Agriculture and Water Resources In Saudi Arabia

By

Dr. Ali Ahmed Haroun

Department of Geography,
Faculty of Social Studies,
The Islamic University of
Imam Mohammed Ibn Saud
Saudi Arabia

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Introduction :

Supplying food for a prospective world production will require in the near future a giant increase in cereals production. Production improvement can be achieved by increasing the total area of arable land utilized.

Irrigation is one means of improving the total volume or reliability of agricultural production by managing water for crops. Water continues to be a vital part of food. The requirement for water of plants cultivated for human nutrition are considerable. Not even the most prdgressive agrotechnical achievements can alter the fact that 400-500 litres of water or more are necessary for the production of one kilogram of organic dry matter.

World food may be sufficient in total, but this does not solve the problem, for it cannot be distributed in the required manner due to political, economic and social problems.

Food production must be safe guarded in the area of consumption, and this arises demands on water resources, especially in arid regions as in Saudi Arabia, since water is a major factor limiting the agricultural development.

The aim of this peper is to show how Saudi Arabia tries to face the problem of food supply by having attention to agriculture.

The main objectives of agricultural development are : 1) to raise per capita income and improve the welfare of rural people, 2) to minimize the country's dependence on imported food, 3) to release surplus labour for employment on other sectors, 4) to increase the resources of the country, not to depend on oil resources only as a main sector.

These objectives will be raising productivity in agriculture and bringing more land into production where water resource permit in accordance with a balanced programme of regional development.

The last fgures of area cultivated, production, imports and exports are very important to the sandy, since the agricultural development is going fast in the last years, but to obtain these figures is very difficult and mostly not exist.

1 — Geographical Features of Saudi Arabia

zsaudi zarabia occupies four fifths of the Arabian Peninsula. It is one of the largest and most arid countries of the Middle East. It covers an area of 2.240 km^2. It extends about 1200 km from north to south, and a similar distance from east to west. It is boarded to the west by the Red Sea, to the east by the Arabian Gulf, to the north by Jordan, Iraq and Kuwait, and to the south by the Yemen Arab Republic, the People's Democratic Republic of Yemen and Oman.

It's topography has been created by regional tilting and uplift of the western margins of the Arabian Peninsula (Fig. 1).

Along the Red Sea lies a narrow plain whose width varies from one place to another. The coastal plains which are characterized by extensive marshland and lava fields are called «Tehama». East of these coastal plains runs a range of high mountains broken by great valleys of which the most important are Wadi Al-himd, Wadi Yanbo and Wadi Fatma.

In Asir, Wadi Atud and Eisha are the most important Wadies. The decline of this range of mountains is nearly vertical towards the west. Consequently the flood waters wash most of the silt on the coast plains and as a result, the land of these plains becomes more fertile.

The highest mountains are in Asir where peaks rise to over 9000 feet. East of this range of mountains lies the Najd plateau with an average height of 4000 to 6000 feet. The elevation drops to 2000 feet at the Al-dhna which faces the Arabian Gulf. The najd plateau extends south-ward to Wadi Al-dawaser, then runs parallel to the Rub Al-khali (the empty quarter).

To the north, the plains of Najd extends for nearly 900 miles past hail until they join the Iraqi and Jordanian borders.

There are number of mountains areas in Najd which run from south-west to north-west into the Nofud. The Nofud are sandy hills, characterised by the fact that it remains dry without vegetation until rain falls, the area is then transformed into fertile pastures suitable for grazing.

A great number of marshes are scattered through out the Najd. These are considered remnants of inland seas whish existed in ancient geological times.

On the eastern side of Al-dahna, the land gradually deelines towards sea level along the Arabian Gulf where the oil fields are situated. The region is termed «Al-Hasa». This is an area underlain by extensive water-tables, some of which appear to be recharged from infrequent local rainfall. Most, however, are not.

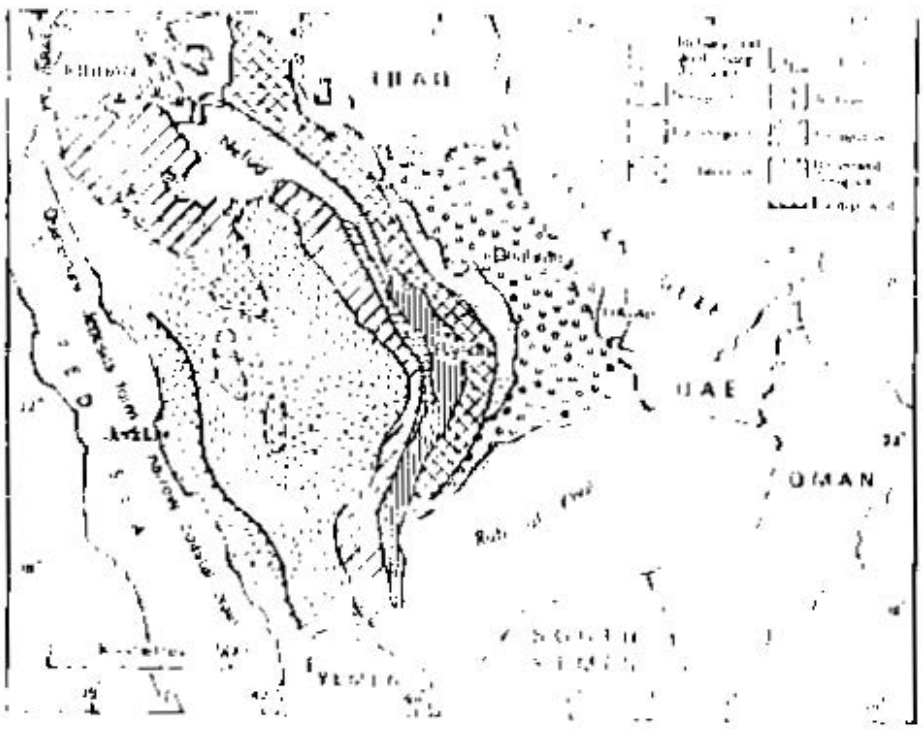

Fig. 1 :Geological map of Saudi Arabia.
Source. Peter Beaumont,

Water development in Saudi Arabia,
The Geographical Journal,
Vol. 143, part 1, March 1977. p. 46.

The coast itself is extremely irregular as sandy plains, marshes and salt flats merge almost imperceptibly with the sea. As a result, the land surface is unstable with water rising in places almost to the surface, while the sea is shallow and full of shoals and reefs for an extended distance offshore.

The south and east of Saudi Arabia are occupied by one of the largest sand deserts in the world (the empty quarter), covering over 500,000 km^2, and measuring over 1200 km by 500 km. The area to which perhaps not always accurately, the name Rub Al-khali (the empty quarter) is given, is far from uniform, but consists of an irregular tilted basin that lies at an altitude of about 1000 m in the west to very little above sea-level in the east and south-east[1].

2 – Climate

Except in Asir, the country has a desert climate. Over the country as a whole, mean precipitation is thought to be about 50 mm per annum. In some parts of the empty quarter rainless conditions may prevail for a number of years, while in contrast parts of the highland areas of the south-west may receive more than 800 mm in a single season as a result of the influence of the moonsoon (table 1).

