Consultant's Report

People's Democratic Republic of Yemen

Evaluation of Soil Status in Some of the Major Agricultural Areas in PDRY

by

Dr. S.Nagmoush

Food and Agriculture Organization of the United Nations

Aden, December, 1983

Table of contents

Page

Acknowledgement

The consultant wishes to extend his thanks and appreciation to all the persons who have assisted him in preparing this report, through their valuable information and comments.

Special thanks are due to Mr. Fadhle Ambool, Director of Research and extension in the Ministry of Agriculture and Agrarian Reform, Dr.Shafiq Ata, Director El-Kod Research Center, Mr. A. Dukail Head of the soil section, Mr. Ali Bin Nissr and specialists at El-Kod research center. Mr. Hussein Bamakhrama, Director Seiyun Research Center, Mr. Ahmed Al-Bar, Head of the soil section, and Dr. Awad Al-Kathery, head of the irrigation section at Seiyun Research Center, for their cooperation and assistance.

Thanks are due to the various staff members of FAO projects which I met during my visit to PDRY for their valuable help and guidance.

Terms of Reference

The consultant received the following terms of reference from FAO.

To assess and advise the Government on various aspects related to soil reclamation, management, conservation and development of land resources for irrigated agriculture through visits to agricultural experiment station, state farms and agricultural development project and holding discussions with concerned staff in Ministry of Agriculture on recommendations and follow-up action.

Introduction

Due to the serious soil problems which have affected agricultural production, especially in areas using underground water for irrigation, FAO suggested to the Government of the people's Democratic Republic of Yemen (PDRY), to bring a soil consultant to advise on matters related to soil improvement, management and conservation.

The consultant was briefed in Rome from 14 to 16 December. He then visited PDRY from 17th Dec., till 11th January, 1984.

During his mission he visited some state farms and cooperatives in the major agricultural areas of Wadi Tuban in Lahej, Wadi Abyan and Hadramout in the fifth governorates. He also visited the two main research centers at El-Kod at Abyan and Seiyun in Hadramout. He visited the main departments concerned at the Ministry of Agriculture and the Ministry of Planning, and held discussions with various staff members at different levels. He also maintained close contact with FAO Representative and had discussion with different project managers.

It is clear that the Government of PDRY has an ambitious plan for the agricultural sector. Investment in agriculture over the 1977-80 years amounted to US$ 230 million or about 35% of the development budget. The principal objectives of the Government's Second Five-Year plan (1981-85) are to achieve self-sufficiency in vegetable production, to cover about 60% to 70% of foodgrain requirements, to increase exports and to provide raw materials for agro-industries.

Although to achieve this goal Agricultural projects were recently initiated to expand and modernize the irrigation system

to increase irrigation efficiency and improve farming techniques to raise productivity, yet the target growth rates set,appear optimistic. Not only planned investments in agriculture were scaled down., but the present irrational use of the limited soil and water resources makes it difficult to achieve the target of self sufficiency of some of the food stuff in a five year period.
The problem of the limited soil and water resources is further complicated, the low productivity of some PDRY soils which is partly related to the quality of irrigation water and its improper utilization, leading to salt build-up on soils and decrease in crop production. The case is more pronounced where tubewells irrigation with poor quality is being used. The water quality for tubewells irrigation in PDRY varies widely. In general, most of the water resources can be classified in the 3rd, 4th and unsuitable classes according to U.S. salinity laboratory system.

Under spate irrigated areas (about 10% of total cropped area), both poor agricultural practices and low irrigation efficiency are contributing to the low crop production.

There is no simple solution to activate the stagnation accuring in the agricultural sector and which has resulted in the decrease of the agriculture's contribution to GDP from 14% in 1975 to 8% in 1980. Soils in PDRY have many limitations affecting their national production. However proper soil and water management will greatly increase their potential productivity and hence contribute to improved crop production and are a MUST.

When one realize that less than 1.0% of the land can be cultivated that the population is increasing at the rate of over 2.8% per year, one immediatly understand the urgent necessity in which the country stands, not only to protect and improve its land and water resources, but also to reclaim and develop all possible areas.

A sound horizontal and vertical expansion programme, involving, improvement, conservation and land reclamation is urgently needed.

It is also important that the Government should identify and correct the limiting factors of crop pnoductivity. However, this approach should be supplemented with accurate agricultural statistical date, a sound programme of agricultural research covering all aspects of crop production and the reorganization of extension service.

2. Background

The people's Democratic Republic of Yemen is situated in the south-west corner of the Arabian Peninsula, it lies between latitudes 12°and 19° North and between longitudes 30° and 43° East.

The PDRY has a total area of about 337000 square kilometer, however the potential arable area is estimated at 225,000 ha or about 0.7% of the country's total land area. It has a population of 1.9 million, of which 470,000 are in the domestic work force, including 200,000 (45%) in agriculture.

The country has limited natural resources. Much of the country is either mountainous up to 2500 meters with rugged plateaux or desertic, the desert areas boarding Rub Al Khali desert of Saudi Arabia.

The climate is arid and, characterised by high temperatures and very little precipitation. The prevailing climatic conditions along with the dominant rugged topography of the terrain have limited agriculture development.

Due to water shortage and the absence of perennial streams the annual cropped area is only about 75,000 ha. Agriculture depend almost totally on irrigation of two types: spate occupies an area of about 40,000 to 70,000 ha and tubewell from groundwater an area of 20,000 ha.

The farm land is divided between :

a) State farms (35 farms) cultivating some 7000 ha mainly from tubewells (85%).

b) Cooperatives (59 agric. coop.) cultivating some 40-50000 ha of which 30-40% is irrigated with groundwater and or the remainder from spate irrigation.

c) Private farm holdings which occupy between 15-25000 ha and are usually spate irrigated.

The cereals occupy about 70% of the cultivated land with wheat and sorghum being the main crops, other major crops includes cotton, about 7% of the cultivated area and is only grown under spate irrigated land, sesame 5%, vegetables (mainly tomatoes, onion and recently potatoes) 5%, and forage crops sorghum and alfalfa planted on about 13% of the total cultivated land.

Although the agricultural sector contributes about 12% to the country's gross domestic production yet the value of agricultural production has been stagnant over the last few years. Since 1975 the production of wheat and cotton has tended to decline. Due to the insufficiency of agricultural production and as consequency of its decline in the last period, the country has to rely heavily on import. The value of import of agricultural products (wheat 55000 tons, wheat flower 26000 tons and rice 36000 tons)during the period 1975-80 increased from US$ 65 million to US$ 200 million in current prices, corresponding to an increase of about 250% in real terms.
However, during the same period livestock production is estimated to have risen by 2% per annum. Livestock production, (is estimated at 120,000 cattle, 1,250,000 goats, 800,000 sheeps and 130,000 camels),accounts for half of the total gross value of agricultural production.

PDRY operates a centrally planned economy with prescribed cropping plans and production targets for each of the 35 state farms and 59 agricultural cooperatives. The plans are discussed at local level and can be sometimes modified than are subsequently amendedcentrally and finalized. This system with

areas of crops planted being pre-determind has led in some instances to imposing a certain cropping pattern which is not suitable to the soil and water conditions prevailing in some farms, and has resulted in low crop production on these farms.

The prices of both inputs and outputs are mostly controlled by the Government

Due to its important role in the country's economy, the government of PDRY has given to the sector high priority in the second Five-Year Plan (1981-1985). It accounts for 22 percent share of the total planned investment (investment to agriculture was 35% of the development budget over the 1973-1980 period). The plan envisaged the vertical expansion of the sector and accordingly, efforts were made to increase production and raise productivity by improving both manpower utilization and the exploitation of available land and water resources with emphasis on irrigation and rehabilitation facilities.

3. Major Agricultural Areas (Fig.1)

3.1 Wadi Hadramout (Fig.2)

3.1.1 Location

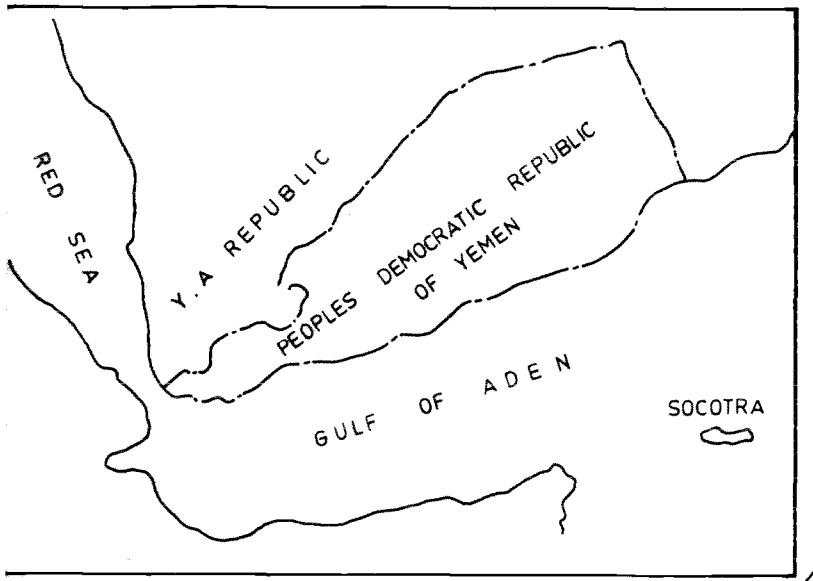
The government is the third largest agricultural region. Wadi hadramout is located in the fifth governorate, north-east of Aden (about 500 Km). It consists of a main valley and several tributary valleys which have eroded deep into the palaeogene limestone plateau of Easter Center PDRY, and the base level is now 150 to 200 m. lower than the plateau. The wadi has dissected the limestone plateau from west to east over a length of some 100 Km. at an altitude of about 600m., the valley and its tributaries are bordered by steep cliffs 200-300 high of the surrounding plateau, narrowing from about 10 Km in the western part to 2 Km in the east (see attached map 2).

