

It is not known how much of Saudi Arabia's ground water originated from the "fossil" period, or from current infiltration. However, it is a fact that the "Wasia Acquifer," which lies under a large area of northeastern Saudi Arabia, contains more water than there is in the Arabian Gulf. Some thirty trillion barrels of this water is believed to be suitable for household use. In an area some thirty miles square east of Riyad, there are about one trillion barrels of potable water at depths between one and two thousand feet.[31] Moreover, in the southwest Wadi Jizan area, an acquifer estimated to contain nearly 8 million cubic meters per year could be drawn from by continuous operation without depleting the underground storage (provided no great change occurred in recharging).[32]

It is, however, unfortuante thaere is a downdip movement which brings the largest concetration of water into the east, along the coast. Solution of soluble mineral salts in the acquifers causes the

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[30] H. E. Hassan Mishari, "Toward Full Water Uitlization in Saudi Arabia," in the Water for Peace, International Conference on Water for Peace. May 23-31, 1967, Vol. 2, p. 833.

[31] Arabian American Oil Company, Aramco Handbook; Oil and the Middle East, Dhahran, 1968, p. 187.

[32] FAO, Land and Water Surveys in the Wadi Jizan, Kingdom of Saudi Arabia, Rome 1966, p. 19.

groundwater to become less useable. It mixes with the "fossil" water contaminated by oil field brines and mingles with seawater as the coast approaches.[33]

Saudi Arabia's large quantities of groundwater, if utilized, would bring more land under cultivation. Thus, labor requirement in the agricultural sector would be increased. The critical question is whether the incremental increase in value of production is greater than the incremental cost of bringing water resources into use. It is doubtful that water resources will be brought into agricultural use. The Saudi Arabian Minister of Agriculture and water is quoted as saying: "Development is first for domestic purposes, second for industrial use, and finally for the irrigation and agricultural development of as large an area as is possible within the limits of water resources."[34] This is not a strange statement for a country where in recent years many regions suffered from declining water levels. In fact, Jiddah (on the Red Sea) was expected to outgrow its existing water supply by 1968. Moreover to the point, Saudi farmers are in no position to develop water resources for their use. The costs of digging thousands of feet and purifying water for use in agriculture is great and unbearable for farmers. Even if farmers could do it, it is still expensive. Clark, talking about Kuwait and Middle East water

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[33]Mishari, op. cit., p. 833.

[34]Mishari, op. cit., p. 832.

desalination cost per cubic metre, says, ". . . such water, however, would still be beyond the reach of agriculturalists."[35]

B - Components of Land. Limited water supply blocks cultivated land expansion. Therefore, the extensive solution to the Saudi Arabian agricultural sector is not feasible. However, farm land has two components, a natural endowment component and a capital structure component. The latter is a consequence of past investments. Most of the time, people refer to land as its natural endowment. "But it is for the most part an empty concept because so many of the differences in the productivity of farm are man-made. . . . In addition, production of factors that substitute for land is of increasing importance."[36]

4-3. The Intensive Cultivation

Land is given and capital is divided into two parts -- those which replace labor (i. e., tractors) and those which replace land (i. e., fertilizers). This division is not "watertight" and in some cases a capital good increasing daily labor-productivity may also raise productivity of land. This study makes these assumptions: investment

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[35] Colin Clark, The Economics of Irrigation, Pergamon Press Ltd., 1967, p. 88.

[36] Schultz, op. cit., p. 17.

on land-productivity-increasing (to be called DPI) has nothing to do with labor productivity.

Labor productivity will only be affected by those investments on labor-productivity-increasing (to be called LPI). One more assumption is labor requirements per unit of area will be affected by investment on DPI. That is to say, the more intensive techniques are used; more labor required per acre. For example, using more fertilizer requires more irrigation, and investment on land might lead to more double cropping.

In Figure 2, there are four axes: East, measuring labor (hours); North, output; West, investment; and South, investment on LPI. The curve AA reflects the relationship between output and investment in DPI. The shape of this curve exhibits diminishing returns though the marginal product need not necessarily become zero. In fact IA is positive output with zero investment on DPI. The curve LL gives the alternative combination of labor and LPI.

Let OI represent the total amount of investment that can be made in a year and OL_n is the labor supply that is to be used. Suppose that II_1 is spent on DPI, then OI_1 will be spent on LPI. Now draw a 45 degree line in the southwest corner and drop a perpendicular from I_1 to intersect the 45 degree line. This represents the amount left over for LPI after spending II_1 on DPI (i. e., it is OV). Now drop two perpendiculars, one from V to intersect LL at f and

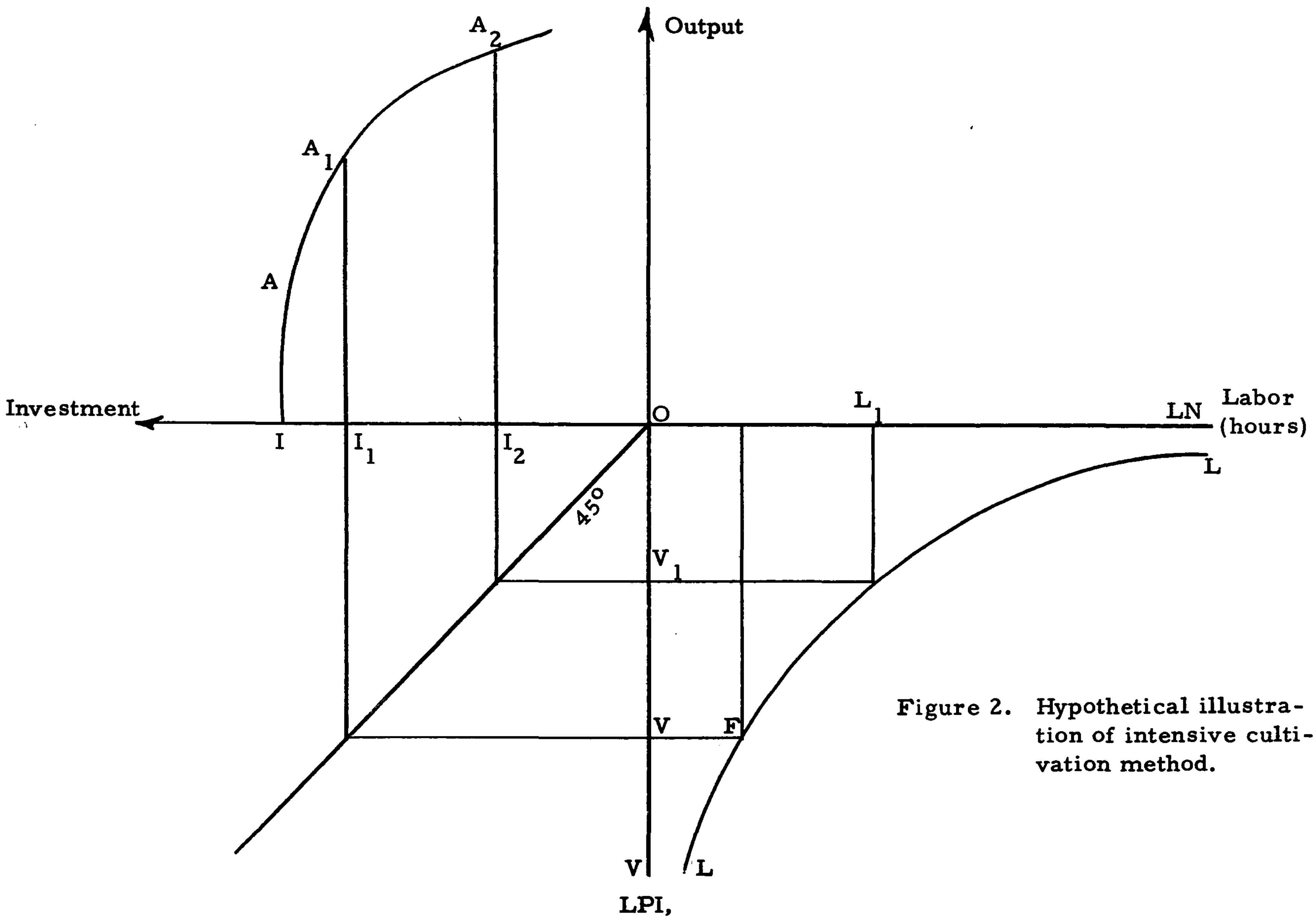

Figure 2. Hypothetical illustration of intensive cultivation method.

one from f to intersect the labor axes at L_1. OL_1 is the amount of labor that will be used and L_1L_n is the unoccupied labor.