Precipitation in the northern part of the country is generally the result of cyclonic lifting associated with the eastward passage of depressions from trhe Mediterranean region, the incidence of these weather systems is normally confined to the winter months and it is at this time that maximum precipitation totals are recorded. The portion of Saudi Arabia south of a line from approximately Madina to Riyadh comes under the influence of the summer south-west monsoon[2]. The northwards penetration of this system is highly variable year to year, making it difficult to assess the effects on precipitation with any accuracy, but in general, summer (monsoon) precipitation increases as a proportion of the total in a southerly direction. For example, at Taif about 40 percent of annual precipitation occures in the six month period April to September compared with only 30 percent at Madina.

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(1) W.B. Fisher, The Middle East, London, 1976. p. 477.

(2) Peter Beamont, Water and development in Saudi Arabia, The Geographical journal, London, Vol. 143, part 1, 1977.

Table 1
Amounts of Rainfall in Different Places
in Saudi Arabia
(1969 – 1978 in mm)

Year	Riyadh	Jeddah	Dhahran	Medina	Taif	Qassim	Khamis Mushait
1969	172,5	129,2	174,1	82,9	28,9	114,4	342,9
1970	14,8	67,5	4,4	14,3	108,7	113,6	216,4
1971	131,7	106,3	47,2	107,8	260,3	98,8	173,9
1972	229,7	105,0	77,1	39,5	213,0	215,0	97,1
1973	69,3	26,6	13,9	0,7	104,7	117,3	163,7
1974	74,1	24,8	136,2	77,9	74,8	116,5	361,3
1975	177,0	25,0	32,6	20,2	182,9	38,4	263,5
1976	257,7	31,0	235,9	45,6	125,7	176,8	215,8
1977	61,6	57,0	88,7	17,0	108,2	49,6	158,4
1978	16,2	80,0	19,6	27,8	101,0	125,7	216,4

Source: General Meteorological Department, Saudi Arabia

During the summer monthly temperatures are always high, rising to between 40° C to 50° C in the central and eastern parts of the country. As a result of the intense summer heat, evaporation figures for Saudi Arabia are high, yielding values of 3000 mm. per annum from open water surfaces. At this time of the year, cooler conditions are found only in the highland regions running parallel to the Red Sea Coastline. In contrast, temparatures in winter moderate considerably almost every where and in the interior deserts of the north and in the highlands, freezing conditions can be experienced.

3 – Soil

Much of the soil is fertile when irrigated. Improper irrigation, however, exacerbated the problem of salination, which presents a grave threat to land use, particularly in eastern Arabia. It results primarily from leaching of the soil and from the deposit of salts, lime and potassium on the surface by the percolative effect produced by extreme surface heat. Saline soils,

known as desert marls, permit limited agricultural production with salt resistant crops, such as date palms, when the surface is not crusted in surface saltpans. These marls are most prominent in Hegaz and in eastern Arabia. In extreme cases no vegetation can grow on the crusty saltpans or limestone pans[1].

Sand-covered areas are suitable for agriculture if sufficiency watered. One of the most serious limiting factors in their use is the susceptibility of dunes to shifting according to the wind. This mobility, often reaching 40 feet a year, has made the dunes a grave threat to oasis, particularly to those in Al-hasa. The government has undertaken countermeasures, such as planting over, 6,000,000 tamarisk and eucalyputs trees against the dunes, erecting sand fences and spraying the windward side of the dunes with asphalt to stabilize them.

A heavy sand-gravel soil is found mainly in Najd and also in Al-hasa, not suitable for cultivation. It produces a luxuriant, but ephemeral vegetation following desert rains which is excellent for grazing.

Loam soils, which have good agricultural potential when properly irrigated are found predominantly in the Najd highlands. These soils are clayey and basically not cultivable, but when mixed with sand, they are highly productive.

The best soils are the alluvial soils of the wadi banks. Rich and fertile sandy-loam soils, they are intensively cultivated, maitly for cereals.

4 – Water Resources

A – Surface water

Water in Saudi Arabia is a limiting constraint for agricultural development. The country has no permanent rivers of bodies of water. The wadis contain water only after rains and then for only a short period, but water which seps through the porous surface is trapped above impervious rock layers underground.

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(1) Norman C. Walpole,
Area Handbook for Saudi Arabia,
New York, 1971, p. 18.

As a country of desert climate, the distinctive trait of the land is of coarse insufficient precipitation. The average amount of rainfall is never great, though heavy showers may occur occasionally. Light rainfalls only wet the soil surface and usually evaporate without having any appreciable effect. The concept of effective rainfall has been proposed, this is the minimum amount of rainfall, occuring on a single occasion that ensures at least some water storage under favourable soil conditions. To be reasonably safe from evaporation, the rain must penetrait to a depth of at least 10-12 cm[1]. The amount needed for this has been estimated at 15 to 20 mm for a single rainfall. The annual effective rainfall commonly amounts to about one-third of the total rainfall.

The distribution of the rainfall and coincidence or otherwise of a adequate supply of soil moisture at periods of maximum crop requirement, also have a bearing on yield levels. A period of drought at the time of earing of cereals will have more adverse effect on yields than if it occurs earlier or later in the growing period.

Excess moisture after sowing may reduce germination, and heavy rainfall during earing may cause lodging and impair pollination.

In Saudi Arabia, the rainy season is between December and March. Runoff is irregular and most of it occurs in short torrents. The distribution of precipitation devides the country into two zones :

A. The South-west region which includes Asir and south Tihama. Rainfall is moderate and falls as the monsoon summer rains as well as winter rain. Although precipitation is considerable (over 300 mm in Asir), it is uneven in distribution which makes it even in suitable marsh for grazing lands[2]. Agricultural development depends on surface water control.

(1) L. Arnon,
Crop Production in Arid Regions,
London 1972, p. 26.

(2) Ministry of Agriculture and Water,
A Guide to Agricultural Investment in Saudi Arabia,
S.A. 1079, p. 34.

B. The other parts of the country where precipitation is low. Agricultural development is possible where underground water resources are available and their utilization is feasible.

Since agricultural development was taken in consideration, the use of water improved. With the capital readily available from oil, Saudi Arabia has initiated a number of further developments, 51 dams have already built over the last ten years[1].

These dams serve several purposes, mainly providing drinking water, irrigating agricultural land, and increasing infiltration so as to recharge ground water aquifers and for flood control.

The most spectacular to date has been the completion of the large dam near Jizan in Asir in 1970 (51 million m^3) to provide irrigation water for some 4000 to 6000 hectars[2]. The Nagran dam is the largest with a capacity of 25 million m^3. Other important dams are Hear, Dariyah, Abha, Rowdat Sudair, Laban, Thadek and Hanifeh (table 2).

B – Ground Water

The water tabl accumulates in porous zones, situaged at a moderate depth below the soil usufave is known as ground water. The upper surface of the saturated zone is called the water-table. Water that is held above the water-table by capillary force is called the capillary fringe (Fig. 2). The thickness of the capillary fringe, and the amount of water held depend on soil texture. The lower limit of the saturated zone is the level at which the underlying rock is practically impermeable to water.