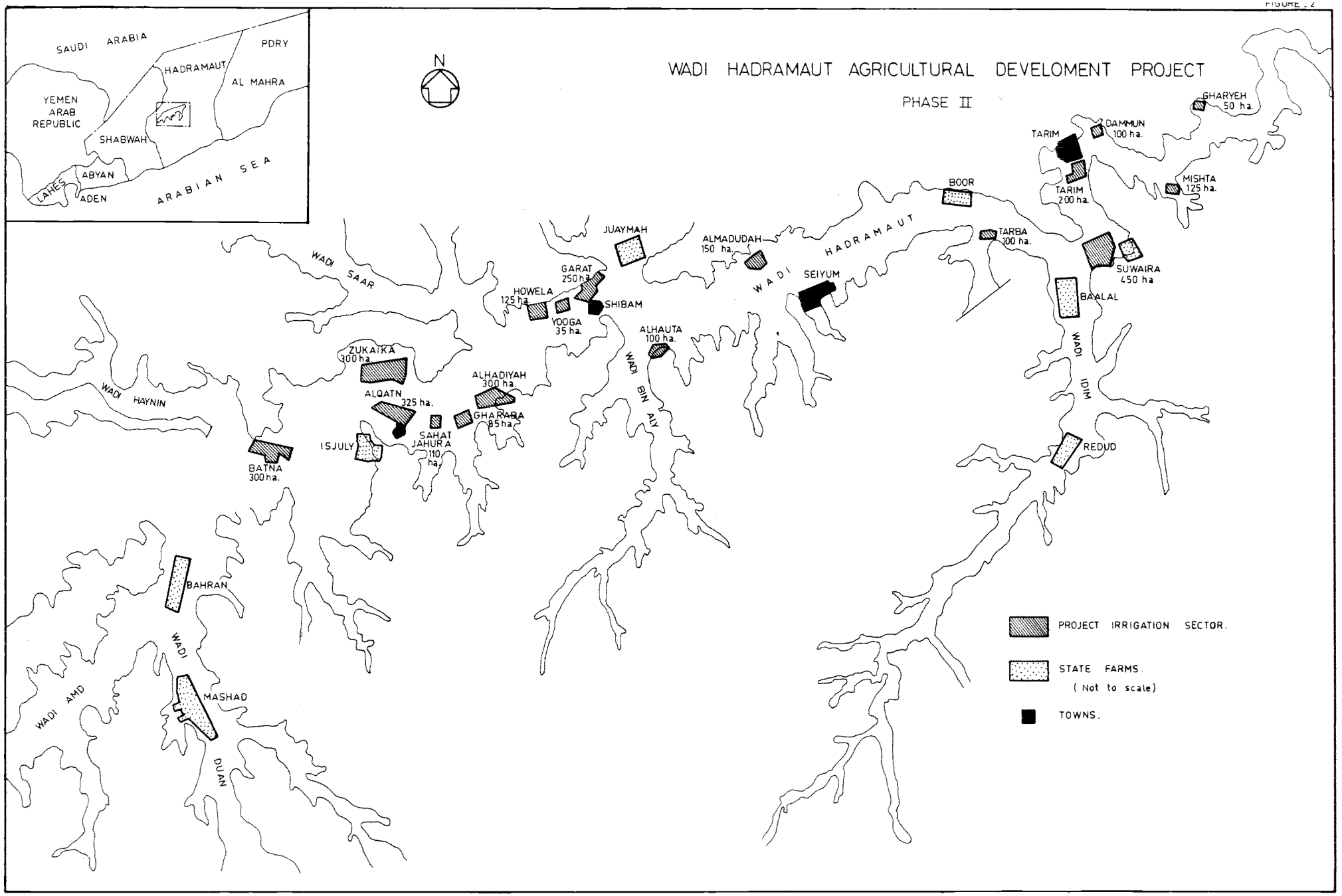
The main landforms covers: the main Hadramout valley, the tributaries of the southern plateau and the tributaries of the northern plateau.

3.1.2 Climate

The villages located at the foot of the cliffs are somewhat protected from sun radiation and windstorms by those cliffs. Rainfall in the valley proper is very scanty amounting to no more than 50 to 60 mm per year falling in heavy showers in March/April and July/September. The climate is hot and dry with maximum temperature ranging from 29°C in December/January to 42°C in July/August, and minimum temperatures from 13°C to 27°C in the corresponding months. The

AGRICULTURAL AREAS VISITED IN PEOPLES DEMOCRATIC REPUBLIC OF YEMEN




SAUDI ARABIA
PDRY
HADRAMAUT
AL MAHRA
YEMEN ARAB REPUBLIC
SHABWAH
ABYAN
LAHES
ADEN
ARABIAN SEA
N
WADI HADRAMAUT AGRICULTURAL DEVELOMENT PROJECT
PHASE II
GHARYEH 50 ha.
DAMMUN 100 ha.
TARIM
TARIM 200 ha.
MISHTA 125 ha.
BOOR
TARBA 100 ha.
SUWAIRA 450 ha
BAALAL
WADI HADRAMAUT
SEIYUM
ALMADUDAH 150 ha.
JUAYMAH
GARAT 250 ha.
HOWELA 125 ha.
SHIBAM
YOOGA 35 ha.
WADI SAAR
ALHAUTA 100 ha.
WADI BIN ALY
WADI IDIM
REDUD
ZUKAIKA 300 ha.
ALHADIYAH 300 ha.
ALQATN 325 ha.
GHARABA 85 ha.
SAHAT JAHURA 110 ha.
ISJULY
BATNA 300 ha.
WADI HAYNIN
BAHRAN
WADI AMD
WADI
MASHAD
DUAN
PROJECT IRRIGATION SECTOR.
STATE FARMS.
(Not to scale)
TOWNS.

average relative humidity values ranging between 40 and 60%. Windstorms especially in the west of the valley have cause sand dune incussions into cultivated land which have led to abandonment of some villages.

3.1.3 Population

The population is estimated at 170,000 inhabitants, about 45000 reaside in the four main towns of Seiyum, Torim, Shiban and all Qatn. The wadi is known for his high rate of male irrigation which was estimated to 44% average family size is 7-8.

3.1.4 Water Resources

a) Surface water The floods which produce surface flown the valley originate from the limestone plateau. The southern plateau receives a reasonable amount of rain betwwn 100-300 mm annual rainfall. It drains about 90 Mm^3 of flood from an effective catchment area of 15200 Km^3 forming only 12.5% of its total watershed of 120000 Km^3. This southern plateau is the main source of the valley's groundwater recharge, both through surface floods on the valley and distant infiltration.

The northern plateau, which is very desertic with annual rainfall of only 60 mm, produces only 24 Mm^3 of flood flows for a catchment area of 5700 Km^3. Infiltration accounts for about 108 Mm^3 of the annual sunoff from the northern and southern plateau.

b) Groundwater Ground water is the main source for irrigation and domestic use an estimated 150Mm^3 being extracted from the shallow aquifer, the underlying conglomerate and the deeper sandstone aquifer. During the fifties and early sixties an unprecedented expansion of ground water irrigation took place with about 2000 open wells fitted with motor pumps over an area of 12500 ha, of of which half came to be cropped annually, with a corresponding neglect and disuse of the spate irrigation system. Farmers cooperatives obtain most of their water for irrigation from those shallow open wells. Since the early 19700, a total of 140 tubewells has been established for both cooperatives and state farms to utilize the better quality water from the lower aquifer.

This expansion of groundwater was of more than local significance because Wadi Hadramout has about half of the area under perennial irrigation in the country and good potential of its future expansion. The estimated capacity of the aquifer for an increased extroaction is 50% of the present extraction. This increased extraction is sufficient for the planned incremental extraction through the Hadramout project of 12.2 Mm^3 for cooperatives in addition to projected increases by the year 2020 of 21.1 Mm^3 and 25.3 Mm^3 for state farms and domestic use.

Groundwater recharge comes from infiltration of flood water in the valley 28.5 Mm^3, re-infiltration of irrigation and domestic water 38.5 Mm^3, and distant recharge from infiltration in the catchment area 48.5 Mm^3. Depletion of the alluvial aquifer of some 15 Mm^3/year, is the reason for the slight decline of ground water level over the last 4 years. Water quality of the upper aquifer, which now provides about two thirds of total abstractions, is generally poor as a result of high to very high salinity. The salinity of open wells 30-40 m. deep varies between EC 3-8 mmhos/Cm; in the conglomerate 50-120 m deep the salinity varies from 1-4 mmhos/cm. Generally, water quality is highest in the tributaries and along the valley's edges. The sandstone aquifer 150-250 deep contains better quality water on the average less than 1 mmhos/Cm.

3.1.5 Irrigated Area

The gross area under command of pump irrigation the valley is 14,500 ha of which about 12,000 belong to cooperatives (five agricultural cooperatives), and the remainder to state farms (eight state farms). Some 15,000 ha is under command of iregular spate irrigation, only partly through a distribution system, and about 2,600 ha gross are under combined spate and pump irrigation command.

3.1.6 Soil Resources

About 467600 ha in the central valley of Wadi Hadramout and the lower reaches of its principal tributaries were covered by the semi-detailed soil study. In 1978, on the basis of 1:25,000 soil maps prepared by the Soviet team of experts, in 1971 SOGREAH drew up a 1:100,000 map of irrigable land in the Hadramout valley using the USBR classification norms. This method of classification takes account of the intrinsic value of the soils (texture and salt content in particular) and the work required for their irrigation and development.

By comparing land resources and water resources, it was possible to identify areas of high potential for agricultural development and maps to scale 1:20.000 for those areas were prepared.

Soils in the wadi are derived from calcareous alluvial and aeolian origin. They vary in texture from sandy to silty loom, usually being coarser in the upper part of the wadi. In general the soil texture is variable within any given farm or area. Salinity has become a major constraint to irrigated agriculture in large area of the wadi due to the use of saline groundwater for irrigation, thus constituting a limiting factor.

According to physical, chemical and enviroment factors (soil properties, topography, drainage) the land was divided into 6 classes:

Class 1 has the highest level of irrigation suitability and comprises 5,412 ha or 11% of the studied area

Class 2 has moderate suitability and comprises 6,007 ha or 12.5% of the area.

Class 3 has marginal suitability and comprises 4,651 ha or 10% of the studied area.

Class 4 designate special use classes such as use of sprinkler irrigation. It comprises 5,494 ha or 11.5%

Class 5 was used as temporary designation for lands requiring special studies before a final land class designation can be made. It comprises 13,063 ha or 26% of the studied area

Class 6 is land not suitable for irrigation development and comprises 13,025 ha or 29% of the studied area

3.1.7 Agriculture

Wadi Hadramout is a sub-governorate, comprising 8 state farms with a total area of 2250 ha., mainly irrigated by tubewell (92% of area), and 14500 ha belonging to five agricultural co-operative farms with 75% of the land being irrigates by tubewell and 25% by spate irrigation. However actual irrigated area varies between 30-70 of the total area (this year 83/84 cultivated area in cooperative was 42% and in state farms 51%), due to insufficient irrigation water, shortage of labor and inadequate use of machinery, hence being about 50% of the land fallow.

Over 60% of the cropped area is under wheat and sorghum; the other major crops are vegetables (mainly onions and tomatoes and recently potatoes was introduced) alfalfa, sesame, citrus and dates, Date palms(700,000 tree), are often cultivated along irrigation ditches, hence using part of the conveyance losses, but generally receive water only during irrigation of the other crops.

Yields are generally low, especially in some of the state farms as they are adversely affected by salinity, inadequate soil preparation and cultural practices, especially poor weed control and uneven water distribution in the field.

In the calculation of net income the state the state farms during the last three years have considerable losses which ranged from YD 100 to YD 162 per hectare, due to high production cost, low yield as well as poor management. In cooperatives the net income varied from YD 36 to YD 72 per hectare mainly due to low expenditure per unit and the higher interest of labour.

3.1.8 Farms Visited

As conditions vary between state farms, agriculture cooperatives and the Hadramout agricultural project, a farm from each was investigated during the visit :

a) Boor State Farm "Yemeni-Soviet Project"
   Is one of five farms managed in wadi Hadramout by the Yemeni-Soviet Project. The other four

farms are Baalal 252 ha, Gaemah 273 ha, Al-Mashhad 420 ha, Bahran 336 ha. When the Yemeni+Soviet Project was established in 1972, It was in charge of the reclamation or rehabitation of the farms (digging of tubewells, levelling, preparing and lineing the irrigation netwash.. etc). The farms were afterwords handed to the state farms dept. in MAAR for management. However since 1978 the Yemeni-Soviet Project became in charge of both phases, the reclamation or rehabilitation and the cultivation and management of the farms until it reaches the stage of productivity. A two years period was estimated for farms to reach productivity. Afterword it is handed over to the state farm Dept. in MAAR. However most of the farms have taken a much longer period than the estimated two years to reach productivity. Since the project was established in 1972, it has reclaimed six farms (Suwairi farm, 315 ha was handed over to Seiyum agricultural research center for management), however the farms were not reclaimed on scientific basis and numerous problems were encountered. The reclamation of new farms was stopped and the Soviet team conducted some studies in the wadi since 1978 till 1981 on geology, hydrology, soils and sociology. However the results of these studies were not submitted to the Government.

The Boor state farm is about 231 ha and is located in the eastern part of the wadi, where usually groundwater is of poorer quality.