Now suppose we have the same amount of investment namely OI, that can be made in a year. But suppose that investment on DPI became II_2 and, hence, OV_1 on LPI. In other words, better seeds, more fertilizer, and better irrigation facilities are used more than before. As a result, outpu would increase from I_1A_1 to I_2A_2. Moreover, since more and better intensive cultivation methods are used, all labor supply will be used up with the same amount of investment. With respect to Saudi Arabia, investing more on DPI will improve the capital structure component of land. This, in turn, required more labor and the unutilized or underutilized labor that exists in the Saudi agricultural sector will be utilized (i. e., the 32,584 unoccupied or underemployed workers would be utilized).

Figure 2 reflects the importance of continuous capital investment required for intensification methods. Amount of investment depends, however, largely on the production functions of various agricultural products. Once these are known, the total amount of capital that should be allocated to the agricultural sector would be reached. This means additional or total output should be taken as datum.

Scarcity of water and, in turn, scarcity of land, dictate the solution for unoccupied labor in the agricultural sector. "Intensification" seems to be the feasible solution and the estimation of substitution between land and technology is, therefore, essential. . . . The marginal productivity of fertilizer and the marginal rate of substitution of fertilizer for land is investigated in the next chapter.

Chapter 5

CONTRIBUTION OF CAPITAL TO PRODUCTION

The objective of this chapter is to estimate the maximum and optimum level of fertilizer. Estimated marginal productivity of fertilizer and the marginal rate of substitution of fertilizer for land will be derived to arrive at a value for both capital's contribution and vertical expansion's contribution to the Saudi agricultural sectors.

5-1. Framework

Use of the following polynomial function of the quadratic form permits an increase or decrease in the marginal physical product. It can be stated as

$$Y = b + b_1 F - b_2 F^2 \qquad (5\text{-}1)$$

where Y is yield per acre, b, b_1 and b_2 are the coefficients, and F is the fertilizer input.

Given the function, various economic principles and relationships can be specified.

(1) Determine the maximum rate of fertilization by equating marginal physical productivity to zero and solve for the maximum fertilizer level.

$$\frac{\partial Y}{\partial F} = b_1 - 2b_2 F = 0 \qquad (5\text{-}2)$$

Thus:

$$F = \frac{1}{2}\left(\frac{b_1}{b_2}\right)$$

where F indicates maximum level of fertilization.

(2) Determine the optimum rate of fertilization specified by equating the marginal physical productivity of fertilizer to the fertilizer-output price ratio, then solve for the optimum fertilizer level.

$$\frac{\partial Y}{\partial F} = b_1 - 2b_2 F = \frac{P_F}{P_Y} \qquad (5\text{-}4)$$

where P_F and P_Y are the prices of fertilizer and output respectively.

The optimum level of fertilizer ($\bar{F}$) is, therefore,

$$\bar{F} = \frac{P_y b_1 - P_F}{2P_Y b_2} \qquad (5\text{-}5)$$

(3) Heady[37] suggested that by multiplying the production function in equation 5-1 by land (i. e., to be called A) and dividing the F magnitude by A in the derived equation, a land-fertilizer production function is achieved.

$$Y = bA + b_1 F - b_2 F^2 A^{-1} \qquad (5\text{-}6)$$

(4) From equation (5-6) the marginal rates of substitution between fertilizer and land can be attained.

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[37]E. O. Heady, Marginal Rates of Substitution Between Technology, Land and Labor, Journal of Farm Economics, Vol. 45, 1963, pp. 137-145.

$$\text{MRS of F for A} = \frac{A}{F} = \frac{2b_2FA^{-1} - b}{b + b_2F^2A^{-2}} \qquad (5\text{-}7)$$

5-2. The Data

It is disheartening that no detailed studies have been made on fertilizer application in Saudi Arabia. However, the total amount of fertilizer used in the whole country is available. The assumption is made: equal fertilizer to each hectare of land. The fertilizer used for wheat production is given in Table 5-1. The yield per hectare is taken from Appendix Table A.

5-3. The Result

The production function showing the response of wheat to fertilizer is represented in the following equation:

$$Y = 20.9 + 155.6\,F - 5.16\,F^2 \qquad (5\text{-}8)$$

taking the first derivative of the equation gives the marginal physical product (MMP_F). MMP_F is the increase in total product due to adding one unit of fertilizer. So

$$MMP_F = 155.6 - 10.32\,F$$

equating MMP_F with zero and solving for F gives the amount of fertilizer necessary to maximize total product from one hectare of wheat

$$F = \frac{155.6}{10.32} = 15.1$$

the 15. 1 kilograms of fertilizer represents the amount that must be added to one hectare of wheat to maximize total product.

Table 5-1. Fertilizer used for wheat production in Saudi Arabia (1954-1963).

Year	Commercial	Natural	Total in tons
1954	171	54	225
1955	299	86	385
1956	526	147	673
1957	350	94	444
1958	513	133	646
1959	825	206	1031
1960	665	159	824
1961	741	177	918
1962	816	187	1003
1963	1072	214	1286

Note: Natural fertilizer is 20 per cent of the commercial in 1963. For the remaining years the percentage of natural to commercial is increased by 1 per cent per year, i.e., natural to commercial become 30 per cent in 1954.

Source: Medawar, op. cit., pp. 27-28.

In order to test whether total product would be maximized by adding 15. 1 kilograms of fertilizer, one has to find the second derivative, (i. e., for the sufficient condition for maximization) and see whether it is negative or positive. If the second derivative is negative, total product is maximum; if positive, then total product is minimum. In this case the second derivative is negative and equal to -10.32, so by adding 15.1 kilograms of fertilizer total product is maximum.

The relevant question, however, is what quantity of fertilizer is needed to maximize farmer's income per hectare of wheat, not what will maximize total product per hectare. In order to determine the quantity of fertilizer that maximizes the farmer's profit per hectare of wheat, the farmer must use varying amounts of fertilizer until the value of marginal product (i.e., MMP_F X price of wheat) equals the marginal input cost (the amount added to total cost due to the purchase of the last unit of fertilizer). In this case, the price of fertilizer is constant and does not change with the change in quantity.

As the price of one kilogram of fertilizer is 7 Qurshs, the price of wheat is 10 Qurshs per kilogram in 1962. Then, using equation (5-4) and equating value marginal product and marginal expense of input gives

$$\bar{F} = \frac{154.9}{10.32} = 15.0$$

So, 15.0 kilograms of fertilizer must be applied to one hectare of wheat in order to maximize farmer's income (i.e., 15.0 kilogram of fertilizer is the optimum level of fertilizer). This means less fertilizer is needed to maximize farmer's income, but more fertilizer is needed to maximize total output--the goal of this study. Thus, more fertilizer should be used than is used at present. However, the difference between maximum and optimum level is not great, about .07 per cent. In fact, though, not all farmers use fertilizer. Literacy and fertilizer uses are highly correlated.[38] Since illiteracy among Saudi farmers is so high, the rate of illiteracy in Saudi Arabia is not known, but it is believed to be very high, one would expect that most cultivated land has never been fertilized. If the rate of illiteracy is assumed to be about 80 per cent and if the same percentage indicates the fertilizer use in Saudi Arabia, then one would expect 80 percent of the cultivated land has never been fertilized. This means available fertilizer has been applied on only 20 per cent of the total cultivated land. Using this assumption the equation follows:

$$Y = 189.63 + 38.969F - .362F^2 \qquad (5\text{-}10)$$

Again we find the optimum is less than the maximum, i.e., 52.8 and 53.6 kilograms of fertilizers. In other words, more fertilizers should be used to maximize total output (Table 5-2).