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(1) Saudi Arabia Monetary Agency. Annual report 1981, p. 66.

(2) Peter Benumont,
The Middle East, Bristol, 1977. p. 320.

Table 2

Main dams in Saudi Arabia

Name	Length in metres	High in metres	Storage capacity Million m.
Jizan	35	51	
Najran	250	6	85
Rear	400	14	3,8
Dariyah	380	9,5	3
Rawdat Sudair	554	14	3
Abha	350	33	2,4
Laban	500	12	2
Thadk	850	7	2
Remfoh	390	9,5	1,3
Turba	380	21	20
Lia	190	45	10
Agar	450	11	7

Source : Ministry of Agriculture and Water of Saudi Arabia.

Fig 2. Ground water zones and belts
Source, L. Arnon,
Crop production in Arid Regions,
London 1972, p. 147.

During wet periods, or following continuous irrigations, the water-table rises, where as during dry peroids, heavy withdrawals will cause the water-table to fall. If there is no impervious layer between the ground-water and the soil surface, the former is known as "phreatic" or "free" ground-water[1].

The ground-water reservoir or aquifer consists of saturated porous rock materials that are sufficiently permeable for the water to move through them by gravity and yield water freely to wells (Fig. 3).

Ground-water that is relatively near the surface can be used by plants. As a large concentration of roots develops in the capillary fringe above the water-table, even a temporary rise in the water-table may cause considerable damage by asphyxiating the roots.

The ground-water reservoirs are the source of water in wells and springs and the flow of streams during rainless periods. Ground-water is the main source of water supply in dry regions. Ground-water reservoirs are in dynamic balance with predipitation, evaporation and drainage to the sea.

Table 3

Main Aqulfers In Saudi Arabia

Aquifer	Surveyed area	Average thickness (meters)	Size
Saq	1	300 - 600	1500 x 240 km
Wajid	2	950	300 x 250 km
Tabuk	1	150 - 170	900 x 150 km
Minjar	5	500	800 x 600 km
Al-Sayyad	5	600	600 km
Al-Masi	4	500	1450 x 900 km[x]
Umi-Srrdhuma	4	240	1000 km[x]
Dumam	4	35	n.a
Neojene	4	300	n.a

Source : Ministry of Agricalture and Water.

A guide to agricultural investment in S.A., 1975.

x Extends into kuwait, Iraq, and Bahrain.

[1] L. Arnon, corp production in Arid Regions London 1972, zvol. 1 p. 146.

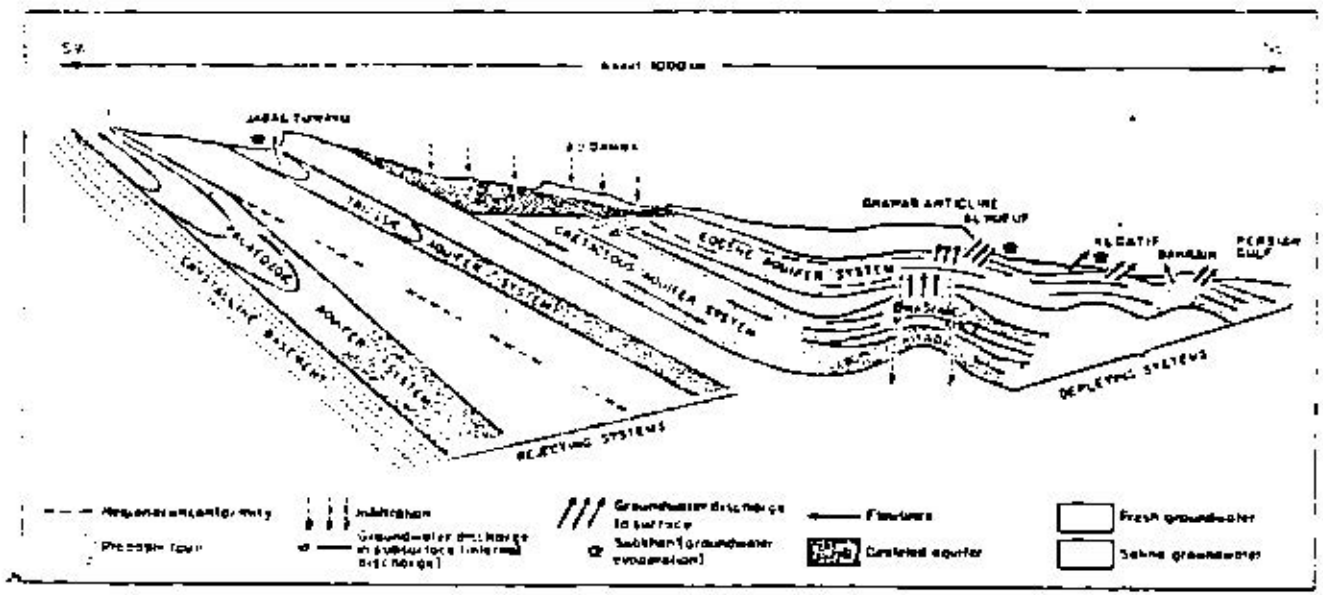

Fig. 3 : Major aquifer Systems in Saudi Arabia.
Source, Peter Beaumont,
Water development in Saudi Arabia.
The Geographical Journal,
Vol. 143, part 1, March 1977, p. 48.

In contrast to surface supplies, the development of ground-water resources is relatively fast and inexpensive, and is therefore a major factor in the economic development of arid regions as in Saudi Arabia.

In Saudi Arabia, ground-water is the main source of water for agriculture and urban uses. Many aquifers have been located, the most important are listed in table 5 in the areas surveyed (Fig. 4).

