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**Policies and models for planning the economic development  
of the non-oil sector in Saudi Arabia**

**by**

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## CHAPTER I. INTRODUCTION

## General Problems of Economic Development

Economic development has occupied a focal point in the world since the late 1940s. The strife of the less-developed countries for development and the willingness of the more-developed to lend a hand have almost rendered all countries and the organ that unites them, the United Nations, to be involved in this complex process.

It is a complex process because it not only implies an increase in output, but also involves a change in economic and other institutions and the structure of inputs and outputs. The interrelationships and interdependencies that exist among the different institutions and structure make this unavoidably complicated.

In their strife for development, the less-developed countries have been handicapped by many kinds of constraints. These constraints are represented by the inadequacy of resources in general. However, the backwardness and rigidity of institutions perhaps are the most limiting of these constraints. Economic development depends on the quality and quantity of natural resources and the extent of their availability, on the abundance of human resource, their skills and their organizational and administrative efficiency, on capital resources and technological know-how. Although the LDCs experience shortages of different resources to varying degrees, capital and management resources have been, by far, the most limiting factors. This complex perhaps, partly explains the involvement

of more advanced countries and international agencies in trying to "fill the gap" by supplying needed capital and technical advice.

The predominance of the agricultural sector in many LDCs over the industrial sector and the dependence of the larger part of population on primitive agriculture for income and living, have triggered the evolution of many theories of economic development. These theories try either to describe reasons for under-development or prescribe paths to development or both. As expected, these theories are by no means, in agreement. Some emphasize industrialization as the vehicle through which economic development can be achieved. Proponents of this view cite as evidence the high correlation between industrialization and per capita income and the relative decline of the agricultural sector in the latter stages of development. Others emphasize priority for agricultural development because the agricultural sector supports the larger share of population and supplies the rest of the economy with resources such as labor, savings and raw materials. They argue that unless the per capita income of agriculture increases through development, the overall increase in per capita income will be hampered. A third view places equal importance in developing the different sectors of the economy for the goals of the overall economic development to be attained.

These issues are not yet resolved and the theory is by no means complete. The uniqueness of situations in different LDCs and the varied experience of the more advanced countries is making it difficult to generalize.

Saudi Arabia has an economic setting quite unlike that of most other countries of the world. The Kingdom has a very advanced and commercialized oil sector. This sector dominates the economy in generating more than half of the GNP, constituting about 99 percent of the total value of exports and earning most of the nation's foreign exchange. Co-existing with the advanced oil sector is a non-oil sector dominated by subsistence agriculture and nomadic pastoralism. Half to three-quarters of the population derive their living directly from agriculture, and the sector employs more than 46 percent of the labor force in the country. Even with a majority of human resources in this sector, its contribution to the GNP in recent years has been less than 10 percent; only 7.7 percent in 1966/67. The low per capita income in agriculture pulls down the average per capita for the country causing Saudi Arabia to rank in the lower level of development spectrum.

Although development planning has been practiced by many of the LDCs early in the 1950s, Saudi Arabia has started serious planning efforts only in 1969/70. Concerned about the dependence of the country on oil and realizing that this is a wasting or stock resource the income of which is exogeneously determined, the government embarked on a number of projects and programs to develop the agricultural sector. The government has also prepared its first five-year plan (1969/70 to 1974/75) with major emphasis on the non-oil sector.

#### Objectives of the Study

This study has developed out of the interest of the author in the

Middle East. The problems encountered in Saudi Arabia are also met by other countries in the region. It is hoped that this study will enrich the knowledge of the author as well as contribute humbly toward solving some of the common problems of this area.

The general objective of this study is to undertake a systematic analysis of the economic development of the non-oil sector in Saudi Arabia. More specifically it aims at:

1. Analyzing the economic performance of the non-oil sectors and evaluate their contribution to the national economy.
2. Exploring and identifying the obstacles handicapping the achievements of the goals of economic development.
3. Summarizing and evaluating previous studies and development efforts by the government and other agencies.
4. Synthesizing policies for alleviating the obstacles to development and achieving the goals and targets of development.
5. Developing a general interregional linear programming model as a more systematic and realistic approach to planning the economic development of agricultural sector.
6. Identifying the data needed for applying the model and methods of generating it.
7. Developing a more specific interregional linear programming model which incorporates the top priorities.
8. Developing an integer programming model for planning the transportation system and road location.

### Sources of Data

The paucity of published material on the Kingdom's agricultural sector compelled the author to use extensively large number of unpublished mimeographed reports, draft material and some government interoffice correspondence as sources of data. (These materials were made available through the courtesy of Prof. Earl O. Heady who obtained them from the government of Saudi Arabia during his visit to Riyadh.)

Reports of consulting firms conducting Area Resource Surveys for the government have been instrumental in making this report possible.

The Statistical Yearbook published by Central Department of Statistics was used to obtain data on land resources. Unfortunately some pages containing important information on oil and balance of payments and other areas were missing from the Yearbook.

When completed, Area Resource Surveys will provide most valuable information about the country's resources. However, periodic adjustments and up-dating are necessary if these data are to be used for planning purposes.

### Organization of the Remainder of the Study

Chapter II provides a quick socio-economic background to characterize the country. A brief look at the social setting and the origin of the Saudis was presented together with a description of the oil and non-oil sectors and their contributions to the national economy.

In Chapter III the structure of the agrisector is described in some detail to complete the necessary background for the following chapters. The data on agricultural resources have been obtained mostly from government figures published in the Statistical Yearbook.

Chapter IV identifies the goals and needs of agricultural development by referring to the objectives of the Five-year Plan for the economic development of agricultural sector. These objectives are taken to reflect the needs of people in Saudi Arabia. The problems encountered in the process of development are those which impede the effectiveness or limit the availability of the factors of production and place limitations on the economic and other institutions.

Chapter V reviews government projects and programs intended to increase cultivable area through irrigation and land reclamation. Brief description of the major projects is presented in the first part of this chapter.

In the second part of Chapter V mention is made of studies carried out by individuals or organizations which have a bearing on this study. More emphasis was placed on Area Resource Surveys conducted by three foreign consulting firms under contract with the government.

The remainder of Chapter V is devoted to summarizing and evaluating the Five-year Plan for the development of agriculture.

Chapter VI deals with specification, analysis and recommendation of policies relevant to the economic development. Particular attention was placed on policies that increase the productivity and/or the availability

of inputs of production, policies on prices and subsidies and policies affecting land tenure, marketing and credit institutions.

Chapter VII includes a general interregional linear programming model for a systematic planning of the economic development of agriculture. Specification of data requirement and delineation of producing and consuming regions were attempted. A cost minimizing model was also developed to incorporate the top priority crops specified in the plan.

Chapter VIII provides a summary of the findings and conclusions of this study.

## CHAPTER II. SOCIO-ECONOMIC BACKGROUND

## Social Background

The Kingdom of Saudi Arabia occupies about four fifths of the Arabian peninsula south of Jordan, Iraq and Kuwait. The exact area of the Kingdom is not known, since most of the borders with neighboring states of Southern Arabia have not been fixed. Official estimates, however, put it at about 870,000 square miles.

Because it is arid and largely desert, the peninsula has since ancient times been sparsely populated by mostly semitic Arabs. It moved suddenly into the center of world attention in the seventh and eighth centuries A.D. as the homeland of Islam, the religion taught by Prophet Mohamed and propagated by his Moslem followers throughout the Middle East, North Africa and much of Southern Asia.

The political center of the rapidly expanding Islamic Empire quickly moved from its birthplace in Mecca, a city in the peninsula near the Red Sea Coast, to Damascus and Baghdad in the more sophisticated fertile crescent. Mecca remained as it has to the present time, the religious center of Islam. Its political importance declined however, and for the most of the 1300 years from the beginning of Islam to the creation of Saudi Arabia, the Peninsula remained isolated from the social and political changes taking place in other parts of the world. Only Mecca and the Red Sea coastal area, the Hijaz, had any contact with the outside world, Mecca as the goal of Moslem pilgrims from all over the Islamic



world and Higaz because of its subjection after the sixteenth century to the Ottoman Empire.

The formal establishment of the Kingdom of Saudi Arabia in September 1932, climaxed 30 years of conquest and amalgamations by Abdul Aziz Ibn Saud, also famous as Ibn Saud. The son of a prince who had been forced into exile by a rival tribe, Ibn Saud devoted himself from the age of 20 to restoring the earlier political eminence of the Saudi family and to uniting the Arabian Peninsula under Saudi rule.

The Saudi Arabs are roughly estimated at between 3 1/2 and 5 1/2 million in 1965. Other various estimates put the population between 3 and 15 million. The U. N. figures showed a population estimate of 7.2 million in 1969. The Saudis share a common ethnic origin, all but small minority groups are Arabs, and a common belief in Islam, which is the strongest unifying force in Saudi society.

Because of the isolation of the Peninsula from the outside world, the social structure and the mode of living of the people changed little over the centuries until the discovery of oil in the Peninsula in 1930s. Economic development caused by the growth of oil industry has been extremely rapid. Between 1945 and 1965 most of the population, including nomads, were introduced to modern technology and material cultural change. Despite the impact of this exposure on the living conditions of most population, social change has been slow.

The chief agent through which modern technology was introduced into Saudi Arabia has been the Arabian American Oil Company (Aramco). A

consortium formed in 1944 by four major U. S. oil companies, Aramco was created to exploit the great potential of the large area of Eastern Arabia, on the basis of a concession granted in 1933 by King Abdul Aziz Al-Saud to one of its founding members. By 1965 production reached an average of two million barrels a day.

Oil production provided revenue, employment and wealth to the Saudi Arabians. Although a source of blessings oil created serious problems after World War II for unprepared government. The basically agricultural economy was incapable of absorbing the huge injection of capital and the government had not yet developed a formal system of financial control. A financial crisis in the late 1950s resulting in a slow down of the rate of expansion of oil exports, forced the government to reconsider its fiscal policies. A modern fiscal system including for the first time the strict adherence to government budgets and financial controls, was established, and the groundwork was laid for the creation of a modern national economy.

#### Economic Background

The economy is dominated by the oil industry which accounts almost for the entire value of commodity exports and for more than 85 percent of the country's foreign exchange earnings. Oil royalties and taxes paid by the oil companies constitute about four fifths of total government revenue and the oil sector provides direct employment for more than 10,000 Saudis.

Until the discovery of oil in 1938, the stagnant economy, based on subsistence arid zone agriculture and desert pastoralism, had exhibited little potential for development along modern lines. Beginning in 1944 the large scale exploitation of oil brought into the country modern technology and large injections of capital which established the basis for previously unimaginable economic growth and modernization.

Oil operations were, as of 1965, in the hands of four foreign companies, operating under the terms of concessions agreements with the Saudi government which owns all the subsoil mineral wealth. By far the most important of the foreign companies was the Arabian American Oil Company (Aramco) founded in 1944 by four major U. S. oil companies, including the company which was granted the first concession in 1933 and which first discovered oil.

As a result of the government spending of the revenue which it receives in the form of royalties and taxes from oil companies, the monetized sector of the economy has expanded to areas outside Eastern Province where the fields of operations of oil exist. The resulting increase in consumer demand and urban development needs has encouraged the establishment of secondary industries in major cities such as Lidda and Rijadh. To support industrial activity, the government has developed elements of a modern economic infrastructure with the expansion of the transportation network, the increase and improvement of health and education services, the location of water and other resources and the establishment of a sound financial system. The country's basic unit of

currency, the Saudi Riyal (SR), has, since the early 1960s, been extremely stable, and is among the strongest currencies of the world.

The high rates of exports and imports to output reflects the importance of external trade in the economy. In the year 1960/61 the combined value of exports and imports of goods and services constituted about 87 percent of the gross domestic product, and imports of capital equipment and construction materials formed about 56 percent of the value of gross domestic fixed capital formation.

In contrast to the rapidly developing oil sector during 1950s, the non-oil sector could not affect to any significant extent the development of the country, mainly owing to the lack of sufficient private and public funds. The traditional agricultural sector has remained relatively static. Production of both crops and livestock is limited by adverse climatic conditions and primitive agricultural practices. Because of the low level of per capita income, significant savings for investment purposes could hardly be accumulated in the private sector. As to the public sector, the necessity for the government to introduce in 1958, a drastic stabilization program requiring strict budgetary controls prevented its effective participation in the development efforts of the country. The stabilization program was necessitated by the failure of the government to curtail public expenditures following a sudden levelling off of oil revenues at the beginning of 1956, which created serious internal and external economic difficulties. Thus the government found itself unable to pay adequate attention to development prior to restoring financial and monetary stability in the country.

Beginning in 1960, however, the government began to embark on an increasing number of development projects. By 1967 budget allocations had increased from 7 to 38 percent of total estimated budget outlays. Taking these developments into account, coupled with the anticipated increase in private savings as a result of rising per capita incomes, the non-oil sector is expected to play an increasing role in the development of the country in the future.

The initiation of development policy in Saudi Arabia began when the government invited the International Bank for Reconstruction and Development to send a mission to investigate the possibilities of economic development. The IBRD's mission visited the Kingdom in 1960 and prepared a report which provided an assessment of existing projects and a limited two year development program. Provision was also made for undertaking certain basic surveys which would serve as a basis for a more comprehensive and balanced program for long-run economic development. The actions recommended by the Bank were concerned mainly with infrastructure. The guiding principle being that the government should invest in those projects which private enterprise was not prepared to undertake. Initially, public investment was to be confined to the development of water resources, the improvement of crop and livestock production and the improvement of transport and communications facilities, education and health.

Among the recommendations of IBRD was the creation of a central planning body. In 1961 the central planning council was established and was entrusted with the technical and financial responsibility for the

planning and implementation of projects. It functioned as a ministerial sub-committee, and its members consisted of the ministers concerned with development, presided over by the prime minister. It prepared a development budget, separate from the general budget, allocating among the several projects the funds provided in the general budget for development. After 1963 these funds were supplemented by those from the economic development fund which was created in that year by special agreements with Aramco and Trans-Arabian Pipe line (Tapline). Three years later, the council was replaced by a Central Planning Organization (CPO) invested with the task of preparing a development plan for the consideration of the Council of Ministers.

Another important step taken by the government in the early 1960s was the establishment of the General Petroleum and Mineral Organization (Petromin) as a state-owned corporation for developing the petroleum and mineral resources of the country, as well as the industry and trade based on the resources.

One of the major obstacles to plan formulation in Saudi Arabia has been the meagerness of general statistical information. Thus efforts to survey agriculture and industry have been undertaken recently.

#### Oil sector

Oil production in Saudi Arabia is controlled by concessionary agreements between the government and foreign oil companies. Four of these companies are operating now in the Kingdom and in the Neutral Zone shared with Kuwait.

Early concessions date back to 1923, when a British company obtained a concession to explore oil in the Eastern Province. The company did not exercise its rights and four years later the agreement was cancelled.

About ten years after the first agreement, the government signed a second 60-year agreement with Standard Oil of California (Socal) in May 1933. The agreement covered an area of 360,000 miles extending from the Arabian Gulf to the westward edge of the Dahna Desert and a preferential area covering parts of central and western Nejd. The company agreed to construct a refinery, supply the government with 200,000 gallons of gasoline and 100,000 gallons of kerosene yearly. It also agreed to advance loans to the government deductible from future royalties, which were fixed at four gold shillings per ton of crude oil (71, p. 245).

Socal sold half of its interest to the Texas Oil Company and the two companies formed the California Texas Oil Company (Caltex) to undertake marketing activities.

In 1938, oil was found in commercial quantities in Damman following three years of drilling operations. One year later, in 1939, a supplementary agreement, also for 60 years, enlarged the concession area to 440,000 square miles to include the Saudi Arabian half interest in neutral zones bordering Iraq and Kuwait. Both 1933 and 1938 agreements were later extended six more years each making their termination dates 1999 and 2005 respectively.

Caltex was renamed Arabian American Oil Company (Aramco) in 1944. Aramco sold, in 1948, 30 percent of its interest to Standard Oil of

New Jersey and 10 percent to Socony Vacuum making the ownership distributed as follows: Standard Oil of California, 30 percent; The Texas Oil Company, 30 percent; Standard Oil of New Jersey, 30 percent; and Socony Vacuum, 10 percent.

In 1948, Aramco started relinquishing its preferential rights and its rights in concession area in general on the basis of a phased program. As of 1965 the total concession area was reduced to 125,000 square miles. Additional relinquishments of 20,000 square miles every five years, starting in 1958, will reduce Aramco's exclusive area to 20,000 by 1993. (See Figure 1 for concession areas.)

In addition to Aramco, three other oil companies operate in Saudi Arabia at the present time. These are Getty Oil Company, Japanese owned Arabian Oil Company and the French-owned Société Auxiliaire de la Régulation Autonome de Pétroles (AUXIRAP), which obtained concessions in 1952, 1957 and 1965 respectively.

Oil has been the leading sector in Saudi Arabia in economic growth as well as many other respects. In spite of uncertainties about future production and prices, which are largely controlled by factors exogenous to the economy, there can be little doubt that it will continue to be the leading sector for years to come.

Evidence of the fact that oil is the leading sector is ample. It produces over 50 percent of gross domestic product, over 85 percent of government revenues, and almost 100 percent of export earnings.



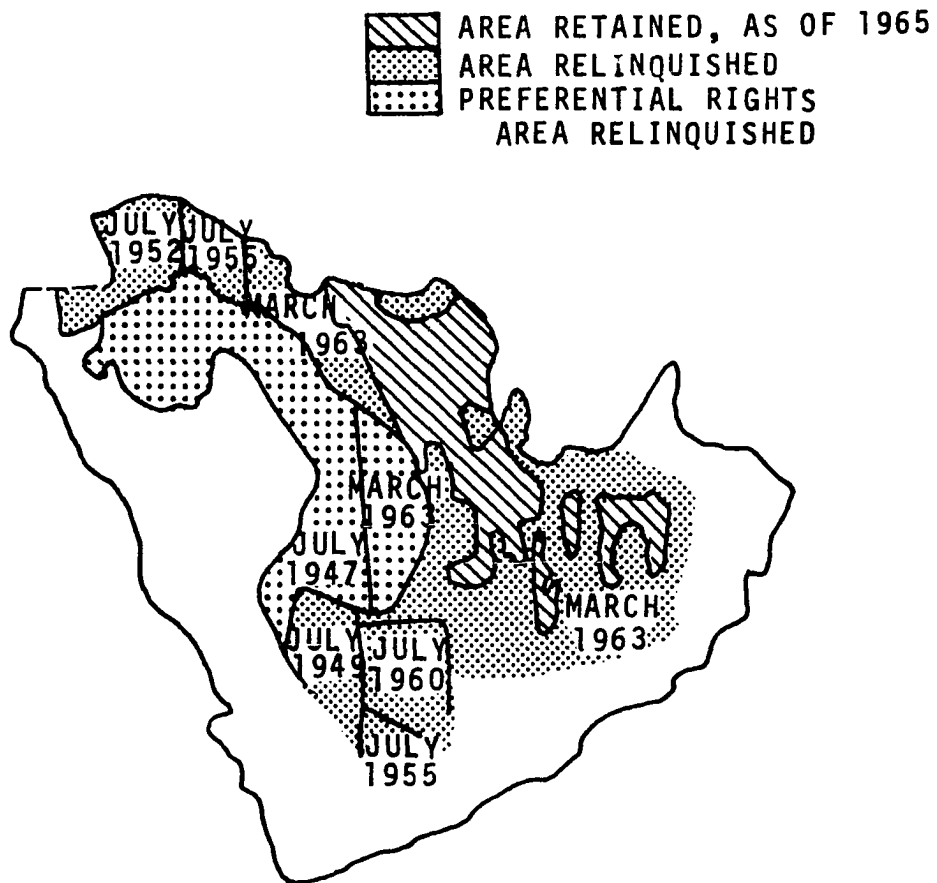


Figure 1. Concession area of Aramco, as of 1965

The fact that oil is an exhaustible resource, that its production and prices are determined by factors exogenous to the system, that it is the major contributor to government revenue and the country's foreign exchange, makes the government ponder about ways and means to decrease its dependence on oil. Within the sector itself, there are opportunities for diversification, such as the development of petrochemical industries based on natural gas, naphtha and other petroleum products available in abundant quantities and at low costs.

Yet there in the non-oil sectors in Saudi Arabia much is needed to be done in the way of developing these sectors and increasing their contribution to the national economy. The government, in making surveys, initiating studies, and implementing programs, is aiming at diversifying the economy and decrease dependence on oil. Since most of these initiatives have been recent, a long way is left ahead to be covered. The major government efforts of developing the non-oil sectors will be discussed in detail in a later chapter.

The following section will attempt a description of the non-oil sectors, their structure, problems and contribution to the economic system of the Kingdom.

#### Non-oil sectors

The division of the economy of Saudi Arabia into oil and non-oil sectors may not give a true picture of the situation. Nevertheless, grouping of the non-oil sectors in oil rich countries in one sector is repeatedly done in many studies. This is mainly due to the fact that the

non-oil sector is usually dominated by agriculture as the single most important sector in the group.

For the purposes of this study, brief description of the performance of some of the non-oil sectors will be attempted. The agrisector will be given more emphasis and the rest of this report will be devoted to its analysis. Reasons for emphasizing the agricultural sector will become evident as this study progresses.

Industrial sector (mining, manufacturing and construction)      Apart from the oil industry, which ranks highest in importance, the Kingdom has several other industries which are directly or indirectly related to oil production or induced by it. The construction industry has been the one most directly stimulated by the existence of the oil industry. It has been the most important non-oil industry since World War II.

The construction industry received its first impetus from Aramco's demand for its own operation and the housing of its employees. The boom spread to areas outside the Eastern Province to satisfy the increased demand for government and business buildings and private homes.

Government reports indicate that the number of construction establishments increased from 200 in 1960-61 employing 1,600 workers to 416 in 1968 employing more than 7,000 workers. The cement plants in Jidda and Hofuf were producing at the rate of 600 tons daily in 1965. Eleven factories were producing cement pipe and 173 producing solid and hollow cement bricks.

The construction industry contributed SR 544 million (4.1 percent) to the GNP in 1967.

In the field of manufacturing, the Kingdom has 9174 establishments, as of 1968, producing (a) foods, beverages and tobacco, (b) textiles, (c) wood and furniture, (d) paper and leather products, (e) petroleum and chemical products, (f) metal products, and (g) small appliances, supplies and transport equipment.

In mining there were 8 establishments in 1968 mainly engaged in production of gold, silver, copper, lead, zinc and iron.

Both manufacturing and mining contributed SR 300 million in 1967 which is 2.3 of the GNP, and employ 28204 laborers.

In its first five year plan for economic development, the following broad objectives were explicitly stated for the development of construction, manufacturing and mining (33);

1. Increase the product of these sectors;
2. substitution of national products for some imported products and raw material;
3. expansion of exports; and
4. development of the capacity of the private sector to undertake these tasks.

Trade sector      The pattern of domestic trade in much of S. A. is still based on the traditional relationship between the desert nomad, settled farmer and town merchants. Surpluses of field crops are traded for livestock products; necessities not derived from field crops or

animals are supplied to the pastoralists and settled farmers by town merchants in exchange for food and raw materials. Trade has been traditionally restricted and production geared to local consumption because of the inaccessibility of distant markets due to transportation difficulties.

Many changes have taken place with the advent of oil, especially in larger towns. As incomes grew, the increased demand for manufactured goods led to a significant increase in trade both domestic and foreign.

The boom in foreign trade starting in 1944 with the beginning of large scale exports of oil, continued until a financial crisis in the mid-1950s, demonstrated the dangers of the exclusive dependence on oil as the major source of foreign exchange and government revenue. A sudden leveling off of oil revenue accompanied by deficit spending resulted in serious balance of payment problem. The credit expansion resulting in additional demand for imports, put severe pressure on foreign exchange reserves and caused the exchange rate of the Saudi Riyal to fall drastically.

A strict stabilization program in 1958 followed by the budgetary reform of 1960 resulted in the establishment of a very liberal tariff structure. Since 1962 imports of consumer goods, luxury items and capital goods have continued. Large trade surpluses have provided income which is more than enough to finance all imports.

Exports of Saudi Arabia are mostly petroleum and petroleum products which account for over 99 percent of the total exports of the country,

Table 1. Exports other than oil include small quantities of livestock and animal products, fish and fish products, dates and pearls.

Table 1. Value of Saudi Arabian imports and exports 1960-61 through 1963-64<sup>a</sup> (SR million)

Year	Total imports	Total exports	Oil and oil products	
			Export value	Percent of total
1960-61	1053.0	3888.4	3875.6	99.7
1961-62	1155.1	4230.1	4219.3	99.7
1962-63	1266.0	4631.7	4610.3	99.5
1963-64	1357.7	5318.2	5275.0	99.2

<sup>a</sup>Source: (71, p. 279).

The composition of imports is varied. In 1966 food items including live animals made up 29.99 percent of total imports, non-durable consumers goods; 9.82 percent, durable consumers goods; 8.31 percent, industrial supplies; 27 percent, and investment goods; 24.88 percent.

The direction of Saudi Arabia's trade is determined by the destination of its oil exports. Western Europe\* used to be the principal market for Saudi oil exports. In 1959-60, 42.3 percent of the total exports of Saudi Arabia went to Western Europe. The figure declined to 32.1 percent in 1962-63 and in 1966 less than 20 percent of the total exports. Japan

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\*This includes U. K., France, Netherlands, Belgium, Italy, Germany and Spain.

has been replacing Western Europe as the principal importer of Saudi oil. In 1966 Japan imported over 20 percent of total exports; which is more than the imports of Western European countries combined (30, p. 324).