If the above derived equations are used to estimate marginal rate of substitution of fertilizer for land, fertilizer contribution is overestimated, as is the marginal rate of substitution of fertilizer for land. The constant term in these two functions (i.e., equation no. 5-7 and 5-10) provides an idea about soil fertility and the weather

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[38] The relationship was found to be significant in Pakistan. See B. A. Quirishi and M. J. Khan. Economics of Fertilizer Application to Wheat Crop. The Pakistan Development Review. Vol. X., Spring 1970, pp. 89-99.

effect in each function. If no fertilizer is used, a production of 20.9 kilograms of wheat (according to equation 5-9) can be produced. However, when equation (5-10) is investigated, 5 kilograms of fertilizer substitutes for almost one hectare (2.47 acres) of land (based on the idea no fertilizer and 1.5 hectare yields 284.4 kilograms of wheat). About 285.7 kilograms of wheat will be produced with a combination, one half a hectare and 5 kilograms of fertilizer. Using this combination, the marginal rate of substitution of fertilizer for land is 0.3. For production of the same output (i.e., 285.1 kilograms of wheat), use a resource combination of 0.34 hectare of land with 6 kilograms of fertilizer. One kilogram of fertilizer substitutes for 0.16 of one hectare, i.e., 6 kilograms of fertilizer substitute 0.8 of a hectare. In this combination, the marginal rate of substitution of fertilizer for land is 0.13 (Table 5-3). Where higher rates of fertilizer are applied, there is an indication fertilizer substitutes for less land, and the marginal rate of substitution tends to be smaller.

The above analysis shows the importance of fertilizer (as a form of capital) and land, and the benefits of using fertilizer. However, the result of the above study should be considered with a considerable degree of caution. Because of the potential importance of fertilizer to Saudi Arabia's agricultural development, it is interesting to use some detailed studies from some neighboring countries to find out

Table 5-2. Minimum, maximum, and optimum output and maximum and optimum fertilizer use in Saudi Arabia.

No. of Equation	Y^a	$\overline{Y}^b$	$\overset{*}{Y}^c$	$\overline{F}^d$	$\overset{*}{F}^e$
5-8	20.9	1148	1128	15.1	15.0
5-10	189.6	1134	1131	53.6	52.8

[a]Y = minimum output, Y when F = 0

[b]$\overline{Y}$ = maximum output, Y where $\frac{\partial Y}{\partial F} = 0$

[c]$\overset{*}{Y}$ = optimum output, Y where $\frac{\partial Y}{\partial F} = \frac{P_F}{P_Y}$

[d]$\overline{F}$ = maximum level of F

[e]$\overset{*}{F}$ = optimum level of F

Sources: Equations 5-8 and 5-10

Table 5-3. Substitution between fertilizer and land using equations 5-10 and 5-12.

Equation	Output	Combination of Inputs		Substitution of F for L
5-10	284.4	F = 0	L = 1.5	1 F:0.2 L
	285.7	F = 5	L = 0.5	1 F:0.3 L
	285.1	F = 6	L = 0.34	1 F = 0.13 L
5-12	1040	F = 0	L = 0.61	1 F = 0.007 L
	1019	F = 10	L - 0.56	1 F = 0.0069 L

Sources: Equations 5-10 and 5-12

how much the above deviates from results obtained from other production functions. Two wheat production functions from the United Arab Republic are used.[39] The two functions are:

$$Y = 3.339 + .0191F - .000029F^2 \quad (5\text{-}11)$$

$$Y = 5.009 + .054969F - .000031221F^2 \quad (5\text{-}12)$$

The two functions are transformed into land -- fertilizer production functions (as in equation 5-6). When equation 5-11 is investigated, the maximum fertilizer is 329.3 kilograms of fertilizer (sodium nitrate), and the optimum level of fertilizer is 216.5 kilograms. Equation (5-12) suggests 88 pounds of fertilizer as maximum, and 40.0 pounds of fertilizer as optimum level. The difference between the maximum and the optimum level of fertilizer in both equations is great. If the U. A. R. wheat functions represent Saudi Arabia wheat function, then, each hectare under wheat production in Saudi Arabia needs about 300 kilograms more fertilizer.

Investigation of equation (5-12) indicates that one ton of nitrogen fertilizer substitutes for 22.6 acres of land, when no fertilizer and 1.52 acres are combined to produce 7.43 ardab of wheat (one ardab - 140 kilograms). The same ton of nitrogen replaces 20.6

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[39] M. A. Zaki, "economic Development in U. A. R. (Egypt) and the Role of the Agricultural Sector," Unpublished Ph. D. dissertation, The Ohio State University, 1965, and F. K. Bishay, Marginal Rates of Substitution Between Land, Labor, and Fertilizer in Relation to the Optimum Planning of Resource Combinations, Unpublished Ph. D. dissertation, Iowa State University, 1965.

acres of land combining 10 pounds of fertilizer and 1.39 acres to produce 7.28 ardab of wheat.

Equation (5-12) suggests that 100 kilograms of fertilizer substitutes for 0.8 hectare. This is a lower ratio than the one derived from the Saudi function. According to equation 5-10, 5 kilograms of fertilizer substitutes for 0.8 hectare. However, the above results show fertilizer plays an important role as a substitute for land in Saudi Arabia.

5-4. Farmers and Fertilizer Use

From the foregoing analysis, the role of fertilizer as a factor substitute for land was investigated. The treatments recommend more fertilizer use. However, a major question arises here: how to get farmers to use fertilizer? Although, the answer of such a vital question is beyond the scope of this study, a hint toward the answer might be useful.

Saudi farmers and government face several problems. Three major factors influence the use of fertilizers by cultivators, namely: (1) the distribution of fertilizers, (2) a cost consideration and credit facilities, and (3) the lack of adequate knowledge of the amount of each fertilizer, or a combination of more than one, needed for a particular crop and method of application. From the government point of view, the problem includes: (1) the expansion of extension services to demonstrate fertilizer application in the fields, (2) the need to organize research, and (3) the distribution of cheap and most appropriate fertilizers.

It is the opinion of this writer, the Ministry of Agriculture should gradually take over the entire work of distributing fertilizer and seeds, and do it in co-operation with private enterprise. Moreover, soil studies and detailed along with semi-detailed maps must be made. Further, realizing 80 per cent of the fertilizer used in the country is imported, and therefore expensive; the government should consider subsidizing fertilizer.

Chapter 6

REMOVAL OF DISEQUILIBRIA

The previous chapter indicates land investment holds considerable importance in Saudi Arabia. Moreover, as seen in Chapter 3, production from existing resources can be increased if farmers are helped to recognize and remove disequilibria. In other words, production economics studies and educational programs have potential in the Saudi Agricultural sector, i.e., oriented production economics research is needed in Saudi Arabia.

Stated simply, policy oriented production econimics research in a developing country is concerned with discovering (in sequence): (1) what decisions farmers make, (2) why farmers make decisions as they do, and (3) what must be changed in the environment to make it profitable for farmers to make decisions to increase production.[40]

In general, the decisions farmers make can be seen from their response to incentives. If farmers are receptive, then there is no need to study the second point, namely, why farmers make decisions as they do. However, if farmers are not receptive, then one could

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[40] John W. Mellor, "Production Economics and the Modernization of Traditional Agricultures," The Australian Journal of Agricultural Economics, Vol. 13, June 1969, No. 1, p. 23.

conclude the decisions they make are not normal and one has to find out why. The normality of farmers' decisions is observed in their physical response to innovations.