Existing irrigation practice as in the rest of the other Yemeni-Soviet farms is based on the use of large well,levelled plots varying in size from 4 to 6 ha to facilitate the use of farms machinery, as most of the agricultural operations from plouthing, seeding, pest control and harvesting of some crops such as the wheat is done by machine. The plots are divided to smaller basins of about 0.4 ha (140m x 30m) for irrigation.

In case of Boor there are seven tubewells with water salinity varying from EC 2.4 to 6.1 mmhos (last water analysis was made in 1981). The discharge capacity of four of the wells is 35l/sec for each wells, and for the other three wells 25 l/sec per well. Water of four of the wells with different salinity (5.5, 6.1, 2.8 and 2.5 mmhos/cm) is collected in one large reservoir and conveyed in lined canals to the fields. The water salinity after mixing of the water from four wells is supposed to be around 4.5 mmhos/cm. Water is applied at the rate of 800-1000m^3/ha per irrigation. Irrigation interval is usually 15 days regardless of soil type or crop requirement. The soil texture of the Boor farm varies from silty loam to loam to sandy loam. Relatively large areas of the farm are affected by salinity.

The land is immediatly cropped after the fiels has been reclaimed and levelled, as a result very poor or no yield is obtained in the first year, poor yield is obtained in the second season and yield of crops start somewhat improving in the third year, but still remains lower than

average yield of the wadi. No leaching is carried before planting to leach the salts from saline areas, but salts are gradually leached through consecutive water given for irrigation as soil permeability is quite good.

The cropped area during this winter season (83/84), is about 88 ha, out of which 64 ha is planted with wheat, 17 ha alfalfa, 2.3 ha tomatoes, 2.0 ha potatoes, 2.2 ha other vegetables.

In general crops grown in basins or strips such as alfalfa and wheat were good, while Vegetable crops grown on furrows were poor. The seedlings are seriously affected by salts accumulating on top of the furrows which was quite evident.

Comments

It is clear that the farm's staff is unaware of the basic principles of development and cultivation of saline soils. Moreover the predetermined cropping pattern which is imposed on the farm and includes salt sensitive crops, and cropping the land without leaching, is resulting in failure of crop production or low yields.

The low productivity of the Boor farm is partly related to the quality of irrigation water and improper utilization, leading to build-up of salts in the soil. Also the lack of knowledge of the staff concerning techniques and management of saline soils. The farm manager is doing a good job but need some guidance.

Recommendations:

1- Close monitoring of both soil and water salinity is very important.

2- Water mixing ratios from different wells should be based on the salinity determination of water from these wells. When irrigating salt tolerant crops EC up to 4.5 mmhos can be used, but for semi-tolerant crops like the vegetables being grown on the farm EC of irrigation water should be 2.5-3.0 mmhos/cm, that means mixing water from only the relatively good quality wells.

3- The choice of crops and cropping pattern of the various plots should be based on their salt content. Hence a soil salinity map for the farm should be prepared if salt content is too high to grow crops, the plots should be properly leached until their salt content is reduced to the level which will allow growing of salt tolerant crops (alfalfa or wheat local variety) for the first two or three years. In the Boor farm it is generally recommended to leach the soil after its reclamation and before planting.

4- A small electrical conductivity bridge (EC) should be available on the farm. It will serve for the monitoring of both soil and water salinity. Cost of the apparatus is about US$ 750. One of the personnel on the farm can easily be trained to collect the soil and water samples and determine their EC.

5- The farm manager should be given some freedom in decision making concerning the choice of crops and cropping pattern, based on the salinity status of the farm.

6- Planting of semi-tolerant crops or crops grown on furrows such as vegetables should only be introduced in the crop rotation after the salt content of the soil is decreased to a reasonable level (4-8 mmhos/cm).

7- When growing crops on furrows, the seeds or seedlings should be planted in the lower part of the furrow side, where the soil has relatively less salt.

8- It is generally preferable in salt affected soils to grow crops which are basin irrigated.

9- The irrigation interval should be reduced, especially during summer to about 6-8 days maximum interval between irrigations so plants will not be subjected to physiological drought due to the high salt content.

10- The quality of irrigation water in terms of salinity and the soil salinity status, will affect the fertilizer programme. The crop performance is affected by the salt content in the soil solution, thus limiting the benefit of the fertilizer used.

b) Al-Suwairi Farm

The area is located in wadi Hajar, right tributary of wadi Hadramout (30 Km east of Seiyum). It is bounded on the north-west by the town Tarim and from two sides by the mountains.

The farm was redeveloped from spate irrigation network in 1976 by the Yemeni-Soviet Project and was handed over to Seiyum Research Center to supervise and implement the activities of the "Improvement of Crop Production Project", the task of the farm was the large scale demonstration of scientific findings obtained by Research Center and to put these into production practices. At present they are implementing activities of the new project of "Farming System Research". Which includes technologies on field operations, input requirements as well as varieties and management practices.

The total area of the farm is about 315 ha. The entire area is under cultivation, however only 50% of the area is cropped each season. Prior to tubewells, spate irrigation was the method of irrigation. Wheat, sorghum, alfalfa and sesame were the main crops. After converting the farm to tubewell irrigation with an irrigation network, considerable area is planted with vegetables like tomato, onion and potatoes and also melons and water melons and small area of citrus trees, in addition to the cereals and fodders.

Soils of Suwairi are stratified non developed soils formed from the alluvial deposits of wasi Hadramout tributary either by overtopping spate flow during high floods or by diverting highly sedimented spate water by farmers into their field. During

these process coarse sediment has deposited near the entrance and the finer material at the far end, with intermediatory sediments deposited in between. In recent period the flood water is carrying mostly sandy material with little silt and almost no clay. As a result, a layer of about 15 to 25 cm thick loamy sand to sandy loam material is spred-ed over most of the farm.
Different areas of the farm are affected to different degrees by salinity, 47 ha are strongly saline, 46 ha moderatly saline, 38ha slightly saline and 174 ha non-saline.

In general the natural fertility of the soil is low, with organic content varying from 0.2-0.4% .

The Suwairi farm is divided in three big blocks comprises 13 plots, irrigated by one main cement lined canals where three or four wells discharge their water. The discharge of each tubewell at present is about 25-35l/sec The salinity of irrigation water ranges be-tween 0.7 and 0.9 mmhos/cm which is considered as one of the best in the wadi. Irrigation practice, is based on the use of long border strip 230m x 6m. To facilitate the use of farm machinery and reduce field water appli-cation loss the plots are properly levelled with slope of 0.001 to 0.002 depending on the soil texture.

Crops grown during winter season 83/84: wheat 33 ha, onion 12 ha, potatoes 16 ha, alfalfa 7 ha. Summer season crops 83 were: cowpea 83 ha, sorghum 26 ha and alfalfa 7ha.

Moreover there is an area of 8.5 ha planted with citrus trees and 50 ha devoted for FAO demonstration farm.

The FAO demonstration farm (initiated in June 1980) is irrigated by two tubewells, each has a 30 l/sec discharge and command a separate area. The ground water quality pumped is good 0.8 mmhos/cm. The water is conveyed to the field in cement lined canals. The field is divided to border strip 120x10m with a 0.001 slope as the soil is loamy but underclain in some areas by a compact layer at 1.0 m depth. The farm (50 ha) is planted by two families of 14 members. The crops grown were alfalfa, the growth is excellent, wheat, the growth was good but some plants are showing symptoms of nutrient deficiency. There is a small area of about 0.4 ha planted with citrus trees 12 years old, spaced 10x10m. Although some organic matter was added to the trees, but they are already showing symptoms deficiency of iron and zinc. The cropping intensity of the FAO demonstration farm is 100%, hence some areas are left fallow during summer season. On an adjacent area, where the soil is sandy to loamy sand a sprinkler irrigation trial is carried on a 2 ha area. The System was a semi-fixed type, but due to shortage in handlabor, the farmer has transformed it to fixed system on lnly half the original area. The area is planted with potatoes, the growth is below average.

The remaining area of Al-Suwairi farm managed by Seiyum research center and where some demonstrations for "Farming System Research"

are carried. It was noticed that wheat planted after alfalfa only fertilized with triple superphosphate at the rate of 120 Kg/ha has a very good vegetative growth, while wheat grown after cowpea fertilized at the same rate has good vegetative growth. The wheat grown after cowpea but not fertilized has medium to poor growth. The potato growth was medium to good.

Areas planted with citrus trees, about 20 ha showed clear deficiency symptoms of micro-elements (zinc, iron); the trees were stunted with appearance of two years old trees although they were six years old.

Comments

Although this farm outstands among the demonstradting farms in adoption of proper fields slopes, long strips and improved irrigation technology which are essential for higher water use efficiency and higher levels of mechanization, yet the following was noticed:

1- Weed infestation of some areas on the farm present a serious problem which is rapdly increasing. The present method of hand picking of some weeds is costly and time consuming. Ploughing dactylon weed without collecting and burning it only helps in propagating it more and more.
Weeds have seriously affected soil fertility, amount of water available to the plants and hence vegetative growth.

2- It was noticed that no crop rotation was implemented to help weed control and improve soil fertility

3- Almost all citrus trees grown on the farm showed clear symptoms of micro-rutrient deficiency. The older trees must have been inadequatly irrigated as over the nutrient deficiency symptoms they were stunted and six years old trees looked like two years old.

4- The cultivated area is relatively small (70-85 ha) as compared to the total cultivable area of the farm (315 ha), this is due to insufficient irrigation water, some engineering problems in the design of the irrigation network which affect water conveyance to some fields.

Recommendations

1- It is strongly recommended NOT to grow citrus trees on highly calcareous soils with calcium carbonate content more than 15-20% especially with medium to heavy texture soils. Such trees will severely suffer from micro-nutrient deficiency (mainly zinc and iron), which will increase with increase in age of the trees. Addition of organic matter can only be beneficial in this respect with young trees; with old trees addition of the deficient micro-elements is a must. Under PDRY present condition this fertilization practice will be costly and not practical.

2- A weed control programe should be immediatly implemented. Some agricultural practices can help in weed control such as following rotation; irrigating the field prior to planting to encourage weed growth which is then ploughed and use of herbicide which is preferably carried during summer to be more effective. Appointing a short term consultant to advise on weed control methods and the types of herbicides to be used is important.

3- Crop rotation should be studied,which will include legume crops to help build the soil fertility,and will allow an increase in cropping intensity of the present cultivated area, thus reducing areas left fallowin summer time and which are subject to salinization. The practice of ploughing the soil after winter cropping to reduce evaporation in summer time and thus salinization should be evaluated under PDRY conditions.

4- Irrigation using the sprinkler system should be limited only to coarse texture calcareous soils. It is important during summer that actual crop irrigation useing the sprinkler be done either early in the morning or after sunset to avoid excessive evaporation loss, and in case of using highly saline water reduce scorching of leaves that may occur.

c) Wadi Hadramout Project

It is clear that phase I of Wadi Hadramout Project which was initiated in 1976 has fulfilled most of its objectives. One of the main objectives of the project was to increase agricultural production in the groundwater irrigated area of about 8000 ha through input supply, construction of feeder roads and provision of extension services.

According to recent assessment of the World Bank report the Project succesfully achieved this goal as comparison of official production statistics of 1977/78 and 1981/82 indicated total increase in the production of all crops with the exception of sesame ranging from 20 to 50%. Yield per hectare of all crops increased as follows: local wheat 93%, Mexican wheat 55%, sorghum 46%, vegetable 44%, alfalfa 36% and sesame 28%.

Due to the success achieved in phase I, it was decided to implement phase II of Wadi Hamdramout project which became operative in July 1983.