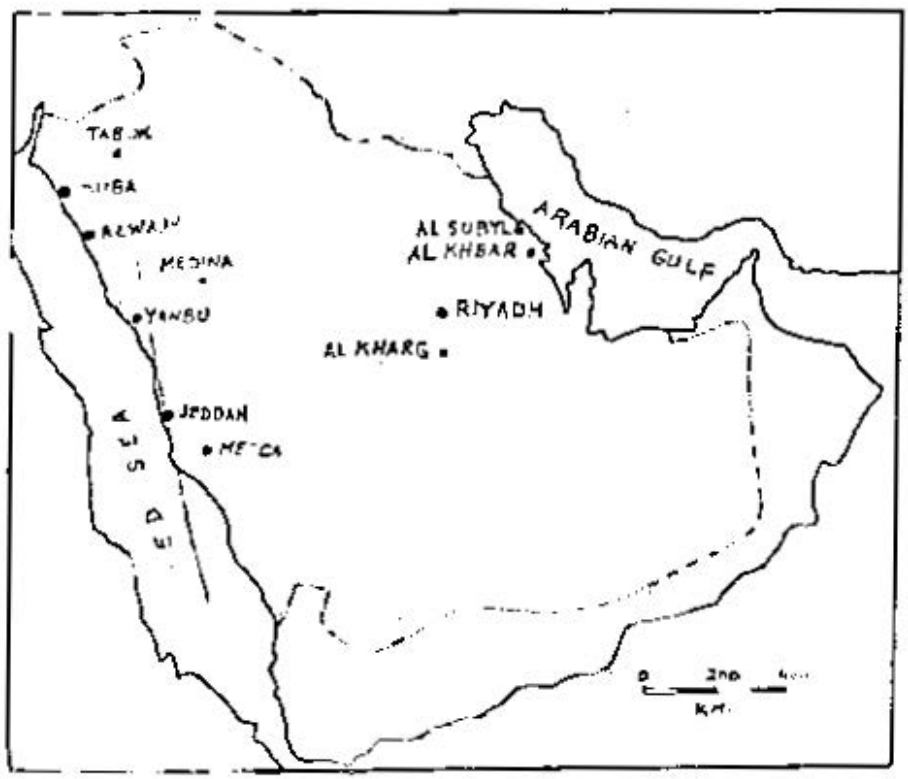

Fig. 4 : Delimitation of Various Areas of Saudi Arabia

The saq aquifer in the north supplies water to Qassim and Tabuk areas, and about 315 million m^3 could be pumped annually without affecting the water level. In Qassim, some wells have a discharge capacity of 1500 gallons/minute. Water quality is excellent and soluble salts range between 450 and 800 parts per million (ppm).

The Tabuk aquifer is also important for agriculture in the Qassim and Tabuk areas. It is estimated that 70 million m^3 can be used annualy without detrimental effects. Water quality is good and soluble to not usually exceed 800 ppm.

Agriculture in Wadi Dawaser area depends on the Wajid aquifer for ground water. Water discharge reaches 800 gdilons/minute in some cases, and water quality is good (400 to 800 ppm).

The Minjur aquifer in the centrtal region is recharged with about 70 million m^3 per year. It is used for agriculture in the khari region and for the capital Riyadh. Water quality is medium and reaches 1200 ppm.

The Um-Brrdhuma aquifer is an important source of water for the eastern region. It is utilized for agricultare in Wadi Al-miyah and the Naradh project. Wells dug in this aquifer can discharge up to 3000 gallons/minute.

The Al-Hasa region utilizes water from Neojene aquifer for agricultural purposes and water quality is medium.

In Qatif, Dammam and Al-Khobar, agriculture depends on the Dantam aquifer. Water quality does not exceed 1300 ppm, and discharge of wells does not exceed 100 gallons/minute.

Many wells have been dug in various parts of the country over the years. In certain areas, the pressure on water use has been veryu high, and the extractin has depleted ground water supplies. Consequently, the drilling of new wells must be approved by the Ministry of Agriculture an Water. In other areas, water reserves are huge, and the potential for agricultural development is considerable. The important wells dug in the aquifer areas are given in table 4.

5. Agriculture in Saudi Arabia

A. Evolution of 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 of the grass which springs up after the erratic rains. Pastoralism, therefore has been traditionally the most important source of agricultural income.

Table 4

Main wells dug in various regions of Saudi Arabia

Location	Aquifer	Depth of well (meters)	Discharge gallons/minute	Water quality ppm soluble salts
Fahid	Saq	1,500	1,000	650
Qassim	Saq	850	500	700
Artr	Aba-Rawath	1,400	400	650
Tabuk	Tabuk	250	250	650
Kamda	Wajid	799	1,618	710
Sulayl	Wajid	1,318	1,200	490
Salboukh	Minjur	1,760	1,000	1,270
Bweib	Minjur	1,983	955	1,536
Nisah	Al-Bayyad	220	950	390
Hafuf	Neojene	100	2,000	1,200
Sharourah	Wajid	1,150	560	800

Sorce : Ministry of Agriculture and Water of Saudi Arabia.

Agricultural development was taken a stage further in 1937 when Ibn Saud's finance minister Sheikh Abdullah Suliman installed a number of pumps, an Iraqi farmer and a palestinian vegetable grower in the oasis of Al-kharj, east of Riyadh. From small beginnings, the project blossomed into a large-scale experimental farm with the assistance of Aramco and sucessive American agricultural missions[1]. About 12 km^2 are being cultivated at Al-kharj and an additional 3 km^2 at neighbouring khafs Daghra, largely with the help of machines and primarily for the Riyadh market.

(1) Peter Beamont,
The Middle East, Pristol 1977, p. 319.

The Al-kharj project was followed in the late 1940's by the establishment of experimental farms in different parts of the country, and an attack was launched on the problems of Saudi Arabia's largest oasis Al-Hasa. Al-Hasa had been suffering from severe depression. Population pressure had become extreme and was increasing, while the cultivated area was continually being diminished by drifting sand and salinity. Date palms, the main crop, were low yielding, partly because of their age and partly because of a high water table. Water though abundant, was inefficiently used.

Attempts to improve the situation began in 1949. Crop diversification was introduced, improved strains were employed and the use of water improved. Pumps allowed the extention of irrigation, while the construction of the Al-dammam to Riyadh railway, and the subsequent completion of modern roads, has solved the marketing problem by allowing export to the capital, on one hand, and to the thriving oil settlements on the other.

The government has, especially since 1962 increased its attention and allocations to agriculture in an effect of increase agricultural production. It has done this through land reclamation, the introduction of knowledge and technique of modern farming practices, to increase numbers of farmers, the distribution of imported seeds at low cost, and the establishment of production and distribution cooperatives and an agricultural credit bank. The result was an increase of agriculture in the national income from 1% in 1976 to 4.7% in year 1980

The success of land reclamation and water development projects would permit not only an increase in the production of farm crops for human consumption, but also the possibility of devoting a larger portion of the irrigated lands to the prodnction of fodder crops for livestock. These fodder crops could then be utilized to supplement the inadequate supplies of natural vegetation upon which most of the livestock in the country depend.

The identification of hydroagricultural resources in the country started as early as 1964. The country was sectioned into eight areas (Fig. 4) plus Jeddah Mecca-Taif region. Primary surveys for the first six covering an area of about 1,3 million km^2 were completed in 1970. the survey of the Arabian shield about 204 km^2 of area eight, is in progress while that of the seventh (Rub Al-khali) empty quarter has not been conducted because of its negligible population.

The six studied areas are the following[1] :

Area 1 (the great Nafud basin) :

A large area suitable for a wide variety of crops. The main regions of this basin are Qassim, Wadi Sirhan, Al-Jowf, Sakakah, Tabuk, Al-ula, Al-kuhayfiyah, and Wadi Al-khuwayer.

Qassim is one of most important agricultural regions of the country, and it is expected to contribute about 30% of the total agricultural production of Saudia Arabia in the near future. It's climate and water resources make it suitable for producing a variety of crops all year round. The main crops are wheat, barley, alfafa, vegetables and fruits, particularly dates, grapes and citrus.

Area 2 and 3 (South – West region) :

This region, plus the Jeddah – Mecca - Taif, extends from Tihama in the west to the borders of Rub-al-khali (the empty quarter) in the east covering Asir, Hijaz platean and Najd plain. It is one of the two regions in Saudi Arabia where rainfall is rather moderate and where rainfed agriculture is common, particularly in the Asir mountains. About 108,000 hectares are cultivated, and an additional 909,000 hectares are arable lands. The major region is Wadi Dawaser which has a good agricultural potential. The government has already contracted a turn-key project of 300 hectarea for complete development and in the meantime is experimenting ith crops most suited for the region.