6-1. Responses to Innovations

Saudi farmers have, on occasion, demonstrated considerable receptivity to innovations. Lettuce, a new vegetable, caught on quickly as soon as its profitability was established. In fact, some of the foods now produced in Saudi Arabia were unknown some time ago.

The receptivity has not been confined to the introduction of new crops. In 1950, farmers responded quickly to opportunities increasing productivity through the use of chemical products and mechanical devices. The mechanization of the water-lifting installations on irrigation wells, a scheme launched by the Ministry of Agriculture, ". . . quickly became popular and after a few years power-operated water-pumping installations had taken over the country to such an extent that an animal-operated well became a curiosity."[41] Moreover, "The installations are remarkably well maintained by the users, which shows their appreciation of the improvement."[42]

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[41] H. Hablutzel, Final Report to the Government of Saudi Arabia on Farm Mechanization Problems and Services, Unpublished F A O Report No. 1611, SAV/TE/LA, Rome, 1963, p. 9.

[42] Hablutzel, op. cit. p. 9.

On the other hand, many examples exist of abortive attempts by the government to promote the use of modern power farm equipment. Attempts to improve the efficiency of the Farm Machinery Hire Service have met with little success, and most farmers still struggle with traditional tools and implements -- mostly rather primitive and inefficient.

Responses to innovations, then, is curiously mixed, and it is difficult to understand why. Part of the explanation is the numberous small holdings accounting for 85 per cent of the country's farm total.[43] These small farms rarely can use power farm machinery the government offers for hire. This does not offer an obvious reason for the non-response to innovation, though. Small farmers can use small tools, i.e., "garden tool" type of machinery. The obvious reason for innovation irresponsive must be in the explanation of lower investment in the agricultural sector.

In general, two lines of reasoning develop. One claims[44] the existence of tenacy systems where rewards from improvements

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[43] There are more than 100,000 agricultural holdings -- a land holding is defined by the Ministry of Agriculture as a farming unit comprising one or more parcels of land, regardless of location, managed by one or more persons -- in the entire country of which 50 per cent are less than 1.5 hectares each and about 85 per cent less than 4 hectares each; only 4 per cent of the holdings have a size of 25 hectares or more.

[44] For example, William Zartman, "Farming and Land Ownership in Morroco," Land Economics XXXIX, Feb., 1963, pp. 187-198.

accrue not to the cultivator, but to the landlord. This alleged restraint hinges on the insecurity of expectations. The second line of reasoning, advocated by Schultz, claims investment is low because "the price of sources of income streams from agricultural production is relatively high in traditional agriculture,"[45] or "the rate of return to capital is low in traditional agriculture."[46] In other words, the "high" cost of adding to the income stream accounts for the lack of noticeable improvement activities. This reflects a constancy of the "state of the art." In following sections, these two hypotheses are discussed.

A - Tenancy System. Saudi Arabia has relatively limited tenancy. The 1960-1963 Agricultural Survey reports 92 per cent of the cultivated area was owner-operated, a per cent relatively high compared with developing countries. Tenancy is limited, according to Islamic tradition, because each farmer or potential farmer is entitled to as much as he and his family can cultivate. A temporary permit, allowing cultivation but not sale, could be obtained through registration with a municipal government agency and the initiation of cultivation. After some time permanent title is established and the land becomes a farm.

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[45] Schultz, op. cit., p. 84.

[46] Schultz, op. cit., p. 84.

Through the Saudi Arabian tenure system, 92 per cent of land is cultivated without rental obligations by the owner. This suggests individual farmer investing in agricultural projects are not deterred by insecurity of land tenure right. It also indicates farmers in Saudi Arabia may be relatively responsive to economic incentives since operators receive any benefits resulting from their efforts.

B - Cost and Return. Although no detailed studies have been made on the relative costs and returns of various agricultural crops, there is evidence of farmer net loss. The agricultural surveys for Ta'if, Jedda, North, and Qaseem report some rough estimates of return and cost for rice, wheat, and barley. Net losses to farmers, as shown in Table 3-5, explain why farmer investment in innovations is low. Any response to innovation might increase the risk of more loss. That is to say, farmers resist new, unknown innovations because existing net return is not encouraging and no possibilities of raising income exists without increasing risk of more loss.

High production costs per se, are not the reasons for net losses, but "innefficiency" in the agricultural sector is. Efficiency and willingness to innovate are influenced by the nature of competition in the market (the type of competition prevailing in a market as related to its structure). Hence, efficiency is influenced by market structural variables.

Market structural variables[47] include the number and size of buyers and sellers operating within the relevant markets, the extent to which firms sell identical or differentiated products, the height of barriers to entry of firms, and the extent of vertical integration. The structural hypotheses follow:

The less number of firms in the market, the less difficult it becomes for sellers to communicate, and the more interdependence of price among them. The more even the size distribution of firms in a market, the more difficult it is for any one firms to dominate the market or be a "price leader." The harder it is for a new firm to enter a market, the more likely it is firms in the market will earn more than "normal profit." Thus, the more firms with more even distribution size, the easier it becomes for new firms to enter a market; the market becomes more competitive.

On the other hand, the more competitive the market, the better the performance of that market. Hence, imperfect competition leads to "bad" performance. Therefore, it is socially undesirable and should be eliminated.

6-2. Number and Size of Farms

There are more than 87 thousand agricultural units in the entire country; 49.9 per cent are less than 1.3 hectare each, about 82.2

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[47] John R. Moore and Richard G. Walsh, Market Structure of the Agricultural Industries, Iowa State University Press, Ames, Iowa, 1966, p. XV.

per cent less than 5 hectare each, and only 4 per cent have a size of 25 hectare or more (Table 6-1).

Table 6-1. Size and number of holdings in Saudi Arabia, 1962/63.

Size of hectare	No. of holdings	Percentage of total	Accumulative
0.0 - 1.3	43444	49.9	49.9
1.3 - 2.5	17236	19.7	69.6
2.5 - 3.8	7515	8.7	78.3
3.8 - 5.0	3479	3.9	82.2
5.0 - 10.0	6372	7.4	89.6
10.0 - 15.0	2752	3.2	92.8
15.0 - 20.0	1542	1.8	94.6
20.0 - 25.0	1261	1.4	96.0
25.0 & over	3510	4.0	100.0
Total	87111		

This indicates that relatively small and medium size holdings form the largest agricultural group in Saudi Arabia. This means there are large numbers of farms in the agricultural sector and, in turn, a competitive market in the sector is expected. As seen in Chapter 3, though, farmers are not efficient and disequilibria exists in the agricultural sector, a factor not extent if the market is a competitive one. The explanation lies on the other side of the coin. Saudi Arabia imports most of its food and the "imported food" market must be considered as part of the agricultural market.

Imported food supplies reach the country through Jiddah, Dammam, Riyad and Mecca merchants. Most of these houses are vertically integrated. Besides importing, they also operate wholesale and retail establishments in the city, where headquarters are located, as well as in other towns throughout the country. The importer merchant competes with his independent retailer customer who receives merchandise from the importer's wholesale store. In some cases, import merchants confine their distributing activities to headquarter's city, then seek some representative house in other towns.

As a whole, the degree of import trade concentration is very high. One firm, for example, is the only fruit importer in Saudi Arabia. Not more than five firms import wheat, and not more than ten firms import any kind of food product. This means it is less difficult for sellers to communicate, therefore possibly more interdependence of price among them.

Before the effect of concentration is discussed, one should look into the reasons for small units within the agricultural sector. These reasons could be considered as "barriers to entry" into farming. The net loss of Saudi Farmers is, in fact, a "barrier to entry." There are, however, additional factors making it hard to enter farming. Large number of farms and "inefficiency" of agriculture, leads to "barriers to efficiency" rather than "barriers to entry."