Among its objectives is to expand and intensify groundwater irrigation to increase production of cereals, fodders, fruits and vegetables.

The total project area is 3225 ha which represents 27% of the command area of cooperatives, or 18% of the total area under

command in cooperatives and state farms in Wadi Hadramout. It consist of 18 sites located throughout valley to minimize risks of water table drawdown and water quality deterioration, and to achieve a relatively even geographical spread of benefits for the population.

Based on the conclusion of the hydro-geological study regarding the capacity of the groundwater for 50% increased extraction, 55 tubewells will be drilled in the project area to increase annual extraction in the project area from 28 to 40Mm^3. Some of the existing shallow wells will be improved and used for pumping during peak demand period, the additional water extraction from the fresher water of sandstone aquifer (EC about 1 mmhos/cm) will enable an increase in irrigation intensity from 52 to 93%.

Water losses on the various project sites will be reduced through the construction of proper irrigation distribution system, land levelling (over 350m^2/ha) and the proper sizing of irrigation borders 100x6 m in farm unit of about 50 ha. This improved system will provide better water distribution, facilitate mechanization and timely cultural practices, reduce labor requirements, increase yield and net income return.

Other irrigation activities will include establishement of 75 ha of sprinkler

irrigation, improvement of spate irrigation infrastructure for 200 ha and rehabilitation of four wadi flow control sills.

Strengthening of other services will include agricultural extension, expansion of the fruit nursery to provide the required seedlings for the 190 ha of new citrus orchards to be established in the project area.

On the basis of soil suitability, labor availability, mechanization, marketing and national goals planning, two cropping patterns will be selected. The first, is predominantly oriented towards cereal production while the second has a larger proportion of vegetables, Both will include a small percentage of new orchards (mainly citrus). Water requirements will increase from an average of 8600 m^3/ha before development to 12370 m^3 and 12400 m^3/ha for the development of the first and second cropping pattern respectively. The first cropping pattern will cover 1625 ha and the second crop pattern 1600 ha. At full development the total annual water requirement will be 39.8 Mm^3 or 12.2 Mm^3 over the present extraction.

The project is expected to generate substantial increases in agricultural production on account of an 80% expansion of the cropped area following the increased availability of irrigation water (from about 1700ha to nearly 3000 ha). In the case of annual crops relatively high yield levels are expected to be

reached five years after completion of physical works in any given area.

Two sites where some activities of phase II Wadi Hadramout project were initiated in cooperative farms were visited :

1- Howela coop. farm

The project area of the farm is 125 ha. The existing irrigation practices, based on the use of small, uneven hand graded level, which are both labor intensive and does not facilitate the use of farm machinery, were subsituted by well levelled border strips 100x6m to reduce water losses, provide better water distribution and facilitate mechanization. Water conveyance and distribution which was done through crude, unlined ditches having few if any permanent structures of water control and distribution (over all irrigation efficiency estimated to be less than 49%), was substituted by proper sized concrete lined ditches.

Salinity of irrigation water is relativey good EC 1.5 mmhos/cm. The wheat and potato crops grown after development have good vegetative growth.

On this farm an area of 23 ha under sprinkler irrigation and 2 ha under drip irrigation for citrus will be established for demonstration.

2- Al QATN Coopative Farm

Three sites were selected on this farm to implement the project activities; Al Qatn 325 ha, Zukaikah 300 ha and Sohat Al Jahaura 110 ha. The soils on this cooperative vary in texture from sandy loam to loam, and they are quite level, hence will need little re-levelling. Salinity of irrigation water varies from 2-3.5 mmhos. So far no activities were initiated.

Comments and Recommendations

There is no doubt that phase I Wadi Hadramout project successfully achieved its objectives and that phase II will contribute if properly implemented to improving agricultural production in the valley. However the following comments are suggested :

1- There is no clear crop rotation followed on the project area rather a cropping pattern. It will be advisable to to study and experiments on different crop rotations to choose a suitable one for each area.

2- Selection of citrus trees to be planted in different projects sites (190 ha) in Wadi Hadramout phase II, is not the proper choice. It is known from previous experience that citrus trees suffer from serious nutrient deficiencies "especially micro-nutrient", when

grown on medium to heavy texture calcareous soils with calcium carbonate content more than 15%. They require continuous fertilization with micro-nutrients, as these elements are not readily available in calcareous soils. Such fertilization practice is expensive and under PDRY conditions will be difficult to fulfill. Hence, it is recommended to select some other fruit trees more suitable to the prevailing soil conditions in Wadi Hadramout. It is suggested that Seiyum Research Center experiments on fruits trees which are calcium carbonate tolerant, such as grapes, pomegnante, figs.

3- A period of five years is estimated for implementation of Wadi Hadramout phase II on an area of 3225 ha. This area represents only 27% of the total command are of cooperatives 14500 ha. At this rate of implementation, improvement of agricultural production on the total area of the cooperatives will require 20 years.
This rate of implementation is not in agreement with the objectives of the second Five-Years Plan, which aims at achieving self-sufficiency of about 60-70% food grain requirements by year 1985.

As Wadi Hadramout is considered the main area for wheat production, in the country the Government should endeavor reducing the period required for improving cooperatives farms in the wadi to about 10 years.

3.1.9 General Recommendations for Management of Wadi Hadramout Soils

The use of the traditional method of spate irrigation with flood water of relatively good quality (EC less than 1.0 mmhos/cm), has protected the soils in the wadi for centuries from salinization. Moreover, the flood water rejuvinated the soil's fertility through depositions of load of sediments it carried every year.

During the fifties and early sixties a very rapid expansion of groundwater irrigation took place in the wadi with about 2000 wells over an area of 14500 ha which represents over half of the area under perennial irrigation in the country.
The use of such waters which are often of poor to very poor quality due to their high salts content has resulted in soil salinization which is rapidly spreading in some areas of the Wadi, and even taking alarming proportion on some farms which were abondoned by the farmers.

Proper management of Wadi Hadramout soils is very important for continuing a profitable crop production. The following general recommendations are suggested :

a) Reclamation of saline soils

1- Close monitoring of soils and water salinity in areas irrigated with underground water is important. An up-todate soil salinity maps should be prepared, showing the salinity level in both surface and sub-surface soil (0-30cm, 30-60 cm). On the basis of this map, various soil treatments for each farm such as leaching with various amounts of water will be determined and also the types of crops to be grown can be selected according to their salt tolerance.

2- Technical responsible staff on state farms and cooperatives should be trained through extension service on the technology of management of saline soils,taking into consideration the following points:

a) Proper levelling of salt affected soils to insure proper water distribution and leaching.

b) Slightly to moderatly saline soils (EC 5-10 mmhos/cm) can be leached under normal irrigated farming, so no special layouts are required for ponding. The amounts of water to be allocated for leaching these soils in addition to the water use of the crop grown may range from 30-60 cm per meter depth of soil depending on the location. This does not necessarily have to be achieved in one year, but may be done over a period of two years. During this period only salt tolerant crops should be planted.

In saline soils (EC 10-20 mmhos/cm), the amount of water required for leaching in addition to crop during the normal farming will range from 60-100 cm per meter depth of soil. Crops grown during this period should be very salt tolerant.
If soil salinity is in excess of EC20 mmhos/cm, leaching the soil prior to planting is recommended. In this case the plots 100x10 m (or smaller plots 50x10 m) are surrounded by bunds 30-40 cm hight. Water for leaching is introduced to 15-20 cm depth and is left to infiltrate through the soil. The continuous or intermittent leaching method is used according to soil permeability and availability or irrigation water for leaching. It is estimated that 100-150 cm depth of water will be sufficient to reduce the soil salt content to a reasonable level.

c- Leaching requirement. In order to keep non-saline soils in their favorable conditions it is necessary that a general practice of continuous leaching be carried out. The slightly saline and moderatly saline soils should be subject to this continuous leaching so they will not revert to their previous saline condition. The practice that is required is to ensure adequate leaching water to maintain the electrical conductvity of the saturated extract at or lower than 4.0 mmhos/cm.

The leaching requirement (LR.) is defined as the fraction of the irrigation water that must be leached through the root zone to control soil salinity at a specified level (usually 4.0 mmhos or less). There are numerious mathematical equations to calculate the L.R which should be tried to select the suitable one under the prevailing soil, water and crop conditions in Wadi Hadramout. However the simplest one is expressed as $L.R = \frac{ECi}{ECd}$ where ECi and ECd are the electrical conductivities of irrigation and drainage water (soil solution) respectively.

Using Wadi Hadramout groundwater which has an average E.C of 2.0 mmhos the leaching requirement will be:

$$L.R = \frac{2.0}{4.0} = 0.5 \text{ or } 50\%$$

d) Crop selection - Salt tolerant crops may be grown during the period of initial reclamation. Alfalfa may be used. Wheat can be grown as the next crop (preferably local variety as it is more salt tolerant than the mexican wheat). At this stage of reclamation it is preferable to grow crops which are planted in basins or border strips rather than on ridges to avoid salt accumulation on top of the ridges. As to vegetables, tomatoes may be grown on slightly to moderatly saline soils.

After the period of initial leaching which normally followed by the continuous leaching requirement practice, practically all crops that are adopted to the prevailing soils, water and climate conditions in the wadi are grown

e) The effect of different cultural practices and irrigation methods on the salt balance in different soil types in the wadi should be studied, for example amount and frequency of irrigation, ploughing vs. no ploughing during the summer fallow, multiple light irrigation vs heavy pre-planting irrigation.

f) The salinity level in both irrigation water and soil will affect the fertilizer programme. The present general recommendations for fertilization programme of various crops needs to re-evaluated and new recommendations concerning fertilizers use on soils with different salinity levels should be studied.

b) Soil fertility management

Soils in Wadi Hadramout have many limitations affecting their natural productivity such as their medium to high salt content, high calcium carbonate content low organic matter and often coarse soil texture. However, the potential productivity can be improved, once adequate water of reasonally good quality and sufficient nutrients are applied, salinity is controlled and the suitable crops are grown.

From the visits made to different farms, and discussions held with some officials, the following recommendations are suggested concerning fertilty management :

1- Inadequate emphasis is placed on fertility salinity interaction. At present only general recommendations are available concerning the fertilization programme for the various crops, disregarding soil properties and salinity. More fertilizer trials are needed to refine the first approximation presently used and to assist in adjusting the recommendations according to soil properties.

2- Soils are generally low in organic matter less than 1.0%. However, the cropping system practiced now has limited acreage of legume crops and does not allow green manuring or plant residue application to the soil. The effect of organic matter on improving soil structure, aggregate stability and renduring some micronutrient available is important on these calcareous soils.

3- Soils are generally high in calcium carbonate content over 15%. This high calcium carbonate content causes fixation of the applied phosphate fertilizer and convert it to less available forms. Under these soils conditions the applied phosphate is extremely immobile. To improve its effeciency it has to be placed where it can readily be absorbed by the roots, hence either with the seed drilling or in pocket or band placement.