Area 4 (Eastern Region) :

Large areas in this region are arable, and 20,000 hectares are under cultivation. The main agricultural areas are Al-Hasa and Qatif oasis, Haradh, Wadi Al-Miyah, and Yabrin are also important agricultural regions.

In order to develop Al-Hasa and Qatif, sand dunes and soil salinity have required special solutions. For example, the Al-Hasa irrigation and drainage project was completed in 1971. It is the largest one-block ir-

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(1) Ministry of Agriculture and Water,
Agricultural investment in Saudi Arabia, Riyadh, 1979.

rigated area in the country. The presently irrigated area is about 12,000 hectares and could be increased to 20.000 hectares after land reclamation.

Haradh and Wadi Al-Miyah have good agricultural potential because of the availability of water in Umm-Erradhma aquifer. About 350,000 km^2 in the Umm-Etradhma area are presently under detailed study to identify water potentialities for the development of suitable agricultural areas. The major crops in this region are dates, alfalfa, and vegetables. About 3,2 million date-palm trees are planted in Al-hasa and Qatif oasis.

Area 5 (Riyadh Region) :

This region covers an area of about 108,000 km^2 surrounding Riyadh. The main agricultural region is the Al-kharj plain with about 18,000 hectares of arable land which has suitable water resources. Al-khari aquifer is evdimated to contain about 10,000 million m^3 and the surrounding limestone-contains additional water reserves.

The Aflaj plain is the second area in importance with a good potential for agricultural development Six other regions with about 17,000 hectares of arable land also have a good agricultural potential

Area 6 (The Red Sea Coast) :

This region extends on the Red Sea coast from the Jordan borders in the north of Yamen in the south and is devided into two sub-regions of different climates part covers an area of 140,000 km^2 with an estimated 3.225 hectares of arable land. Agricultural development in limited because of low water reserves and light precipitation. The southern part covers an area of 54,000 km forms a part of the Asir province, and has a great potential for agriculture, especially in the south and north. Tihama surface water constitutes the major source of irrigation water and amounts to more than 1400 million m^3. Sorghum and millets are the main corps in Jizan region.

Agricultural labour is a main constraint on agricultural development in Saudi Arabia. According to the 1974 population census, 40 percent of the total manpower was employed in agriculture and fisheries (table 5). Because this figure includes bedouins who live mainlyh on livestock production and fisheries, the number of agricultural workers may be overestimated. But it was a problem to find census including manpower employed in agriculture only, even in the last ones.

The shortage in skilled labour has been partially alleviated by the hiring of foreigners especially form Egypt, Many private agricultural enterprises are manged by non-Saudi nationals. The government recognized the importance of developing the quality of human resources, so training programs, and agricultural colleges are established to fill the gap of the shortage in quantity and quality of agricultural labour.

Table 5

Manpower by Occupational Groups
(1974/75 in thousands)

Occupation	Saudi	Non-Saudi	Total
Agriculture and fishing	655.2	27.5	682.7
Professionals	135.4	104.4	239.8
Craftsmen and labourers	222.7	122.9	345.6
Clerical / personnel	109.1	11.8	120.9
Commercial	66.2	41.1	107.3
Services	117.8	66.3	184.1
Managerial	18.6	4.2	22.8
Total	1.325	378.2	1.703.2

Source : Central Department of Statistics of Saudi Arabia, 1975.

B – Irrigation :

Irrigation is almost entirely by flooding the fields. The way in which the land is flooded depends on the source of water supply in the various agricultural regions.

On the Tihama coastal plain, cultivation depends almost entirely on monsoon floods in june through September, although winter rains from December to Febraury permit dry farming to limited extent. Wadis are dammed partially or completely to divert the floodwater to the cultivated basins. The basins, which are surrounded by dikes, are soaked one by one, starting with the upper lands.

Dry farming is practiced to a greater extent on the higher elevation in the Asir mountains, where terrace farming is highly developed. To supplement the menger rainfall the rain falling on uncultivated slopes is collected and

diverted to the walled terraces by channels which are often cemented to prevent seepage. The waters are allowed to descend from terrace to terrace. It is generally consudered that between two to four hectares of uncultivated land must be used as a catch basin for every hectare of land under cultivation[1]

In Estern Region, irrigation of the larger fields, which are mainly devoted to dates and rice, it done by diversion of water from artesian springs by gravity through canals to the fields. The fields are irrigated at specified times, and then the farmer allows the surplus water to drain into a secondary canal which leads the water to a lower field. The saline content of the water increases as it passes through each field. When it has become too salty to be usable, the remaining watr is allowed to evaporate, forming a "Sabkha" (salt flat) at the far end of the cultivated area.

To irrigate the smaller fields in Eastern Region devoted mainly to alfafa and vegetables, water is lifted from springs and wells by animal power or mechanized pumps into irrigatin ditches running along the sides of the fields or into a reservoir from which it is diverted at will. If only small amounts are needed, the water from the irrigation ditches is lifted by a simple hand-operated lift.

Wells and pits provide the water for the oasis agriculture throughout the country, particularly in the interior and in the Hejaz, Lifting is done by pumps.

With agriculture so dependent on scarce water resources, it is essential that water be efficiently tapped from its sources and carefully preserved. Much water has been wasted because of a lack of knowledge about water requirements for different crops in different environments. Water facilities are generally aimed at immediate water distribution.

In recent years, the Ministry of Agriculture and Water has been active in the development of a number of irrigation projects. The Al-Hasa Irrigation and Brainage Project is an excellent example. The introduction of large scale farming and the establishment of the Saudi Arabian

(1) Norman G. Walpole,
Area handbook for Saudi Arabia,
London, 1971, p. 217.

Agricultural Bank in 1964 1964 have prompted farmers to adopt modern irrigation system which are mechanized and save jabour. Irrigation systems and equipment were the largest recipients of loans from the agricultural Bank in 1977.

New projects primarily use either the drip or sprinkler irrigation method. The drip system is more widely used for irrigating vegetables and orchards and its use is being encouraged by the government. The center pivot irrigation system was introduced in 1977 with only one such system. At present (1983), are over 30 systems in operation, and each is capable of irrigating up to 50 hectares.

C - Water Rights

Most landowaership is valueless accompanied by the possession of water. Regulations covering the ownership, distribution use of water are therefore of primary importance. Community rights seem to apply only to the unowned water resources such as rain water falling on unowned cultivated land.

Most water rights can be sold, purshased, rented and inherited independently of land. Thus, those who acquire land in excess of that which they can sufficiently irrigate have the possibility of purchasing or renting additional water rights from those who own more water rights than they need for their plot of land. Only in Asir and on the coastal plain of the Red Sea where precipitation is relatively plentiful, are water rights bound to the land and not to the individual.

Water regulations among the settled farmers are highly developed and complex, covering the rotation of use of water which correspond to the water rights. The distribation of water is often supervised and controlled by officials appointed and paid by water owners and users.