6-3. Barriers to Efficiency

Barriers to efficiency indicate those variable influencing outcome or results of the agricultural sector. Many factors could be included here, but this analysis will deal only with more important factors.

A - Water Problem. Agricultural water in Saudi Arabia is almost entirely produced from sub-surface sources. Water is a private enterprise; each farmer has a well he draws water from for use on his own farm. The high cost of digging puts farmers in a bad position. They are not able to dig deep enough and when pumping commences, water starts to decline. Irrigation stops even before the land gets enough water.

Moreover, after harvest, the land is usually left untouched until the following planting season. The high degree of evaporation causes the fine soil to dry out quickly, harden -- and become difficult to plow. Labor and capital requirements are extremely high because plowing leaves the land in rough condition, unsuitable for planting. The clods must be broken down in an additional, costly operation. Of course land productivity is expected to be low.

To lower the cost of production and raise productivity of land, land should be irrigated before it is plowed. This saves power, reduces damage to equipment, and helps to speed up tillage operations. At the same time it saves the farmer a lot of money. What farmers need is some kind of "demonstration on the farm." This would help farmers recognize and remove disequilibria, as seen in Chapter 3, existing in the agricultural sector.

B - Plant Diseases and Pests. Since the creation of the Agricultural Bank in 1964,[48] no annual report has come out without mentioning some crops were infested by pests or plant diseases such as Nematode (the snake worm). What is even more distressing is the incidence of plant disease is not restricted to crops standing in fields. Many diseases are carried through the seasons and damaged grain is stored.

Farmers in Saudi Arabia neither have the knowledge to detect disease, nor the means to prevent them. When farmers discover diseases and inform the Ministry of Agriculture, the " . . . pest control services failed to cover all regions in the right time."[49]

C - Lack of Capital Supply. The finance system in Saudi Arabia is unique; remember, the Islamic laws occupy a prominent place in Saudi Arabia and prohibit charging interest. However, banks illegally charge very high interest rates -- sometimes reaching 50-100 per cent.

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[48]Kingdom of Saudi Arabia, Saudi Arabian Agricultural Bank, annual reports, 1965/65 - 1968/69.

[49]Saudi Arabian Agrilutural Bank, annual report, 1966/67, p. 5.

In 1964, the government recognized this problem and the Saudi Agricultural Bank was created. It has become the principal, if not the only, source of agricultural credit for Saudi farmers.

Bank capital comes from government sources. So far, credit has been increasing modestly. The amount of money available to the bank is not sufficient.

The government will not allocate more money to the bank because the bank fails to loan money or eliminate all uncollected debts from its accounts. The bank has a very large (but unuseable) loan "portfolio." These, of course, prevent the bank from clearly justifying its needs for additional capital.

Moreover, the Saudi farmers are not aware of the idea of banking. Most farmers, especially in villages where there is no branch of the bank or any affiliated agency, have not heard of the bank and if some of them do, they do not think the bank is for them. They believe the bank is for big farmers, and they have no idea - whatsoever - how to get a loan.

D - Marketing Factors. One of the most critical impediments to agricultural development in Saudi Arabia is lack of organization in marketing and distribution services, especially for the more perishable products.

Marketing processes for almost all products are unorganized and subject to a wide variety of problems: too many production steps;

too many intermediaries handling very small volumes; near monopolies at wholesale levels (such as imported fruits).[50] All these factors are mitigated against farmer's receiving a reasonable and fair price. Consumers too, are forced to pay more because of inefficiencies in marketing and distribution processes.

Production in small, scattered units placing considerable dependence on natural forces makes the problem of agricultural marketing more difficult. Sale produce is available in small quantities. Grading becomes difficult. Unfavorable weather conditions prevent produce from coming to market. Perishable products, particularly have difficulties as compared to more durable kinds of farm commodities. Lack of adequate storage facilities creates more problems. Accomodations for market storage are not adequate to handle an increased supply of farm produce. In many cases, quality of storage forces the farmer to sell his produce as soon as the harvest is over. Gluts are created on the market meaning lower prices to the farmers. Moreover, the non-existence of grading and standardizing makes selling more difficult.

Vital to good marketing systems are reasonably stable prices, i. e., without discontinuous intra- or interseasonal changes, at a remunerative level. Unless farmers have confidence in prices, they will hesitate before incurring additional work or expense to increase

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[50] There is one fruit importer in Saudi Arabia.

their output or raise its quality. In Saudi Arabia, prices of agricultural products move up and down every month -- in fact, every day. Prices of perishable products could be expected to fluctuate through a very small range, but as Table 6-2 shows, prices fluctuate heavily between one month and another. What is even more distressing, fluctuations are not restricted to perishable products but to the more durable crops, i.e., wheat and barley (Table 6-2).

Although the above factors make production cost high and agriculture inefficient, there are other factors that make it worse. As mentioned above, the agricultural market is not competitive. Therefore, in accordance with traditional price theory, the "market conduct" would be expected to be non-competitive.

6-4. Market Conduct

Market conduct is defined as the patterns of behavior enterprises follow in adapting or adjusting to market structures where they sell or buy. Market conduct variables include sales promotion policy; product variation policy (non-price conduct); coordination of price, product, and sales-promotion; and methods employed by firms determining price and output.

As mentioned before, the food market in Saudi Arabia consists of one large firm (or one group of joint-profit-maximizing firms), influencing price by its own action; and a large number of small firms unable to influence price by their own action. The large firm

Table 6-2. Monthly average wholesale and retail prices of wheat and barley in Saudi Arabia (SR/Kg).

	Region	1965		1966						
		Nov.	Dec.	Jan.	Feb.	March	April	May	June	July
Wheat	Qaseem									
	Wholesale	0.63	0.60	0.65	0.53	0.52	0.51	0.53	0.53	
	Retail	0.68	0.75	0.70	0.63	0.59	0.57	0.60	0.59	
	Western									
	Wholesale		1.00	0.54	0.60	0.86	1.00	1.06	1.05	1.05
	Retail		1.25	0.72	0.75	1.09	1.22	1.24	1.25	1.25
	Central									
	Wholesale	0.63	0.67	0.63	0.68	0.56	0.67	0.77	0.44	0.54
	Retail	0.70	0.81	0.70	0.70	0.67	0.77	0.95	0.72	0.68
Barley	Qaseem									
	Wholesale	0.36	0.42	0.45	0.45	0.35	0.40	0.45		
	Retail	0.41	0.47	0.51	0.55	0.41	0.50	0.53		
	Western									
	Wholesale		0.30	0.30	0.30	0.43	0.50	0.53	0.33	0.30
	Retail		0.45	0.50	0.38	0.57	0.70	0.71	0.54	0.55
	Central									
	Wholesale		0.57	0.55	0.56					
	Retail		0.66	0.67	0.67					

Source: Kingdom of Saudi Arabia, Statistics and Agricultural Economics Paper, No. 3 and 4.

or group sets the price which will maximize its own profit (or joint profit), using the supply curve of the forms as given. In Figure 3a, S is the supply curve of the firms in aggregate, and D is the total market demand. The horizontal difference between D and S gives the demand curve facing the food importer (or importers), shown in D_1 in Figure 3b. The importer (or importers) sets his output and price to equate marginal revenue (derived from this demand) to his marginal cost. Farmers take this given price, and supply in aggregate, the quantity indicated in Figure 3a. Production costs are high in Saudi Arabia, therefore prices set by importer are lower than production costs. This leads to the "loss" incurred by farmers.

Methods groups of firms employ determining price, influence the economic results flowing from the agricultural sector. The methods employed by firms are influenced by the market structural variables. Therefore, performance of the Saudi Arabian agricultural sector is influenced by the food-imported sector of the whole food market.

In spite of this, the government has made conditions worse by subsidizing most of the imported food. The average rate of subsidy amounted to about 16.5 per cent of import value (CIF).[51] What is the motive behind this subsidy? -- Provide a cheap food supply for a

[51]The subsidy rate is exactly equal to the rate of devaluation of the Saudi Riyal Vis-aVis the U. S. dollar in 1958/59 (from S. R. 3.75 to S. R. 4.50 to $1).