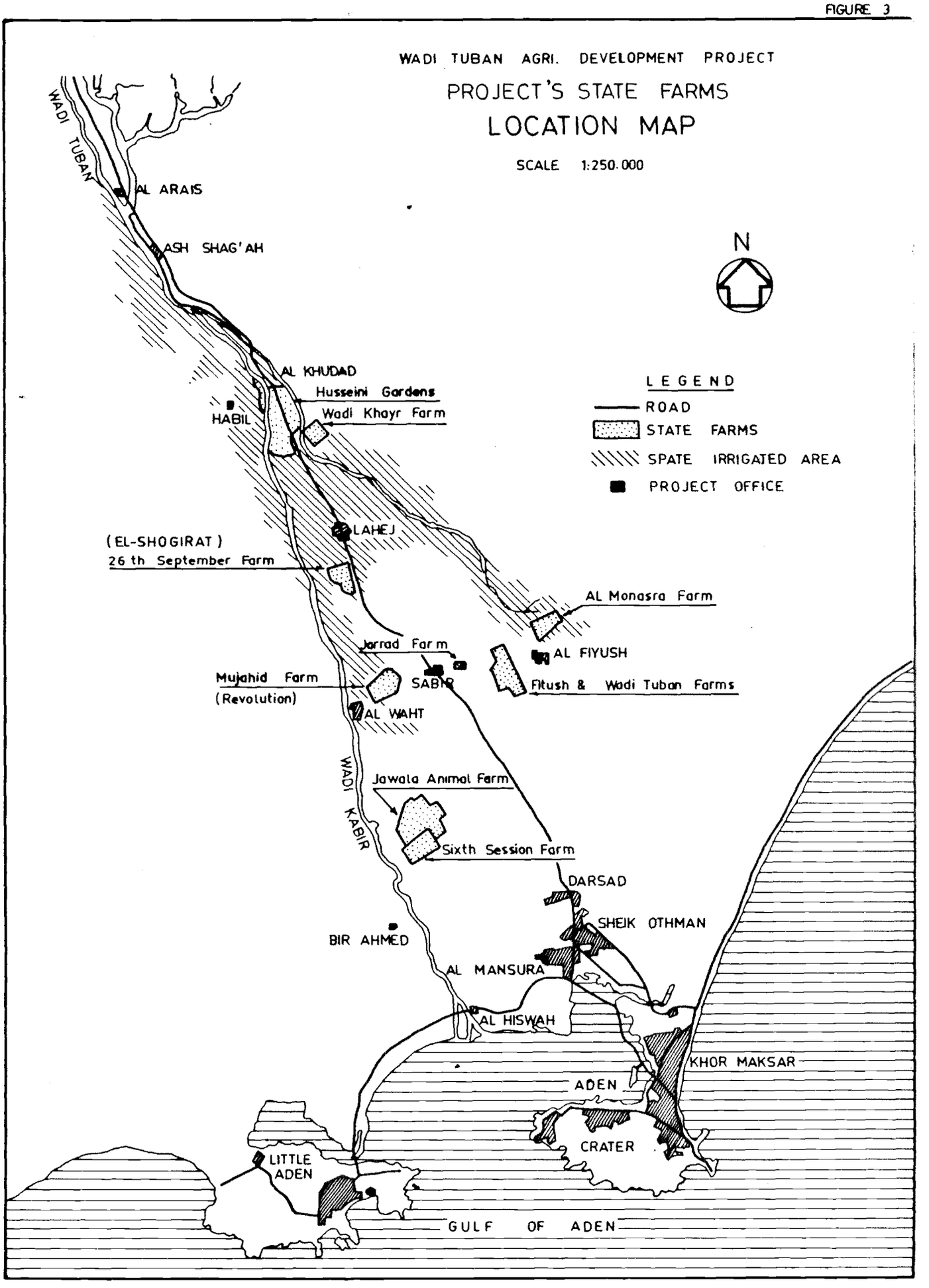
It is worthwhile experimenting on foliar application using dilute concentrations

4- The present use of urea fertilizer under these alkaline soil conditions and presence of high $CaCo_3$ percent results in relatively high loss of nitrogen by volatilization, besides the temporarily build up of ammonia which may cause a high rise in pH . Such pH level could be injurious to seedlings. It is therefore recommended to use nitrogen fertilizer with acidic effect such as ammonium sulfate.

5- At the pH level of such calcareous soils it is expected that most of the micro-nutrients will not be in the available form. Thus a fertilization programme using nicronutrient is requested in particular for fruit trees.

6- Under the present soil levelling practices implemented on state farms and also in forming the bunds in spate irrigated areas removal of the top soils results in reduction of the soil productivity. It is recommended that if the present land forming operation procedures can not be modified that special fertility management such as addition of organic manure, green manuring or growing of legumes crops such as alfalfa should be practiced for a period of two to three years to correct the reduction which has occured in soil productivity by removing the top soil.

FIGURE 3


WADI TUBAN AGRI. DEVELOPMENT PROJECT
PROJECT'S STATE FARMS
LOCATION MAP
SCALE 1:250.000
N
LEGEND
ROAD
STATE FARMS
SPATE IRRIGATED AREA
PROJECT OFFICE
WADI TUBAN
AL ARAIS
ASH SHAG'AH
AL KHUDAD
Husseini Gardens
Wadi Khayr Farm
HABIL
LAHEJ
(EL-SHOGIRAT)
26 th September Farm
AL Monasra Farm
Jarrad Farm
AL FIYUSH
Mujahid Farm
(Revolution)
SABIR
Fitush & Wadi Tuban Farms
AL WAHT
WADI KABIR
Jawala Animal Farm
Sixth Session Farm
DARSAD
SHEIK OTHMAN
BIR AHMED
AL MANSURA
AL HISWAH
KHOR MAKSAR
ADEN
CRATER
LITTLE ADEN
GULF OF ADEN

7- At present both local and high yielding varieties are fertilized using the same rate of fertilizers. It is expected that the newly introduced high yielding varieties will have higher requirements of fertilizer to attain their potential yield. It is recommended to increase the rate of addition of both the nitrogen and the phosphate fertilizers for these high yielding varieties.

8- It is recommended to carry out fertilizer experiments on both spate and groundwater irrigated lands or lands where mixed systems are applied for the chief crops.

3.2 Wadi Tuban "Lahej Governorate" Background

3.2.1 Location (Fig.3)

The wadi Tuban Delta in the second Governorate of Lahej is one of the key agricultural areas, not only by its size, but also because it is so near to the town of Aden. It is located about 8.5 Km north west of Aden and the coast of the Gulf of Aden (see attached map). It is bounded from the west by wadi Al Kabir and from the east by wadi Al Saghir. Wadi Tuban is about 40Km long from its southern boundries up to Batais Weir.

Its geographic area is approximatly 1800 Km^3. The population of the wadi is estimated at 27,000 inhabitants.

3.2.2 Climate

Although the rainfall on the coastal plain is low, average less than 120 mm per year from May to October the average annual rainfall at the end of the catchment on the mountain region in the Yemen Arab Republic exceeds 1500 mm/year.

The average temperature (gaoulah climatological station) is about 29°C.December and January being the lowest average 25.5 and July and August the highest aver. 32°C. The average relative humidity is 69 percent the highest being in April 74 percent and the lowest in July 65 percent.

3.2.3 Water Resources

Wadi Tuban drains a mountainous catchment basin of over 3500 Km^2 which extends about 100 Km north-westward to Taiz and Ibb in the Yemen Arab Republic were rainfall exceeds 1500 mm/year, concentrated in tow periods, the most important July and September the less important between March and May. The water resources of the Tuban Delta are used for both domestic and irrigated agriculture, both by diverting the irregular seasonal flow of the wadi and by topping the water stored as groundwater.

a) Surface Water

The annual flow of wadi Tuban averages 125Mm^3, most of which is directed in the upper part of the delta for the irrigation of seasonal crops. Rainfall is expected only in July/ September and less in April/June. The summer

flows consist of brief floods or spate of which an average of about 50 occur each year some reaching several m^3/sec. Most of these flows are directed for irrigation for seasonal crops. The steep slopes and irregular topography of the delta have encouraged the development of a large number of separate irrigation areas each commanded by its own offtake. Total number of offtake are 63 commanding an area of 9500 ha. An average of less than 50% of the total command area is irrigated in any one year.

b) Groundwater

An average 70% of the surface water reaching the Tuban delta infiltrates to recharge the groundwater stored in underlying alluvium. The total recharge of the Tuban aquifer averages 80 to 90 Mm^3. Most of the recharge results from infiltration in the upper part of the delta. There are however few pumped wells in the upper part of the delta as most of the available land is already developed for spate irrigation. Most of the groundwater abstractions are concentrated at the lower part of the delta.

The total salinity of the Tuban groundwater is generally high, EC is about 1.5 mmhos. The EC of the groundwater increases as it moves away from the recharge area. There is further deterioration in the quality of the Tuban groundwater 6 to 9 Km from the coast. The EC of the groundwater in this zone at the lower part of the delta is over 5.0 mmhos/cm

however, there is no evidence of seawater intrusion. In addition to the potential salinity hazard there is also moderate to severe toxicity of the Tuban groundwater due to its cholride and boron content.

In 1979/80 the gross of the 325 pumped wells in the Tuban delta was about equal to the average annual rehcarge of 80 to 90 Mm^3. This includes the 18 Mm^3 abstracted for domestic use and the gross requirement of the 3500 ha of state farms (2100ha) and cooperatives (1400 ha), irrigated with groundwater. Given the average of about 50% of the irrigation water is returned to the aquifer, the net abstraction 1979/80 could be 50 to 55 Mm^3, equivalent to 60% of the average annual recharge (groundwater Develop. consultants, 1981).

c) <u>Water Demand for Irrigation</u>

Italconsult (1973) gave the total arable area in the Tuban as 27060 ha. Even allowing for the field bunds, canals and access roads, this is much greater than the maximum area being irrigated at present :

- Spate irrigation	5970 ha	(mean area 1974/75 to 1978/79 is only 4200ha however it can vary from 5,000-10,000 ha according to size and time of floods).
- Irrigated by pumped wells	3500 ha	(2400ha ground water irrigated area and 1100h irrigated by mixed system
- Irrigated by springs	165 ha	
Total	9635 ha	

In very dry years as in 1983 the estimated area under spate is only 25-35% of the total command area under spate irrigation. However for pumped irrigation the size of the groundwater reservoir is so large 73000 Mm^3 that mining during dry years may be allowed.

Hence, land is not a constraint in wadi Tuban. The area already developed for spate irrigation (9530 ha) far exceeds the maximum irrigated area (5970 ha), and the capacity of the existing offtakes. It is believed that the present abstraction from groundwater exceed the safe yield of the aquifer and a moratorium has been imposed on the drilling of new irrigation wells.

The demand for groundwater may also be constraint in the long terms by its poor quality, particularly in the lower part of the delta. Most of the groundwater used for irrigation these has an E.C. in excess of 2.5 mmhos/cm and some forms use water with E.C. in excess of 5.0 mmhos. Although many crops can be grown providing sufficient water is applied to prevent a salt build-up in the root zone, difficulties have been experienced using such water on Al Sha'ab and 6th Session farms.

3.2.4 Soil Resources

A detailed soil survey and land classification were conducted by Italconsult (1975) on the irrigated and abandoned land, that cover an area of 16,730 ha, as well as on 18,500 ha of adjacent virgin lands.

Three classes of arable lands, i.e classes 1,2 and 3 with decreasing suitability for irrigation and one class of nonarable land, class 6 were identified. The areas of class 1,2 and 3 are 9,480 ha, 5,290 ha and 12,290 ha and 12,270 ha respectively or 26.9%, 15.0% and 34.9% of the total area surveyed(35,230 ha). While the area of class 6 land which is nonarable is 9,170 ha or 23.2% of the surveyed area.

The virgin lands surveyed (18,500 ha),consist of flat sandy and non gravelly alluvial deposits laid down by the Tuban, Kabir and Soghir wadis. Soils are generally sands,loamy sands or sandy loams and in some areas contain gravel Abundant gravel and stones occur at or near the surface especially in the northern part near the apex of the delta. Apart from few areas, the virgin lands are generally only marginally suitable (class 3) or actually unsuitable for irrigation (class 6), the main dificiencies being sandy texture, presence of gravel or stones at shallow depth, or presence of sand dunes.