Water from wells, pits and springs is considered private water and the rights to it are assigned to individuals. The person or persons who contribate to the construction of the water equipment own the water and have exclusive rights to use or sell it.

Usually a property owner holds the rights to all the water sources on his land. No permit is necessary for constructing a well on one's own proper-

ty, but a permit from the district Amir is required if the well is to be built on previously uncultivated land. Wells which are dug by nomads belong to the tribe as long as it remains in the area. Once it leaves, the well becomes public property.

The water for artesian springs which are found in Mastern province depend on the original owner's contribution to the construction of spring casings, reservoirs and the distribution mechanism, and on the inheritance or purchase of these rights. They are registered with the village administration, and a "water responsible" supervises the water distribution, which is done on a time basis.

Water rights which are bound to the land as they are in Asir are rights to the floodwaters derived from the wadis which are dammed to divert the water to the cultivated fields by means of canals. Each canal irrigates a plot of land which carries the water rights. Upper lands are irrigated before the water is let through to the lower lands before the upper ones have been thoroughly soaked.

Traditional water rights are limited to the lands which have traditionally held the rights. Lands which have been brought into cultivation since the original water rights were distributed have second grade rights that is they are irrigated only if there is surplus water. Some lands have no rights at all and only occasionally receive surplus water. The traditional regulations are so strong that they effectively prevent landowners from increasing their water rights by the construction of new dams, even if new "wadis" have been formed.

The contributions toward the upkeep of the canal depends on the size of the land being irrigated. However, the farmer working the lands which have only secondary rights pays half as much as those with land with primary rights.

Rainwater belongs to the owner of the land on which it falls. He cannot, however refuse this water for the irrigation of land where crops are in danger. Rainwater falling on lands owned by the state can be used by any cultivator. The cultivated land nearest the rainwater usually has priority.

D – Crop Production :

The cropping pattern which will develop with irrigation depends on the agricultural productivity of the land. About 331,000 hectares of land are under cultivation of winter crops in the country (table 6). Of this area 72 percent of the land is not irrigated, While 23 percent is irrigated. In addition, about 72,000 hectares are planted with permanent crops.

Cereal crops constitute the largest group of crops in Saudi Arabia (table 7). Among these, sorghum constitutes the leading crop. It is grown both as a winter and summer crop mainly in the south-west region around Jizan. The area allocated to this crop has increased steadily over the years. Millet is another important crop grown in the same region. It should be noted that estimates for all crops vary considerably from one source to another.

Wheat is another important crop. It is grown mainly in the Asir, Riyadh, Mecca and Qussim region. The area planted with wheat has been increasing steadily and new high-yielding varieties have been introduced into the country. This we can learn from the increase of area cultivated. It was 62,000 hectares in year 1974 increased to 80,000 hectares in 1977 (table 7), and to 85,000 hectares in 1980[1].

Tomattoes among the vegetables rank (table 8) and are grown as winter and summer crops in most regions of the country especially in Riyadh, Mecca and Esatern Region. Other vegetables include dry onions, eggplant, squash and okra. Watermelons constitute another important crop.

The permament crops of the country are mainly dates, grapes, and citrus with the first being the most important. There are about 11 million date palms.

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(1) F.A.O. Production Yearbook, Vol. 55, 1981.

Table 6

Cultivated areas of winter and Permanent Crops
in the various regions of Saudi Arabia
(1975/76 in hectares)

Region	Winter Crops[x] Irrigated	Temporary Crops[x] Not Irrigated	Total	Permanent Crops
Eastern	1,949		1,949	10,241
Riyadh, Afif,				
Al-Khasira	21,847	123	21,970	19,345
Qassim	17,186		17,186	4,818
Hail	4,885		4,885	5,817
Jouf, Qurayat				
Tabuk	61	151	212	2,360
Medina	1,867	1	1,868	4,301
Mecca	18,780	42,320	61,100	13,246
Asir	15,709	16,582	32,291	7,833
Al-Bahah	1,563	5,202	6,765	560
Jizan	3,337	175,623	178,960	1,383
Nijran	3,949		3,949	1,688
T o 1[illegible]133	240,002	331,135	71,592	

x Includes alfalfa.

Source, Ministry of Agriculture and Water of Saudi Arabia.

Table 7

Estimated Area of main crops in principal Regions in Saudi Arabia (1977 - 78) in Hectares[1]

Region	Winter temporary crops					Summer temporary crops		
	Wheat	Millet	Sorghum	Maize	Barley	Millet	Sorghum	Maize
Eastern	2 09,0	–	–		5,9	–	–	–
Riyadh, Afif, Khasra	150 01,3	20,0	2 79,0	86,3	4 45,7	1 66,1	7 58,6	
Gassim	109 76,4	–	–	–	13 08,3	–	23,97,3	5,0
Hail	11 28,8	–	–	–	88,8	–	–	–
Jouf, Qurayat, Tabouk	2 16,0	–	–		59,2		–	1,1
Medina	14 21,0	20,8	–	–	2 01,1	6,5	1,7	7,5
Mecca	75 31,8	32 28,2	187 58,8	8,0	10 55,2	24 80,6	561 81,5	2 41,8
Asir	166 27,0	11 48,3	67 73,0	41,6	37 80,2	54,2	184 88,4	19,0
Al-Baha	45 69,2	4 08,3	20 95,9	1,9	10 72,3	1 57,4	15 07,5	1 86,2
Jizan	–	191 85,6	1 541 61,4	2 13,5		66 75,1	408 90,9	–
Najran	22 31,8	–	–	–	4,8		1 63,4	–
Total :	599 12,3	240 11,2	1 820 68,1	3 51,3	80 21,5	95 39,9	1 203 99,3	4 60,6

(1) 10 Donums = one hectare = 2,379 Feddan.

Source : 1. Central Department of Statistics, statistical yearbook 1979, (S.A.).

2. Ministry of Agriculture and Water of Saudi Arabia.

3. Personal work (The table is a rework from different tables, and the areas are changed from donums to hectares.

Table 8

Estimates of permanent crops, and some other important crops in S.A.

(Production by ton 1977 / 78)

Region	Permanent Crops Dates	Grapes	Citrus	Sesame (1)	Tomatoes (1)	Potatoes	Onions	FodderCrops Winter (2)	Summer (2)
Eastern	113,240	,298	,982	..	28,115	16	6,706	,548	19,845
Riyadh,Afif,Khasra	100,709	13,682	3,893	–	70,999	9	11,314	8,828	62,212
Qassim	85,569	9,620	4,975	–	15,961	–	73,348	18,842	45,744
Hail	31,172	1,788	,123	-	1,815	-	,717	1,893	6,608
Jouf,Quraiyat,Tabuk	3,266	4,027	-	–	2,226	–	1,207	16	2,120
Medina	19,356	6,595	,308	-	3,369	2	,153	12,174	6,328
Mecca	57,516	3,110	1,377	,121	28,113	1,120	,300	15,624	7,167
Asir	21,962	8,863	5,406	1,193	5,758	3,353	1,302	10,823	43,407
Al-Bana	,364	5,476	–	–	2,077	51	3	5,663	18,625
Izan	-	–	,212	15	,212	13	–	94,607	12,151
Najran	5,234	1,420	1,591	-	10,880	61	-	7,049	14,686
Total :	411,388	55,877	28,867	1,329	169,525	4,625	95,032	175,707	226,983

(1) Winter and Summer crops.