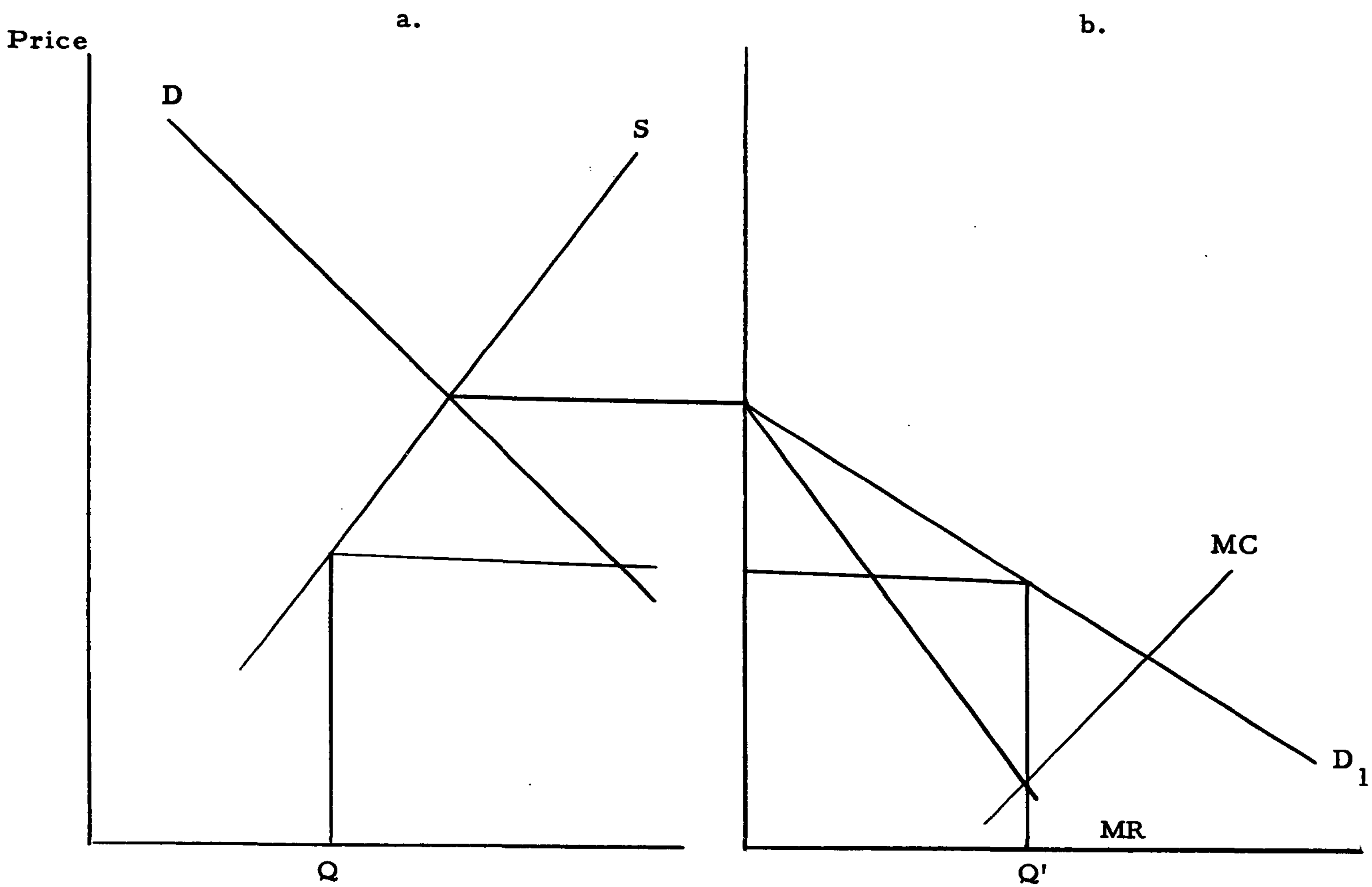

Figure 3. Illustration of the Saudi Arabian trade market.

country heavily dependent upon food imports. This has in fact, lowered farmers' returns by 16.65 per cent and may even have discouraged farmers from producing more output.

In theory, given a free price mechanism, output of a commodity could be expected to increase when there is an increase in its price. Conversely, output is expected to decrease when there is a fall in price. However, the responsiveness of output obviously does not depend on the price of that commodity alone, but also on the price of its substitute or substitutes.

In developing agriculture, however, there is little agreement on how farmers respond to price changes. Various hypotheses about the responsiveness of developing agriculture may be divided into three major categories:

(1) The hypothesis that farmers in underdeveloped economies respond quickly, normally, and efficiently to relative price changes. Major proponents of this hypothesis are Bauer,[52] Schultz[53] and Mellor.[54] Bauer in his "West African Trade" argued that Africans respond rapidly and in an orthodox manner to price fluctuations. Schultz says "The doctrine that farmers in poor countries either are

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[52]P. T. Bauer, West African Trade, Cambridge, 1954.

[53]T. W. Schultz, Economic Crises in World Agriculture, The University of Michigan Press, Ann Arbor, 1955, p. 49.

[54]J. W. Mellor, The Economics of Agricultural Development, Cornell University Press, 1966, pp. 199-200.

indifferent or respond perversely to changes in prices . . . is so potently false and harmful." Mellor went as far to suggest that short run responses may be greater in underdeveloped agriculture than in advanced agriculture because of greater flexibility in respect to factor inputs and distribution channels.

(2) The hypothesis that marketed production of subsistence farmers is inversely related to price. The advocates of this hypothesis suggest farmers may have a fixed or relatively fixed monetary obligation as is necessary to obtain the desired money income. Major proponents of this hypothesis are Neumark,[55] Mathur and Ezekiel,[56] Khatkhate,[57] and Enke.[59]

(3) The hypothesis that institutional constraints are so limiting that any price response is insignificant. Most proponents of this hypothesis contend institutional and cultural constraints limit, to relative insignificance, the responses implied by generally accepted microeconomic theory. Therefore, the application of economic theory to

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[55] S. D. Neumark, "Some Economic Problems of African Agriculture." The Journal of Farm Economics, Vol. XLI, Feb. 1959, p. 48.

[56] P. Mathur and H. Ezekiel, "The Marketable Surplus of Food Price Fluctuations in a Developing Economy." Kylos Vol. XIV, pp. 397-398.

[57] D. R. Khatkhate, "Some Notes on the Real Effects of Foreign Surplus Disposal on Underdeveloped Economics" the Quarterly Journal of Economics, Vol. LXX VI, May 1962, pp. 188-192.

[58] S. Enke, Economics for Development, Prentice Hall, Inc., 1963.

the study of agricultural output supply must necessarily be misleading or, at best, irrelevant.

6-5. Responses to Price Changes

The response of Saudi farmers to price changes of agricultural products has never been studied. This is the purpose of this section.

Single commodity output responsiveness, namely wheat and barley, to changes in prices of these commodities is herein examined. In other words, price elastiticites of supply are investigated.

Established theory is applied to explain observed facts in Saudi agriculture from 1950-1063. If existing relationships are generally in agreement with ruling theories, then little or no explanation is necessary. However, when facts do not agree with the theory, a closer look at the cause of deviation is necessary.

A - Assumptions.

1. Weather has not influenced yield.

2. The degree of risk is unchanged.

3. As prices change in a given proportion, output changes linearly in a constant proportion.

B - Model Adopted and Method of Estimation. Since farmers do not know average price, except for prices they and their neighbors receive, farmers are likely to use past experience as their guide in making predictions on price for a given year. Determinants of expected price for a given year may be expressed by means of an equation:

$$Qt = P^{a}_{t-1}$$

which when expressed in logorithms would be

$$\text{Log } Qt = \log a + \log P_{t-1}$$

where P_{t-1} represents the average annual price lag of a specific commodidy, and Qt is output for the given year of a specified commodity.