As regards to the irrigated lands, they have been influenced mainly by man through the spate irrigation which has been used for centuries. The annual process of sedimentation by the suspended loamy and silty material which is deposited as a result of spate irrigation has raised the original ground level by as much as 8 - 10 meters in some areas, particularly in the northern part of the delta and along the wadi beds

(the thickness of the crust yearly deposited in the area north of Lahej ranges from 2 to 4 cm, while in the southern part of the delta it reaches a thickness of only few millimeters).

In general the soils of wadi Tuban are well drained, their initial inherent fertility is relatively high, but decreases with cultivation.

The levels of salinity and alkalinity in the various soil types depend mainly on the type of irrigation system, i.e on the quality of water (spate or groundwater) used for irrigation. In general loam and silt loam soils are irrigated by spate and are generally free of salinity and free or slightly affected by alkalinity, while sandy, loamy sand and sandy loam soils are irrigated by groundwater and are free to moderally affected by salinity and moderatly to strongly affected by alkalinity.

The higher salinity levels found in the groundwater irrigated soils compared with those that are spate irrigated, are due to the higher slainity of the groundwater over E.C. 2.8 mmhos/cm compared with that of the spate water (over 0.9 mmhos/cm). However, the low or moderate levels of salinity found throughout the irrigated soils as compared to salinity level one may expect when using such saline water for irrigation is due to the good infiltration and drainage characteristics.

3.2.5 Agriculture

Since 1973, most of the area under spate irrigation in the Tuban delta has been planted with cotton and sorghum. The latter is mostly grown for fodder and after ratooned. The following table shows the percentage of the various crops grown under spate irrigated land and the yield obtained:

Crop	% of total irrigation	Yield/Ton/ha
Cotton /medium staple	44.8	1.12
sorghum/maize	48.7	12.3
Sesame	3.1	0.21
Melon/squash	2.6	3.2 /9.3
Tomatoes (may receive an irrig.)	0.8	12.6

Under spate irrigation the fields are laid out in irregular terraces with each field surrounded by a bund 1.0 to 1.5 m high. The fields are Ploughed before the arrival of the water which is applied to an average depth of 60 cm for cotton and 45 to 50 cm for other crops. However, the fields are very poorly levelled so that there is considerable variation in the depth applied within each field.

Some water percolates through the root zone and is beneficial in preventing the accumulation of dissolved salts. However because the variation in the depth of application, leaching will not be uniformly distributed and some increase in soil salinity in the higher parts of the fields is expected : on average it is estimated that 25% of the irrigation water percolates through the root zone.

In the groundwater irrigated areas, the irrigation system includes a collecting tank, where the water is pumped and a distribution network. Earth canals are generally used, but with the wadi Tuban Development Project concrete lined canals and also piped distribution outwork are being built.

Levelling is not accurate and therefore the plots are generally divided into very small basins (with furrows when required) varying in size between 15 and 100m^2. More advanced water application methods such as borders are now being applied in state farms.

The frequency of irrigation and the volumes of the water applied each time vary considerally for any given crop from farm to farm, mainly because of the soil characteristics, but also according to the different approaches followed by the farmers. In general the fodder or grain crops may receive only 2 to 3 applications in a season, vegetables may receive 9 to 11 applications.

The main crops and yield in wadi Tuban (1978/79) are given in the following table :

Crop	Cropped area in ha		Yield Ton/ha	
	State farms	Cooperatives	State farms	Cooperatives
Sorghum fodder	1710	1270	9.57	12.3
" grain	295	403	0.64	0.44
Maize	54	-	0.97	-
Sesame	79	368	0.30	0.21
Cotton	-	1820	-	1.12
Tomatoes	391	313	8.53	12.66
Melons	241	189	6.63	3.22
Squash	36	34	6.70	9.31
Other crops(vegetables)	111	154	-	-
T O T A L	2920	4550		

3.2.6 Farms Visited

a) Shugayrat (26th Sept.)

It is one of the 8 state farms included (out of the 12 state farms in wadi Tuban) in the wadi Tuban Development Project which was initiated in 1978. The project is financed by IDA/5.2 million dollars) and arab Kuwait Fund (6.3 million dollars), and local component (1.0 million dollars). The total cost of the project 12.5 million dollars envisages the rehabilitation and improvement of an area of 1755 ha in 8 state farms, and was to be completed by 1983. However due to delay in receiving the equipments and machinery and setting of the machine and training of the staff, the new date set for completion of the project is 1986.

The component of the improvement which includes :

- Land levelling (over 700 m^3/ha)
- Construction of lined canals and water structures
- Rehabilitation of existing lined canals
- Improvement of spate canals and structures
- Construction of axcess and on farm roads and also feeder roads
- Purchase of farm machinery and provide training
- Provide water supply for six villages

The area of Shugayrat farm is 180 ha, equiped with 7 wells. The estimated water requirement for the farm is 2.6 Mm^3/year, however the available water from groundwater is 2.23 Mm^3/year. The difficient amount of water will be net for about 25% of the area through spate irrigation rather than increase the rate of pumping from tubewells, which can result in a salinity problem.

The soil texture on the farm varies from loamy sand to silty loam and the soil profile is quite deep (over 6m). The calcium carborate content ranges from 5 to 20% which causes some phosphate fixation. So far limited salinity problems are encountered on some areas, but do not represent a serious problem. The E.C of groundwater varies from 1.8 to 2.2 mmhos, hence it is suitable for most crops grown on the farm.

The main crops grown on the state farms are vegetables (tomatoes, okra, eggplant, melons) sorghum, maize, alfalfa and sesame. Also there is some fruit trees (mangoes, papaya, guava and easter apple). The present cropping intensity on state farms ranges between 20 to 105%. The projected cropping intensity with Wadi Tuban Development Project ranges from 145 to 200%.

The work is satisfactorily progressing in shugayrat farm. It is estimated that 85% of the rehabilitation work was completed on the farm during the visit. However, it is important that continuous maintenance of the irrigation system should be carried, as it

was noticed that the life time of the lined canals on most state farms is much lower than the predicted.

b) 6th Session Farm

It was of special interest to visit this farm which is located in the lower part of of the delta, as it is seriously affected by salinity and in some areas also by alkalinity.

Recently, a team from El Kod agricultural Research Center conducted a study (June 1983) to determine the extent to which the farm is affected by salinity as large areas are at present abandoned.

The area of the farm is 240 ha, irrigated by 10 tubewells. However during the visit only 3 tubewells were regularly used because of their relatively good underground water quality, 4 are occasionally used and the remaining 3 wells are not used anymore because of the high salt content of their underground water.

The study included making 24 auger holes and 6 soil pits and collecting soil samples from various depths (0-30, 30-60, 60-90 and 90-120 Cm) for determination of electrical conductivity in 1:1 extract, and mechanical analysis. Water samples were also collected from the 10 wells for E.C determination for comparision with previous analysis conducted in 1971 and 1979.

The following table shows the results of the analysis

Well No.	Water table depth m.		E.C mmhos/cm		
	1981	1983	1971	1979	1983
12	23.1	28.0	1.8	2.1	-
13	21.7	27.3	1.2	3.4	4.1
14	22.0	27.0	1.7	4.0	4.6
15	23.7	28.9	2.6	3.9	4.4
16	22.4	31.3	2.5	1.5	2.8
17	20.5	25.8	2.0	4.0	4.3
18	20.6	25.4	2.2	4.7	5.5
19	18.8	26.1	2.5	-	7.2
20	-	-	-	3.9	3.7
25	-	25.0	2.4	8.2	-

It is clear that due to overpumping on the farm and surrounding areas there has been a considerable lowering of the water table (from 5 to 8 m), when comparing the 1981 to 1983 recording. This was reflected in increase in the EC of the groundwater which has more than doubled for some wells when cmparing the initial salt content in 1971 to 1983.

As a result of this deterioration in the groundwater quality large areas of the farm have been abandoned. At present only 85 ha are under cultivation (sorghum, sesame,water-melons), 95 ha were abandoned a year ago and 60 ha were abandoned over two years age and are now infested by weeds.

Soil analysis did not show any high salt concentrations in most of the different sites up to a depth of 120 cm except for few samples. Probably salt build up did not occur due to the high permeability of the sandy or loamy sand soils prevailing on the farm.

It is believed that failure of crop growing could be due to both an alkalinity problem soil pH on numerous soil samples from 8.5-9.0 as was noticed from the soil appearance and to the high salt concentration of the irrigation water itself. Moreover the coarse texture soils prevailing in large areas on the farm along with the long irrigation interval were also important factors affecting crop growth.

Recommendations

- Close monitoring of water salinity and alkalinity should be kept. The use of wells No.18 and 19 should be discontinued and keeping a close watch on water quality of well No.14.

- It is important to determine the ESP for layer of medium texture soils, and soils with pH over 8.5 (as most pH determinations vary between 8.5-9.0). Soil samples with ESP above 15 will need gypsum requirement or some other amendments.

- Addition of organic matter will improve both the soil physical and chemical characteristics, plus the supplying of some nutrients.

- Irrigation frequencies should be based on the soil moisture characteristics and the crops water requirements. With water quality as the one used on the farm (E.C above 4.0 mmhos except two wells No.16 and 20), the soil should not be allowed to dry and the field should be irrigated when about 35 to 45% of the available moisture is depleted.

- To study the possibility of conveying the flood water through the old flood irrigation canal located on the northern boundary of the farm. Sedimentation of the silt carried by flood water will improve the coarse texture soils and their water holding capacity.

3.2.7 General Comments on Wadi Tuban

a) Irrigation Water

The potential hazards to crops due to the total salinity and the relative abundance of sodium cation in irrigation water is great. In the Tuban delta the hazard of even the recharge water can be classified as "high". Although the sodium hazard of the recharge water is low, the salinity and sodium content of the groundwater increases as it flows through the aquifer and in certain areas a very high salinity hazard is accompanied by high to very high alkalinity hazard. Near the cost in particular in the south-eastern corner of the delta the groundwater could be classified as too saline for irrigation use,

although some of the water is used for irrigation of sorghum.

In addition to the potential hazards due primarly to its total salinity,most of the Tuban groundwater has a moderate to severe toxicity for certain crops due to its high chloride and boron content. Chloride is present in concentration generally exceeding 4 meq/l and in the lower part of the delta its concentration exceeds 10 meq/l. Boron was found in concentration varying from 0.3 to 3.6 mg/l. In the north eastern part of the delta boron concentration exceeds 2.0 mg/l.

Chloride and boron toxicity applies mainly to perennial crops such as fruit trees,although maize and some vegetables may be affected adversely by boron in concentration exceeding 2.0 mg/l. The annual crops grown in the delta are primarly affected by the total salinity of the irrigation water. However their tolerance varies considerally and may be increased by improved irrigation practices, assuming 15 to 20% of the irrigation water is available for leaching the soluble salts through the root zone.

b) Crops and Yield Under Spate

The number of crop species grown with spate irrigation is rather limited. Without doubt the most important crop is cotton, followed by sorghum, millet, water melons, sesame and tomatoes. However with this method of irrigation, the one irrigation given to cotton (60cm.) is able to provide only 55% of the potential requirement and 45 to 65% for other crops receiving 45 to 55 cm of water.

c) Constraints of Irrigation Systems

c.1 Spate Irrigation

- Low efficiency of the flood distribution network with the consequent damages to the canals and difficult control of the flows.

- Irregular control of the basin filling, often requiring the passage of water from one basin to another

- Unsatisfactory levelling of the bottoms of the basins and inadequate heights of the borders of the basins with resultant irregular watering of the areas to be cultivated causing a loss (estimated to 20-40%) of the area really irrigated.