The largest single source of Saudi imports has been the United States. This has been mainly due to Aramco's purchases of equipment and other goods from American firms. The closest competitors to the U. S. in supplying Saudi markets are the Western European countries and Japan.

Foodstuffs are mainly supplied from the Middle East especially from Lebanon, Syria and Jordan.

The balance of payment stands in favor of Saudi Arabia. This is mainly due to two reasons; one is the exports of oil which has been referred to earlier. The other source is the annual pilgrimage to Mecca and Medina of hundreds of thousands of Moslems from all over the world.

Recent estimates of the balance of payments for Saudi Arabia are not available at the time of writing this report.

Transportation and communication      A variety of transport routes are available in Saudi Arabia, ranging from caravan routes to airports. A number of the ancient caravan routes, especially in the Asir highlands, are still in use. Camels are used for transport in villages and towns that cannot be reached by automobile.

The government has had an ambitious program of road construction which has the objective of strengthening the domestic economy. A total of 6,695 kilometers of asphalted roads were completed between 1950 and 1968 (30, p. 268). Paved roads now connect the important cities in Hijaz,

Nejd and the Eastern province. Among the new government projects in the construction of roads in the difficult mountainous terrain to connect the rich agricultural areas with the different towns of the Kingdom.

The only railroad in operation is the single-track, standard gauge railroad owned by the government. It extends for 357 miles from the eastern port of Damman to Riyadh. Passenger trains run during the day and freight trains during the night carrying oil products, agricultural produce and consumer goods between the eastern coast and the capital. Ocean freighters at the port of Damman can discharge their cargoes directly into railroad cars for shipment to any destination on the line. In 1967 the railroad handled 672,000 tons of freight and carried 97,000 passengers (30, pp. 296-97).

Air transportation assumes special importance in a vast country when major cities are separated by hundreds of miles of desert. The Kingdom has three first class airports at Jidda, Riyadh and Dhahran and numerous secondary airports and landing strips.

The major seaports are located at Jidda on the Red Sea, and Damman and Ras Tanura on the Arabian Gulf. Other ports are found in Yanbo, Jizan, Khobar and several other cities in Saudi Arabia. Some of these ports are used only when there is pressure on the major ports.

The postal and telecommunication systems are being improved and expanded. The automatic telephone system will be completed in 1971 and radio-telephone and teleprinter service is to be expanded and improved. Studies are undertaken to assess the increased demand for telephones and



the appropriate charges to users of telecommunications services.

Efforts are also being made to improve postal services. Mail must still be carried by means of animals to rugged and remote areas. Planning is concentrating on the identification of problems and measures to overcome them and the determination of additional facilities required.

Agricultural sector      Because of the importance of the agricultural sector in Saudi Arabia, and the role that it is expected to play in the economic development of the country, a separate chapter is devoted in this report for studying the structure and nature of this sector.

## CHAPTER III. STRUCTURE AND NATURE OF AGRICULTURE SECTOR

The topographical and climatic conditions in S. A. renders the agricultural sector to be relatively unimportant in its contribution to the GNP (about 7.7% in 1966/67), especially when it is compared to the booming oil industry. Nevertheless, possibly as much as 75 percent of the population is engaged in farming and herding, and agriculture provides employment for about 46% of the national labor force.

There is ample evidence throughout the country of prosperous agriculture in the past. Outlines of former gardens, irrigation ditches and ruins of ancient dams in Taif and Khayber are examples of this evidence. Over-use of ranges, uncontrolled exploitation of trees and shrubs and an overall neglect of land conservation and water resources have contributed to the deterioration of much of the formerly productive land.

Since the mid 1960s the government has been making serious efforts to reclaim land mainly by seeking ways of increasing and preserving the water supply, since it is the availability of water which largely determines the areas suitable for agriculture. Because of the scarcity of available water resources vast areas of the country are utilized only by nomads who travel long distances with their herds in search for the grass. Pastoralism has been traditionally the most important source of agricultural income and as of 1965 provided a livelihood for approximately 50 percent of the population (71).

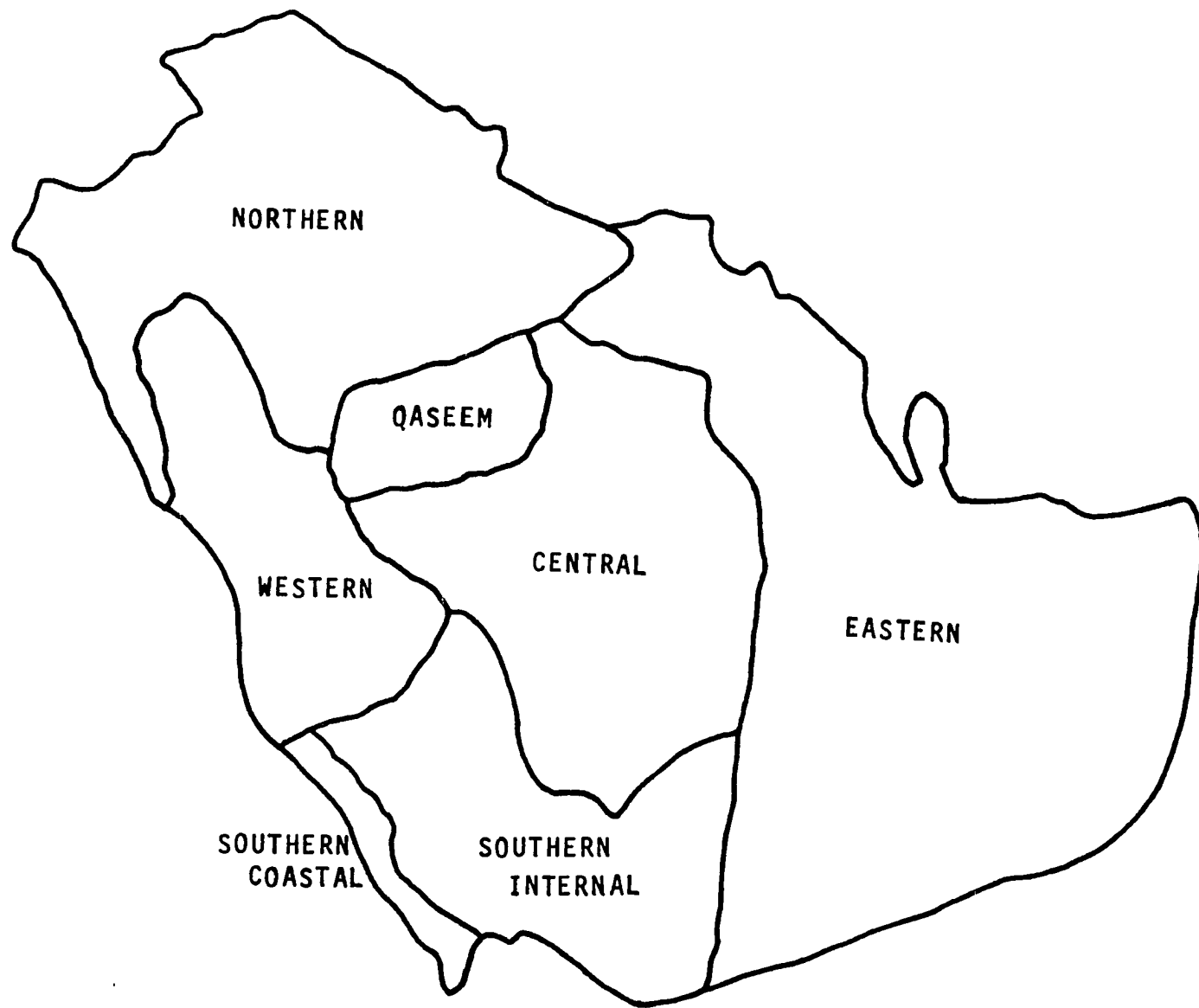
Of the pastoralists approximately 200,000 to 300,000 are Bedouins who wander constantly with herds of camels over hundreds of miles of

their tribal districts. The remainder are semi nomads who raise mostly sheep and goats. They remain at permanent watering places near villages in the dry season and move out into the remote areas of their tribal districts after the annual rains. Some live in huts and cultivate crops such as millet, sorghum and watermelons during their sedentary phase.

The average growth rate of agriculture for the period 1962/63-1966/67 has been estimated at 3.9% per year with the possibility of being actually lower. The growth rate varies greatly among sub-sectors with highest rates in the poultry and vegetable production. In the date and the livestock sub-sectors the growth rate has been static or even declining.

The country has become increasingly dependent on imported food stuffs in the last 10-15 years. This has been due to a high population growth rate estimated at about 2.7% per year, higher income, urbanization, changing consumption habits and a growing number of foreigners working in the country. The annual value of agricultural imports more than doubled between 1957 and 1967 with an annual increase of 11% per annum, accounting for about 30% of total imports later in the period. Cereals and animal products are the most important items imported followed by fresh and preserved fruits and vegetables, sugar, coffee and tea. The country, however, exports some fruits and vegetables as indicated in "Saudi Econ. Survey" of Aug. 6, 1969. An average of 500 tons of fruits and vegetables are exported daily to Kuwait, Bahrain and the Arab Gulf area. These exports come mostly from Qaseem and the Eastern Province. (See Figure 2.)

Figure 2. Geographical areas of Saudi Arabia



Imports of animal products increased by 15% per annum between 1957 and 1967. For 1966 alone, about 935,000 sheep and 24,000 head of cattle were imported representing a total value of SR 169 million. The imports of cereals increased about 14.5% per annum during the same period and were valued at SR 263 for 1967.

Until 1966, a long list of imported food stuffs received a price subsidy of 16 2/3% of the C.I.F. price. The subsidy amounted to SR 50 million in 1965/66. On January 25, 1966 these subsidies were discontinued except for wheat grain, rice and meat. On July 1, 1968 the subsidy on wheat grain was reduced to 12.5% and a year later was further reduced to 8.33%.

### Agricultural Resources

#### Land resources

The Arabian peninsula is made up of three geographic zones: a narrow coastal plain along the Red Sea, a mountain range, highest in the south separates the coastal plain from a great plateau which slopes east towards the Arabian Gulf. Soils tend to be coarse in texture with low content of organic matter. Sand, loam and sandy loam is common. Since much of the groundwater has a relatively high salt content and because of the irrigation practices salinity is quite wide spread. The main part of the cultivated land is found in the southern coastal province and on the inner side of the mountain range. The cultivated land on the plateau is found in the form of scattered irrigated areas and oases, mainly in the Central Province, Qaseem and Western Province as illustrated in Table 2.

Table 2. Area and number of agricultural holdings by region and type of tenure<sup>a</sup> in 1968 (donums)

Region	Area of holdings		No. of holdings	Area per holding		Percent of area rented
	Total	Cultivated		Total	Cult.	
Northern	326,507	104,682	11,510	28.4	9.1	0.1
Eastern	126,136	101,593	9,098	13.9	11.2	18.6
Western	339,648	252,098	19,518	17.4	12.9	1.6
Qaseem	2,695,748	319,635	9,071	297.2	35.2	4.3
Central	680,274	515,128	8,540	79.7	60.3	16.4
Inner South	457,833	381,963	38,816	11.8	9.8	9.3
Coastal South Qunfudhah	905,927	752,439	43,312	20.9	17.4	3.3
Jizan	2,113,376	1,537,136	48,188	43.9	31.9	0.4
	<u>7,645,449</u>	<u>3,964,674</u>	<u>188,053</u>	<u>40.7</u>	<u>21.1</u>	<u>5.8</u>

<sup>a</sup>Source (30, p. 205).

The total cropped area is 419,600 hectares which gives a cropping intensity of 1.08 or on the average a little more than one crop per year (3, p. 5). This indicates that much of the cultivated land is left as fallow or idle, and that with increasing water availability there could be a great potential for increasing the cropping intensity.

In general, temperatures are too high in the summer months reaching 40°C or even 45°C occasionally. In winter, temperatures may drop below freezing. There is also wide variations between day and night temperatures especially in inland areas. Humidity is low except in coastal regions.

On the average, most of the country receives less than 5 inches of rainfall annually. (See Table 3.) The highest and most dependable rainfall is in the highlands of the south western part of the country, where most of the cultivated land of Coastal South and Inner South is located. The average over most of this area is about 16 inches although as much as 40 inches has been recorded. Strictly speaking, however, all cultivated land is classified as irrigated since the so called rain-fed land is also partly irrigated by water spreading at flood times.

#### Water resources

Water for irrigation comes partly from streams and rivers which form after rainfall. Run-off water is the main source of irrigation in the Central South. This is done by water spreading and some storage in tanks and small dams. Because of the dependence of the Southern provinces on the rainfall the area of winter crops may vary considerably from year to year.



Table 3. Annual rainfall at selected stations, 1959-66 (millimeters)

Station	1959	1960	1961	1962	1966
Dhahran	148	-	80	-	40
Hayil	-	-	-	-	73
Jizan	-	-	-	-	257
Liddah	47	41	34	96	66
Medina	41	85	45	-	26
Riyadh	66	50	53	-	14
Tayif	-	-	132	-	155
Turaif	64	25	28	-	-
Al-Wajh	-	-	-	-	40

Ground water is the most important source of water for irrigation. It comes mainly from two sources. One is water from shallow wells found along valley floors in alluvial fill and fed by current rainfall. This water is easily used up when there is a series of dry years but quick recharge takes place during periods of rain. The second source is deep fossil water found at depths exceeding 2000 meters and may be as many as 30,000 years old. The recharge of this source is negligible, and therefore it has to be treated as an irreplaceable scarce resource. Development of water resources of this kind requires efficient use of water to (minimize) waste.

Since the introduction of powerful drilling rigs and deep well pumps about 30 years ago, a large number of public as well as private wells has been drilled. The total number of wells exceeds 62,000 wells distributed all over the country as shown in Table 4.

Systematic investigations of water resources by foreign consulting firms have shown that underground water resources to be far greater than previously estimated.

About 31.3 percent of the total cropped area of 420,000 hectares is irrigated from wells and springs and about 288,000 hectares or 68.7 percent are rain-fed irrigated. More than 90 percent of the rain-fed area is in the coastal south.

It was later found by resource surveys that the rain-fed area is large in the Southern Internal Province in years of plentiful rainfall.

#### Human resources in agriculture

Estimates indicate half to three-quarters of the people in Saudi Arabia depend directly on agriculture for their living. Of those, nearly one third are nomadic people called Bedouins. The others are commonly known as settled farmers who live as permanent residents at fixed locations and make their living by raising crops. This classification oversimplifies the picture, however, since some of the nomads cultivate wild crops using manual labor and some may have permanent sites to which they return seasonally. On the other hand some of the settled people although concentrating on raising crops, may also keep sheep, goats and cattle. Some may spend part of the year with herds as part-time nomads.

Table 4. Irrigated land by source of irrigation - S.A. in 1968<sup>a</sup>

Region	Land irrigated by wells						Area irrigated by springs	Rainfed area	Total irrigated area
	No. of wells		Area irrigated (donums)						
	Artesian	Ordinary	Artesian	Ordinary		Total			
				with engines	without engines				
Northern R.	46	7,385	2,425	55,129	26,214	83,786	4,031	16,883	104,682
Eastern R	-	-	-	-	-	-	-	-	-
Western R.	121	10,918	3,300	53,758	40,310	97,368	18,836	135,894	252,098
Qaseer	3,985	958	-	-	-	309,591	7,870	2,174	319,635
Central	522	6,787	54,363	435,151	9,376	498,890	5,098	11,140	515,128
Southern Int.	-	30,877	-	145,241	127,247	272,488	1,147	108,327	381,962
Southern Coastal Qunfudhah	-	-	-	11,755	199	11,954	1,263	773,049	786,266
Jizan	-	-	160	807	-	967	-	1,835,051	1,836,018

<sup>a</sup>Source (30, p. 209).

Agriculture's human resources are not distributed uniformly over the vast area of Saudi Arabia. The densest concentration of people is in the south, particularly in the Asir highlands. Over most of the Kingdom, permanent settlements are found only around oases or watering places. The grazing lands are populated only by nomads, whose location shifts with the availability of feed and water. In the desert, therefore human population is very sparse and transient. The population of the major cities is not closely related to local agricultural productivity.

The rapid changes that have taken place in the Saudi society and economy during the last decade raise the question as to whether the Saudi farmer will be able to adapt to the process of modernization. The more settled farmers seem to be pragmatic in attitude toward mechanical devices, and to have no reservations about abandoning outdated techniques for modern methods. Evidence of their change in attitudes is witnessed in their willingness to substitute gasoline and electricity for human and animal power in lifting water. They seem also to be willing to buy or hire from others any input they need and do not possess, whether that input be capital or labor. These and other examples suggest that the commercialization of agriculture in Saudi Arabia may come faster than many other countries of similar nature.

Bedouins and nomads      The traditional Bedouin economic and social systems are gradually and indirectly being transformed through the development of other sectors of the economy. Other direct measures,

principally settlement programs, are being undertaken, although these affect only a small percentage of the nomadic population at present. So far there has been no systematic attempt to relate the betterment of the Bedouins with the productivity of range resources of the Kingdom through combined projects of gradual settlement and range management. The term Bedouin refers here to the truly nomadic population of the Kingdom, who (32, p. 29) 1. live in tents, and move throughout the desert with their livestock, and 2. earn most or all of their living from livestock. It has been estimated that the purely nomadic Bedouins make about 20 percent of the Kingdom's population.

A variety of schemes for assisting the Bedouins has been attempted for the last half-century. The main objectives have been the betterment of the economic conditions of the Bedouins through direct assistance and at the same time providing a means for them to participate more fully in the social and economic life of the country. These different schemes may be classified into three categories (32, p. 32): (1) direct relief payments, (2) complete settlement schemes, and (3) gradual or partial settlement schemes.

#### Land use

According to government figures about 90 percent of the total area of the Kingdom is used as pasture or rangeland. A limited area is covered by forests which together with the rangeland is largely publicly owned. About 7.65 million donums, or one-third of one percent is in private agricultural holdings. Of this, slightly more than 3.96 million donums is cultivated land.

Table 5. Field crops area according to regions - 1968<sup>a</sup> (donums)

Region	Winter crops					Summer crops					Total
	Wheat	Barley	Hilba	Broad beans	Others	Millet	Sorg.	Sesame	Rice	Others	
Northern	60,388	9,037	-	177	-	6,287	31	-	-	18	75,938
Eastern	-	-	-	-	-	889	-	-	7,886	-	8,775
Western	72,195	83,395	-	-	6	6,967	3,328	-	-	629	166,520
Qaseem	155,701	16,048	872	10	259	6,474	6,244	-	-	679	186,287
Central	248,306	8,089	449	68	-	39,277	33,057	-	-	-	329,246
Southern Internal	180,738	74,409	474	131	9,393	2,186	96,566	-	-	404	364,301
Southern Coastal											
Qunfudhah	610	3,455	-	-	2,719	391,533	376,531	16,925	-	711	792,484
Jizan	1,673	26,140	-	-	-	557,576	1,043,249	208,428	-	874	1,837,940

<sup>a</sup>Source: (30, p. 210).

Table 6. Land use of holdings by region - 1968<sup>a</sup> (donums)

Region	Permanent crops				Field crops			Vege- tables	Total area
	Palm and fruit trees	Clover	Henna & coffee	Total	Winter crops	Summer	Total		
Northern R.	23,201	4,430	6	27,637	69,602	6,327	75,929	7,774	111,340
Eastern R.	-	14,835	64	14,899	-	8,775	8,775	8,886	32,560
Western R.	47,124	3,177	326	50,627	155,596	10,924	166,520	40,098	257,245
Central R.	61,236	74,894	-	136,130	256,912	72,334	329,246	152,308	617,684
Qaseem R.	26,485	78,473	-	104,958	172,890	13,397	186,287	83,003	374,248
Southern Internal	63,472	39,154	145	102,771	266,440	99,587	366,027	14,113	482,911
Southern Coastal	2,021	1,626	-	3,647	34,798	2,595,847	2,630,645	2,831	2,637,123

<sup>a</sup>Source: (30, p. 207).

The total cropped area is approximately 4.29 million donums which means that on some cultivated land more than one crop is raised in one year. On the average the multiple cropping ratio is 1.08 which is not great.

To a great extent, Saudi Arabian agriculture is concentrated in the southwest where farmers rely largely on rainfall for the irrigation of crops, such as sorghum, millet, sesame which are adapted to that region. Their combined area is nearly 2.80 million donums of the total of 2.88 million donums for all rainfed crops. These three crops, therefore, account for almost two-thirds of all the area of non-tree crops (3, p. 9).

Wheat and barley are the third and the fifth ranking crops in area. They are grown where well or spring irrigation can be practiced, which helps explain the high yields relative to other countries of the Middle East\*.

Vegetables are nearly always irrigated. Although produced on year-round basis, they only account for 7 percent of the area of crops in the Kingdom. This seems to be strange on account of the fact that vegetables have been more profitable to farmers with tomatoes and watermelons topping the list.

It is hoped that the newly inventoried land and water resources and the data from resource surveys - these will be presented separately in a later section - which were done by three contracting companies, will be

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\*Wheat est. at 2880 kgm/hectare F.A.O. 62/63  
Barley est. at 1600-2100 Ministry of Agr. 61.



the basis for planning the development of agricultural resources for higher productivity and efficiency.

#### Land tenure and farm size

The total area of agricultural holdings in Saudi Arabia is put at 7,645,449 donums in government reports as of 1968, and the total number of holdings is reported as 188,053. As shown in Table 2 above, the average area per holdings for the nation is 40.7 donums (about 10 acres). Of the total area of holdings, about one-half is cultivated land.

There is much variation in average size of holdings among the different regions. While the average holding in the Inner Southern Region is only 11.8 donums, it is 297.2 donums in Qaseem. The area of cultivated land per holding varies less widely ranging from 9.1 donums in the Northern Region to 60.3 donums in the Central Region.

The wide variation in size of holdings can be explained in part by the patterns of land use and labor intensity in production. Holdings that are operated on a subsistence basis tend to be small. An average holding of 10 donums can yield enough for family sustenance if it is sufficiently productive. Upon examination of Table 7, it can be seen that the average holding approximates this size in several of the Kingdom's Regions.

Another factor which may place a limit on the farm size is the availability of family labor. In Jizan, where the crops are raised with little or no irrigation other than water spreading, labor requirements are reduced and the area farmed by the family proportionately increased. The

relatively large areas per holding in Qaseem and Central Regions, by contrast, is likely to be related to more mechanization in these areas and more commercial farming with the use of hired labor.

The forgoing description of farm size does not give a true picture of the actual distribution. Large holdings, though relatively few in number, exert a pronounced effect on the arithmetic mean size. Actually, about 46% of the holdings are less than 0.5 hectare, 25% between 0.5 and 1.0 hectare, 25% between 1.0 and 5.0 hectares and only 4% are more than 5.0 hectare ( 3, p. 4). Such problems as insufficient income, inefficient production and lack of opportunity for investment are encountered by Saudi farmers with small holdings.

Farmers who shifted from cereals to vegetables and who adopted intensive methods to improve yields have experienced increased labor requirements. Such farmers have already begun seeking machinery to substitute for labor, which is enough of a reason to increase farm size to make more efficient and profitable use of available machines which are suited to use on large holdings. As these and other technological and economic changes invade the rural scene, the characteristics of the typical production unit in agriculture may be expected to change with respect to area, investment, operating budget, use of inputs from non-farm sources, and reliance on commercial markets for the products.

Table 2 also shows that tenure in Saudi Arabian agriculture favors landownership as opposed to renting. Over the country as a whole, only 5.8 percent of the land is rented. In two of the regions (Northern and

Jizan) the proportion of rented land is less than 1 percent, and the highest proportion found in any region is 18.6 percent. Explanation of this variation is not readily available.

#### Agricultural services and institutions

Marketing and transportation      Crop production and animal husbandry in Saudi Arabia are largely for subsistence of farm families or for sale in local markets. However, there are indications of a trend towards a more commercial agriculture. One example is the poultry industry which is entirely a commercial enterprise.

One of the principal obstacles inhibiting efficient marketing of farm products facing the producer in marketing his output is the lack of adequate transportation and communications. Although steady progress is being made in the construction of major highways, there is little in the way of an adequate network of farm-to-market roads. Truck transport on rough, unsurfaced roads and desert tracks is high. Farmers may either transport produce by animal power or pay trucking rates up to at least three times the rates on surfaced roads. In addition, the delay and damage to perishable produce caused by inadequate transportation results in sharply reduced quality and lower producer prices.

A recent survey of the J-M-T area indicates that over 60 percent of the fruits and vegetables (excluding dates), 80 percent of the meat (excluding Hajj Slaughter), and more than 95 percent of the cereals consumed in the region are imported, mostly via the port of Jidda. Subsidization of imported food products by the government hurt the farmers by

further depressing domestic food prices.

In addition to the problem of transportation, the shortage of price and market information creates uncertainty concerning the profitability of selling products in different market.

Marketing is also hampered by lack of standards and grades, limited storage, processing and refrigeration facilities. As a result prices vary seasonally and geographically among the different regions in the Kingdom. These differences are evidence of the lack of marketing information and distribution facilities and the unequal impact of the inter-regional and international competition.