(2) Area by donums including Alfalfa.

Source : (1) Ministry of Agriculture and Water of S.A.

(2) Central department of Statistics, Statistical yearbook 1979, S.A.

(3) Personel work (The table is a rework from different tables)

More areas are planted with citurs trees. There were more than one million trees in 1975/76 of which more than 600,000 are in production stage.

In terms of area under field crop cultivation, the central Region comes the first, followed by the southern region, Qassim, Taif and Al-Hasa (Fig. 5)

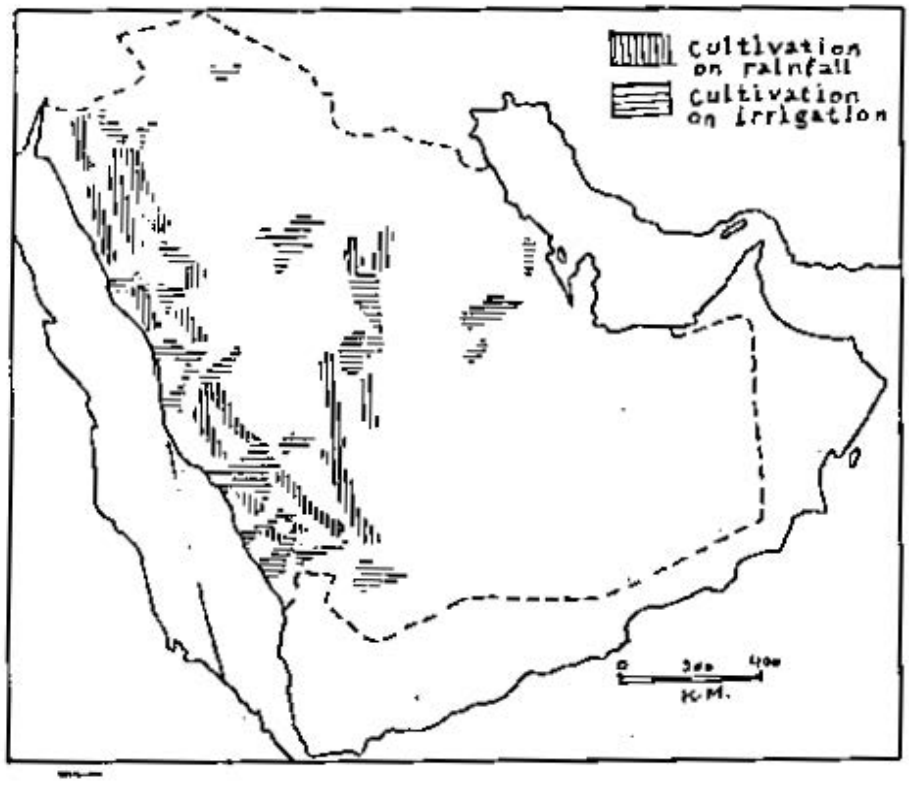

Fig. 5 : Main Agriculture Areas of Saudi Arabia.

We can learn the importance of agriculture from the decrease of imports of wheat, barley and millet (table 9).

Table 9

Quantity of Principal Imports to S.A.
(1976 – 1978 In m.tons)

Item	1976	1978
Wheat	36940	29307
Barley	118991	53389
Maize	196487	304732
Rice	243983	404070
Millet	10299	4082
Wheat flower	336770	380311

Source : Central Department of Statistics, S.A.
Statistical Yearbook, 1970/1979.

E. **Farm units :**

Agricultural holdings in Saudi Arabia have different characteristics in different parts of the country. While the smallest holdings are found in the mountainous regions of Asir, Al-Baha and in the Eastern region (2-5 hectares). In Najd farm units ranged between 6-20 hectares, while in Hejaz farm units ranges between 10-30 hectares. The largest are in Qassim and in Riyadh-Afif. There are farms of as much as 100 hectares and a few even larger.

The Ministry of Agriculture and Water is at present encouraging large-scale farming and business type farm enterprises This should lead to a reduction in high fixed investment costs per unit of land and may lower final production costs.

The size of land distributed depends on whether the beneficiary is an individual or a company, and on other factors such as the total of virgin land to be distributed under the programme relative to the number of applications, the fertility of the land, availability of water, the applicant's qualifications and experience in agriculture. The area distributed to in-

dividuels normally ranged between 5 – 20 hectares. The maximum area per company is 500 hectares.

5 - Crop rotation :

Crop rotation is practiced in all agricultural areas. On irrigated highlands of Asir there is usually a triennial rotation of wheat, sorghum and lentils or wheat, barley and lentils. Both sets of rotations are planted early in March and harvested in July.

A second cropping season applies when the monsoon rains are utilized, the planting is in late May, the harvesting in October. The land remains fallow in the infrequent cases of insufficient rain. In the Tihama coastal plain there is a triennial rotation of sorghum, millet and sesame. On the irrigated land, the crops are planted in late May and are harvested in October. Under dry-farming conditions, they are planted in November and are harvested in July.

Perennially irrigated land is cultivated every year. In Majd and northern Hijaz a biannual rotation of wheat and barley or barley and occasionally, legumes is practiced. Planting is in late February or early March, harvesting is in July. The land is left fallow the rest of the year. In truck farming areas such as Wadi Fatma, two crops are usually grown each year. In Al-Kharj, three crops are grown each year. In the low-lying of Al-Hasa and Qatif in Eastern Region, where the availability of water from artesian wells and springs favors agriculture, crops are grown the year round.

6 Problems of Agriculture in Saudi Arabia

Despite the low precipitation totals prevailing overmuch of the country, Saudi Arabia is fortunate in possessing large volumes of ground water contained in eleven major aquifers. The government over the last decade has initiated a number of large water resources projects. But despite these projects and the remarkable efforts to assure water resources for agriculture, there are some problems efforts to assure water resources for agriculture, there are some problems facing the development of agriculture as :

The increasing urbanization led to an increase in water consumption needed for agriculture. The government has decided upon desalination methods as a solution to the problem. The government established a number of large desalination plants on the Red Sea and Gulf coast

(fig. 6), but still not enough, since there are big towns still depend on ground water as Riyadh, Qassim and Hail.

- The most glaring need in dealing with arid land irrigation as in Saudi Arabia is to apply the scientific knowledge. The Government must get to the farmers and show them what should be done, since farming practices are in general, cues that have been used for centuries.

- Soil evosion by surface water and wind presents a serious problem cultivated land.