C - Data Used. Data for quantities of wheat and barley have been taken from Tables A and B in the Appendix. Ideally, prices used in the computation of the regression equation should be the prices paid to producers, lagged by some period of time deflated by some index (i. e., index of prices of agricultural commodities or index of the prices of the competing crop). Due to the absence of harvest prices or wholesale prices, import prices in Saudi Riayl were used in this study. Import prices are used because competition among farmers in the selling sector, it is believed, tends to assure prices of imported crops (Jiddah wholesale prices); and actual prices paid to domestic crop producers tends to be equal. Wheat prices are deflated by the price index on flour (1957 = 100). Barley prices are deflated by the price index on maize (1956 = 100) (Table 6-3).

Table 6-3. Deflated prices of wheat and barley (Saudi Riyals per ton), 1950-1962.

Year	Wheat Prices	Barley Prices
1950	279	173
1951	244	392
1952	252	285
1953	268	273
1954	260	270
1955	276	175
1956	121	269
1957	321	304
1958	279	241
1959	577	270
1960	298	340
1961	288	285
1962	295	246

Sources: Prices of wheat, barley, flour, and maize are taken from Saudi Arabia, Statistical Yearbook, 1385 A. H., 1965 A. D., p. 181. But the prices shown in this table are calculated by the author.

D - The Results. Statistical evidence presented below yields the following results:

$$\text{Log QW} = 3.13569 + 0.64263 \log P_{t-1}$$

$$R = 0.38$$

$$\text{Log QB} = 3.36583 + 0.43451 \log P_{t-1}$$

Correlation Coefficient (R) = 0.29.

The results indicate output of wheat (QW) and barley (QB) are correlated with current prices, but the examination of coefficients of correlation indicate these relationships are not significant at either 0.05 or 0.10 levels of probability. However, graphic depiction of the data seems to indicate different supply patterns exist. The overall time series was segmented into two periods, 1950-1957, and 1957-1963. The results were as follows:

1950 - 1957 $\log QW = 5.41381 - 0.38359 P_{t-1}$
$R = 0.54$

1950 - 1957 $\log QB = 4.36035 - 0.02713 \log P_{t-1}$
$R = 0.080$

1957 - 1963 $\log QW = 3.85812 + 0.41860 \log P_{t-1}$
Standard error of estimate = 0.1567
$\log QB = 3.62975 + 0.37137 \log P_{t-1}$
Standard error of estimate = 0.1163
$R = 0.25$

Thus it appears wheat and barley supply reacted perversely to price changes from 1950 - 1957.[59] During the succeeding time period, 1957-1963, the quantity supplied still reacts inelastically to price

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[59] The coefficients that are derived from the two equations for 1950-1957 have negative signs and, thus, indicate that farmers reacted perversely to price changes.

changes. The elasticity of supply, however, appears to have increased. If a confidence co-efficient of 0.95 is used for both wheat and barley, the elasticity coefficients fall between 0.82 and 0.02 for wheat, and 0.67 and 0.07 for barley. Evidently, wheat and barley producers were more conscious of price movements in the latter period than in the earlier period. The lower elasticity co-efficients for wheat and barley could be explained by production costs and food policies prevalent in Saudi Arabia. Prices in Saudi Arabia do not represent competitive prices because of subsidy and imperfect competitive markets. Indeed, farmers will not respond to such prices when they are lower than production cost.

The government price policies -- which are included in the market structural variables -- make the food market in Saudi Arabia unfavorable for farmers to compete and receive a competitive price for their product. In other words, the government makes the food market more "imperfect" leading on to "inefficiency."

The study cannot stop at this level but must take the next step: diagnose policies which might change the environment in the agricultural sector to make farming profitable.

6-6. Recommendations

The key problem of Saudi Arabian agriculture is intensity production and the inability of farmers to recognize and remove disequilibria. Crucial deficiencies are in the way. "Barriers to efficiency" are among these, therefore, they must be removed. There are many others. The most important recommendations should be proposed.

1. Water is too precious to be wasted; it should be used in agricultural undertakings where marginal returns are highest. In Saudi Arabia, this can only come about through comprehensive planning. The government needs to make studies of crop potentialities, their prices, and their marketing possibilities. Then it must plan accordingly for water use alternatives. Further, lands under unstable climatic conditions should not be used for crops such as wheat and other drought intolerant products. This will lead to stable farmers' income and lower production costs.

2. The existence of small holdings in Saudi Arabia should be a matter of concern.

The predominating factor for the small holding, beside lack of other choices of employment, is the law of inheritance. Each heir shares a claim to the land when the owner dies. When he dies, each heir takes over a part of the field. This leads to fragmentation, i. e., scattered fields not contiguous with each other.

It is a serious matter and in the opinion of this writer, some preventive measure to prevent further deterioration must be taken. No holding should be transferred or partitioned in such a way as to aggravate the problem, i. e., amend the existing laws in order to prohibit any further breaking up of farms below a certain size. Further, this writer suggests a system of land leases, perhaps perpetual leases, be developed through legislative action. This may seem far fetched owing to the deep attachment farmers have for the land; but if the Saudi agricultural section is to become viable, some coercive action is necessary. Cooperative organization, not presently in existence in the agricultural sector, is another measure that should be encouraged (for example, loans available on the basis of membership).

3. The maladjustments that exist in the market have to be removed if Saudi agriculture is to secure fair prices for produce. In fact, an improved system of agricultural marketing is sine qua non for agricultural development in Saudi Arabia. Further, the government should develop some policies for preserving competition within a private free enterprise system. If "regulations of competitive behavior" must be avoided, then subsidizing farmers must be considered.

6-7. Conclusion

The record of responses to innovations is a mixed one. Net losses explain why farmers resist innovations. Net losses occur because farmers are inefficient. Inefficiency of farmers, however, is explained by some "exogenous" factors. Market structural variables, natural factors and government policies are among the "barriers to efficiency."

Farmers are "poor and inefficient, but farmers have nothing to do with inefficiency." That is to say, farmers might become very efficient and receptive to innovations if the environment in the agricultural sector changes.

Chapter 7

SUMMARY AND CONCLUSION

The main purpose of this study is to find a way to accelerate agricultural production in Saudi Arabia. Any way suggested depends on the current state of input utilization and production efficiency. The allocation efficiency of resources in the Saudi agricultural sector is analyzed. This is done by constructing two production functions. The first production function is for wheat and the second for barley. From these production functions the value marginal productivities of land and labor are found and the allocation efficiency is investigated.

It is found that value marginal product of land under barley is higher than that of land under wheat (Table 3-3). This indicates if some land was shifted from wheat production to barley production, farmers' income would definitely increase. Moreover, the value marginal products of land, both under wheat and barley, are much less than the marginal expense of land (Table 3-4). Thus, farmers' net loss exists (Table 3-5). This indicates an unprofitable resource-use in the agricultural sector of Saudi Arabia.

An interesting result emerging from the present study is that marginal physical product of labor is very low in wheat production and negative in barley production (Table 3-3). This is a serious finding, therefore, another look into labor utilization is necessary.

Using the concepts of "labor availability" and "labor requirements" in the agricultural sector, 32, 584 unutilized workers are found to exist (Table 3-7). This estimate indicates too much labor is used relative to land in the existing input-input relationships of Saudi Arabia. This suggests disequilibria of resources, the result of a very low land-labor ratio.

Thus production from existing resources can be increased if farmers are helped to recognize and remove disequilibria. Because there is a gap between "labor requirements" and "labor availability," any agricultural development plan must consider closing this gap and altering the existing land-labor ratio.

There are two ways to change the land-labor ratio: one is transfer labor from the agricultural sector to any other sector of the economy (i. e., called the "labor squeeze" solution). The second solution is increase land.