Agricultural credit Changes needed to transform primitive agriculture into modern agriculture are founded on additional inputs of capital and labor. Lack of funds prevent many farmers from adopting new methods although they may be convinced of their superiority to traditional methods. Credit has proven to be very effective in less developed countries as a tool for speeding the required change for economic development.

The agricultural bank, established in 1964, represents an important step forward to meet the farmers need for credit. The number of loans has been rapidly increasing, and the total value of loans has increased from SR 4.41 in 1964/65 to SR 55.7 million in 1969/70. The bank started with a capital of SR 10 million, which has grown to SR 53 million as of January 1970. It has now 25 branches distributed in the different regions of the Kingdom. The number of the loans given to farmers since the initiation of the bank to January 1970 reached 14095, which is

unfortunately very low (about 8%) percent of the total number of agricultural holding in the country. This indicates that there is much scope for an increase in the coverage of the bank.

The bank has been extending loans of different durations and for different purposes. During the first two years of operation medium term loans (two to five years) made up 97 percent of the total volume of loans with the short term loans making up the remaining 3 percent. However, short term loans have increased in number over time although the average size of a loan has not changed very much. Only very few long term loans (more than 5 years) have been made by the bank. The bulk of the loans has been for irrigation facilities. In the year 1387-88 about two-thirds of the loans went for some aspect of water supply.

There is a close cooperation between the bank and the Agricultural Extension Service on a program of supervised credit, which may have an important impact on the introduction of new technology. Short term credit for purchasing fertilizers has become increasingly important.

Agricultural education and extension      The only College of Agriculture in the Kingdom was established by the University of Riyadh a few years ago. The first class was graduated in 1970. Because of the limited number of graduates Saudi agricultural graduates, the Ministry of Agriculture employs a large number of foreigners to staff its offices. Since many of these foreigners experts are on contracts of short durations, and because they normally leave the country upon expiration of these contracts,

outstanding problems and unfinished jobs may continue to exist after their departure.

Five vocational agricultural schools were established in 1960 to supply education at the primary level. Students of secondary education level have been sent abroad to Egypt and Jordan and other countries for training. Recently, vocational agricultural schools have been established in the country and are supported now by F.A.O. which also cooperates with the Ministry of Agriculture in providing in service training for government employees. Some local firms are also cooperating by providing agricultural machinery and equipment for training.

A separate Research and Development Department in the Ministry of Agriculture maintains eight research stations in the country. The main research station is located at Qatif and supported by a U. N. project. It is again observed here that the trained Saudi are in short supply and, therefore, a large number of foreigners are doing the research.

The Agricultural Extension and Services Department is the main link with the farmer. In addition to extension, this department provides services to the farmers in the fields veterinary medicine, plant protection and agricultural engineering. These activities are carried by 500-600 field employees, of whom only 10-15 are college graduates, about 65 Saudis with vocational agricultural training and 400-500 contracted foreigners.

The foregoing discription of the agrisector leaves the impression that much is yet to be done in the various agricultural activities in the way of improving the efficiency of production and the economic development

of the sector.

In the following chapter an attempt is made to summarize the goals and needs in agricultural development and the obstacles and conditions to be met.

#### CHAPTER IV. GOALS AND NEEDS IN AGRICULTURAL DEVELOPMENT AND OBSTACLES AND CONDITIONS TO BE OVERCOME

##### Goals of Agricultural Development Plan

Saudi Arabia is fortunate to be endowed with a great natural resource, namely, oil. Revenue from oil has been the major source of financing the development in the country. Although the oil sector is highly industrialized and vastly commercialized sector, the non-oil sector predominantly agricultural in nature, is lagging behind in its stage of development, its productivity and its contribution to the national income.

Since oil is an exhaustible resource, it is only natural that Saudi Arabia should derive maximum benefit from it while it lasts. This necessitates the channelling of oil revenue in such a way as to create a self-sustained growing economy capable of generating enough savings and investment compatible with continued growth without reliance on one sector.

This task cannot be achieved without the transformation of the non-oil sector which happens to be dominated by agriculture. The agricultural sector suffers from multitude of problems that are presented later in the chapter. However, the transformation of agriculture is of paramount importance not only to the farmers, but also to the economy as a whole, which is the broad goal of the economic development of agriculture.

The development theory has stressed the importance of agricultural development in the overall process of economic development for (1) it releases agricultural labor for non-farm employment, (2) it helps the



balance of payment by exports or through reduction of imports by import substitution, (3) it is necessary because it meets the rise in demand for food as population increases, and (4) through increases in productivity and incomes, it furnishes additional savings which are needed for investment in all sectors of the economy.

In Saudi Arabia, the main goals of agricultural development are two-fold. One, is to provide better incomes and living conditions for the farmers. The second is to allow them to participate more affectively in the development of the country. The government states its objectives in developing the agricultural sector in the following manner:

1. Improvement in the efficiency of producing agricultural products and increasing their output for the following purposes:
  - (a) Obtaining increased income and improved living conditions for producers, and thus providing opportunities for entrepreneurship and employment in agriculture comparable at least to those of other economic sectors.
  - (b) Achieving, in the public interest, an abundance of food supplies as well as savings for domestic consumers.
2. Establishment of sound plans for resources distribution and utilization for the welfare of this and future generations, in the following way:
  - (a) Finding and adopting improved technology appropriate to the needs of farming systems and cropping patterns being established by producers.

- (b) Encouraging and promoting, through strengthened extension and training programs, the adoption of selected production systems and improved farm and ranch practices.
- (c) Implementing rational investments in basic production and distribution facilities.
- (d) Providing for efficient use of water for both domestic consumption and agriculture, according to the needs of a growing population and the expanding requirements for the development of feed and food supplies.
- (e) Fostering and encouraging the rational organization of public and private infrastructures and, particularly, establishing market-supported institutions and distribution practices.
- (f) Establishing economic and effective conservation and resources control measures.
- (g) Encouraging and establishing a strong and independent private entrepreneurship, concurrent with the strengthening of public services to the private sector.

Agriculture's contribution to the national development goals also includes the following benefits to the country not readily clear from GDP or employment data:

1. Increased employment in other sectors, as the agricultural output is transported, processed, marketed, resulting from increases in agricultural production.
2. Domestic production of selected crops and livestock, which reduces the need for imports.

3. Substantial opportunities for production of commodities (for domestic consumption) at costs lower than those of foreign-produced substitutes.
4. Self sufficiency, which is economically attractive because of its strategic implications and because of the resulting reduction in dependence on foreign exchange.

The plan goes on to outline quantitative production targets and suggest that the potentials for agricultural development involve increases in area, yield, and value.

The projected increase in area is based on the data from resource surveys. These show that Saudi Arabia has additional land resources that can be put under cultivation, and subterranean water that can be used for irrigation. The area of irrigated cropland, accordingly, can be expanded 5 to 10 percent over the five years following the inception of the plan.

Yield increases are assumed to be achieved through substitution of improved varieties and the application of new techniques.

Value increases are achievable through replacement of low-valued crops by high-valued crops. As an example it is suggested that cereals be replaced by vegetables selected for higher values per unit area of land.

#### Problems of Agricultural Development

The process of economic development, in general, can be looked at as a function of several endogeneous and exogeneous factors. Put in functional form it can be illustrated by:

$$D = F(X_1, X_2, \dots, X_n)$$

where D refers to the state of economic development or underdevelopment,  $X_1$  may refer to natural resources,  $X_2$  to human resources,  $X_3$  to capital,  $X_4$  to technology,  $X_r$  to market and  $X_{n-1}$  to exogeneous factors, etc.

The economic development of agriculture in Saudi Arabia is no exception. It is a function of all the above mentioned factors plus some other factors characteristic of the country's agriculture and rural population.

In presenting the obstacles to agricultural development, this report will follow the functional approach as outlined above.

#### Natural resources

The availability and utilization of natural resources were presented in a previous chapter. It may be appropriate to mention again that, with the exception of oil, Saudi Arabia has limited supply of natural resources which are also misused or underutilized.

Topography, climate and the scarcity of water resources limit the cultivable area to a meager .18 percent of the total area of the Kingdom. This land displays the double problem of being occupied by high population concentration and low productivity.

Resource surveys inventorization of land and water resources supplies the basis for optimism in regard to expanding the cultivable area in the Kingdom and improve the agricultural sector's contribution to the overall development of the Kingdom. However, many questions have to be answered before the dreams become realized. How to use water economically, what

to produce on the newly irrigated land, how much to produce of the different crops and where to market the products are only few of these questions. How these problems are solved will determine the immediate future of the agricultural development in the country.

Perhaps the most depressed of Saudi Arabia's resources are the range resource. Consecutive years of drought and (the) continuous overgrazing of the patches that become green due to sporadic rainfall, have contributed to the poor conditions prevalent on the pastures. In 1925 tribal legal claims to particular pasturage districts were abolished by the government in order to maintain peace among the tribes. Since then, the Bedouins and seminomads, who own 80 percent of the livestock in the country, often disregard traditional tribal limits as they follow the rains. Areas where pasture is found are almost inevitably overgrazed and often prevented from reseeding themselves. Consequently, both the quality and quantity of the animals are held down.

In areas of the Kingdom where ground water has been discovered and made available for irrigation, waste and irresponsible use are very common. In the absence of water code and the regulation of water user charges, there is apt to be an indifference on the part of agriculturists on how efficiently water is used.

#### Human resources

Generally speaking, human resource is the major factor on whose articulation and skill depend the productivity of other factors of production. The availability and adequacy of productive labor and industrious

entrepreneurship determine to a large extent the degree of success or failure of any development endeavor. This is true of all sectors, in any country, provided that the human resource has access to proportionate supplies of other productive factors including technological knowhow.

Unfortunately, Saudi Arabia in general and the agricultural sector in particular, are lacking an adequate supply of efficient human resource. As in other less-developed countries, farmers have low levels of education or even all together illiterate. Illiteracy, adherence to traditional methods of farming, and ownership of very small holdings are all factors contributing to the characterization of agricultural (sector) as a subsistence sector.

The fact that the agricultural sector employs about 46 percent of the total labor force, and yet the country remains as a net importer of large amounts of foodstuffs, demonstrates clearly the low productivity of farm labor. This coupled with the severe shortage of entrepreneurial class among farmers, makes the education and development of human resource an indispensable prerequisite for any development plan for the agrisector.

Recognizing the shortage in skilled labor and trained personnel, the government has enlisted the help of foreigners as employees, technical advisers and planners. Many of these foreign specialists, however, come to Saudi Arabia on short term contracts and they leave the country after conducting the survey, research or project they were entrusted to do. This leaves much to be done locally after preliminary studies are completed. If we realize that the job can't be completed by Saudi's we can

understand why many things remain outstanding. The only alternative for Saudi Arabia then, would be to develop its own human resources to furnish the basis for planning and executing the economic development of the country.

### Capital

Theories of economic growth and development place great emphasis on capital accumulation and growth as prime movers in the process of economic development. Some models even go th the task of explaining that the net addition to the capital stock (investment) is all that is needed for growth. Others attribute the lack of development on the part of many LDCs to the inability of these countries' population to raise enough savings and mobilize these savings for purposes of economic growth. Although this appears to be true to a large extent, the process of economic development has proved to be so complex and may vary from one country to another. This accounts for the multitude of theories that try to explain the economic development.

In Saudi Arabia, it has been long recognized that the subsistence agrisector, being what it is, has been unable to accumulate capital. By definition, when farmers produce for subsistence, they cannot possibly save and hence cannot accumulate capital. Fortunately oil was discovered in the country and the government derives its revenue mostly from oil royalties and taxes. It is realized in Saudi Arabia that any efforts for development must start with government spending in infrastructure

in education, health, extension, projects, etc. Higgins model (21, p. 818) on the development of Libya as a case of development of with unlimited supply of capital, almost applies to Saudi Arabia as well. Here, as in Libya, income from oil accrues at no or very little cost to the Saudi Arabians. The investment of this income, however, should be carefully planned. Allocations to different sectors and projects within sectors are among the most important tasks of the government of Saudi Arabia.

### Technology

The state of technology in the Saudi agrisector is primitive. Modern techniques in production and marketing are lacking. Change is obstructed by and adherence to traditional methods. In addition, the physical conditions of the country, the low level of education, the lack of transportation and communication and the limited number of extension agents are all factors contributing to keeping many farmers isolated.

Even if the farmers are exposed to modern technology, it is doubtful that it will be readily adopted. For one thing, some techniques which are productive render a certain set of climatic conditions, soil type and management may not be equally productive under another set. The uncertainty associated with the adoption of new practices, inputs, etc. acts as a barrier not only in Saudi Arabia, but also in most of LDCs. On the other hand the cost associated with using machinery, and the uneconomic use of machines on small holdings, render mechanization of agriculture unattainable and undesirable among small farmers.



### Other problems

A host of other problems handicap the process of economic development. These problems will be summarized in the following paragraphs.

1. Marketing problems: marketing facilities are considered in many LDCs as part of the infrastructure of the economy. In Saudi Arabia such facilities are minimal. Markets are distantly separated, information about prices is not available and poor transportation and communication facilities tend to isolate villages from the rest of the economy. This usually results in a large number of local markets with few or no external linkages. Consequently, many government policies and programs do not affect appreciably, producers' activities in remote areas.

The absence of market price information and the uncertainty that arises, therefore, reduces the incentives of farmers to produce for the market and cause them to produce only to satisfy their needs. This is particularly true if the farmer has to transport his produce, which may be perishable, long distances using animal backs, only to find the prices do not justify all the trouble.

Other marketing facilities like refrigeration, storage and processing are not available thus intensifying the farmers' problems.

2. Lack of proper institutions. It hardly need mentioning that rural institutions can be used as instruments or vehicles for change. Land tenure institutions, credit institutions, marketing institutions and planning institutions are all very important for implementing economic

development at the agricultural as well as on the national level.

Such institutions are not abundant in rural Saudi Arabia. It follows that all kinds of economic activities including production, marketing, borrowing and lending and investment are haphazardly determined.

3. Goals, values and attitudes of farmers. These emanate from the social, cultural religious background of the rural population. Since a large number of farmers produce for subsistence, they do not place high emphasis on market mechanism. It follows that for these farmers, decisions affecting production, consumption investment are conditioned by the above mentioned non-economic factors affecting the producers objectives. It so happens that the social religious structure as it exists in agrisector is not easily conducive to change.

The planning unit of the Ministry of Agriculture in its effort to identify the bottlenecks in agricultural growth, and to prescribe ways and means of removing them, drafted the following questions as the focus of attention (31, pp. 56-58):

1. Are selected market institutions and information systems being developed to assure more stable markets for the priority agricultural products?
2. Can the extreme fluctuations in commodity prices and depressed prices be avoided?
3. To what extent can incentives to producers be developed to encourage an increase in commercial farming?
4. Are the work plans of principal projects of the research, extension, training, land management and water developments targeted directly

toward utilization of specific resources? Will the work plans resolve specific problems of production which may be related to the priority programs and plans?

5. Is there effective coordination of efforts by Ministry agencies to assist the farmer, and is the assistance from other non-Ministry sources being utilized to achieve greater impact?
6. Can radio and other information media be used more effectively in encouraging farmers to adopt improved practices?
7. Is there adequate project planning for the optimum development and conservation of available agriculture, water, and other resources in the Kingdom?
8. Is the present manpower of the Ministry being well used? Are the programs for manpower training being developed in relation to the specific need of the sector?

## CHAPTER V. PROJECTS, STUDIES AND PLANS

It was mentioned earlier in Chapter II that the government concern over the development issue in the early 1960s, prompted the invitation of an IBRD mission to the Kingdom. (Initial) public investments took place along the lines established by IBRD's recommendations. In 1960 the government established the Supreme Planning Board which was replaced three years later by Central Planning Organization (CPO) which was invested with the task of planning in the Kingdom.

In this chapter, a run down of the government's efforts in economic development will be attempted. It is evident that much of the government efforts, plans, investments, etc. affect largely the non-oil sector, since the production and growth of oil sector is exogenously determined. Government programs affecting the agricultural sector are entrusted to the Ministry of Agriculture and water and reference to the government implies the Ministry and vice versa.

Many private individuals, corporations and international agencies have contributed in various capacities in programs initiated by the government. Presentation of the substance of this chapter will take place along the following line:

1. Projects undertaken by the government as part of the infrastructure needed for agricultural development.
2. Summary of studies and surveys undertaken by the government or by individuals, institutions, corporations and international agencies on behalf of the government. Special attention will be given to the

recent agricultural and water surveys which has been done by contracting firms.

3. A summary of the five year plan for the development of the agricultural sector.

### Water and Agricultural Projects

The Ministry of Agriculture and Water in Saudi Arabia is undertaking the execution of several water and agricultural projects throughout the Kingdom. Only the most prominent projects will be briefly presented hereafter. These are "Al-Hassa irrigation and Drainage Project", "Faisal Settlement Project", "Wadi Jizan Development Project", "Riyadh Water Project", "Desalination Project", and "Dams and Small Water Project" (35, p. 4).

#### Al-Hassa Irrigation and Drainage Project

This project lies in Al-Hassa of the Eastern Region, some 75 kilometers west of the Arabian Gulf. The cultivated area is approximately 25 kilometers by 15 kilometers. The project area contains the town of Hofuf, with a population of 60,000, Al-Mubarraz 27,000, and 48 villages spread throughout the project area. There are about 330 wells and artesian springs with approximate average production of 1.7 cubic meter per second.

The main purpose of the project is the reclamation of 20,000 hectares with the application of modern irrigation and drainage methods. The project aims also at closing down any well whose production is less than

10 liters to improve the output of the other wells.

The project contains a system of canals, pumps, main and lateral drains. The total length of canals is 1600 kilometers and the drains 1500 kilometers. The details of the system can be seen in Table 7 below.

The execution of the project started in 1966 and was expected to be completed in five years.

Table 7. Al-Hassa project statistics<sup>a</sup> (length in kilometers)

Item	Irrigation		Drainage		Total length
	Number	Length	Number	Length	
Main Canals	16	153	3	145	298
Sub-Canals	333	270	171	176	448
Lateral Canals	-	1200	-	1200	2400
Syphons	105	-	3	-	108
Crossings	12	-	200	-	212
Bridges	14	-	24	-	38
Reservoirs	4	-	-	-	4

<sup>a</sup>Source: (35, p. 7).

#### Faisal Settlement Project

One of the problems facing the Saudi government is that a large percentage of the population is nomadic Bedouins. Any program of agricultural development cannot be complete without the incorporation of these

Bedouins and the utilization of the human and animal resources at their disposal. For this purpose the Ministry of Agriculture and Water has adopted a policy of settlement of these Bedouins.

Faisal Project will be probably the first of its kind in the Middle East. It is estimated that it will cost SR 90 million and will take five years to be completed. It provides for the settling of 1000 Bedouin families on 400 hectares of reclaimed land. Construction when completed will comprise (62, p. 15):

50 wells with 50 submersible pumps

71 km main canals and 236 km lateral canals

3000 meter pipelines for irrigation with sprinklers

20,000 meter concrete pipes

45 km main and 260 km lateral drainage canals

46 km bituminized roads, 139 km metalled roads and 232 km field paths

14 reinforced concrete bridges

440 km wide break hedges

880 km fencings

1000 living units and 60 other buildings

1 gas turbine station

22 km 66 KWA line and 65 km 20 KWA line.

The project will include also an agricultural research and experiment station where the Bedouins selected for the project will be trained before they become full settlers.

This project will have a great significance for Saudi Arabia and for

the neighbouring states having similar problems. It is also expected to contribute to the increase in the food production in the Kingdom.

#### Wadi Jizan Development Project

The agricultural potentialities of Wadi Jizan were revealed by the preliminary surveys conducted by the FAO in the mid 1960s. A comprehensive survey of the water and agricultural resources was completed by an Italian company. On the basis of its report the government decided to start executing the Jizan Dam Project, which is the basic phase of the plan for the Wadi development.

The dam is made of concrete gravity type and it stands 35 meters high and has 71 million cubic meters of storage capacity. The cultivated area benefiting from the stored water is 80,000 dorums. The dam will also allow for (35, p. 10):

1. Control of the rain water which normally flows into the sea
2. Avoidance of damages caused by run-offs to villages, irrigation and agricultural facilities
3. Guarantee of the availability of water the year round and possibility of growing two crops per year
4. Doubling of the agricultural product and of the agricultural productivity and consequently, the flourishing of the national income as a whole.

In addition to the dam construction, the basic plan for the Wadi includes the construction of modern irrigation and drainage systems, construction of a model farm for agricultural experiments, and improvement



of the existing agricultural patterns.

In addition to the abovementioned projects, the Ministry of Agriculture and Water has established the Riyadh water works, Al-Khubar and Jidda plants for the production of potable water and many other smaller dams for urban and agricultural uses.

The government investment in these projects is considered an essential feature of the agricultural development plan as will become clear later.

#### Previous Studies and Surveys

Many studies have been undertaken since the government in Saudi Arabia became overly concerned about the economic development of the country in the early 1960's. Experts, institutions, international agencies and professional firms have all been involved in such studies for short or long terms depending on the nature of the study. Among the experts are Asfour (4), Simmons (52), Heady (19), Brown (6), Little (43) and Heady (16). All have contributed articles and recommendations to be applied to various aspects of agriculture in Saudi Arabia.

International organizations and research institutions like IBRD, FAO, Ford Foundation, Economic Research Institute of the American University of Beirut and Stanford Research Institute have all been involved, at one time or another over the decade of the 1960s, through studies plan formulation and design and implementation of agricultural projects.

Much of the studies conducted by all these persons or groups have been handicapped by lack of adequate data on the Kingdom's resources. An

almost unanimous recommendation has been that the government should conduct surveys and have the resources inventoried for use in future studies. For that reason the Ministry of Agriculture contracted three professional firms, an American, Italian and a French to conduct area resource surveys over the whole territory of the Kingdom. Because these resource surveys constitute a landmark in Saudi Arabia's economy and because of their significance to future studies and plans, a brief presentation and evaluation of these surveys will follow. Reference will be made to the other abovementioned studies where it is appropriate in this report.

#### Area resource surveys

Within the field of long range economic planning, comprehensive surveys have been started for the development of water and agricultural resources. The Kingdom was divided for this purpose into eight\* areas the surveys of which were entrusted to several international consulting firms. Table 8 shows these areas, their sizes and other pertinent information and Figure 3 shows the location of these areas on the map of the Kingdom.

The following is a brief description and the method of documentation of these areas:

#### Area I

This area is known as the Great Nefud area and it includes Qaseem,

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\*Jidda-Mecca-Tait Area (JMT) was later awarded to the contractor of areas II and III making total areas nine.

Table 8. Area resource surveys<sup>a</sup>

Area	Period of contract (years)	Completion date	Firm & nationality	Total area (000 km <sup>2</sup> )
I	3.5	October 1968	Parsons Basil (American)	370
II and III	3.5	March 1969	Italconsult (Italian)	226
JMT	3.5	March 1969	Italconsult (Italian)	16
IV	3.5	December 1969	Italconsult (Italian)	362
V	3.5	December 1968	Sogreah (French)	105
VI	3.5	May 1970	Sogreah (French)	194
VII				640
VIII				280

<sup>a</sup>Source: (35, p. 2).

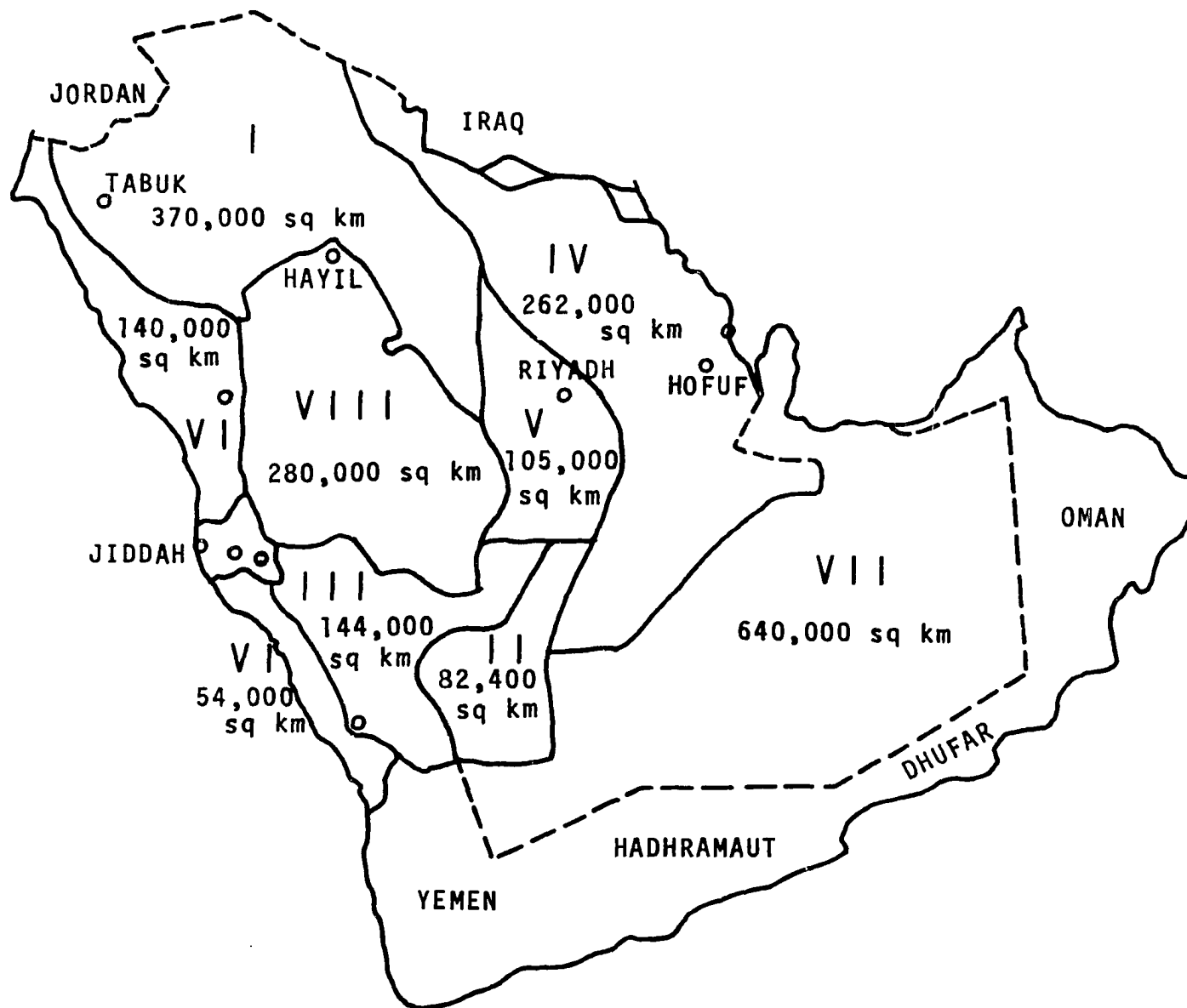
Wadi Sarhan, Jauf depression Sakaka and Tabuk. The resource surveys reports for this area consitute six separately bound volumes.