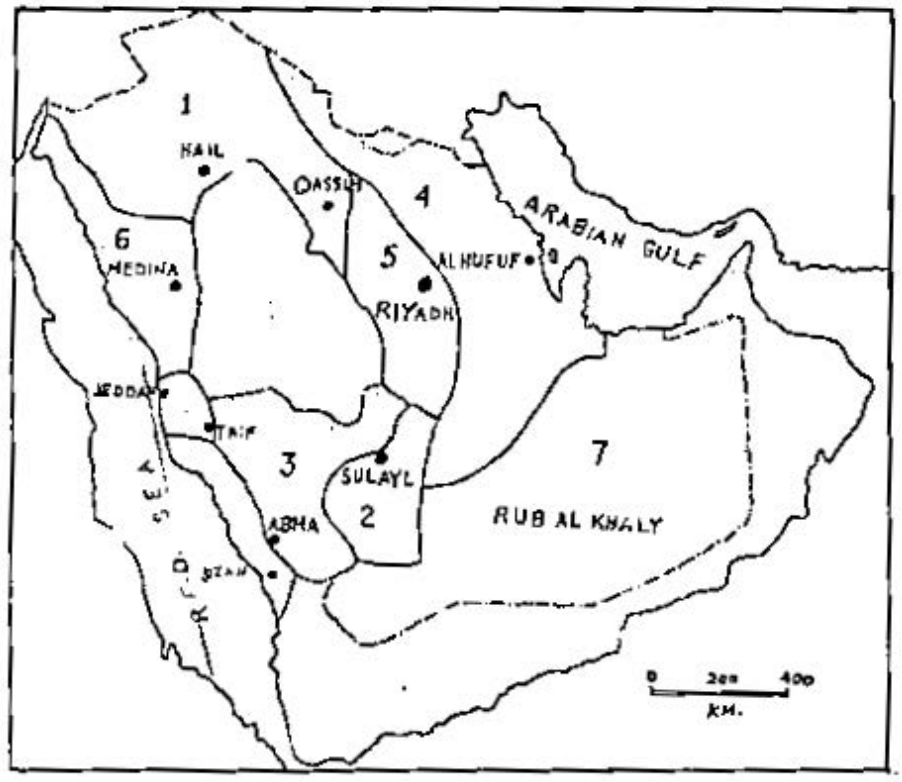

Fig. 6 : Location of Main Disalination Plants in Saudi Arabia.

- Except the alluvial soils in the wadi valleys, the soils are seriously deficient in nitrogen and phosphates. This we can learn from the increased imports of fertilizers which increased from about seven million tons in 1979 to about 13 million tons in 1980.

  The possibility of population must be taken into account, since a great part of labour needed for agriculture (table 5) are foreigners, some are not well experienced, Others are from countries differ in the method of agriculture compared to Saudi Arabia. All these factors have their influence on the production.

- Inadequate training of farmers is one of the main causes of the misuse of water and reduced effeciency, unless the farmer understands the value of water.

  One of the great problems facing agriculture in Saudi Arabia is salinity as in the Eastern Region. Salinity is due to the presence of high-water table caused by the excessive seepags. To improve such situation, the first step should be to provide suitable drainage which allows for the lowering of water table below the critical level of capillary action.

- Design and operation of water supply systems should provide the required amounts of water at the time needed together with messuring devices which maintain uniform flows at the farm level to cope with the water requirements of crops.

- Agriculture in Saudi Arabia depends mainly on the limited ground water resources of varying salinity, and irrigation under such arid conditions leads to increased soil salinity. The overuse of ground water resources results in deterioration in water quality which in turn aggravates the salinity problem, particularly where the water quantity is insufficient for adequate leaching alfalfa, being relatively salt tolerant constitutes one of the main crops in the country.

- The extraction of water from underground aquifers may induce undesirable intrusion of sea water or connate brines into the aquifer which over a period of time can cause the quality of the water in the wells in the intrusion path to deteriarate and become unsuitable for irrigation. The deterioration usually is gradual occuring first in the

wells nearest the source of the brines of remedian action is not taken substantial portions of the aquifer may become unasable or several decades or longer. Reduction in pumping drafts artificial rechage of imported water by speading grounds or injection wells, or the use of water or injection or withdrawal wells, are methods which have been used successgully to half, and in some cases to reverse the intrusion[1].

Saline intrusion into well fields in coastal areas near saline bodies of water should always be expected to occur sooner or later. The reasons for sustained increases in salinity of any wells should be investigated promptly, regardless of well field location, so that remedial action can be taken, if necessary before irreparable damage is done to the aquifers.

The wide scale irrigation programmes in the country bring about some serious dangers in the field of health. The health problems that arise are of course those of water transmissible diseases, such as schistosomiasis, but also those connected with the immigation of new populations, the creation new rural communities, and new habitats and housing. All these phenomena cause a potential aggravation to the environment. To acheive this target, action in the field of health should begin as early as the planning phase of an irrigation project, in view of the evolution of the situation, the forecast of the dangers, the discussions ofthe choice of the measures ot be taken. This action has to be continued during the implementation phase during the excution of the project and long after the irrigation system has been built and put into operation, so as to assume the surveillance of the health situation and the maintenance and the improvement of the results that have already been achieved.

- The health service can be efficient only if integrated in the project as part of a whole, financially administratively, and only if sincerely accepted by those responsible for the programme[1].

(1) Fredrick L. Hotes,
Arid land Irrigation in Developing Countries, London 1978, p. 149.

(1) Alexis Coumbaras,
Arid and Irrigation in Developing Countries,
London 1979, p. 345.

Saudi Arabia has large areas of sandy soils. Such soils have very low water-holding capacity and the effeciency of water use is excesdingly low under the traditional irrigation methods. It is very costly to develop such lands.

Sand dunes represent a great problem in Najd and in Eastern Region. The hedges are important for protection of land from the drifting sand dunes

Conclusion :

Saudi Arabia is going fast in economic development, especially in agriculture to face the problem of food demand. As a consequence, demands on water resources are growing, since water is a major factor limiting the agricultural development in Saudi Arabia.

Despite the low precipitation totals prevailing over much of the country, Saudi Arabia has a huge volumes of groundwater in eleven aquifers. These have been developed in the Eastern region mainly for irrigation purposes.

Saudi Arabia, to have advantages of the existance of water resources, it has established the dams, wells, loans to the farmers, facilitate the means of transportation, training, import fertilizers, the new technology began to replace the old that have been used for centuries, and a reorganization of the entire production sector began to occur.

Saudi Arabia began to make use of its coastal waters by means of desalination techniques to face the problem of towns situated in areas where groundwater resources cannot be easily tapped, also to keep on groundwater for agricultural use.

Though Saudi Arabia has succeeded to have good results, there are some problems facing the agricultural development as : 1) the problem of salinity in irrigated areas which exists in the soil if water is applied excessively, or in the absence of drainage 2) the sandy soil areas which have a very low water holding capacity. 3) inadequate training of farmers and the shortage of Saudian agricultural labour, 4) soil erosion by surface water and wind, 5) the drifting sand dunes as in the Eastern region and Najd, 6) the soils except in the wadi vallays are seriously deficient in nitrogen and

phosphates, 7) the misuse of water resources, since the improved water use and soil management practices are needed.

The above problems must be in mind in the agricultural policy, to obtain the benifits of any efforts done in this field, and to have the advantages of the water resources existance in an arid area as in Saudi Arabia.

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