The "labor squeeze" solution is unacceptable. Socio-cultural barriers to occupational and geographical mobility are more pronounced in Saudi Arabia.

Limited water supply bottlenecks the expansion of cultivated land. Therefore, the extensive solution for the Saudi Arabian agricultural sector is not feasible.

However, farm land has two components -- a natural endowment component and a capital structure component.

Fertilizer, as a form of capital, is investigated. Two fertilizer functions are constructed and minimum, maximum, and optimum output are derived. Maximum and optimum fertilizer use in Saudi Arabia are also estimated (Table 5-2). Marginal rates of substitution of fertilizer for land is calculated. A certain combination of fertilizer and land has the marginal rate of substitution of 0.3. Another combination of fertilizer and land has the marginal rate of substitution of 0.13 (Table 5-3).

Becuase the two fertilizer functions used are not built on detailed studies, it was necessary to use some detailed studies carried out in some neighboring countries. Two fertilizer functions from the U.A.R. are used and marginal rates of substitution of fertilizer for land are derived and compared with Saudi Arabia (Table 5-3). All functions show how fertilizer can play an important role as a substitute for land. This suggests intensive cultivation as the solution.

Moreover, as was mentioned before, production from the existing set of resources can be increased. This means production economics studies and educational programs have a great potential to make positive contributions to the Saudi agricultural sector.

Stated in its simplest form, policy oriented production economics research is concerned with discovering, in sequence, (1) what decisions farmers make, (2) why farmers make decisions as they do, and (3) what must be change in the environment to make it profitable for farmers to make decisions increasing production.

The normality of farmers' decisions can be seen from their physical response to innovations. The record in responses to innovations is found to be curiously mixed. The obvious reason for irresponsiveness to innovations lies in the explanation of low investment in the agricultural sector. Farmers' net losses explains why investment for innovations by farmers is low. Inefficiency in the agricultural sector is a reason for high production cost. However, efficiency and willingness to innovate and increase resource productivity are influenced by the nature of competition in the market.

The food market in Saudi Arabia is very highly concentrated and the "conduct" is noncompetitive. Moreover, the government, by subsidizing imported food, makes the food market unfavorable for farmers to compete for a fair price for their product.

Farmers are "poor and inefficient, but farmers have nothing to do with the inefficiency." That is to say, farmers might become very efficient and receptive to innovations if the environment in the agricultural sector is changed.

To conclude this study, there is disequilibria within the agricultural sector in Saudi Arabia. Thus, total production from the existing set of resources can be increased through production economics studies and educational programs which help farmers recognize and remove disequilibria. Moreover, to alter the existing unfavorable land-labor ratio, more investment on land is required, i.e., the "intesification" of the Saudi agricultural sector seems to be the solution.

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APPENDICES

Table A. Wheat production, area, and yield (1950-1963).

Year	Quantity Tons	Index	Area Hectares	Index	Yield Tons/H	Index
1950	20200	100	21800	100	0.93	100
1951	23432	116	24917	114	0.94	101
1952	26664	132	28034	129	0.95	102
1953	29896	148	31151	143	0.96	103
1954	33228	164	34268	157	0.97	101
1955	36360	180	37385	171	0.97	102
1956	39592	196	40502	186	0.97	102
1957	42836	212	43800	201	0.98	105
1958	57250	283	51370	236	1.1	122
1959	71380	354	58954	270	1.2	134
1960	85670	425	66531	305	1.3	149
1961	100224	496	74108	340	1.4	126
1962	114446	567	81685	375	1.4	162
1963	129201	640	89390	410	1.5	161

Table B. Barley production, area, and yield (1950-1963).

Year	Quantity Tons	Index	Area Hectares	Index	Yield Tons/H	Index
1950	15268	100	17163	100	0.88	100
1951	16398	107	18107	106	0.91	103
1952	17528	115	19081	111	0.92	105
1953	18650	122	20025	117	0.93	106
1954	19780	130	20969	122	0.94	107
1955	20910	137	21913	128	0.95	108
1956	22040	144	22857	133	0.96	109
1957	23800	151	23800	139	1.00	113
1958	27846	179	24693	144	1.13	126
1959	31892	207	25586	149	1.25	140
1960	35938	235	26479	154	1.36	155
1961	39984	262	27372	159	1.46	166
1962	44030	290	28265	165	1.56	177
1963	48245	316	29182	170	1.65	188

Table C. Dates production, area, and yield (1950-1963).

Year	Quantity Tons	Index	Area Hectares	Index	Yield Tons/H	Index
1950	250000	100	21752	100	11.5	100
1951	247690	99	24906	114	9.5	83
1952	245575	98	28060	129	8.8	77
1953	243460	97	31214	143	7.8	68
1954	241345	96	34368	158	7.0	61
1955	239230	95	37522	172	6.4	56
1956	237115	94	40676	187	5.8	50
1957	235000	94	43900	202	5.3	46
1958	238760	96	40216	185	5.9	51
1959	242520	97	36629	168	6.8	57
1960	246280	98	33042	152	7.5	65
1961	250040	100	29455	135	8.5	74
1962	253800	102	25868	119	9.8	85
1963	257606	103	22281	102	11.6	101

Table D. Vegetables production, area, and yield (1950-1963).

Year	Quantity Tons	Index	Area Hectares	Index	Yield Tons/H	Index
1950	29226	100	4128	100	7.1	100
1951	28122	86	3966	96	7.1	100
1952	26975	92	3805	92	7.1	100
1953	25828	88	3644	88	7.1	100
1954	24681	84	3483	84	7.1	100
1955	23534	80	3322	80	7.1	100
1956	22387	76	3161	76	7.1	100
1957	21240	72	3000	72	7.1	100
1958	67543	231	7980	194	8.5	120
1959	113846	390	12960	316	8.8	124
1960	170149	582	17940	436	9.5	134
1961	218452	747	22920	558	9.5	134
1962	282755	967	27900	680	10.1	142
1963	345485	1182	33132	803	10.4	146

Table E. All crops production, area, and yield (1950-1963).

Year	Quantity Tons	Index	Area Hectares	Index	Yield Tons/H	Index
1950	355657	100	95316	100	3.7	100
1951	367393	103	111233	117	3.3	89
1952	379129	107	127150	134	3.0	81
1953	390865	110	143067	150	2.7	73
1954	402601	113	158984	167	2.5	68
1955	414337	116	174901	184	2.5	68
1956	426073	119	190818	201	2.2	59
1957	437805	123	207400	218	2.1	57
1958	518795	146	213207	224	2.4	65
1959	59985	169	219014	230	2.7	73
1960	680775	192	224821	237	3.0	81
1961	761765	215	230740	242	3.3	89
1962	842755	237	236435	248	3.6	97
1963	925326	260	242829	254	3.8	103

Table F. Expenditures and returns from cultivating one dunum of rice in the Eastern region in Saudi Arabia.

Expenditures (total)	171
Preparing the soil	20
Sowing and seeds values	47
Irrigation	15
Fertilizers	20
Harvesting, threshing and weeding	59
Revenues	228
Gain	57

Source: Statistics and Agricultural Economics Paper, No. 3, March 31, 1966, p. 20.

Note: Acre = 1.6 dunum

Table G. Expenditure and returns from cultivating one dunum of wheat in various regions in Saudi Arabia.

	Central Region	Qaseem	Ta'if	Northern
Expentitures (total)	235	144	159	161
Preparing the soil	26	17	31	24
Sowing and seeds values	13	11	12	12
Irrigation and fuel value	80	35	25	30
Fertilizers	---	---	---	25
Harvesting and threshing	50	29	41	26
Land rent	66	52	50	44
Revenue (total)	240	104	140	133
Gain (+), loss (-)	+ 5	-40	-19	-28

Sources: Statistics and Agricultural Economics Papers, No. 3, March 1966, p. 87.