#### Area II and III

These two areas include the Southern Tuwaiq mountains, Aflaj, Wadi Dawasir, Tathleeth and the area extending from the eastern part of Asir mountains to Taif north and to Wadi Besha, Beni Ghamid, Bani Zahran and Najran south.

The contractor undertook additional surveys in the Jidda-Mecca-Taif (JMT) area. The report on the JMT was made part of the overall final

Figure 3. Subdivision of Saudi Arabia for purposes  
of agricultural resource survey



report on Areas II and III which consists of 31 separately bound volumes.

#### JMT Area

The surveys conducted in this area were made under supplementary agreement to the contract for the surveys of Area II and III. The reports on this area constituted 17 separately bound volumes.

#### Area IV

This area includes Al-Hassa, Qatif and Haradh. The survey was completed and the final report was published in 29 separate documents.

#### Area V

This area includes the capital, Riyadh and a large part of Tharj to the south and Sudair to the north. Sogreah presented the final report in a total of 15 separately bound documents.

#### Area VI

This area includes Tihama and Jizan. The documentation of resource surveys in this area are in the process of completion, with the exception of Wadi Jizan area the survey of which was done earlier by the constructor of Area II and III under a U. N. special fund project.

#### Areas VII and VIII

As far as is known, the surveys for these areas are still in the planning stage.

Because these resource surveys were completed by three different consulting firms, there is a noticeable lack of uniformity in criteria

and definitions in the final reports of these firms. This is the major criticism of the resource surveys. For the data to become a useful tool in the hands of the analyst, it has to be compiled, adjusted and classified in condensed forms. This job is being done by Stanford Research Institute in contract with the Ministry of Agriculture and Water.

Another limitation of the resource survey data is that it represents the resources at a point in time and hence adjustments are continuously needed as the conditions of the resources change over time.

There is no doubt, however, that, when resource surveys are completed for Areas VII and VIII, and the data for the whole country is compiled, adjusted, and correlated, it will be extremely useful for programming and planning purposes.

#### Summary of the Proposed Five-Year Plan for the Agricultural Development

Although development planning has been practiced in most of the less-developed countries, including the Middle Eastern, for the last two decades, Saudi Arabia has not been engaged in comprehensive term planning until very recently. CPO entrusted with developmental planning in the Kingdom has put forth "Guidelines for the Development Plan, 1390/91 - 1394/95\* encompassing all sectors of the economy. Directions are made to the different ministries and departments to propose plans for their respective sectors, to be submitted to CPO for consolidation in a national plan. For the agricultural sector, the Ministry of Agriculture

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\*Corresponding to 1970/71 - 1974/75.

and Water, more specifically the Planning Unit of the Ministry, in cooperation with a team of experts from Stanford Research Institute has undertaken the task of formulating a plan for development.

The broad national objectives of development were summarized in the guidelines as "rapid, sustained, and broadly-based growth, with improved participation by and greater rewards to those dependent on agriculture for their livelihood."

Sectoral objectives for agriculture as mentioned in the guidelines are as follows (33, p. 47):

1. To increase the rate of growth of the agricultural sector
2. To increase the production of adapted agricultural commodities
3. To improve the level of living and the technical capabilities of the rural population
4. To encourage private sector investment, both monetary and non-monetary, in agriculture and agro-industries
5. To safeguard the resource base for sustained growth by application of appropriate concepts and techniques of conservation.

To substantiate these objectives, the guidelines have specified certain implications and constraints which will be summarized as follows:

1. In general, the expansion of agricultural productivity will be fostered on both the extensive and intensive margins. Government projects will be directed to utilize new land and water resources as well as increasing the yield on the existing cropland. However, technically feasible expansion will not be undertaken if commodities



from the expansion can be produced at higher cost than other sources such as imports. Similarly, investment in agriculture by the government shall not take place if rate of return is higher elsewhere in the Kingdom.

2. The possibly overestimated growth rate of agriculture of 3.9 percent annually over the period 1382-83 to 1886-87, cannot be sustained without the implementation of programs and projects accompanied by some major structural and institutional changes in the agricultural economy. Accordingly, the anticipated growth rate in the initial years of the plan will be about 4 percent increasing to 5 percent towards the last years of the plan period. The average growth over the plan period would be about 4.5 percent, an increase of 25 percent by the end of the plan.
3. Special problems exist in applying the national welfare objectives to the nomadic people of the Kingdom. This requires special programs so that the Bedouins may be comparably benefitted by the modernization of the society.
4. The development of agriculture will require new skills and abilities of the human resource. Hence, the agricultural entrepreneurs and workers have to be significantly educated and trained. Such investment in human resources may enhance the mobility of the rural labor force to other sectors as the faster growth in these sectors leads to sectoral imbalance of the labor force.

5. Much of the investment needed in modernization of agriculture can and should come from the government in the form of the needed infrastructure. However, emphasis should be placed on teaching the farmer and helping him to be able to make his own investment for achieving more productive enterprise. Government programs to teach the needed skills and to facilitate expansion through extension of credit deserve highest priority.
6. Cost and benefit analysis should be made to determine the allocation of the newly inventoried resources of cropland and water.

#### State of agriculture before the plan

The state of agricultural development at the time of plan formulation may be presented in the following points:

1. The contribution of agriculture to the GDP increased from SR 866 million in 1962-63 to SR 974 million in 1968-69. A level of about SR 1,000 million was expected to be attained in 1969-70. Since other sectors grew at a higher rate, the contribution of agriculture to GDP fell from 10.1 percent in 1962-63 to 6.1 percent in 1968-69 and was expected to be about 6 percent in 1969-70 (31, p. 1).
2. Agricultural production was showing more diversification, with perhaps one-half to two-thirds of the value added from plant production, in contrast to earlier dependence on livestock and subsistence date groves. Recent trends in agricultural production are as follows:
  - (a) Vegetable production increased substantially, as farmers responded to a strong market demand.

- (b) Field crops increased at a lesser rate than vegetables.
  - (c) Range livestock production declined in drought periods, but has shown some recovery later in 1960's.
  - (d) Poultry production increased markedly during the five years preceeding the plan.
3. The importance of agriculture in the economy is indicated by the proportion of the population dependent on agriculture. About 65 percent of the total population was estimated to be rural in 1969. Three-quarters of the rural population was estimated to be settled and the remaining quarter to be nomadic. It was estimated that only 46 percent of the total labor force was employed in agriculture in 1966. A significant shift of agricultural workers to other occupations has been noticeable recently. This has been due to continuous drought and more remuneration in urban jobs.
4. Reference can be made to Chapter IV for description of marketing, credit, technology, etc.

With the directives from central planning organization and the background of agriculture in perspective, the Planning Unit of the Ministry of Agriculture embarked on a plan formulation for the agrisector. The presentation of the summary of the plan will follow this outline.

- 1. Projections of supply and demand
- 2. Targets and priorities
- 3. Support activities and policy emphasis
- 4. Financing of the plan.

### Supply and demand projections

In the introductory statement in the draft plan, the Planning Unit makes it clear that:

"The projections for the agricultural sector were estimated without the usual benefit of information on the investments planned for other sectors. This information is crucial for agricultural planning. The lack of investments in secondary roads and telecommunications, for example, which may be acting as constraining factors on present and planned agricultural production, are not considered. Thus, the significant considerations to be achieved through the study and coordination of the linkages effects of economic planning are not included in the estimates for agricultural sector."

The significance of the abovementioned limitation is that it isolates the agricultural sector from the rest of the economy, and in as much as the linkages between agriculture and other sectors are important, the projections will not be true to reality.

Demand projections      The demand projections use elasticity coefficients shown in Table 9 which were obtained from cited consumer surveys. The demand estimates, made for the plan, were based on the estimated rate of population growth of 4.7 percent and a rate of growth of the GNP of 8.1 percent.

Asfour's (4) methodology for the projection of demand was used for the plan. It was assumed that price relationships would not change from the base year through the plan period. This assumption allowed the use of physical quantities of food to be used instead of the value of those amounts for the projection of demand in the plan period from the quantities in the base year.

Table 9. Elasticity coefficients of demand for food<sup>a</sup>

	ERI Riyadh	Aramco Eastern Province	Asfour Saudi Arabia	FAO Near East & Africa	IWP Near East	Gittinger Iran	Used for these projections
Cereal & cereal preparations	0.2	0.13	.2	0.2	0.52	0.58	0.2 - 0.5
Meat and fish	0.4	0.6	.4	1.3	0.84	1.38	0.8
Fats and oil	0.3	0.6	.5	.8	-	0.81	0.6
Milk, dairy food, eggs	1.3	-	1.2	1.2	1.1	0.88	1.2
Vegetables	0.4	-	0.6	.7	0.7	0.66	.5
Fruits	0.6	0.8	0.6	-	0.6	0.49	.6
Dates	-0.06	-	-0.1	-	0.1	-	-0.1
Sugar, jams, etc.	.6	-	0.5	1.2	-	.99	0.5
All food	.43	.44	.44	-	-	-	-

<sup>a</sup>Source: (34, p. 8).

Demand was determined for the base year 1962 for Asfour study, from estimates of domestic output by the Ministry of Agriculture and Water plus statistics on imports of the Ministry of Finance. Adjustments were made on estimates for some products like millet and sorghum because they were found to be low. The data for the base year is shown in Table 10.

Demand for food is assumed to be a function of the population which was estimated for planning purposes by the Central Statistical Department. These estimates were originally for calendar years. For the purpose of the projections, interpolations were used to adjust the estimates for fiscal years as shown in Table 11 together with estimates of GNP as were presented in the CPO Economic Report. The base year for the demand data is used as the base year for a population index which increases to 162.3 for the last year of the plan. The rate of growth of GNP of 8.1 percent per year, over the five year period preceeding estimation, is assumed to continue for the next nine years.

In the projection of demand, the income elasticity was related to per capita income rather than the normally used disposable income or private consumption expenditure.

Coefficients of income elasticity of demand for food in the Middle East were determined by different studies with the resulting coefficients varying widely. Studies made in Saudi Arabia by the Economic Research Institute of the American University of Beirut and by Aramco show low elasticities of demand for food relative to other countries of the Middle

Table 10. Base year demand for foodstuffs in Saudi Arabia in 1961-62<sup>a</sup>  
(000 metric tons)

Commodity	Domestic production	Imports	Total demand
Meat and flour	129	92	221
Rice	4	100	104
Sorghum	110	-	110
Millet	150	21	171
Other cereals	3	6	9
	<u>396</u>	<u>219</u>	<u>615</u>
Vegetables, fresh	342	28	370
Vegetables, preserves & preparation	-	12	12
	<u>342</u>	<u>40</u>	<u>382</u>
Fruits, fresh	86	30	116
Fruits, preserves & preparation	-	4	4
Dates	258	-	258
	<u>344</u>	<u>34</u>	<u>378</u>
Meat & preparation	36	11	47
Fish & preparation	5	1	6
	<u>41</u>	<u>12</u>	<u>53</u>
Vegetable oil	-	2	2
Fat & butter	19	9	58
Milk	154	5	159
Other dairy products	4	2	6
	<u>177</u>	<u>18</u>	<u>195</u>
Sugar & preparation	-	67	67
Coffee, etc.	-	12	12
Miscellaneous	-	2	2
		<u>81</u>	<u>81</u>
Total	1300	404	1704

<sup>a</sup>Source: (54, p. A2).

Table 11. Population and GNP for Saudi Arabia - fiscal year 1381-82 through 1394-95<sup>a</sup>

Year	Population millions	Index of population	GNP at constant prices SR millions	GNP per capita SR	Index of GNP per capita
1381-82	3.77	100.0	6671	1769.5	100.0
82-83	3.95	104.7	7259	1837.7	103.9
83-84	4.13	109.5	7625	1846.2	104.3
84-85	4.31	114.3	8552	1984.2	112.1
85-86	4.50	119.4	9236	2050.4	116.0
86-87	4.70	124.7	9907	2107.9	119.1
87-88	4.90	130.0	10709	2785.5	123.5
88-89	5.12	135.8	11577	2261.1	127.8
89-90	5.31	140.8	12515	2356.9	133.2
90-91	5.47	145.1	13528	2473.1	139.8
91-92	5.62	149.1	14624	2602.1	147.1
92-93	5.78	153.3	15809	2735.1	154.6
93-94	5.96	158.1	17089	2867.3	162.0
94-95	6.12	162.3	18474	3018.6	170.6
95-96			19970		

<sup>a</sup>Source: (34, p. 44).



East. The coefficients used by the Planning Unit for the purpose of plan projections were adjusted to reflect expected changes in consumption function. (See last column of Table 9.)

For the computation of factors for increase in demand the following formula was used:

$$Z = P + E (G - 100)$$

where

Z is the increase factor in demand

P is the population index

E is the elasticity coefficient

G is the GNP per capita index

The computed increase factors are shown in Table 12 and the projections of demand for foodstuffs for the fiscal years of the plan, 1390-91 through 1394-95 are shown in Table 13.

Supply projections Estimates of area under cultivation and mean yields were used as the basis for projection of physical outputs which are taken to be representative of supply projections.

The base year was chosen to be 1383 (1963) which happens to be midway between 1380 and 1386, the beginning and the final date of the agricultural census. The census estimates, however, were updated by the findings from the resource surveys mentioned earlier.

Yield data for base year were based on FAO Production Yearbook, 1967, and estimates of variety of other sources.

Table 12. Computation of increase factors for demand for foodstuffs<sup>a</sup>

Year	Population index	GNP per capita index	Increase factors by elasticities						
			-0.1	0.2	0.4	0.5	0.6	0.8	1.2
1381-82	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
82-83	104.7	103.9	104.3	105.5	106.3	106.6	106.6	107.8	109.4
83-84	109.5	104.3		110.4	111.2				
84-85	114.3	112.1		116.7	119.1				
85-86	119.4	116.0		122.6	125.8				
86-87	124.7	119.1							
87-88	130.0	123.5							
88-89	135.8	127.8							
89-90	140.8	133.2	134.5	147.4	154.1	157.4	160.7	167.4	180.6
90-91	145.1	139.8	141.1	153.1	161.0	165.6	173.0	176.9	192.9
91-92	149.1	147.1	144.4	158.5	167.9	172.6	177.4	186.8	205.6
92-93	153.3	154.6	147.8	164.2	175.1	180.6	186.1	197.0	218.8
93-94	158.1	162.0	151.9	170.5	182.9	189.1	195.3	207.7	232.5
94-95	162.3	170.6	155.2	176.4	190.5	197.6	202.7	218.8	247.0

<sup>a</sup>Source: (34, p. A7).

Table 13. Projected demand for foodstuffs in Saudi Arabia - 1381-82 and 1390-91 through 1394-95<sup>a</sup>  
(000 metric tons)

Commodity	Demand in 1381-82	Elasticity	Projected demand				
			1390-91	1391-92	1392-93	1393-94	1394-95
Wheat and flour	221	.4	356	371	387	404	421
Rice	104	.5	176	180	188	197	206
Sorghum	110	.2	168	174	181	188	194
Miller	171	.2	262	271	281	291	302
Other cereals	9	.2	14	14	15	15	16
Subtotal	615		976	1010	1052	1095	1139
Vegetables, fresh	370	.5	610	639	668	700	731
Vegetables preserved & preparations	12	.5	20	21	22	23	24
Subtotal	382		630	660	690	723	754
Fruits, fresh	116	.6	201	206	216	227	235
Fruits preserved & preparations	4	.6	7	7	7	8	8
Dates	258	-.1	364	373	381	392	400
Subtotal	378		572	586	604	627	643
Meat and preparations	47	.8	83	88	93	98	103
Fish and preparations	6	.8	11	11	12	12	13
Subtotal	53		94	99	105	110	116
Vegetable oil	2	.6	3	4	4	4	4
Fat and butter	28	.6	48	50	52	55	57
Milk	159	1.2	307	327	348	370	393
Other dairy	6	1.2	12	12	13	14	15
Subtotal	195		370	393	417	433	469
Sugar and preparations	67	.5	111	116	121	127	132
Coffee	12	.5	20	21	22	23	24
Miscellaneous	2	.5	3	3	4	4	4
Subtotal	81		134	140	147	154	160
Total	1704		2776	2888	3015	3142	3281

<sup>a</sup>Source: (34, p. 9).

To project future supply in 1394-95, it was first necessary to estimate data in 1389-90 i.e. one year before the plan. Table 14 shows production data in the base year, 1383 and in the year 1389-90. It can be seen that the net increase in area was only around 2 percent over the period of six years.

Table 14. Estimated area, yield and production of leading crops in Saudi Arabia in 1383 and 1389-90<sup>a</sup>

Crop	Area (000 hectares)	Yield metric tons per hectare	Production (000 tons)	Area (000 hectares)	Yield metric tons per hectare	Production (000 tons)
Wheat	72	1.79	129	75	1.80	135
Barley	22	1.58	35	23	1.60	37
Rice	1	2.3	2	1	2.0	3
Sorghum	101	1.09	110	102	1.1	112
Millet	156	1.0	150	155	1.0	155
Alfalfa	22	80.0	1733	22	80.0	1760
Vegetables	31	10.7	342	34	15.0	510
Dates and fruits	22	15.4	344	23	15.4	354
Other	24	-	-	25	-	-
Total	451		2860	460		3066

<sup>a</sup>Source: (34, p. A9).

The projected increase in agricultural production during the five year plan was based largely on two premises. One is that area under cultivation will increase. The potential increase in crop area due to the major projects is estimated at 19,000 ha, 13,000 ha of which are anticipated to come from the Al-Hassa Project alone.

The second potential for the increase in production is built on the assumption that major technological change and agricultural development will take place in the cultivated areas of Al-Kharg, Qaseem, Qatif, Aflaj, Dawasir, Najran, Tabuk, Jouf and Sakaka. It is assumed that credit will be available for the development in these areas and others.

It is believed that the crops that will prevail in the last year of the plan 1394-95, will be those showing highest profitability according to estimates by the Ministry of Agriculture and other agencies. It is anticipated that on previously cultivated land, the shift will be in favor of vegetables, alfalfa and perhaps wheat.

As for the land newly brought under cultivation, it is anticipated that these will be used for producing barley and alfalfa with yields expected to be low due to problems of salinity, low fertility, lack of uniformity, etc.

The projected changes in the use of the presently cultivated land, and the new cultivable land are shown in Table 15 below.

Yield increases in Saudi Arabia over the plan period are assumed to come forth through the public sector support for the private sector development and change. The desired impact on the private sector is

Table 15. Anticipated changes in area of crops raised resulting from shifts in crop selection and from new land development 1389-90 to 1394-95<sup>a</sup> (000 hectares)

Crop	Crop land use shifts		New land development				Total
	Percent	Area	Al-Hassa	Haradh	Jizan	Private projects	
Wheat	10	7	2	1	0	4	14
Barley	-10	-2	3	0	0	4	5
Rice	0	0	1	0	0	0	1
Sorghum	0	0	1	1	1	0	3
Millet	0	0	0	0	0	0	0
Alfalfa	9	2	2	2	0	2	8
Vegetables	10	3	3	0	1	1	8
Dates & fruit	5	-1	0	0	0	1	0
Other	-38	-9	1	0	0	2	-6

<sup>a</sup>Source: (34, p. A14).

planned to be in adoption of modern technology, intensification of agricultural production and increased area of crop land. The public sector is planning to bring about such changes through credit programs, subsidies on fertilizer use and import of machinery, price support and a program of extension.

The area, yield and production of the major crops as anticipated in the fifth year of the plan are shown in Table 16. Area of crops will have increased by 9 percent over the base year, and by 7 percent over the

Table 16. Area, yield, and production of leading crops in the fifth year of the development plan (1394-95)<sup>a</sup>

Crop	Area (000 ha)	Yield tons/ha	Production 000 tons
Wheat	89	2.6	231
Barley	28	2.0	56
Rice	2	3.8	7
Sorghum	105	1.25	131
Millet	155	1.03	160
Alfalfa	30	86.0	2580
Vegetables	42	16.0	672
Dates & fruit	23	14.5	354
Other	19		

<sup>a</sup>Source: (34, p. A17).

estimated 1389-90 area. Production of food crops will have increased 23 percent over 1389-90, an annual increase of over 4 percent. The growth of the agricultural sector during the plan period is shown in Table 17. Prices applied to the production estimates are those reported in Area I study by Parsons-Basil.

The predicted value of agricultural production in the last year of the plan 1394-95, is SR 1.3 billion, which compared to SR 1.1 billion in 1389-90, represents 24 percent during the five years of the plan, for a compound rate of 4.9 percent annually.

Table 17. Growth of the agricultural sector during the plan period (000 metric tons and 000,000 SR)<sup>a</sup>

	Constant price (SR per thousand tons)	Base year 1383		Pre-plan year 1389-90		Fifth year 1394-95		Percentage increase in value	
		Production	Value	Production	Value	Production	Value	Plan	Annual
Wheat	720	129	93	135	97	231	166	71	11
Barley	608	35	21	37	22	56	34	55	9
Rice	700	2	1	3	2	7	5	150	20
Sorghum	734	110	81	112	82	131	96	117	3
Millet	734	150	110	155	114	160	117	3	1
Alfalfa	80	1733	139	1760	141	2380	190	35	6
Vegetables	354	342	121	510	181	693	245	35	6
Dates	500	258	129	250	125	240	120	-4	-6
Fruit	834	86	72	94	78	100	83	6	1
Total crops <sup>b</sup>			767		701		866	24	4.3
Meat	3700	12	60	48	128	71	262	47	8
Broilers	4500	3	15	4	18	6	29	61	10
Eggs <sup>c</sup>	24	1500	4	50	10	75	15	50	8
Fish	2000	24	24	30	60	36	72	20	4
Dairy products <sup>d</sup>	1000	30	45	210	210	252	252	20	4
Total animal product			148		476		630	32	5.8
Total agriculture			915		1177		1496	27	4.9

<sup>a</sup>Source: (34, p. 10).

<sup>b</sup>Total excludes alfalfa which is almost altogether an input for animal products.

<sup>c</sup>For eggs, price is per dozen and production in millions of eggs.

<sup>d</sup>Dairy products are shown as milk equivalent.



### Targets and priorities

It was explained earlier that the potentials for agricultural development in Saudi Arabia involve increases in cultivable area improvement in yields and value of the output. With these potentials in the background and building on the projections of supply and demand for foodstuffs in the Kingdom, the government stated its targets for increases in agricultural production of grains, vegetables, meat and other products as shown in Table 17, and described briefly below (31, pp. 8-10).

Grains Wheat production is expected to increase by an average of 11 percent annually, reaching a level of output of 231,000 metric tons per year in the last year of the plan, compared to the production of 135,000 tons in the preplan year. Barley production will reach 56,000 tons compared to 37,000 in the preplan year, which represents an average annual increase of 9 percent per year. Rice production in 1389-90 was estimated at 3,000 tons will increase to 7,000 tons in the last year of the plan, thus averaging an annual increase of 20 percent.

Forage Forage production, primarily alfalfa and clover will increase from 1,760,000 tons in 1389-90 to 2,380,000 tons in the final year of the plan representing an annual increase of about 6 percent. The above tonnage is based on the green-weight equivalent. It is assumed that the market weight of the product will be less because of drying and baling.

Vegetables Vegetable production will increase from an estimated 510,000 tons in 1389-90 to 693,000 in the final year of the plan representing an annual increase of 6 percent.

Livestock Animal products are expected to increase, partly due to the expected increase in forage production. In 1389-90 meat production was at a level of 48,000. It will increase to 71,000 representing an annual increase of 8 percent over the plan period.

Poultry Both broiler and egg production will increase in an overall amount exceeding 60 percent by the final year of the plan. It is expected that egg production will increase at about 8 percent annually reaching a level in the final year of the plan sufficient to supply more than half of the national demand.