- Inadequate size of basins that are often below the minimum area which permits the mechanization of certain important operations

c.2 Groundwater Irrigation

- The most important, is the farmers little experience of surface irrigation which is still influenced by traditional experience of spate irrigation. Irrigation efficiency is estimated to less than 50%.

- Little experience as to the most adequate forms for the various types of soil and crops, of surface preparation of the land and of irrigation methods (furrous, bassins, etc.).

- The poor soil levelling, which compels the use of small size basins have high labour requirements.

3.2.8 General Recommendations for Wadi Tuban

- The spate irrigated area should not be expanded, but if possible all excess flood water should be conveyed to areas affected by salinity in lower part of the delta.The relatively good quality of flood water will help in leaching of accumulated salt due to use of poor quality groundwater

- It is quite evident that the present extraction can not be largely increased without eventually causing the salinization of the groundwater reservoirs. There is no doubt that this must be absolutly avoided. In case the groundwater should become unsuitable for domestic use, as the wadi Tuban is the main source of water supply for Aden town, very costly desalination process should be introduced to cope with town needs.

- The danger of seawater intrusion exist in the near future if no control on overpumping is enforced. It is recommended to use water meter guages on tubewell pumps to help controlling the amount of water extracted for irrigation

- Large production increases may be expected from the amelioration of the groundwater irrigated land. It is recommended to speed up the implementation of projects such as

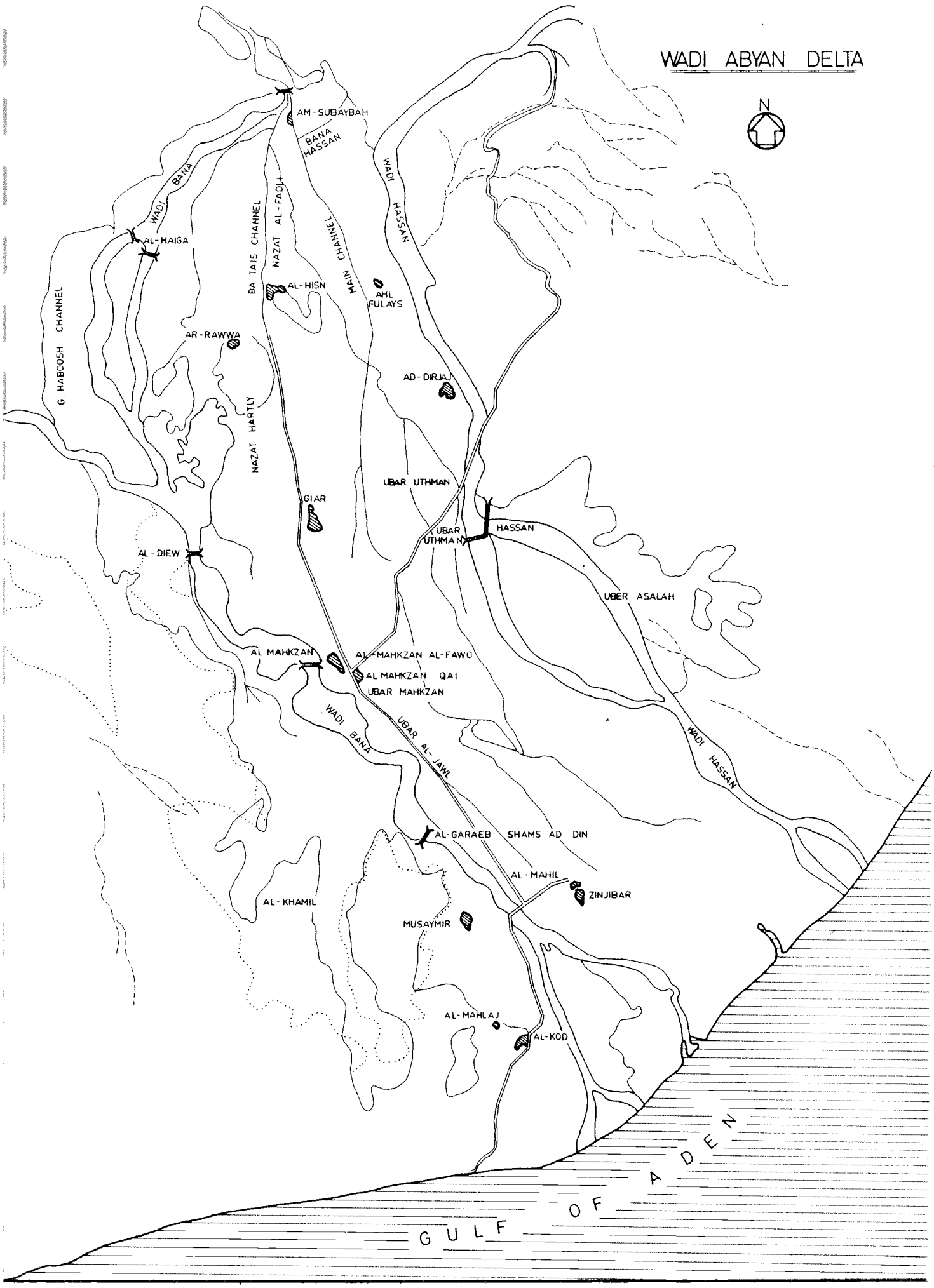
the one carried by F.A.O in wadi Tuban, with the purpose of improving the irrigation system, the levelling made more accurate, the cropping pattern modified and the cultivation practices improved.

- Leaching of saline soils can be obtained in the upper 2 meters of the soil by useing a depth of 60-80 cm of groundwater. This amount can be given on increment of 15-20 cm for each leaching.

- Soils strongly affected by alkalinity can be improved by use of soil amendments such as gypsum, sulfur or sulfuric acid. However the economic of such practices should be studied as alkalinity is mainly due to the groundwater which will be a continuous source of the alkalinity hazard.

- The possibility of drilling some boreholes in spate irrigated areas where floods arrive infrequently should be studied. With such boreholes it is possible to step up production and eliminate that chance element with dependence on floods. Two crops a year can also be grown in this manner.

- The proper methods of land preparation in spate and in groundwater irrigated areas should be investigated at El Kod Research Center. Some of the equipment used for land preparation operations result in soil compaction or deterioration of the already poorly developed soil structure. Training of tractor operators is very important.


WADI ABYAN DELTA
N
AM-SUBAYBAH
BANA HASSAN
WADI BANA
WADI HASSAN
AL-HAIGA
BA TAIS CHANNEL
NAZAT AL-FADL
MAIN CHANNEL
AL-HISN
AHL FULAYS
G. HABOOSH CHANNEL
AR-RAWWA
AD-DIRJAJ
NAZAT HARTLY
UBAR UTHMAN
GIAR
HASSAN
AL-DIEW
UBER ASALAH
AL MAHKZAN
AL-MAHKZAN AL-FAWQ
AL MAHKZAN QAI
UBAR MAHKZAN
WADI BANA
UBAR AL-JAWL
WADI HASSAN
AL-GARAEB
SHAMS AD DIN
AL-MAHIL
ZINJIBAR
AL-KHAMIL
MUSAYMIR
AL-MAHLAJ
AL-KOD
GULF OF ADEN

- The problem of setting up a windbreak and of dune fixation should be more thoroughly considered. The planting of windscreens to shelter the cultivated areas from wind erosion or wind effect on crops is important and is recommended even if the area occupied by windbreaks reduces the useful area of crops. At present Wadi Tuban development Project implemented on some eight state farms out of the twelve state farms are planting windbreaks as part of their development plan. However the species, the density and spacing of windbreaks should be further investigated.

- Data on the content in nutritive macroelements (N,P,K) under various irrigation methods should be studied and appropriate experiments in the Wadi Tuban delta on fertilizing of both spate and groundwater irrigated lands or where mixed systems are applied should be carried for the major crops.

3.3 Abyan Delta "Third Governorate"

Background

3.3.1 Location (Fig.4)

Abyan governorate "the third governorate" plays an important role in the country's agricultural production as it contributes to about 30 percent to the National Agricultural Plan.

It is bounded from the east by Shalwa governorate, from the west by Aden governorate, from the south by the Gulf of Aden and from the north by the Yemen Arab Republic.

The area of the governorate is about 28187 Km^2 comprising 8 percent of the country's total area, with a population of about 320,000 person, distributed among the three main districts : Khanfer district about 180,000 person, Lodar 110,000 and Mudia about 50,000 person.

The Abyan governorate is characterized by three agricultural ecological areas i.e the coastal, the medium and the high altitudes. Various field crops, vegetables and fruits are produced all year round. The main agricultural area is the Abyon delta, located toward the center of the governorate and extending from north to south towards the Gulf of Aden.

3.3.2 Climate

Two distinct seasons are evident in the Abyan delta. The period between November and May is affected by the Northwest mansoon. This is the cooler season characterized by milder easterly winds and clear sunny weather. From June to October it is the period of southwest mansoon, which is characterized by hot, dry and dusty weather.

The temperature, is however moderate due to its proximity to the sea, only occassionally rising above 41.5^{o}C or falling below 7.5^{o}C. The humidity is high throughout the year, particularly at night and in the early morning. In the summer the relative humidity is frequently over 82%.

The annual rainfall ranges from 30 up to 150mm. Small showers may occur in January on the coast.

3.3.3 Water Resources

Wadi Abyan drains a mountainous catchment area of over 15,450 Km^2 composed of three wadies. The most important being wadi Bana 9625 Km^2, followed by wadi Hassan, 3875 Km^2 and wadi Suhaybiah 1950 Km^2.

The average yield flow 161 Mm^3/year (max. 287 Mm^3 and min. 86 Mm^3). The estimated (groundwater recharge within the delta proper due to seepage from wadis, canals and irrigated land was found to average 97 Mm^3/year (seven years average estimated by Dar Al Handassah Engineers), or 56% of water flow. The subsurface in flow in delta recharge can therefore be estimated at an average of 100 Mm^3/year, which is considered as the safe yield of the aquifer. However the groundwater levels are subject to decline in years of low wadi flows due to decrease recharge.

The water quality EC is 1-2 mmhos/cm in the north (at Batais in upper part of the delta) and the area between Musaynin and El Kod in the south. In the central and south eastern part of the delta it is highly saline E.C 7 mmhos/cm area Al Makhzan, sometimes reaching 10 mmhos/cm in the south east. The salinity of groundwater is due to aquifer formation from marine origin. The sodium absorption ratio is also high in water. Fortunatly, however, the greater part of Abyan delta soils have good

permeability allowing easy leaching. The suspended material of the flood water is about 0.7% by weight, is mainly silt 50-70%, sand 20-40% and clay 4-12%.

3.3.4 Soil Resources

Abyan delta soils consist of recent alluvial deposits laid down by the wadi. The alluvial deposit is mainly composed of silt and sand and little clay near the coast. Sand dunes are found in south-western and north-eastern part of the delta with scattered rock outcrop.

Abyan delta area is about 53,000 ha. A semi-detailed soil survey was conducted in 1971 by Dar Al Handassah Engineers. Five soil series were identified based mainly on soil texture, depth and soil salinity. They were classified according to USBR into 4 classes:

- Class 1 1945 ha or 37% of total area
- Class 2 11000 ha or 21%
- Class 3 4900 ha or 9% are arable
- Class 6 17350 ha or 33% non arable

It was found that two third of the delta is potentially cultivable (about 36000 ha).

As the largest cultivated area is under spate irrigation which relies on a single flood irrigation, the soil moisture properties were studied and the available water in the Abyan delta determined for different soil texture classes.