Other products The expected increase in the production of fish and milk products will be a moderate 4 percent annually.

The overall increase in the production of agricultural sector will be 4.9 percent annually, with the crop production and animal product sub-sectors increasing annually at 4.3 percent and 5.8 percent respectively. These targets are assumed by the government as not unrealistic. The low annual growth of the agricultural sector over the period 1382-83 to 1388-89 was attributed to several years of drought.

Whether the government has been overly optimistic and unduly liberal in stating the targets for the growth of agricultural sector, remains to be seen.

Priorities For the prescription of priority programs to attain the goals and targets for agriculture, the Ministry of Agriculture and Water has been concentrating on the following guidelines (34, p. 14):

1. Selection of a limited number of commodities whose production can be increased most efficiently, and the instituting of programs to increase their output.
2. Selection of individual projects having early maturities and high profit. These should be among those commodities whose productions can be increased most efficiently.
3. Concentration of effort on providing supporting and institutional services to implement the programs and projects called for in the first two steps.

Wheat, vegetables, fodder The first priority is given to intensive short run impact programs to increase production of wheat, vegetables and forage during the five year plan. The recommended goals for these programs are:

Table 18. Targets for selected major crops<sup>a</sup>

Crop or program	Percent increase in total output	Net additional production (000 tons)
Wheat	40	60
Vegetables	35	180
Forage	25	630 <sup>b</sup>

<sup>a</sup>Source: (34, p. 15).

<sup>b</sup>Green weight.

Emphasis on these products was due to the following reasons:

1. They are major commodities in terms of acreage and production as can be seen from the following table.

Table 19. Area and production of selected major crops<sup>a</sup>

Crop	Area (000 ha)	Production (000 tons)
Wheat	60-80 <sup>b</sup>	135
Vegetables	35	500
Fodder	32	2500

<sup>a</sup>Source: (34, p. 15) .

<sup>b</sup>Cropped area in wheat is variable depending on rainfall and the amount of stream runoff.

2. Production of these crops is, or can be, profitable for farmers.

Table 20 shows estimates of preplan and potential returns and costs per hectare as shown by the Ministry of Agriculture (34, p. 18).

3. Domestic production of all three crops can be competitive with imports. These crops are produced in the Kingdom without price subsidies to producers. Actually, in 1389-90 there were import subsidies on wheat and flour and the import subsidies on meat were removed only lately. The removal of import subsidies could result in higher prices for the benefit of local producers. On the other hand, there have been input subsidies in the form of low cost tractor services, free application of pesticides by the Ministry, etc.

4. Increased output of these crops is assumed to be obtained by using simple recommended practices many of which are already known to the farmers or can be introduced easily through Ministry technicians.

Presentation of the detailed crop programs for the achievement of the indicated targets will not be attempted in this report. However, the principal points to each program will be stated for the sake of reviewing the complete highlights of the development plan.

Specific to the wheat program, the following points constitute the focus of the action programs.

1. Introduction of high-yielding Mexican wheat varieties through a seed-multiplication demonstration program that combines the efforts of the Extension and Research Departments.
2. Increase in the use of fertilizers.
3. Adoption of a price support system for wheat in the second or third year if studies show support is needed.

It hardly needs mentioning that, essential to the success of such programs, producers' attitudes have to be favorable. The experience of the less-developed countries in efforts to develop the agriculture is full of evidence of failure of development programs due to the conservativeness of the producers in accepting new production techniques.

An additional feature of the wheat program includes a subsidy on the purchase of fertilizer equivalent to one-half its cost. This feature is extended further to include fertilizers purchases for all other crops besides wheat.

Table 20. Estimated present and potential returns for selected major crops<sup>a</sup> (SR per hectare)

	Gross returns	Production costs <sup>b</sup>	Net returns <sup>c</sup>
Pre plan production			
Wheat <sup>d</sup>	1,350	835	515
Vegetables <sup>e</sup>	4,550	3,260	1,350
Fodder <sup>f</sup>	6,400	4,700	1,700
Potential production			
Wheat <sup>g</sup>	2,045	1,175	870
Vegetables <sup>h</sup>	6,500	3,900	2,600
Fodder <sup>i</sup>	5,500	3,300	2,200

<sup>a</sup>Source: (34, p. 18).

<sup>b</sup>Cash and non-cash costs except imputed rents.

<sup>c</sup>Net returns to management and land ownership.

<sup>d</sup>Yield of 1.5 tons per hectare at a value of SR 600 per ton plus value of straw.

<sup>e</sup>Yield of 14 tons per hectare at a value of SR 300 per ton.

<sup>f</sup>Yield of 80 tons per hectare at a value of SR 80 per ton.

<sup>g</sup>Yield of 3.5 tons per hectare at a value of SR 420 per ton and a value of straw at SR 572 per hectare.

<sup>h</sup>Yield of 20 tons per hectare at a value of SR 325 per ton.

<sup>i</sup>Yield of 100 tons per hectare at a value of SR 50 per ton.

Specific to the target for the vegetable production the Ministry is concentrating on two main measures:

1. Providing technical assistance to farmers in proper cultural practices, and in timing of planting and harvesting operations to lessen price fluctuations.
2. Providing assistance in developing improved marketing services, including improvement of market facilities, analysis of present and potential international fruit and vegetable movement and the effects of imports on domestic production, formation of better marketing organization and analysis of possible alternative measures to stabilize prices.

For fodder it is envisioned that two possible types of enterprises could be established. (1) The livestock operators would use range grazing land to maintain breeding stock. Young stock would be sold to farmers who produce irrigated fodder to feed and fatten the stock for market. (2) Farm produced fodder would be used as a feeding supplement to the rangeland for the breeding animals and the market stock.

Other programs Following in the line of priority programs are the large-scale irrigation projects, well drilling, small-scale irrigation, livestock and meat production and dates. Description of measures to be taken on the public sector and private sector levels, in order that these programs enable the agrisector to achieve the targets of the plan, is presented in a detailed outline form in the development plan.

### Services and policies

According to the plan, the foregoing priority production programs and land development projects require strong backing from supporting and institutional services from the Ministry and other agencies and the private sector. Such supporting services as credit, Ministry department services and subsidies will be described briefly below.

Credit Credit is almost indispensable for crop production programs and small-scale irrigation programs. As an example, it is estimated that construction of wells and irrigation systems in collaboration with public land distribution will require loans in the neighborhood of SR 100 million. Credit will also be needed for variety of other programs to the extent that a loan value between SR 200 and SR 300 million will be developed by the end of the five year plan.

Ministry departments Programs must be initiated to coordinate research and extension services and the training of man power to support both.

Subsidies Four types of subsidies are anticipated in the five year plan:

1. A subsidy equivalent to one-half the cost of all fertilizers used in the Kingdom.
2. A program of providing price support for production of the new wheat varieties in order to induce farmers to adopt them.
3. Subsidies for small irrigation projects.



4. A subsidy on the importation of farm equipment covering small tractors and other specified equipment and spare parts used for agricultural production. The projected cost of subsidies is shown in Table 21.

Table 21. Projected cost of subsidies<sup>a</sup> (000,000 SR)

Type of subsidy	Year					Total
	1	2	3	4	5	
Fertilizer subsidy <sup>b</sup>	3.3	7.0	13.5	26.0	38.5	88.3
Wheat price support <sup>c</sup>	0.0	1.0	3.0	8.0	11.0	23.0
Small irrigation projects <sup>d</sup>	21.0	21.0	21.0	21.0	21.0	105.0
Machinery imports <sup>e</sup>	15.0	15.0	15.0	15.0	15.0	75.0
Total	39.3	44.0	52.5	85.5	85.5	291.3

<sup>a</sup>Source: (34, p. 51).

<sup>b</sup>Total subsidy is approximately double the wheat price support and subsidy cost.

<sup>c</sup>Based on an import price of SR 400 per ton and a support price of SR 500 per ton.

<sup>d</sup>Approximately 3,000 hectares per year with a subsidy averaging SR 7,000 per hectare.

<sup>e</sup>Based on projected agricultural machinery imports of SR 40 to 50 million per year with a subsidy equivalent to one-third the purchase price.

Policy emphasis      The Ministry of Agriculture is aware of the need for a framework of consistent policy which can be used for the orientation of its programs and projects. In the first and the second phases of plan formulation, the Ministry was assisted by special advisory assistance and consultations for the analysis of present and future policies relating to the implementation of the plan. It has been recognized that the policies used are subject to modifications, improvements, and refinements, as required to carry the plan objectives.

The stated Ministry policy to carry out the sector plan can be summarized in the following points:

1. Assisting and encouraging private investment in agriculture and agro-industries and use of public investment to support and augment the private investment to the fullest extent possible.
2. Emphasizing and promoting further commercialization of agriculture.
3. Strengthening the capabilities of all departments of the Ministry.
4. Devoting greater emphasis to programs and projects designed to increase the near-term output.
5. Utilizing data of the land and water resource surveys for establishing sound plans.
6. Bringing into production the three largest publicly sponsored irrigation projects.
7. Moving away from free production services as soon as possible. Instead technical assistance and supporting infrastructure should be strengthened.

8. Establishing fair rates for user charges on public services and investment projects.
9. Encouraging the integration of the Bedouins into the economic and social structure of the Kingdom.

Furthermore, the Ministry intends to have coordination between its own policies and the National Plan policies.

#### Financing of the plan

The total requests of all departments for financing the agricultural sector five year plan amounted to 1,718.5 million. Breakdown of this amount into the different budget sections is shown in Table 22.

Table 22. Summary of budget requirement for all agricultural programs by budget sections<sup>a</sup>  
(000,000 SR)

Budget section	Authorized for 1389-90	1390-91	1391-92	1392-93	1393-94	1394-95	Total five years
I. Salaries & allowances	48.6	59.9	74.1	86.6	98.0	107.2	425.8
II. General expenditure	23.5	22.7	23.5	24.2	24.2	25.6	121.0
III. Subsidies & support programs	-	39.3	44.0	52.5	70.0	85.5	291.3
IV. Recurring	0.4	53.6	53.0	60.4	59.2	62.2	288.3
Non-recurring	120.3	144.5	115.4	114.3	118.6	99.2	592.1
Total	192.8	320.1	310.0	337.9	370.8	379.7	1718.5

<sup>a</sup>Source: (34, p. 80).

CHAPTER VI. SYNTHESIS OF POLICIES FOR THE ECONOMIC  
DEVELOPMENT OF AGRICULTURE

The effectiveness of any economic policy depends on many factors including the quantity and quality of available economic data, the degree to which the economist is familiar with this data, the body of economic theory upon which the economist draws and his knowledge of this theory, the economist's knowledge of the intricacies of the relevant political structure, the relation between the economist and the policy maker, the political disposition of the policy maker and the recipients of the policy costs and benefits, among other things. The degree of development of the country, its political and economic structure, its resources, finances, etc. have a direct bearing on the quality of the policy used and its effectiveness. It is often said that in less developed countries, haphazard and instantaneous policies are common. Appeals for popular supports may induce the policy maker to employ policies which may produce instantaneous popular effect but are not to the long run advantage of the economy. Examples are plentiful in the areas of taxes, tariffs, credit, etc. It so happens in many countries that power groups exert pressure on policy makers to produce policies which favor these groups, thus contributing to further the inequality of income distribution, unequal opportunities with resulting dissatisfaction, disapprovals and demand for change.

In general, economic policy problems are concerned with the behavior of a given economic structure, or a set of structures in response to changes in policy instruments. The quality of technical advice on such

economy problems is closely related to the economist's knowledge of the particular structure, or set of structures. Such knowledge can be qualitative or quantitative in nature. Qualitative knowledge is usually restricted to the determination of the directional impact of economic policy changes on the economic structure. Quantitative knowledge does not only permit the determination of directional impact but also provides an estimate of the magnitude of the impact of a change in economic policy. Knowledge of directional impact is essential to economic policy formulation. Because the conduct of economic policy demands quantitative decisions, it is also necessary to develop quantitative knowledge of economic structure.

According to Tinbergen (57) quantitative economic policy is restricted to the analysis of the changes in the magnitudes of policy parameters within a stable economic structure. The methodology was not extended to the structural reform in economic system.

Due to the absence of quantitative knowledge of the economic structure of Saudi Arabia, and because economic policy there aims at producing a structural reform in the economic structure the following treatment will be qualitative in nature.

Agricultural policy is part of economic policy which is implemented to benefit consumers or provide gain to producers or both. Heady (14, p. 14-15) specifies two main categories of policies. The first is developmental policies which focus on the supply functions of commodities and resources. These generally produce an increase in commodity supply and

reduce the real price of food to consumers. The other category comprises the compensation policies which attempt "to compensate farmers in various manners in order that positive sum utility outcomes, or Pareto - better conditions...can be better guaranteed." Compensation policy tries to restrain the increase in supply, or reduce supply so that farm income can be increased.

Emphasis in Saudi Arabia is placed on policies that increase the supply of agricultural products. These policies are mostly developmental in nature. In its effort to increase supply, the government used import subsidies at the risk of reducing domestic producers' income.

The following analysis is concerned with specification and recommendation of policies that are believed to bring the economy closer to targets specified in the development plan. The author will draw on the literature of policy recommendations made by numerous experts and agencies since the beginning of the decade of the 1960's, the body of economic theory, experience of other countries and personal knowledge of some aspects of the Middle East economies and peoples.

In the context of this framework, this report will discuss policies on the following categories:

1. Inputs of production
2. Prices and subsidies
3. Institutions
4. Other support activities.

## Inputs of Production

### Human resources

The human element is considered a key factor in agricultural development because of the importance of decision making involved in all economic activities. Land, capital, technology are important factors too, but for these to be productive they have to be developed, organized and operated. The human element is a resource of skill and entrepreneurship as well as productive energy.

Saudi Arabia, although not deficient in population, depends to a large extent on foreign human resources virtually at all levels of economic and government activities. This is mainly due to the shortage of trained Saudis who might have had the foreigners positions.

Education is the only way out of this shortage. It may take time but it is essential to the creation of more productive and efficient human resource base. Education can play a key role in improving the labor and entrepreneurial input. It can raise the level of aspirations and reduce the social and economic barriers to occupational and geographic mobility.

In a study on a less-developed agricultural region in Greece, Yotopoulos (75, p. 131) found out that the capitalized value of education for the average household is higher than the capital value of other forms of capital, namely live capital assets (animals and plants), plant assets (houses, irrigation, ditches, etc.) and equipment assets (tractors, implements, etc.). He computed the average education of the household



in that region was 2.74 years per household member which is apparently comparable to primary education. He assumed that agricultural activities, as a result of one year's education for each member of a household, provide real net earnings stream of  $Y_0, Y_1, \dots, Y_n$  over a period of 54 years (age 15 through 69). The alternative stream of earnings that the household would have received without education in the same period is  $X_0, X_1, \dots, X_n$ . The marginal product of education was defined as the difference between these two alternative income streams.

$$K_j = Y_j - X_j \quad (1)$$

He expressed the capitalized value of one year's education per member of a household as

$$V(K) = \sum_{j=1}^n \frac{k_j}{(1+r)^j} \quad (2)$$

where  $r$  is the relevant rate of discount,  $k_j$  is the marginal product of one year's education per household member in year  $j$  and  $n$  is the total number of years. Assuming no increase or depreciation in learning over the period and a constant marginal product of education, he simplified Equation (2) to

$$V(K) = \frac{k}{r} \left[ 1 - (1+r)^{-n} \right] \quad (3)$$

where  $k$  is the constant MP of one year's education per household member,  $r$  as above,  $n$  the number of productive years in each member's life until he reaches 69, and  $(1+r)^{-n}$  is a correction for the finiteness of life that tends toward zero as the length of the working life increases.

The value of Equation (3) was calculated from annuity tables at 5 percent rate of discount and  $n = 1$  to 54 to cover all age and brackets from 15 to 69. The results were weighted by the number of household members in each bracket. He estimated the weighted capital value of one year of education per household member at 8,437 drachmas\* (drs.). Since the average household has 2.24 years of education per member, the total capital investment in education is equal to 18,900 drs. per household compared to 17,393 drs., 3,341 drs. and 223 drs. for live capital, plant assets and equipment assets respectively. From his study Yotopoulos concluded:

"No matter how we approach education, whether from the point of view of capital investment, from the side of its marginal product, or from the aspect of its share in the total output, it seems that the meager amount of 2.24 years of education per household member is an important factor of production in our sample of Epirus farms. This may well be another shred of evidence pointing to the fact that the greatest assets in Greek agriculture are the farmers themselves." (75, p. 133).

This study was cited principally to demonstrate the possible value of educating farmers and the contribution of education as a factor of production.

At the farm level, it may be too late for adult farmers to receive formal education. However, adult education programs could help in educating farmers and the author believes that such a program should receive a high priority. The program could be part of the Ministry of Education or under a specialized department in the Ministry of Agriculture and Water.

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\*One U. S. dollar is equal to 30 drachmas.

In addition to basic education, farmers need agricultural education which may be communicated to farmers through the adult education program, especially if it is part of the Ministry of Agriculture, through extension, or through media.

An additional problem in Saudi Arabia is the existence among farmers of a large percentage of nomadic Bedouins who are dispersed throughout the Kingdom. Education of the Bedouins could be a most difficult task unless, of course, they are settled in permanent areas. For the nomadic, Saudi Arabia may need to do similar to what Egypt is doing in facing a similar problem; place the schools along the routes Bedouins use often. In other words, take the schools to them if they do not go to schools. This might be very expensive to do in a country the size of Saudi Arabia. However, it could be used as supplement to settlement programs that are being executed.

It was pointed out previously, that many extension agents and specialists working in Saudi Arabia are foreigners. This suggests that this is another area where the Kingdom needs to develop its human resources. This is particularly important because in many instances, farmers tend to believe that foreigners are not really serious and genuinely interested in helping them.

All agencies and experts visiting Saudi Arabia recommended the strengthening of the agricultural extension department. This will be treated in a later section. It is the development of the human resource needed for the staffing of the department that is discussed here. One

good source of extension agents is the agricultural institutes similar to those functioning in Jordan. These supply two or three years of agricultural education beyond the high school diploma. Saudi Arabia may need to establish such institutes to the extremely needed extension manpower.

Adequate staffing of the Ministry departments is essential for planning and implementation of policies and programs. Supplemental additions and present in-service training of present staff are necessary to reduce the dependence of the Ministry on foreign agencies and experts to do these jobs. The School of Agriculture of the University of Riyadh should be a very effective step in this direction.

In order to increase the effectiveness of the human resource base in agriculture, the government has recognized the need for settling the nomadic Bedouins. These do not only constitute a large proportion of the farmers in the Kingdom, but also own most of the livestock of the country.

Since the Bedouins are disciplined to obey their chiefs and observe the regulations of the tribe, a proposition to utilize these qualities is hereafter suggested. Why not try establishing cooperatives on a pilot project basis. These could be single purpose livestock production cooperatives, or multipurpose, production, credit and marketing cooperatives. Such projects, of course, require training the Bedouins in cooperative principles and practices. If such cooperatives can be established and the benefits from them realized by the Bedouins, they may be the solution to several problems emanating from the nomadic style of Bedouins life.

The author believes that any and all policies leading to the development of human resource base in the agricultural sector will prove to be a

great asset in the immediate as well as the long run, not for the agri-sector alone, but for the economy as a whole. The recommendations discussed in this section can be summarized in the following points:

1. Providing adequate general education in the rural areas to reduce illiteracy. This includes implementing adult education for farmers who are above school age.
2. Providing farmers with the agricultural education regarding production and marketing practices. Such education can be made part of the adult education program or through extension or farmers organizations and cooperatives.
3. Implementing special educational programs to reach the Bedouins. This can help the government's efforts in settling them by making the Bedouins more conscious through the acquired knowledge of ways and means of improving their living conditions and how could all this be achieved through settlement.
4. Training more Saudi extension agents and reducing the dependence on foreigners in the field. This entails that the government should try to strengthen the Agricultural Extension Department. This goal can also be enhanced by building agricultural institutes to provide two or three years of education after completing high school. In addition to being good farmers themselves, the graduates of such institutes will help meet the needed demand for the various education programs including adult education and extension.

5. Providing pre-service and in-service professional training for the personnel staffing the various agricultural departments. This professional training will gradually reduce the Kingdom's dependence on non-resident foreign advisors and consultants. It also provides the continuity in planning, execution and follow-up practices.
6. Trying agricultural cooperatives among settled Bedouins on pilot project basis. The incorporation of the Bedouins into the economy of the country will bolster the human resource base and also improve the livestock production. Cooperatives may provide the necessary link to bring this part of the population to the market economy.

#### Natural resources

For better utilization of natural resources for the purpose of economic development, certain policies need to be instituted for the use of land, water and range resources. Problems of utilization of these resources have been discussed earlier. The extremely low ratio of cultivable land to total land, the pattern of land use and small size fragmentation of land holdings, the scarcity of water and the waste associated with water use, the overgrazing of the range resources coupled with drought are all symptoms that characterize the Kingdom's natural resources.

Land      One way to increase the efficiency of agricultural production on cultivated land is through consolidation of small holdings. However, this may be impracticable with the previously cultivated land simply because it is a meager .18 percent of land in the Kingdom. If this

land is to be redistributed, there will be chances of increasing the number of landless and unemployed in the agrisector.

For land distribution of the new settlement projects, the appropriate farm size was designated between 5 to 10 hectares. Eligibilities for new or additional land are ordered in this manner: (1) an owner of adjacent land, (2) inhabitants of the area, (3) a person more capable of using the land efficiently, (4) persons already employed in agriculture, and (5) persons who do not already possess land. Under a recent ordinance, the Public Land Management can distribute land to companies if they meet certain requirements of the law.

An alternative to companies could be the establishment of cooperatives whereby adjacent units owned by cooperative members could be cultivated using larger machines than a single farmer can afford to use economically. This kind of arrangement is being done in Egypt, especially among cotton growers who have been beneficiaries of the land distribution schemes of the government. The cooperatives alternative, however, will require time and therefore may not apply to the near term targets of the government for increasing agricultural production. A "crash program" was suggested by Heady (16, p. 78) in which "commercial farm which possess capital, skilled manpower and experience to implement rapidly the conversion of barren land into productive cropping activities. Heady (16, p. 79) goes on to say, however, that the creation of large farms to produce rapid development is a goal in conflict with the social goal of getting more of the society to participate in development. It is also in conflict with

accommodating the Bedouins so that the harshness of their living can be reduced and the ratio of human resource to range resources can be reduced and the productivity of range can be increased.

Heady then specifies that the competitive relationship between size and mechanization on one hand, and equity and participation in the development process on the other hand can be resolved by granting short term concessions to commercial farms providing in the contract (1) that the company employs persons to be transferred into settled agriculture as the majority of its labor force and (2) that the capital budget and contract terms allow a rate of return to the company which covers the outlay for its commercial operations plus investment for training settlers.

Such a proposal will serve the double purpose of rapid economic development and the objective equity and settlement of the nomadic population. It also serves the goal of reducing the pressure on the range by decreasing the ratio of human to range resources through the settlement programs.

Water resources      Until recently, Saudi Arabia was thought to be one of the driest countries of the world. The studies carried by or on behalf of the government, however, showed that the underground water resources in the Kingdom are much greater than estimated and that at the present rate of withdrawal, the water supply will be adequate for much of Saudi Arabia for centuries to come (32, p. 22).

The government has been making heavy investments in constructing irrigation and drainage projects of this newly discovered water, the goal



being the utilization of water resources for agricultural and overall economic development of the country. Large expenditure is also being made in killing wells that are uneconomical to operate, or to regulate the flow of other wells or to prevent salinity due to over pumping. Another problem besides salinity, has been the waste in water use in the absence of water user charges and the guidance and restraints in the most productive use and conservation of this vital resource.

Policies have been directed toward the establishment of water code and suggestions have already been made which, if implemented, will control drilling and pumping, prevent salinity, stop wastage of water and damage of land and reduce the threat to health in addition to improving human relations. Codes have been proposed but not yet applied (13) (37). For such codes to be effective, they must not contradict the Islamic law relating to water rights, the people must be willing to submit to the law and support, and all responsible authorities should be willing to enforce it.

The code should provide for precise allocative mechanism, and through pricing, return to the government a portion of its investment in water development. The receipts of the government then could be used for further water and agriculture development elsewhere in the Kingdom.

In the absence of a pricing mechanism, water might be used in certain areas to the extent that its marginal value product is zero, while in other areas the MVP is appreciably higher. If a price is to be placed on water use, in a purely competitive economy, water will be used to the

point where the price is equal to MVP which is a necessary condition for allocating efficiency.

A question remains as what price should the government place on water use. The government needs to consider that the productivity of any irrigation project is expected to more than pay for its cost and maintenance, otherwise it would not have been undertaken in the first place. Therefore, in pricing water the government should figure out a charge which will cover the amount of investment involved or at least a major portion of it.

If the price of water were to be determined by the market, there will be a possibility of excluding from this market many potential users who cannot afford to pay the market price. For this and other reasons particular to Saudi Arabia and inconsistent with the goals of the development plan, non-market price based on tradition, religion, equity, and volume of government investment among other relevant factors, will be found more suitable at least for the present situation. Economic development may produce enough social and economic changes to merit the use of an alternative pricing mechanism in the future.

Range resources All studies agree that the rangeland of Saudi Arabia constitutes a very important agricultural resource. It supports the nomadic Bedouins and contributes most of the livestock production in the country. Yet the problems associated with the use and management of

this resource have long been the center of attention of the MAW in Saudi Arabia. Policy recommendations for the development of this resource emphasize the necessity of reducing the human and animal to range ratios. For the conservation, proper utilization and buildup of the range resources, a code is extremely needed to regulate the use of public range. Such code according to Parson-Basil (37, p. 7) must:

1. Limit livestock numbers to the grazing capacity of the range and direct special emphasis to the total reduction of camels and goats which are the most destructive grazers.
2. Bring about optimum integration of range land with irrigated feed base for the good of both.
3. Provide complete management of all range sites by:
  - a) Proper stocking of livestock.
  - b) Proper seasonal use.
4. Foster a comprehensive range research program including:
  - a) Watershed diversion projects to aid in the re-establishment of native plant species.
  - b) Reseeding of native plant species.
  - c) Demonstrations of benefits of proper management.
5. Carry out an intensive program of public relations and education regarding range management.

An extremely efficient government agency is needed to administer the extension, education and research programs required for the success of the enactment of a range code.

Research into the adaptability of plant species other than the native ones may aid in increasing the carrying capacity of the range.

Another possibility which might prove successful in the development of the range resources, is the initiation of cooperative societies which may be used as vehicles for carrying the needed improvements. As was pointed out earlier, the Bedouins are used to the tribe discipline, and so if they are properly educated, could form successful cooperative societies.

In summary, policy recommendations for the utilization of natural resources to attain the goals of the development plan include the following:

1. Distribution schemes of the land brought under cultivation as a result of irrigation and development projects should consider factors like farm size, equity of distribution, participation of people and the goals of the development plan.
2. Farm size should be large enough to enable farmers to produce on commercial levels. It was mentioned before that more than 46 percent of holdings are less than .5 hectare. Producers on such small farms cannot produce beyond subsistence levels and their access to improved technology and mechanization is minimized.
3. The planned distribution of 5 to 10 hectares as the appropriate size designated by the government may solve the problem of size. However, output of these farms may not achieve the targets of the development plan unless the farmers are supplied with adequate inputs to work

these farms. Making such inputs on credit, fertilizers and other biological inputs and small machines available to producers is essential for achieving productivity increases. Recommendations concerning inputs of production will follow later.

4. It is strongly recommended that the pressure on the range resources be reduced. This can be achieved in coordination with land distribution schemes and settlement of the nomads. The coordination and reconciliation of these goals calls for an extensive amount of work in the fields of education and public investment.
5. Economic use of water resources calls for the application of a water code that will regulate the flow of water and user charges.
6. The success of a water code hinges on two main things; one is the establishment of a responsible authority to implement the code, and two is the enlistment of people's understanding and cooperation. The government is encouraged to do both.
7. In pricing water the government needs to consider such factors as the amount of public investment involved, tradition and religion. For this reason a non-market pricing may prove more suitable in the beginning.
8. To regulate the utilization of range resources the government is advised to implement a range code as described in the text of this chapter.
9. Research has to be initiated to explore the possibility of increasing the carrying capacity of the range by introduction of adaptable high

yielding varieties. This range research along with other adaptive research can be conducted by a special research division under the agricultural extension department and linked to the overall system of agricultural education.

### Capital

Of the many problems that impede the economic development of the less-developed countries, shortage of capital has probably received the greatest amount of economists' attention. This is not to say that they have singled out capital as the only variable in the process of development. Economists do not even agree on whether the capital occupies the key role in this process. Nevertheless, the importance of capital in increasing the productivity and income of agriculturists is not disputed. The availability of capital resources has been cited as a distinguishing factor between agriculture in advanced countries and less-developed countries perhaps more than any other factor.

Agricultural development, as a part of the overall economic development process needs capital resources with the land and labor available in the agricultural sector. Capital formation is needed to cope with the employment of additional population which in less-developed countries grows at a faster rate than the advanced countries. Capital is needed to reclaim more land, use better methods and materials. Unfortunately, due to low incomes in agriculture, farmers are unable to save enough to channel to investment and capital formation. Those farmers who can save out of their incomes, are not a majority. Most of their savings will be

hoarded or changed into luxury items or entertainment because of the lack of financial institutions that can channel their savings into investment or because of the lack of confidence of these farmers in the existing institutions. The result is that capital is needed at the farm level as well as at the sectoral and national level. In most of the cases the government steps in to supply the needed capital, often borrowed from external sources.

In Saudi Arabia, the inability of the farm sector to raise the necessary funds for the purpose of development is similar to other less-developed nations. Fortunately, however, the country is endowed with a great national resource, oil, and the government is rich. The government is recognizing that capital formation has to come mostly from the public sector, and therefore, is supplying it at two levels:

1. Building the social overhead capital in the form of roads, irrigation projects, dams, etc. This is necessary for the process of development.
2. Supplying credit to farmers through the Agricultural Bank and subsidies on services and inputs through Agricultural Extension Department. The credit situation has been presented in the chapter on Agriculture.

So far the Agricultural Bank has been reaching less than 3 percent of the total agricultural holdings in the country. It has been extending loans mostly for drilling wells and small irrigation projects. In the course of the Five-Year Plan it is expected that the need and demand for

credit will increase putting pressure on the Bank's resources and staff. It is expected that more loans will be demanded for biological inputs such as improved seeds, fertilizers, etc. which will be mostly of short-term nature in contrast to the intermediate term loans emphasized by the Bank previously. Demand for long-term loans is expected to increase due to the projected increase in cultivable area and the need for investment on the newly distributed land.

To prevent capital input needs from restraining the development of agriculture, the government has to supplement the Bank's resources and staff adequately to be able to cope with the increased demand and to save the farmers from falling victims to private money lenders who charge high interest rates.

To avoid loss of government loans through default or low repayment capacity, the government needs to coordinate more closely credit services with extension service and technical assistance. Perhaps the intensification of loans in kind associated with a program of supervised credit will be most effective in this direction.

Encouraging the establishment of farmer credit cooperatives will substantially supplement the Bank and Agricultural Extension Department activities in the distribution and collection of loans and transmitting of technical information to farmers. Saudi Arabia may benefit from the successful experience of other Middle Eastern countries like Jordan, Egypt and Cyprus in the field of cooperatives. In Jordan, cooperative credit societies are common throughout the country. Individual cooperatives join as members of the National Central Cooperative Union (CCU)



which pools the orders of the member cooperatives and obtains the loans from the Agricultural Credit Corporation (ACC). Loans are then advanced to the member cooperatives by the CCU which also maintains warehouses in different locations to sell the farmers the necessary seeds, fertilizers, etc. The government of Jordan also supports an independent Cooperative Institute which holds courses and offers seminars for members of the cooperative movement. A parallel system of cooperatives also exists in Cyprus and has met with success.

Briefly, policy recommendations concerning capital includes: (1) the necessity for expanding the Agricultural Bank services to meet the expected increase in demand for credit, (2) coordination of extension and credit services to insure the use of credit productively, (3) more emphasis should be placed on extension of credit in kind, (4) use of supervised credit, and (5) encouragement or initiation of cooperative credit societies along the line of those in Jordan, Egypt and Cyprus.

### Technology

The importance of technology has long been recognized to the extent that it has recently gained the status of a factor of production in addition to the conventional factors of land, labor, capital and management. In every economy, more-developed or less-developed there exists a set of "technological factors", a term which includes the extent of factor endowment, how the factors are combined in the production process i.e. the choice of a certain technology of production, whether the allocation of resources is optimum or not, whether there is a technological progress and

at what rate this progress is taking place.

In a static economy, the choice of technology is equivalent to the optimal allocation of resources in production. Roughly, the rule of choice here is to use that combination of techniques of production in various sectors which will employ resources in proportions as close as possible to the proportion of the resources availability. The optimality criterion in this case does not involve the maximization of productivity of any particular resource and the objective is the maximization of total output obtainable from all resources available to the country. In a dynamic context time will be involved and difference in the period of the production processes, durability, quickness of payoff will be taken into consideration.

The choice of technique in developing economy usually starts from the static criterion. Modification of this criterion arises from problems involving time, goals of economic growth and other factors like economics of scale and external effects.

Technological progress usually involves changes in the techniques of production, as for example producing more output by the same amounts of inputs, or producing the same output with less inputs. Such technological progress may come forth through improvement in the existing inputs through training of labor for instance. Or it can come from adopting new technology in the form of different kinds of seeds, fertilizers and use of mechanization.

For the less-developed countries to attain technological progress.

there must be an awareness of the people of the existence of improved technologies. These technologies must be attainable by producers, adaptable to the conditions under which they operate and they must also meet some objective of these producers (20, pp. 173-178).

The agricultural sector of Saudi Arabia, like in many other less-developed countries, is characterized by labor, intensive production, techniques and primitive technology. To attain technical progress needed for the projected increase in production to meet the development targets, the government needs to improve the production techniques of farmers by improving their knowledge and through the introduction of new technologies.

Emphasis should not be on capital intensive technology like large scale mechanization because it results in unemployment of labor which can't be absorbed by the oil sector. The alternative would be for a policy of encouraging the use of biological inputs and small scale mechanization. This will both increase agricultural production and keep more people employed.

Awareness of farmers about the new technology can take place through extension and mass communication. Adaptability can be established through adaptive research and attainability of the new technology can come through government subsidization and credit. This of course leaves for the government the extra task of sponsoring adaptive research to determine which varieties can adapt and/or be modified to suit the Saudi environment.

Recommendations for improving the technology of production in Saudi Arabia's agriculture include: (1) emphasis on labor intensive technologies

to avoid creation of unemployment in the agricultural sector, (2) providing relevant information through extensive or mass communication media to create among the farmers the awareness of the existence and usefulness of the improved technologies, (3) encouraging adaptive research for testing the adaptability of improved varieties to Saudi soil and climate, and (4) enabling the farmers through subsidization and credit extension to attain the improved technologies which prove adaptable to the particular situation.

### Prices and Subsidies

#### Prices

Prices that will be discussed here are both output prices and input prices. Prices, in general, can be great motivation or disappointment to the producers depending on magnitude and direction. Producers are motivated by high output prices or low input prices or both. The directional impact of an economic policy adopting high output and/or low input prices is that the producers try to produce and sell more thus increasing the food supply and their incomes.

If commodity prices are too low at the farm level the government can help the farmers in different ways. One method is price support, whereby the government guarantees farmers a level of prices above the market price. This usually results in excess supply which will require storage and distribution facilities. Another method policy instrument is the payment of subsidies to farmers based on per unit of output produced.

Any of these two policies can be implemented only at a high cost to the government. A third substitute for higher commodity prices is lower prices for inputs employed by farmers.

Reduced input prices have the same effect as high commodity prices in encouraging increased output, higher farm incomes and overall agricultural development. In case input prices are considered too high, at least two different policies can be used by the government to reduce cost of production to farmers. Either by paying a subsidy per unit of input used or through public supply of inputs like machinery, fertilizers, etc.

There are other indirect policies which may affect prices of inputs or commodities and, therefore, encourage or discourage producers depending on how they affect these prices. Structural and institutional changes brought about through government policy indirectly affect farmers decisions by affecting prices.

The MAW in Saudi Arabia has made it clear as to what price support and subsidies will be used. According to MAW "wheat is the only crop that should be considered for price support within the next few years because it is the only one on which there have been quantifiable market and cost observations." (31). With regard to subsidies, it might be recalled that these will include use of fertilizers, machinery, imports and small irrigation projects. However, the MAW makes it a policy "to move away from providing free farm production services and materials as soon as possible. Systems of subsidy, if needed should encourage individuals to do things for themselves." (31).

Over the immediate past the commodity price policy in Saudi Arabia has not been conducive to increased farm output and agricultural development. On the contrary, the import subsidies on livestock, cereals and dairy products worked as depressants to domestic prices. Such import subsidies potentially benefit consumers on the expense of producers. Quantitatively, the effect of these subsidies cannot be calculated due to the lack of the appropriate statistics.

It was mentioned earlier that the government has removed most of these subsidies excepting that on wheat which has been reduced and will soon be removed. Instead the government is encouraged to impose moderate import tariffs on foodstuffs while at the same time encourage farmers to produce more so that the consumers will not be hurt.

### Subsidies

Some discussion of different kinds of subsidies was presented in the preceding paragraphs. A consolidation of the relevant policies on subsidies will be attempted hereafter.

Commodity subsidies represent a proxy price policy instrument for encouraging farmers to increase output through using more resources, better technology and thus contributing to the agricultural development effort. Simultaneously they help to lower food prices to the consumer. By increasing the food supply at a given market demand, prices will be driven down apparently is behind the government's previous policies on import subsidies. It is here argued that commodity subsidies, while improving returns to farmers, they also serve the purpose of keeping the

prices down for consumers. In this same vein, Heady (16) suggests transferring the same government outlay which was paid as import subsidies, to a subsidy program for Saudi Arabian farm products moving into the market. This policy could start with wheat which has high priority in the development plan. It could also be applied to alfalfa and limited number of vegetables and livestock products.

Input subsidies are among the policy instruments that can be used to enhance agricultural development by encouraging farmers to adopt modern crop technology in the form of fertilizers, better varieties, crop protection techniques, mechanization, etc. It is certain that the use of modern technology requires more capital than the farmers can raise and this fact acts as a deterrent to the transformation of agriculture. It, therefore, becomes necessary for the government to step in and supply either the necessary credit needed, or make it possible for the farmers to use new technology through input subsidies. This, the government could do through fertilizer, machinery imports and small irrigation projects.

The government may find that emphasis on other biological aspects of production such as the use of improved varieties and pesticides, etc., besides the use of fertilizers, would be extremely helpful in increasing yield per donum of land. It is recommended that the government advances a flat per donum subsidy plus 40 percent of the cost of seed, fertilizer, and pesticides for wheat, barley, sorghum, rice and forage crops produced under a prescribed set of technologies (16, p. 70). The 40 percent of

the cost of seeds, fertilizer and pesticides should be advanced in kind to assure that it will be used for improvement in production and not for other family purposes. Subsidy in kind serves an additional assurance that the farmers are actually using the prescribed set of technologies.

Such input subsidies aim at increasing farmers incentives to use better technology. They also serve to (a) reduce capital outlay of the farmer, (b) reduce somewhat his uncertainty in shifting to a technology which he is not used to, and (c) improving substantially his profit incentive by making this shift (16, p. 72).

To increase livestock production on settled agriculture, it is recommended that the government subsidize the farmers by supplying veterinary help, medicine and other related services which may be effective in achieving the goals of the development plan. For the pastoral livestock production, government help is needed in an integrated long-run program of range management and settlement of the Bedouins which are discussed elsewhere in this report.

Mechanization and machine subsidies are more sensitive than other crop production and livestock programs. Given the size of the labor force in agriculture, the extent of underemployment prevailing high degree of mechanization and wheat it entails in the necessity of increasing farm size may intensify these problems. It was mentioned earlier that increasing mechanization and farm size poses conflict of the goals of equity and participation and rapid economic development. That is probably the reason why the government planning to subsidize importation of small



machinery and small equipment and spare parts rather than heavy machines.

It is suggested that in the subsidization of the machine imports, differential rates should be used depending on (1) the size and power of the machines, (2) on the degree of consistency between the use of the machines and the goals of equity and social participation and (3) the effect of machine import on relative supply and price of labor and capital.

In summary, to provide incentives for farmers to increase production and participate more effectively in the development plan, the government is encouraged to give attention to the following policy recommendations concerning prices and subsidies:

1. Provide opportunity for the farmers to earn adequate income by insuring that the prices of farm products are reasonably high or prices of inputs reasonably low or a combination that provides the needed incentives.
2. In case commodity prices are too low for any particular product, the government can help through a price support program, subsidies to be paid per unit of output or provide inputs at reduced prices to farmers.
3. If input prices are high, the government can help by paying a subsidy per unit of input used or provide public supply of inputs in the form of machinery, fertilizers, etc.
4. For crops given top priority in the development plan, a mild import tariff will protect local producers. If this is associated with a program encouraging supply, the resultant increase in output will leave the consumers unharmed by the import tariff.

5. For the top priority products, namely wheat alfalfa and vegetables, it is suggested that the government provide input subsidies to insure that the farmers are using the desired varieties and required amounts of fertilizers, insecticides, etc.
6. Subsidies on livestock production should be limited and supplied in the form of veterinary help to settled farms.
7. Machine subsidies should concentrate on small machines only.
8. Such programs are recommended in the early stages of the development plan and should be gradually discontinued as the farmers acquire the levels of income and knowledge that facilitate the adoption of the desired practices and insure the proper functioning of the pricing mechanism.

### Institutions

Economic literature abounds with analyses of the interrelationship between institutions and the process of economic development. The existence of efficient institutions is very important for the success of the development process which aims at a change which might involve the institutions themselves. The analysis of the relationship between institutions and agricultural development is not the subject of this section. Our objective is confined to the study of the needed institutions in Saudi Arabia which will help the country achieve the targets of the development plan and hence the policies on the part of the government, that will bring these institutions to the level of competence consistent with the above objective.

To accomplish the objective of this section, a listing of the different rural institutions and a brief description of how they contribute to the process of agricultural development, will be mentioned first, followed by policies needed in Saudi Arabia to establish new institutions or modify the existing institutions for achieving the development targets. The process of agricultural development is very complex and depends on all kinds of institutions; political, legal, social, cultural, religious, and economic institutions. These institutions are so much interrelated that isolating and studying an individual category is a difficult if not impossible task. However, for our purposes, concentration will be on the following institutions:

1. Land tenure institutions
2. Factor and product marketing institutions
3. Credit institutions.

#### Land tenure institutions

Land tenure institutions are defined as the legal and contractual or customary arrangements whereby agriculturists gain access to productive opportunities on the land. The general role of these institutions is to accelerate and not to retard the achievement of development goals. Within agricultural sector, they affect the productivity and income of farmers and therefore affect the income distribution, the demand of non-agricultural production, labor shifts from agriculture to other sectors and investment in and out of the agricultural sector of the income generated in that sector. These are the areas which require decision-making from the policy maker.

In Saudi Arabia land tenure institutions are very complicated. Only a small fraction of the land is owned by farmers in the form of mulk. It applies only to arable land and more commonly found in Asir. Most of the land area in the Kingdom is miri land, the control of which is ultimately vested in the state. Another form of tenure is land permanently endowed to religious or charitable institutions and it is called waqf.

There is also ownership of large tracts which are usually granted by the government from its miri land. These large tracts are called ikta. Some of these are so big the owners lease them to sharecroppers at high rate. Once the government approves the registration of the ikta tracts they become private property or mulk.

Mushaa land is collectively owned property of extended families who have decided to keep their land intact rather than divide it among heirs according to Islamic law. This kind of tenure is more common in Nejd and in Eastern Province.

Village communities, oasis communities and communal pastures belonging to settled farmers represent a non-family type of collective ownership of land. Land is jointly owned, worked, cultivated and harvested and the shares of the crops are equally divided among the working adult men and women of the community.

Land under all forms of tenure may be leased through sharecropping agreements, term leases or heritable leases. Of these, sharecropping is most common. About 70 percent of the sharecropping agreements provide that the owner supply land, water, seed and in some cases, housing. If

tenant works all year and provide draft animals, fertilizers, farm equipment, he pays the owner 50 percent of the grain crops and 75 percent of the dates. On the other hand, if the tenant only provides labor at threshing and harvesting time, the owner receives 80 percent of grains and 95 percent of the dates.

As is clear, the system of tenure in Saudi Arabia is not one that provides incentives for higher productivity and investment in agriculture. It is suggested that for the newly reclaimed land as well as the previously cultivated land, some modifications of land tenure institutions are needed to (1) provide incentives for the cultivators to increase his productivity, (2) provide for improved technical and managerial innovations, and (3) improve formation and access to capital.

Modifications to increase incentives may be in the form of dividing the large tracts ikta land among laborers and tenants in units they can cultivate efficiently. Registration of land provides security and removes the uncertainty facing the owners. If the units are too small, consolidation or preventing of further partitioning of land may induce farmers to adopt new technologies and management practices. The increase of productivity of cultivators due to security, certainty and improved cultural practices, increases their incomes and eventually their savings and investment. Alternatively, a farmer having a title on land and his productive capacity will have access to borrowing from local banks or cooperative credit societies. Cooperation will complement modifications in land institutions toward the goals of the development plan.

### Factor and product market institutions

A part of the package of programs and policies that promote agricultural development is the existence of an efficient marketing mechanism and institutions. In transforming agriculture from subsistence to commercial farming the marketing mechanism becomes an indispensable means of moving commodities and inputs among origins and destinations.

Marketing institutions can become effective policy instrument variables if the necessary infrastructure of transportation, processing, storage, refrigeration and communication of market information is adequate. In this context marketing institutions may create new inputs of production, analyze supply and demand of inputs and commodities, innovate in the distribution of these inputs and commodities and transmit to consumers, producers, and resource owners communicative knowledge which aids each party in maximizing its objective function.

From the various reports (69, 70) written on the marketing structure and problems in Saudi Arabia, it appears that the Saudi markets for domestic agricultural production are extremely localized or regional in character. Such marketing structure prevails usually in subsistence oriented agriculture where farmers produce for themselves and for the immediate local markets. Although this has been true of many areas of the Kingdom, other problems have contributed to this kind of market structure. Farmers are isolated in remote areas, lack of transportation facilities, lack of market information and uncertainty of demand and prices in other markets high cost of trucking and fear of spoilage of

produce transported on animal backs are some of the factors contributing the characterization of Saudi markets.

Recommendations of various experts and organizations have centered around the removal of these barriers if the marketing subsector is to take its share in the development plan. The planned increase in production during the plan calls for emphasis on inter-regional and international markets. This necessitates the transformation of the localized marketing structure along with transforming the agrisector as planned.

Initiation of market institutions is essential for the transformation of the marketing subsector. Among the recommendations of the F.A.O. team to Saudi Arabia was the regulation of the Marketing Section of the MAW so that it can perform the following major tasks (69, p. 21):

1. Analysis of demand and prices including the preparation of tables and charts on retail and wholesale prices for domestic and international markets and analyzing these prices monthly or periodically.
2. Analysis of supply conditions including the analysis of the seasonality of supply and its relation with the demand conditions, collaboration with extension service concerning practical demonstrations to producers in timing of harvesting, picking and proper delivery to market. Its work also should include assessment of agricultural raw materials, assembly and analysis of input factors, transportation costs, commission of brokers and auctioneers and investigate the possibility of establishing farmers cooperatives.

3. Improvement of marketing facilities including grading, standardization, introduction of proper crates, boxes and improve packaging in general. It also should carry preinvestment investigations on feasibility of establishing storage, refrigeration and processing facilities, training of registrars of prices, and supply advice and recommendations to local producers and importers of foodstuffs.
4. Research projects should be carried regarding most significant marketing problems of the country.

The establishment of this Marketing Section with all its subsections and its registrars and investigators throughout the Kingdom, if proceed as planned, will go a long way in providing the structural change needed in the marketing subsector.

It should not be forgotten, however, that the success of any institutional change will depend on the availability of the needed infrastructure in the form of roads, railroads, market information networks and other storage, refrigeration processing facilities.

Specialized market news services should be established for each of the grain markets, the fruits and vegetables market and the livestock market. It is recommended also that the government establish export and import offices for each of the above mentioned markets.

Finally, at the farm level farmers marketing cooperatives and organizations should be encouraged. These eventually can assume the task of the Marketing Section at the local and possibly regional levels.



### Credit institutions

The importance and contribution of credit to the economic development of Saudi Arabia was presented in a previous chapter. In this section, some of the major objectives of credit institutions will be emphasized together with policy analysis and recommendations for Saudi Arabia.

In general, the objectives of credit institutions include the following:

1. Fostering the economic development by facilitating the injection of capital into agriculture. This comes through making, supervising and collecting loans in the field of production and marketing of farm products.
2. Continuous up-grading of the capabilities of the agricultural credit staff and providing for the training for expanding this staff.
3. Mobilizing the savings of the farm sector if this is possible.
4. Furnishing and/or coordinating technical assistance at the farm level.

Credit institutions are influenced in carrying out these functions, by other social, economic, cultural and legal institutions that prevail in the rural sector. More specifically, the efficiency of credit institutions depends on the adequacy of the rural infrastructure, the efficiency of the marketing system, the status of land tenure institutions and the continuity in governmental policies.

The major credit source in Saudi Arabia is the Agricultural Credit Bank. The limited coverage of the services of this bank and the expected increase in demand for credit during the course of the Five-Year Plan

necessitates a set of measures to be taken by the government. First, estimates of demand for credit should be made through classification of farmers and the study of their finances and needs. Such estimates will give the government clues as to how much expansion is needed in the present capacity of the bank. Secondly, studies should be carried out to determine the effect of other institutions on credit institutions. As for example the effect of religious restraint on the dissemination of credit policies. Moslems are religiously forbidden to accept or pay interest. Cultural traditional matters have an effect also. Some people refuse to borrow because it is not prestigious to be in debt. Thirdly, the government needs to expand the present credit facilities, and provide training to expand the staff of the credit institutions. Finally, possibilities for establishing cooperative credit societies on the lines explained in the previous chapter, should be explored. Credit societies can perform most of the functions of credit institutions outlined above. To start with, these cooperatives may need to borrow all funds externally. However, as a cooperative volume of business increases as more members join, enough savings may be raised to satisfy most if not all of the needs of the cooperative members. For the long-run encouraging the establishment of cooperating may prove profitable to the government of Saudi Arabia.

From the preceding discussion on institutions it can be concluded that these are interrelated and that the existence of the proper cooperating institutions is essential for implementing the changes called for in the development plan. The main policy recommendations concerning

these institutions can be summarized in the following manner:

1. Modification of tenure institutions in Saudi Arabia is essential for providing the needed incentives to farmers, the technical and managerial innovations and capital formation.
2. Redistribution of the ikta land so that it can be used more productively.
3. Regulation of formal or written relations between landlord and tenants to provide more security and incomes to tenants.
4. Emphasize the interregional characteristics of the agrisector and implement the infrastructure that incorporates the isolated areas into the economy.
5. Provide the Marketing Section of the MAW with adequate staffing and supporting services to enable it to carry its functions properly.
6. Establishment of specialized market news subsections for individual crops to facilitate the dissemination of relevant news to interested farmers regularly and quickly.
7. Establishment of export and import boards for individual crops to keep all concerned posted on the movements of the different products.
8. Expansion and adequate staffing of the Agricultural Bank which is the main credit institution in the Kingdom.
9. Initiate research to estimate farmer's credit needs and provide means to meet these needs.

10. Evaluate the effect of cultural, religious and other non-economic institutions on the performance of economic institutions.
11. Initiate cooperative movement in the rural areas to supplement the existing institutions.

CHAPTER VII. TOWARDS AN INTERREGIONAL LINEAR PROGRAMMING MODEL  
FOR PLANNING THE ECONOMIC DEVELOPMENT OF AGRICULTURE

Regional programming (planning) is becoming widely recognized as an important tool for the economic development of agriculture. Being so complex, however, accounts for its lack of adoption in many less-developed countries. This complexity arises from differences in ecological, structural and technological conditions under which agricultural production takes place in the different regions. National development plans for agriculture are often prepared with undue consideration of these regional differences, a practice which may result in misallocation of resources and development funds and therefore, the inability to achieve the developmental targets.

Regional studies and comparative advantage analyses are extremely helpful in pinpointing the potentialities and the economic characterization of the different regions. Similarities and/or differences then can be used for dividing a certain country into programming regions which can be fit into a programming model which will be the expression of the interregional interrelationships among all regions with respect to production, transportation and marketing.

Interregional linear programming has been helpful as an analytic tool as is indicated in the studies (25, 17, 9, 56, 74). However, most of these studies agree that there is too much aggregation that remains when assumptions are made regarding the uniformities among regions with respect to resources, soil types, coefficients of productions, etc.

Operationally, the technique of interregional linear programming permit, under certain conditions and restrictions, the simultaneous treatment of production activities of final, intermediate and joint products, of transfer activities and transportation activities within and between regions given assumptions about resources, supply, demand and other institutional and behavioral factors, an apparent advantage over studying regions or activities separately. As an optimizing technique, an interregional linear programming model is suited to answer questions pertaining to the spatial resource allocation that optimizes a certain given objective function. The objective function is thought to represent the behavior of an individual economic unit or group of units under competitive conditions. The regional disaggregation provides for better specifications of productive factors and their interdependences than the national aggregative level. It should not escape notice, however, that the usefulness of interregional linear programming as a predictive or normative tool in research and planning is limited by proper characterization of the conditions of production of the economy, specification of programming coefficients, resources and other constraints and limitations.

#### Linear Programming

In general, linear programming technique involves the optimization (maximization or minimization) of a linear function subject to a set of linear inequalities, as for example

$$\text{Max } f(x) = c'X$$

$$\text{Subject to } AX \leq b$$

$$\text{and } X \geq 0$$

where,

$c'$  = the transposed column vector of weights (prices) corresponding to each structural activity of the problem.

$X$  = the activities levels obtained in the optimum solution.

$A$  = an input-output coefficient matrix relating each level of activity to the resource use and related cost structure.

$b$  = resource supply and other constraints given in the formulated problem.

The objective function may be maximization of profits, gross income, net income, etc. or minimization of costs of production, transportation, etc.

#### General assumptions of linear programming

The general assumptions of linear programming as applied to inter-regional activity analysis are:

1. The objective function is linear and separable, with each of its components depending on only one corresponding activity level. This assumption allows the possibility of specifying separable objective function for each region (or groups of production units within a region).

2. Linearity of production functions based on constant input-output coefficients within relevant range and constant prices of resources and products.
3. Additivity of production processes in the that two or more processes can be used simultaneously and that the resulting output and inputs used are the sum of their individual output and inputs.
4. Divisibility products may be produced and factors may be used in quantities which are less than whole units, i.e. all factors and resource being continuous and infinitely divisible.
5. There are finite number of relevant processes available for combining factors into products. Resource supplies, input-output coefficients and costs of production are assumed with certainty.

#### Relevance of interregional models to planning agricultural development in Saudi Arabia

Agricultural production in Saudi Arabia is scattered in discrete locations over the wide expanse of the country. Apart from the Southern Region and Qaseem which have somewhat large agricultural areas, the rest of producing locations are concentrated in oases of different sizes depending on ground water availability. The discovery of ground water in several locations as shown in Figure 4 form the basis of the government efforts in developing the agricultural sector. As it can be readily seen, these locations are discretely located with hundreds of miles of desert separating them from each other and from the market regions which





Figure 4. New development locations

are concentrated in the center of the country stretching between the Arabian Gulf and the Red Sea.

Agricultural development involves large amounts of public investments in developing these new locations and in constructing the necessary roads between them and the market regions. Questions as which locations to develop and which roads to "put in" are vitally important for agricultural development. The setup as it exists in Saudi Arabia lends itself to a spatial interregional model to help answer such questions. Hence, since such a model is highly needed an attempt will follow to formulate it in a general form first. Identification of the data requirements and means of obtaining them will be presented next. Finally modification of the generalized model will be made to meet certain assumptions consistent with the Five-Year Plan for the development of agriculture.

The general model could be used to obtain an optimal allocation of resources intraregionally and interregionally. It may be used to maximize an objective function such as gross income or net income from agriculture or to minimize capital requirement of the development program. An optimal solution at any point in time will indicate the adjustments needed in the actual setting concerning prices, subsidies, investments, etc. which will move the agricultural sector in the direction of the optimal setting. Presented hereafter is a model for the economic development of agriculture in Saudi Arabia followed by attempting the identification of the requirements needed to make this model or any modified form of it operational in Saudi Arabia.

Objectives of such a model include finding an optimal allocation of resources in the region and among regions for the fulfillment of an objective function such as maximization of net income from agriculture in the Kingdom. The optimal solution at a point in time will show the divergence between the actual value of agricultural products and the value in the optimal solution. This gives clues as to the adjustments needed through government policy on prices, subsidies, etc. which will move the agricultural sector towards the optimal position.

#### Assumptions

The following simplifying assumptions guide the formulation of the model:

1. There are  $n$  spatially operated producing areas and  $m$  spatially consuming regions in the agricultural sector of Saudi Arabia.
2. Each of the producing areas has a well-defined set of activities and each of these activities have constant input-output coefficients.
3. The producing areas are internally homogeneous with respect to resources and their uses and resource inputs for each activity are known.
4. Costs of each activity (production, transfer and transport) are known.
5. Requirements of the consuming regions are known.
6. Competitive conditions prevail in the economy with maximization of profit assumed to be the economic motive of producers.

In addition to these assumptions, the model is also subject to the general linear programming assumptions which were outlined in the preceding section.

Notations used

$K$  will be used as a subscript indicating the producing area,  $K = 1, 2, \dots, n$ . The Kingdom is divided into (9) areas which are distributed discretely with miles of desert sand often separating them. Figure 5 shows these producing areas.

$L$  will be used to denote the consuming regions. These are the Eastern, the Central and the Western consuming regions.  $L$  therefore, runs from 1 to 3 to indicate these regions. Details on these regions will follow later.

$j$  is a subscript that refers to production and transfer activities. These include crop production, livestock production, poultry production, etc.,  $j = 1, 2, \dots, r$ .

$b$  is a subscript denoting resources,  $b = 1, 2, \dots, s$ .

$i$  is a subscript that refers to intermediate products,  $i = 1, 2, \dots, p$ .

$f$  is a subscript that refers to final product,  $f = 1, 2, \dots, q$ .

$t$  is used as a subscript denoting transportation activities,  $t = 1, 2, \dots, g$ .

$X_{jk}$  denotes the level of production activity  $j$  in producing area  $k$ . The crop production activities may be represented by rotations. It may be necessary sometimes to put restrictions on certain crops to avoid infeasible solutions or to make possible certain adjustments.

An individual crop rotation may produce more than one final and intermediate product. Final products are those which leave agricultural sector and used as such, while intermediate products are those which are

produced in the agricultural sector and used by the sector in producing final products. In case a product can be both final product and intermediate product, a dummy activity in the model is used to convert an intermediate to final product.

$X_{tk}$  represents the level of transport activities  $t$ , in region  $k$ . Most of the transportation in Saudi Arabia is done through trucking. A limited amount of railway transport exists as described earlier. Because of the vastness of the country, the prevalence of desert land throughout the Kingdom and mountainous land on the western coast, many small markets are isolated because of lack of transportation facilities. So the model can be designed to solve for the optimum transportation system needed for agricultural development.

$R_{bk}$  refers to the level of resources available in area  $k$ . This level is assumed known.

$R_{ik}$  represents the level of intermediate products in area  $k$ . Initially  $R_{ik}$  is equal to zero.

$R_{fk}$  requirement of final products by area  $k$ . This could be used as a constraint in the model to make sure a predetermined level of certain final products must be made available.

$N_{jk}$  refers to net income for all production, transfer and transport activities. It can be calculated from the equation:

$$N_{jk} = \sum_{f=1}^q a_{fjk} p_{fjk} - (AVC)_{fjk} \quad (7.1)$$

where,

$\sum a_{fjk} p_{fjk}$  is the gross value of final products produced per unit of  $j$ th activity in area  $k$ .

$p_{fjk}$  is the market price of the final product.

$a_{fjk}$  is the quantity of final product produced by unit of activity.

$(AVC)_{jk}$  is the variable cost per unit of an activity for those items of inputs that are not included in restrictions.

If there is just one final product from a certain activity, the net income  $N_{fk}$  will be calculated from the equation

$$N_{fk} = a_{fjk} p_{fjk} - (AVC)_{fk} \quad (7.2)$$

It is clear that for activities producing only intermediate products, the net income,  $N_{jk} = - (AVC)_{jk}$  since the first term on the right of Equation 7.1 vanishes when no final products are produced.

$T_{fkk'}^1$  denotes cost per unit of transport activity for transporting final products from area  $k$  to  $k'$  in the  $l$ th consuming region,  $k \neq k'$ .

$T_{f1'k}^1$  denotes cost per unit of transport activity for transporting final products from the  $1'$  consuming region to  $k$ th producing region of the consuming region  $1$ .

$T_{ikk'}^1$  represents the cost per unit of transport activity for transporting intermediate products from area  $k$  to  $k'$  in the  $l$ th consuming region,  $k \neq k'$ .

$T_{i1'k}^1$  denotes the cost per unit of transport activity for transporting intermediate products from the  $1'$  consuming region to the  $k$ th producing area of the consuming region  $1$ .

$T_{bkk'}^l$  is the cost per unit of transport activity for transporting mobile resources from producing area  $k$  to area  $k'$  of the  $l$ th consuming region,  $k \neq k'$ .

$T_{bl'k}^l$  is the cost of a unit of transport activity used for transporting mobile resources from the  $l'$  consuming region to the  $k$ th producing area of the consuming region  $l$ .

Net income from a unit of transport activity from a final product  $N_{tk}$  can be calculated from the equation

$$N_{tk} = N_{fk'} - N_{fk} - T_{fkk'}^l \quad (7.3)$$

where,

$N_{fk'}$  is the net income of a final product in the area of destination, which is equal to:  $(p_{fk'} - (AC)_{fk'})$  and

$N_{fk}$  is the net income for that final product in the area of origin which is equal to:  $(p_{fk} - (AC)_{fk})$  and

$T_{fkk'}$  is transport cost.

In cases of transporting intermediate products and mobile resources the net incomes,  $N_{tk}$ , from the transport activities is  $-T_{ikk'}$  and  $-T_{bkk'}$  respectively. This is negative income as the signs show.

$C_{ijk}$  and  $C_{bjk}$  are coefficients for intermediate products and resources for production and transfer activities. For the intermediate products  $a_{ijk}$  is positive when the product is used as input and negative when it is an output.

$C_{fj}$  is the amount of final product produced by a unit of a production activity or converted by a unit of transfer activity.

$C_{itk}$  and  $C_{btk}$  are respectively amounts of intermediate and resource available locally to be used by a transfer activity.

$C_{itkk'}$  and  $C_{btkk'}$  are amounts of intermediate and resource transported per unit of a transport activity from producing area  $k$  to  $k'$ .

$C'_{itkk'}$ ,  $C'_{btkk'}$  and  $C'_{ftkk'}$  are the quantities received in area  $k'$ .

In case there is no loss in these quantities, we have

$$C_{itkk'} = C'_{itkk'}$$

$$C_{btkk'} = C'_{btkk'}$$

$$C_{ftkk'} = C'_{ftkk'}$$

The last coefficient  $C_{tk}$  represents the number of units of transport used by a transport activity in area  $k$ .

#### Mathematical form

Mathematically, the general model could be represented by an objective function, constraints and conditions in the following form (for simplicity it will be assumed that there are  $k$  regions in which production and consumption take place simultaneously):

$$\text{Max } f(x): \sum_{k=1}^n \sum_{j=1}^n N_{jk} X_{jk} + \sum_{k=1}^n \sum_{t=1}^g N_{tkk'} X_{tk} \quad (7.4)$$

This objective function is separable. In this form it is so general and aims at the maximization of net incomes of the regions of the agriculture sector. Different constraints can be used in a model like this, as for example constraints on land availability, range capacity, minimum



availability constraints of certain crops and livestock products, maximum amount of government funds available for investment to increase agricultural production and/or productivity of resources in agricultural sector.

Specifically, the maximization of the objective function above is subject to the following constraints:

$$\begin{aligned} & \sum_{j=1}^r C_{bjk} X_{jk} + \sum_{t=1}^g C_{btk} X_{tk} + \sum_{t=1}^g C_{btkk} X_{tk} \\ & - \sum_{k=1}^n \sum_{t=1}^g C_{btkk} X_{tk} \leq R_{bk} \end{aligned} \quad (7.5)$$

$$\begin{aligned} & + \sum_{j=1}^r C_{ijk} X_{jk} + \sum_{t=1}^g C_{itk} X_{tk} + \sum_{t=1}^g C_{itkk} X_{tk} \\ & - \sum_{k=1}^n \sum_{t=1}^g C_{itkk} X_{tk} \leq 0 \end{aligned} \quad (7.6)$$

$$i = 1, 2, \dots, p$$

$$\begin{aligned} & - \sum_{j=1}^r C_{fjk} X_{jk} + \sum_{t=1}^g C_{ftkk} X_{tk} \\ & - \sum_{\substack{k=1 \\ k \neq k'}}^n \sum_{t=1}^g C_{ftkk} X_{tk} \leq -R_{fk} \end{aligned} \quad (7.7)$$

$$\sum_{j=1}^r \sum_{t=1}^g C_{tjkk} X_{jk} \leq R_n \quad (7.8)$$

$$x_{jk}, x_{tk} \geq 0 \quad (7.9)$$

The general resource restraints shown in Equation 7.5 above read from left to right the amount of a resource used by all production in a region, resource used by transport activities of a region, amount of resource exported to other regions and the total receipts of a resource from other regions respectively. If the resource is immobile the third and fourth terms are each zero.

As mentioned earlier, resource constraints of all kinds may exist in an optimization model. In Saudi Arabia the cultivable area is a limiting resource, availability of water, capacity of range, etc. constitutes limitations of different degrees in different regions.

The intermediate products constraint Equation 7.6 shows from the left the quantities of an intermediate product produced by production activities or converted by transfer activities or the intermediates used up by production activities. If the intermediate are inputs a positive sign is used, if outputs a negative sign is indicated. The second term in the constraints indicate the amount of local inputs for transport activities of a region. The third and fourth terms would vanish for immobile intermediates.

In the case of immobile intermediates, the constraint simply states that the requirements of an intermediate product by production activities and as local inputs for transport activities, cannot exceed the output of  $i$  from production activities. The equality between demand and production of  $i$  will hold also if there is one  $i$  produced.

However, if the  $i$ 's are produced as joint products, their production may exceed their requirement because the production of these  $i$ 's is not determined only by the demand for them as inputs for production activities and transport activities, but also by net income and resource requirement of activities that produce these intermediates as joint products along with other final products.

When  $i$ 's are mobile the third term in Equation 7.6 indicates shipments to other regions and the fourth term receipts from other regions.

Requirements of minimum products shown in Equation 7.7 are from the left: amount of final commodity produced by all production and transfer activities, exports to other regions and receipts from other regions. Usually, the inequality sign to meet minimum requirement will be greater than (7). To have this minimum requirement sign conform with maximization problem, both sides of the inequality are multiplied by (-1), thus making it  $\leq -R_{fk}$ , where  $R_{fk}$  is minimum requirement of a certain final product in region  $k$ .

The first run of a programming model of Saudi Arabia would perhaps have minimum requirements at the national level which can be derived from projections of demand for different commodities. Regional requirements can be established when data availability permits.

Transport constraints is at the national level, stating that transport units that are used by all transport activities of all regions cannot be more than what is available. It might be emphasized again that if the model is run without transport constraints, the solution will include the

total transportation requirements at the optimum value of the objective function. Alternatively, integer programming could be used in Saudi Arabia to determine the amount and location of roads necessary to achieve optimum level.

#### Theoretical solution of the model

The nature of solution of the programming model is affected by the quality and quantity of constraints placed in the model. For example, maximization of the objective function 7.4 without placing any final commodity requirement restrictions of the type 7.7 will yield an efficient solution of the model in which output of final commodities will be specified at the optimal level i.e. the level that maximizes net income from all regions. This solution, although indicating efficient allocation of resources given the sets of prices and factors, it does not guarantee an efficient allocation of commodities among regions. Commodities will tend to flow towards the high net income regions.

A solution of this kind shows that an increase in the output of any commodity can be done only at the expense of reducing the output of other goods which results in decreasing the value of the objective function and therefore inefficient solution.

Putting final product restrictions on the maximization problem will help solve the misallocation of commodities among regions but at the same time it reduces the value of the objective function. While the minimum restrictions produce better distribution of commodities in the different regions they cause the solution to the problem to be semi-efficient.

Solution with the existence of commodity restrictions can only be obtained if these restrictions are not binding or if there are multiple solutions to the problem, at least one of which fulfills these restrictions.

If the transportation system serves as a constraint to the maximization problem, the solution will show the optimal pattern of transportation congruent with the spatial allocation of resources and the overall maximization of the objective function. If, on the other hand, the transportation restriction is left out of the model, the solution will indicate the requirements of transport facilities at the optimum solution. This information is valuable for the policy makers who want to know how much roads and other transportation facilities are needed to meet certain targets in development.

In addition to obtaining production and transportation pattern in this maximization problem solution, an output of shadow prices of limiting resources, or what is called the dual solution, is also obtained. Mathematically, it has been proven that (1) every linear programming (primal) problem has an associated dual problem, (2) the dual of a maximization problem is a minimization problem and vice versa, and (3) if the primal and the dual are feasible, both have an optimal solution of the same value.

Economically, the dual of an efficient allocation is extremely important because it generates the imputed prices of resources and factors of production. These are the marginal value productivities of scarce resources in the final optimal solution of the programming problem.

The dual solution of the model described in this report provides shadow prices for all limiting resources (wages, interest, rent, etc.) and intermediate products. In the case of mobile resources, the existence of differences between shadow prices in different regions is an indication of misallocation of resources. It implies that production can be increased by shifting resources from areas where marginal value productivity is low to areas where it is higher.

The shadow pricing system is important for investment allocations and planning decisions in the interregional framework. The (MVP) of scarce resources in different uses and for different regions can be used for resources and price adjustments.

#### Delineation of producing areas and consuming regions

It might be recalled at this point that the estimates and projections of population, income demand and supply were all made at the national level in formulating the plan in Saudi Arabia. The targets of growth in the different subsectors in agriculture were also aggregated to represent the nation as a whole. Such a plan, with all its production and transport activities, can lend itself to an optimization linear programming model incorporating the whole country in one region. Such a model would not recognize interregional differences and interdependencies on which an interregional linear programming model is based. Therefore, for purposes of applying the interregional model specified in this chapter, the country has to be delineated into consuming regions and producing areas within these regions in a manner that will satisfy the assumptions of

interregional linear programming. Application of the model afterwards, depends on the availability of data, pertaining to these regions, that lends itself to linear programming. Traditionally, the Saudi government has been reporting agricultural data on the basis of the geographic regions of the Kingdom as shown in Figure 2 of Chapter III. The source of such data has been the Statistical Yearbook published by the Ministry of National Economy. Recently, however, the government has contracted foreign firms which have been carrying area resource surveys on subdivisions of the country which are different from the geographical regions. These subdivisions were shown in Figure 3 of Chapter V. Since the resource surveys are more recent and more comprehensive they are thought to be more useful as sources of data on resources, production patterns and transportation facilities in the Kingdom. However, these subdivisions were not designed as producing areas for interregional models. There are many differences among these regions, in areas, production patterns and techniques, availability of resources, etc. In other words, these areas are probably more heterogeneous than homogeneous. Nevertheless, these subdivisions may still be used because they have the most up-to-date data which, after adjustments and correlations among the different subdivisions are made, could provide part of the information for programming.

The Kingdom could be divided into three consuming regions encompassing the nine resource survey subdivisions. Let us call these three consuming regions the eastern, the central and the western. To a large degree this subdivision is arbitrary. It is based on the premise that most of the larger towns of the Kingdom, constituting most of the demand

for agricultural products fall in these three regions. The consuming regions and the producing areas falling within these regions are shown in Figure 5 below. The eastern consuming region contains producing areas IV and VII and the towns Hofuf, Dammam, Al-Muharaz, Al-Khobar, Qatuf, Rahim, Bagaig, Tasqbh, Shehat, Safwa and Dhahran with a total population of 278,900. The central consuming region contains producing areas I, II, III, V and VIII and the towns Riyadh, Buraida, Unaiza, Al-Saih, Al-Ras, Al-Badeah, Al-Bakairiah, Al-Agda, Tabuk and Sakaka. The western consuming region includes producing areas IV and J.M.T. and has in it these major cities: Jidda, Mecca, Medina, Tayif, Wanbu, Al-Bahr and Tatbah.

Although the reports from resource surveys provide most recent information on the agricultural sector, they suffer from the following limitations: (1) they are not complete; reports on Area VI have not been completed and surveys of Areas VII and VIII are still in the planning stage, (2) the reports which have been completed on other areas do not contain all the data relevant for linear programming application. For example, some reports lack information on transportation, most do not have disaggregated input-output coefficients pertaining to individual production or livestock activities. Cost coefficients are not reported for individual activities.

The data derived from these resource surveys will have to be qualified according to the above limitations.

In reality, agricultural production in Saudi Arabia is distributed in discrete locations, in oasis or where water is available for irrigation. This is more so in the case of crop production than for livestock



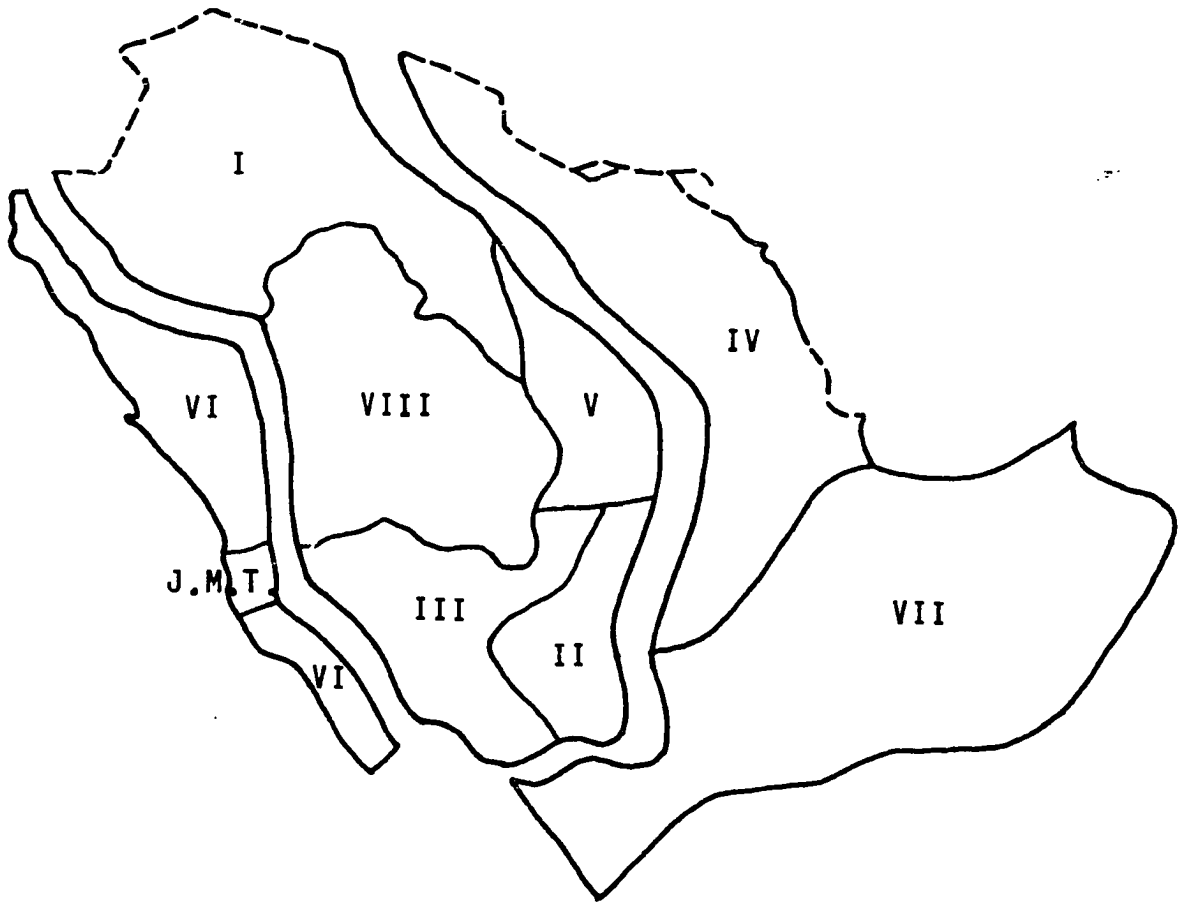


Figure 5. Delineation of consuming regions and producing areas

production which is more dispersed on the range resources. While a more discrete delineation of production areas reflect a more accurate image of the situation of crop production activities, it may tend to exclude livestock activities. This is perhaps one of the good reasons why the government should intensify its efforts in coordinating the range livestock production with the forage production on settled farms.

#### Data requirements for model application

The application of the interregional model indicated above for the maximization of the net income from agriculture in the different regions of the country, requires substantial amount of information concerning all variables entering the models. Data on levels of all activities, prices, costs, input-output coefficients, requirements of different commodities in different regions are examples of information needed to be fed into the model for its application. Such data is rarely available and therefore it has to be derived, projected, modified, etc. to put it in a form amenable to interregional linear programming.

In terms of applying our model to Saudi Arabia the following data is needed:

1. All  $X_{jk}$  i.e. the level of production activities  $j$  in region  $k$ . Production activities include crop production activities, livestock production, transfer or dummy activities of both crop production and livestock activities. This information could be obtained from government figures adapted from resource surveys for use in the development plan. Crop production activities include all the cereals namely

wheat, barley, rice, sorghum and millet, all vegetables including tomatoes, melons, cucumbers, pumpkins, etc., all fruits including apples, apricots, oranges, grapes, etc., all fodder crops including alfalfa, sorghum, maize, cereal, straw, etc. and all livestock products including meat, milk, eggs, etc. In matrix form:

$$X_{jk} = \begin{bmatrix} X_{j1k} \\ X_{j2k} \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ K_{jrk} \end{bmatrix}$$

Since there are  $k$  regions, this information is needed for all of these regions separately.

2. To calculate the net income per unit of the  $j$ th activity we need the quantity of final products produced by each unit of activity,  $a_{fjk}$ , the market price of the product,  $p_{fjk}$  and the average variable cost per unit  $(AVC)_{jk}$ . In matrix forms:

$$a_{fjk} = \begin{bmatrix} a_{fj1k} \\ a_{fj2k} \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ a_{fjrk} \end{bmatrix}, \quad p_{fjk} = \begin{bmatrix} p_{fj1k} \\ p_{fj2k} \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ p_{fjrk} \end{bmatrix}, \quad (AVC)_{jk} = \begin{bmatrix} (AVC)_{j1k} \\ (AVC)_{j2k} \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ (AVC)_{jrk} \end{bmatrix}$$

3. The level of transport activities in each region  $X_{tk}$ , and the net income of a transportation unit  $N_{tkk}$  as explained in the model. In matrix form:

$$X_{tk} = \begin{bmatrix} X_{t1k} \\ X_{t2k} \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ X_{tg} \end{bmatrix}$$

The calculation of net income from transport activities depends on the knowledge of prices of final products, intermediates and mobile resources in regions of origin and destination and the corresponding costs of transport activities as shown in Equation 7.3.

4. Resource levels in each region  $R_{bk}$  represented in matrix form as:

$$R_{bk} = \begin{bmatrix} R_{b1k} \\ R_{b2k} \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ R_{bsk} \end{bmatrix}$$

where  $b = (1, 2, \dots, s)$  represents land, labor, capital, machinery, fertilizers and all other inputs of production in each region. This kind of information is partly available from resource surveys and government figures.

5. Requirement of final commodities by each region,  $R_{fk}$ ,

$$R_{fk} = \begin{bmatrix} R_{f1k} \\ R_{f2k} \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ R_{fqk} \end{bmatrix} \quad f = (1, 2, 3, \dots, q)$$

As mentioned earlier, this could be used as constraints in maximizing the objective function. The requirements for the different kinds of final products at the regional level is not available and, therefore, they have to be derived. This can be done if per capita incomes, consumption propensities and elasticities of demand for the different products are established at the regional level. As mentioned earlier, Asfour projections and government projections for planning purposes have all been done on the national levels. For an interregional model the disaggregation at the regional level is necessary.

6. Input-output coefficients for production, transfer and transport activities constitute a huge matrix. It represents the per unit requirements of these activities of resources (b) intermediates (i) and final product (f). If we let  $A_k$  to symbolize this matrix for a certain region k, it can be put in matrix form as:

$$A_k = \begin{bmatrix} A_{bk} \\ A_{ik} \\ A_{fk} \end{bmatrix} \quad \text{with an order} \\ (s + p + q) (r + g + (n-1)g)$$

In which  $A_{bk}$  is that part of the matrix representing technical coefficients for resources, indicating the quantity of a resource required per unit of activity in region k. In this matrix, a positive sign is associated with coefficients of inputs and exports while a negative sign is associated with coefficients of imports.  $A_{ik}$  is the part of the matrix representing coefficients for intermediate products. Positive sign is associated with coefficients of inputs and exports and negative sign with coefficients of output and imports.  $A_{fk}$  represents the part of the matrix showing technical coefficients for final products. It was mentioned earlier under (2) in relation to calculation of net income of activities. It represents the amount of final product produced per unit of production or transfer activities or transported per unit of transport activity. Positive sign is associated with coefficients of output and imports and negative sign with coefficients of imports.

Much of this data is not available at the regional level and some of it is not available at all even at the national level. Regional data can be derived from the resource surveys upon their completion, but only after adjustments, correlations and updating\* are made on the original data to make it usable by linear programming technique.

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\*SRI is under contract with the Saudi government to do such jobs.

### Modification of the Model and Policy Implications

It might be recalled that the Saudi government has to use different kinds of policy instruments in its endeavor to achieve increases in agricultural production and improve the contribution of the agrisector to the national economy. Public investment on irrigation and land reclamation projects, settlements of the nomads, subsidies and price support, technical advice, education, etc. have all been mentioned as possible policies to achieve such objectives. In deciding on policy alternatives, analyses have often been done on the basis of isolated situations or projects without due consideration to other situations or projects, a practice which may result in misallocation of resources or public investment funds.

In an interregional planning model, all regions of the country are included simultaneously in the model and when a solution is obtained, it will specify the optimum pattern of production and transportation that maximizes or minimizes a certain objective function. It has been mentioned earlier that the nature of the solution will be patterned according to the constraints limiting the achievement of the objective function. A model with open restraints except for the availability of resources will produce a solution of the problem of allocating these resources. Such a solution will provide clues to the government as to what policies would move the resources towards this optimal allocation. It might be relocation of population, changing production patterns, installing more transportation facilities, etc.

Putting minimum demand requirements as regional restraints to the model reduces the value of the objective function and produces semi-efficient solutions which also means that returns to resource owners have been reduced. To induce the production of commodities for which minimum requirements have been specified at the required level, subsidies may have to be paid to producers. These subsidies indicate the amount by which prices of the respective commodities may be raised so as to make their production to raise to the minimum level specified in the respective regions. In the dual solution of the model these subsidies are imputed back to resource owners as an increment to their resources employed for production of commodities under consideration.

Comparing the solution of the model with and without minimum demand requirements will indicate which category of resource owners in the different regions has gained due to these constraints, and which category has incurred losses. A policy issue is raised here as to whether to tax away from the resource owners who have gained an amount equivalent to the subsidies which are to be paid to resource owners who has lost.

It is also evident from this analysis that these subsidies indicate the amount of adjustment that has to be done on the actual market prices. If the market prices are adjusted in amounts equivalent to these subsidies, a model run with these adjusted prices will yield a solution satisfying the minimum demand requirements without actually specifying these as constraints to the objective function.

The model can be modified to reflect some specific goals or priorities



of the Five-Year Plan for the development of the agricultural sector. The plan, for instance, places high priority on wheat, vegetables and forage crops in the early stages of the plan period. A question may arise as to how much acreage should be planted in each of these crops to meet certain requirements. In this case a model can be developed involving these three categories of crop production activities. Because vegetables include several kinds of crops, reference can be made to one crop of the group. Let this be tomatoes. Similarly let alfalfa represent the forage crops. Keeping in mind that there are three consuming regions ( $L = 1, 2, 3$ ) and nine producing areas,  $K = (1, 2, \dots, 9)$  the objective function may be summarized as:

$$\text{Min } f(c) = \sum_{j=1}^3 \sum_{k=1}^9 C_{jk} X_{jk} + \sum_{j=1}^3 \sum_{l=1}^2 \sum_{l'=1}^2 C_{jll'} T_{jll'} \quad (7.10)$$

$l \neq l'$

where,

$C_{jk}$  = the cost of producing one unit of the  $j$ th commodity in the  $k$ th producing area.

$X_{jk}$  = the level of the  $j$ th producing activity in the  $k$ th producing area ( $j = 1, 2$ , and  $3$  for wheat, tomatoes and alfalfa respectively).

$C_{jll'}$  = the cost of transporting one unit of the  $j$ th commodity to (from) the  $l$ th consuming region from (to) the  $l'$ th consuming region ( $1 - 2$  is the maximum number of such activities for any crop since there are 3 consuming regions).

$T_{j1l'}$  = the level of transportation of the  $j$ th commodity to (from) the  $l$ th consuming region from (to) the  $l'$ th consuming region).

The objective function as summarized above is the minimization of the cost of production and transportation of these three commodities. The solution of course would be the same if the objective function is the maximization of profits.

Total production is constrained by the total cropland (irrigated or unirrigated) available in the  $j$ th producing area.

$$\sum_{j=1}^3 A_{ijk} X_{jk} \leq b_i \quad (i = k = 1, 2, \dots, 9) \quad (7.11)$$

An additional limit may be put on the maximum acreage for any one crop as

$$A_{ijk} X_{jk} \leq b_{ij} \quad (7.12)$$

where,

$A_{ijk}$  = The amount of land used by one unit of the  $j$ th activity of the  $i = j$ th producing area ( $j = 1, 2, 3$  for wheat, tomatoes and alfalfa),

$b_{ij}$  = The amount of land available for use by the  $j$ th crop in the  $i$ th producing region, and

$b_i$  = The total cropland available within the  $i$ th producing area.

In addition to the above land constraints, minimum requirements for wheat, tomatoes and alfalfa may be indicated as in inequalities (7.13, 7.14, 7.15) below. These requirements must be satisfied by producing

areas within consuming regions or by transportation from other consuming areas.

$$\sum_{k=1}^n X_{1k} P_{1k} + \sum_{l=1}^2 Y_{11l'} T_{11l'} \geq D_{11} \quad (1 \neq 1') \quad (7.13)$$

$$\sum_{k=1}^n X_{2k} P_{2k} + \sum_{l=1}^2 Y_{31l'} T_{21l'} \geq D_{21} \quad (1 \neq 1') \quad (7.14)$$

$$\sum_{k=1}^n X_{3k} P_{3k} + \sum_{l=1}^2 Y_{31l'} T_{31l'} \geq D_{31} \quad (1 \neq 1') \quad (7.15)$$

The notations used for these demand equations are:

$D_{jl}$  = The demand for the  $j$ th commodity in the  $l$ th consuming region.

$Y_{jl1'}$  = The amount of the  $j$ th commodity transported to (from) the  $l$ th consuming region from (to) the  $l'$ th consuming region.

$P_{kj}$  = The per unit output of the  $j$ th activity in the  $k$ th producing area.

In this version, the model assumes that the cropland is the only limiting factor of production, and that other factors, namely capital and labor are assumed, to exist in sufficient amounts. The cropland available can be derived from the resource survey data and the projected increase in cultivable land produced by the irrigation and reclamation projects.

To apply this model, regional demand requirements, input-output and cost coefficients have to be computed. A substantial amount of research is needed all over the Kingdom to furnish regional data necessary for the generation of these coefficients.

As in all interregional programming models of the same nature, the solution will contain an optimum intraregional and interregional crop production pattern under the particular farm programs and demand requirements in Saudi Arabia. It is possible from such a solution to estimate shifts in the cropping pattern to approach the optimal situation.

The solution also will include an optimal product transportation routes and their magnitude. This kind of information is extremely useful to policy makers in their planning for transportation and transportation-linked industries.

Of great importance also, are the resource and product shadow prices which are also obtained as a result of solving this model. The importance of shadow prices was discussed earlier.

#### Integer Programming and Planning of Road Location

Adequate transportation infrastructure in the form of roads and other transport facilities is vital for linking the different regions of the Kingdom and integrating the isolated producing locations into the economy. The usefulness of linear programming in providing optimal solutions to the transportation problem has been mentioned earlier. However, ordinary linear programming solutions may contain fractional values for the variables as the optimum values. When roads, as part of transportation infrastructure, are the variables under study, solutions containing fractional variables are not wholly meaningful. For example, if there are producing areas A and B and markets I and II the need is for a whole road between area A and market I, or between area B and market II. A

linear programming solution containing half a road from A to I and half a road from B to II is not meaningful and undoubtedly undesirable.

To avoid fractional values for some or all variables, certain requirements have to be added to the basic formulation of the linear programming models. Such requirements may be added in the form of new restrictions specifying that only integer values of certain variables are allowed in the solution. When discrete values of variables are involved, the problem becomes one of integer rather than linear programming.

Integer programming is particularly useful in agricultural development projects which may each need to be considered at distinct levels. For example, an area development study may consider the effect of irrigation on the economy. The nature of investment and the availability of data may be such that only a few subprojects are to be considered in the problem. Irrigation may be one of several completely different projects which are to be analyzed in study.

The integer programming model developed hereafter is concerned with investment allocation for road construction. The model aims at finding locations of roads that minimize capital requirement and at the same time be consistent with other goals of the development plan.

Let us assume that there are  $P_i$  roads to be put in,  $i = 1, 2, \dots, I$ , and that within each road there are  $Y_{ij}$  activities represented by miles in each road,  $j = 1, 2, \dots, J_i$ . It is desired to formulate the model such that no  $Y_{ij}$  is allowed to take on a non-zero value unless the road  $P_i$  is in the program. The assumptions of interregional linear programming

stated earlier are maintained for this model with the additional integer aspects.

Further notations used in the model include:

$R_b$  indicates resources other than capital used in road building;

$b = 1, 2, \dots, B,$

$k$  indicates commodities produced in producing locations and shipped to demand regions;  $k = 1, 2, \dots, K,$

$l$  indicates consuming regions;  $l = 1, 2, \dots, L,$

$m$  denotes producing locations;  $m = 1, 2, \dots, M.$

The direct problem is represented by the functional:

$$\text{Min } \sum_i \sum_j C_{ij} Y_{ij} \quad (7.16)$$

Subject to:

$$\sum_i \sum_j a_{bij} Y_{ij} \leq R_b \quad b = (1, 2, \dots, B) \quad (7.17)$$

$$\sum_{i,k} X_{ikl} = D_l \quad l = (1, 2, \dots, L) \quad (7.18)$$

$$\sum_{ik} X_{ikm} = S_m \quad m = (1, 2, \dots, M) \quad (7.19)$$

$$\sum_j Y_{ij} = P_i \quad (7.20)$$

$$0 \leq Y_{ij} \leq 1 \quad Y_{ij} \text{ is an integer variable} \quad (7.21)$$

$Y_{ij} = 0$  the  $j$ th mile of the  $i$ th road  
out of solution,

$Y_{ij} = 1$  the  $j$ th mile of the  $i$ th road in the  
solution

$$0 \leq P_i \leq 1 \quad P_i \text{ is an integer variable} \quad (7.22)$$

$P_i = 0$ ,  $i$ th road is out of the solution

$P_i = 1$ ,  $i$ th road is in the solution

$$Y_{ij}, X_{ikl}, X_{ikm} \geq 0 \quad (7.23)$$

where

$C_{ij}$  denotes capital inputs of the  $j$ th activity in the  $i$ th road.

$a_{bij}$  denotes the input required of the  $b$ th resource by the  $j$ th  
activity of the  $i$ th road.

$X_{ikl}$  denotes the commodity  $K$ , transported via road  $i$  to the demand  
region  $l$ .

$X_{ikm}$  denotes the commodity  $K$  transported via road  $i$  from the produc-  
ing area  $m$ .

$R_b$  denotes the available resources other than capital resources.

$D_l$  denotes transported portion of demand of different commodities  
through different roads to consuming region  $l$ .

$S_m$  denotes the supply of different commodities ready to be trans-  
ported from producing area  $m$ , through different roads.

The first constraint simply states that the utilization of a certain  
resource by all roads cannot exceed the amount available. This constraint  
pertains to resources other than capital inputs.

The second constraint requires that shipments of all commodities coming via different roads to the demand region 1 should be equal to the amounts demanded of the commodities by this region.

The third constraint states that the amounts shipped by producing areas through different routes should be equal to the supply in excess of the need of that area. It is assumed that the producing areas will use some commodities as intermediate products and others as final products. All unused quantities will be shipped out of that area.

The remaining restrictions are concerned with the integer part of the model.

The solution of such a model will provide answers as to where to put in the roads in such a way that will minimize capital investment and satisfy the supply and demand conditions of the different regions.

It is possible to include in the objective function of this model an additional part for minimizing the cost of shipments of commodities among regions. In this case, the objective will be to minimize the capital input requirement for building roads and the cost of transporting commodities.

#### Some Limitations of Interregional Models

Most of the limitations of the interregional linear programming models originate from the nature of the assumptions as outlined at the beginning of this chapter. The further these assumptions are from the real world setting, the more limited the usefulness of these models.



Delineation of producing areas is almost arbitrary. There is no sound criteria upon which to depend in delimiting these areas especially when the country is so large and exhibits a wide range of differences including the climatic, geographical technological aspects. In Saudi Arabia a realistic delineation will result in producing locations discretely distributed and distantly separated.

Producers do not adopt the same production patterns in the different producing areas. They may choose among alternatives and substitute different factors and products depending on the relative prices.

Nor do the producers have identical input-output coefficients. Land used for a certain crop activity may vary among different farms. It may even vary in different locations on the same farm. Management as a factor of production is rarely alike. The assumption of constant input-output coefficient is indispensable for interregional linear programming, but it should always be remembered that this might be far from describing the real economic setting.

Other assumptions regarding similarity of production techniques within regions, the non-existence of returns to scale, the homogeneity of products, etc. which are made at the beginning of the chapter may not actually characterize the real world and to that extent they exert limitations on the use of such models.

However, if all relevant variables in actual setting are to be equally accounted for, the volume of computations would probably become without limit and would exceed any manageable proportions.

## CHAPTER VIII. SUMMARY

Oil sector dominates the economy of Saudi Arabia. It generates more than 50 percent of the GNP, over 25 percent of government revenue and constitutes over 99 percent of the total value of exports thus earning most of the foreign exchange of the economy. Oil is produced under concessionary agreement between the government of Saudi Arabia and the Arabian American Oil Company (Aramco), a consortium of four American oil companies.

Alongside the highly commercialized, rich oil sector is a non-oil sector dominated by subsistence agriculture and nomadic pastoralism. This study concentrates on this non-oil sector.

Saudi Arabia is an arid largely desert country. The rough topography, low rainfall and scarcity of underground water permitted the cultivation of only .18 percent of the total area of 870,000 square miles. Many of agricultural locations are remotely isolated accounting for the non-market subsistence oriented production pattern.

An estimated one-half to three-quarters of the population derive their living from the agrisector which also employs about 46 percent of the total labor force. In this sector productivity is low, underemployment is rampant resulting in low per capita income and an overall contribution to the GNP of less than 10 percent.

The average growth rate of the agriculture has been estimated at about 3.9 percent annually during the period 1962-1967. Subsector growth rates differ with vegetables and poultry production having the highest

rates and dates and livestock production the lowest rates. With a high population growth rate of 2.7 percent per year, the higher incomes accruing from oil and the inability of the domestic production to meet demand, the country has become increasingly dependent on imported foodstuffs for the last 10-15 years. Between 1957 and 1967 imports of agricultural products increased at annual rate of 11 percent and accounted for over 30 percent of the total imports of the country towards the end of that period. Until 1966 a long list of foodstuffs received a price subsidy of 16 2/3 percent of the C.I.F. price. These import subsidies have affected domestic production by reducing prices thus reducing the incentives of the producers.

The obstacles to increased productivity and overall agricultural development seem to stem from the poor conditions of agricultural resources and rural institutions. The small size of farms, scarcity of water, overuse of pastures, shortage of credit, low level of technology and absence of proper marketing credit and land tenure institutions are all factors constraining agricultural development.

The problem areas can be summarized in the following manner.

1. Natural resources are characterized by low productivity due to scarcity of water and lack of conservation. Range resources are overused by nomadic Bedouins which partly explains the decline in growth rate of livestock production. The newly discovered water is partly wasted due to the absence of a water code to regulate distribution and changes of water use.

2. Human resources in agriculture although abundant are not efficient. This is mainly due to low levels of education, adherence to traditional methods of production.
3. Capital is short at the farm level and the attempt of the Agricultural Bank to supply the needed capital has succeeded in reaching a very limited number of farmers.
4. The state of technology ranges from primitive to modern but it is mostly primitive. Change of technique is obstructed by lack of education, lack of capital and the rough conditions of the country.
5. Rural institutions are primitive, rigid or altogether lacking. There is an apparent need for more and better marketing, credit, land tenure and other institutions.

With these problems in the background, the government of Saudi Arabia started efforts to develop the agricultural sector early in the 1960s. It has since invited foreign experts and organizations, established government organizations as for example CPO and the Planning Unit of the NAW, started an infrastructure of land and water development projects in Al-Hassa, Al-Kharj, Jizan and other locations. The government has also contracted three foreign firms to carry on the Area Resource Surveys for the whole country. These, when completed, will furnish valuable information about resources that might have otherwise remained unknown. Finally the government has formulated an ambitious Five-Year Plan for agricultural and overall economic development covering the period 1970/71 - 1974-75. Details on government efforts were presented in Chapter V.

Recommendations on economic and agricultural policies which are thought to be needed for the achievement of agricultural development targets were presented in Chapter VI. These cover the areas of all resources, prices and subsidies and institutions.

For a more systematic planning and analysis, Chapter VII presented three interregional linear programming models. The first is a general model which aims at maximizing net income from production, transfer and transport activities in agriculture. A framework of data requirement and calculation was presented. The second is a modified model which aims at minimizing the cost of production and transportation of the products having top priority in the Five-Year Plan. For this model delineation of the country into 3 consuming areas and 9 producing areas was attempted. The third is an integer programming model for planning public investment on roads. The integer formulation is used to eliminate the possibility of obtaining fractions of roads as the case might be in an ordinary linear programming solution. The objective of this model is to minimize the capital input requirement for building roads given a certain number of constraints concerning the availability of other factors of productions and supply and demand for commodities to travel on these roads.

While this study does not claim to have solved the problems of agricultural development in Saudi Arabia, it is hoped that it will contribute towards a more systematic treatment of the economic development of the agricultural sector in the Kingdom.

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## APPENDIX

## Definitions and Abbreviations Used

S. R.	Saudi Riyal (\$1 = SR 4)
A. H.	After Hagra Moslem lunar year
MAW	Ministry of Agriculture and Water
CPO	Central Planning Organization
Aramco	Arabian American Oil Company
Socal	Standard Oil of California
Donums	One quarter of an acre
Hectare	Ten donums

## Conversion from Hira Years to Gregorian Years

Hira	Gregorian Year	
	From	To
1370	October 13, 1950	October 1, 1951
1371	October 2, 1951	September 20, 1952
1372	September 21, 1952	September 9, 1953
1373	September 9, 1953	August 29, 1954
1374	August 30, 1954	August 19, 1955
1375	August 20, 1955	August 7, 1956
1376	August 8, 1956	July 27, 1957
1377	July 28, 1957	July 17, 1958
1378	July 18, 1958	July 6, 1959
1379	July 7, 1959	June 24, 1960
1380	June 25, 1960	June 13, 1961
1381	June 14, 1961	June 2, 1962
1382	June 3, 1962	May 23, 1963
1383	May 24, 1963	May 12, 1964
1384	May 13, 1964	April 30, 1965
1385	May 1, 1965	April 20, 1966
1386	April 21, 1966	April 10, 1967
1387	April 11, 1967	March 29, 1968
1388	March 30, 1968	March 19, 1969