The following table gives an idea on the available moisture in the root zone (up to 100 cm)

Soil Texture	Bulk Density gm/cm^3	⅓Atms% Aver.	15 Atm.% Aver	Available Moisture Cm/100 cm soil depth
Loamy sand	1.4	4.5	1.8	3.9 - 7.9
Sandy loam	1.3	11.5	4.9	8.3 - 19.0
Loam	1.2	18.9	7.2	13.8 - 26.3
Silt loam	1.1	23.9	9.1	16.3 - 28.2
Clay loam	1.1	27.6	11.4	17.0 - 29.6
Silty clay loam	1.1	30.4	8.7	22.8 - 28.0

Loamy sand have very low available water range, not exceeding 7.9cm per 100cm of soil depth. This indicate that once a year water application to this soil is wasteful since most water applied will percolate to deeper depth. Only loam texture or heavier textural soils are able to store in one to two meters soil depth any reasonable amount of available water.

Under spate irrigation, the texture and depth of surface soil is very important in determining its suitability for cultivation. Sandy surface horizion reduce total available moisture and affect germination due to rapid drying after irrigation. Soil with sandy surface 25 cm thick is considered as class 2 and 25-50 cm thick class 3, more than 50cm class 6.

Other factors affecting productivity in the delta such as soil salinity which is significant in the extreme south coast of Zinzibar and Al Rowa and Al Mokhazan where leaching of those soils is necessary.

Erosion, most of the south eastern part of the area is somewhat affected by wind erosion. In some areas liability to water erosion by severe floods as the one of 1982 present a serious danger and should be studied to suggest suitable control methods.

3.3.5 Agriculture

The agricultural sector, including livestock production is considered as one of the most important sources of income in the governorate.

There are two distinct farming systems, the spate irrigation based on cotton and sorghum production which comprises 73% of the cropped area and engages the vast majority of the small farmers organized in cooperatives. The groundwater system based on fruits and vegetables production and comprises 27% of the cropped area mainly organized in state farms.

The governorate comprises 14 cooperatives scattered in all districts, where 85% of cropped area (about 17,000 ha) is under spate irrigation and 15% (about 3000 ha) irrigated by underground water through 2090 shallow wells and 52 tubewell. All state farms are situated in Kharfar district and Giar centre with the exception of one farm found in Mudia's district (medium altitude area). Almost all the cropped area in state farms or 99% (about 2500 ha) is irrigated by underground water through 144 tubewells.

Although the cultivable area in the 14 cooperatives is about 50,000 ha, however the total cropped area varies between 11,000 to 22,000 ha according to flood in-tensity, usually it averages about 17,000 ha. The remaining area which is about 60-70% of the cultivable land is left fallow. Of the total cropped area, 89% is under field crops (45% of field crops is forage sorghum, 25% long staple cotton, 15% maize, 10% millet and 5% sesame), 10% vegetables and 1% fruit.

In the state farms the cultivable area is about 4000 ha, but the cultivated area is about 2500 ha, out of which 60% is under field crops (60% forage sorghum, 22% sesame, 15% maize and 3% cotton and tobacco), 18% vegetables and 22% fruit trees.

The distribution of crops varies according to the three agricultural ecological zones of the governorate. In coastal areas long staple cotton, sorghum, maize, millt, sesame, tobacco, groundnut and cowpea are the major field crops, while tomato, eggplant, green onions, chillies, okra and melons are the main vegetables. As fruits are concerned, papaya, mango, bananas, guava and limon are the major fruits. In medium altitude areas, the main field crops are sorghum, maize, millet and sesame, while the main vegetables are tomatos, pepper, squash, cucumber, potato and water melon. Oranges are the main fruits in this area. In high altitudes areas, sorghum, millet, wheat and barley are the major field crops, while tomato, potato, cabbage, cauliflower and carrots are the main vegetables. Peaches, apricots and grapes are the main fruits.

According to Abyan Agricultural Department, 68% of potatoes, 53% of tomatoes, 50% of sesame, 100% of long staple cotton and 100% of fruits with stoney seed are produced by Abyan governorate.

In generl crop yield are lower than the potentail yield which can be obtained for most crops, due inadequancy of inputs especially fertilizers or their unavailability at the proper time and the poor management. In cooperatives low yields and low land utilization (less than 30-40% of cultivable area) are due to shortage of flood water and low water use efficiency, problems of hand labour and mechanization low quantity of fertilizers applied and very poor plant protection and weed control, in brief under-developed agricultural technology. On state farms poor management often due to lack of know-how, low utilization of man-power and machines are important factors affecting crop production and the reason of the low land utilization (50% of the cultivable land).

3.3.6 Farms Visited

In the coastal area (Abyan delta), two farms were visited where F.A.O "Irrigated Farming System Research Extension Project" is being implemented for the improvement of irrigation system. One is a state farm "7th October" the second a cooperative "Zinzibar". The Giar center in the northern part of the delta was also visited to have an idea of the damages caused by the 1982 desastrous flood. In the medium altitude area of Mudia Um-Qooz state farm was visited along with a private farm.

a) 7th October State Farm

The farm is located in south-western part of Abyan delta. This farm represents the groundwater irrigated area of coastal region.

The area of the farm is about 460 ha, but only about 60% of this area is cultivated. It is irrigated by 31 tubewells (20 are equipped with electric engines and 11 with diesel engines). The average discharge of the well is about 40 l/sec. The majority of the irrigation canals are earthern canals, and only few are lined with cement.

The farm is divided to small fields,fairly levelled, varying in size from 0.1 to 0.2 ha, surrounded by high bunds, which are heavily infested with weeds.

Basin irrigation is used with groundwater irrigation, however flood water is supplied whenever it is available. Under these conditions it is difficult to use mechanization or improved irrigation efficiently.

Soil texture varies from silty loam to sandy loam, but is mainly loamy. The soil is somewhat calcareous as calcium carbonate content ranges from 10-17%. As groundwater is of a fairly good quality, soil salinity does not represent so far a serious problem, although some salt accumulation is evident on top of the ridges. However, the pH is generally high more than 8.0 and reaches 8.5 to 8.7 in some soils, indicating possible alkalinity problem.

Due to levelling and reshaping of some areas, fields showed considerable variation in soil fertility and some of their physical characteristics such as soil structure and infiltration rate, this was reflected on crop growth.

Regarding the crops planted on the farm, orchard (mainly banana and papaya) occupied 61% of the total cultivated area, then field crops (maize, forage sorghum and sesame) occupied about 25% while vegetables (tomato, okra, eggplant, green pepper, cucumber, onion, water melon) is about 14% of the area.

The Irrigated Farming System Research and Extension Project which was initiated in 1982 by F.A.O with one of the objectives of improving irrigation system in both underground and spate irrigated farms, is demonstrating the improved technology on a 10ha field.

The previous small uneven field plots (0.05 ha-0.1 ha) which were irrigated with any measurement control just by adding a 20-25 cm depth of water for the first irrigation, followed by different number of irrigations of 6-8cm depth canals according to crops, are now substituted by well levelled soil plots 120m x 48m, with border strips 120 m long x 6m wide. This new practice has facilitated the use of farm machinery and increased both its efficiency and the irrigation efficiency. Water is introduced through a Parshall

flume and is measured for each irrigation. Optimum cropping pattern, applying recommended agricultural practices (crop variety, seed rate, date of plantin, land preparation, method of planting, fertilizers rate and time of application, irrigation amount and interval control of posts and diseases and cultivation) are being used and studies.

Field crops (maize), vegetables (tomatoes, okra, melon and water melons), and fruits are grown on the demonstration field. In general seed germination and vegetative groth was good (except for some phosphorus deficiency symptoms showing on the maize leaves).

Recommendations

- Although soil salinity does not represent a problem on the farm, yet acumulation of salt on top of the ridges grown with vegetables indicate a possible salinity hazard. It is recommended to occasionally determine the EC of the soil and if an increase of E.C over 4 mmhos is found, to leach the accumulated salt using a 20-25 cm depth of water, especially after crops grown on ridges or furrous such as vegetables.

- Better weed control should be implemented using a suitable herbicide preferably in summer time to obtain better results. Banana fields were seriously infested with weeds which resulted in relatively low yield (15-20 T/ha).

- Fertilization programme (kind of fertilizer, rate and time of application) should be properly studied, as some crops were showing nutrient deficiency.

- Addition of organic matter, whenever possible (15-30 T/ha), can greatly improve the soil's chemical and physical characteristics and increase crop production of vegetables and fruits.

- Soils are generally high in pH ranging from 8.1 to 8.7. This high pH level will cause conversion of the phosphate applied as soluble fertilizer to less available forms. To improve its efficiency it must be placed where it can readily absorded (drilled during seeding, in pockets or land placement). Also at this high pH most of the micro-nutrient will not be in the available form. Thus a fertilization programme using micro-nutrient is required especially for fruit trees.

- The land forming operation associated with the new irrigation techniques, causes removal of top soil, thus reducing the productivity of the land. Special care in fertilization and addition of organic matter is required to maintain the productivity of the top soil of such fields.

b) Zinjibar Cooperative Farm

This cooperative represents the largest cooperative in the governorate with about 3000 menbers who are working partly in team and partly individually on small scattered

units of production. The total area suitable for cultivation is about 10810 ha, of which an average of 28 percent (2720 ha) is usually cultivated. Out of the total cultivable area 85 percent is spate irrigated (9180 ha), and 13 percent (1690 ha) relies on underground water for irrigation. The farm has 20 tube-wells and 57 shallow wells. The average area irrigated by one tubewell is about 16-20 ha. The water is dilevered from the wells to the fields in earthen canals. The E.C of under-ground water is about 2.5 mmhos, with few wells of E.C 3.4 mmhos/cm.

The floods are usually expected from July to September and from February to March, giv-ing rise to two seasons. However, as the farm is located at the far end of the wadi, con-sequently it is the last to receive flood irrigation water. The little amount of flood water conveyed to the spate irrigated area (85% of total area), is the main reason for the limited cultivated area of 28%).

Soils in Zinjibar are formed from alluvial deposits by wadi Bana and wadi Hassan. They are mainly sandy loam to loamy sand as the alluvium contains high proportion of sand and silt and little clay. The texture variability is also observed within the soil profile, which is due to the special nature of sediment deposition, windblown sand in the coastal area and non-acting on the soil. In general soil prevailing on this farm have medium to low suitability for spate irrigation due to their relatively coarse texture with low water hold-ing capacity.

Soils on the farm are not saline, except some areas irrigated by underground water. The average soil pH is 8.2 and the exchangeable sodium is relatively high. Calcium carbonate content varies between 10-12%. The organic matter content in the surface layer is less than 1 percent and decreases downward the profile to 0.2-0.4 percent.

The farm is divided to samll improperly levelled plots, usually varying in size from 0.1-0.2 ha. The plots are surrounded by high bunds totally infested by abnoxious weeds. Such poorly levelled small plots, with high bunds result in low irrigation efficiency estimated at 40-45 percent and low land use efficiency which is about 45 percent. Moreover under these conditions efficient mechanization, improved irrigation techniques and improved crop production practices are very low.

Due to the large area under spate irrigation most of the cultivated area is under field crops, 88%, theyare mainly maize, sorghum, sesame and cotton. Vegetables occupy 9% of the area with tomatoes, pepper, okra and eggplant being the main vegetables grown. Orchards occupy only 3% of the cultivated area, are mainly bananas and some papayas.

Most of the agricultural operations are carried out by hand with a minimum operations being mechanized (mainly ploughing for seed bed preparation). All other agricultural practices such as weeding miter-row cultivation,

plant protection are hardly being implemented. Facilities possessed by this farm are very limited (especially farm machineries), and are hardly enough for either expansion of the cultivated area or for introducing intensive farming system.

In underground irrigated areas the canals are not lined and inadequatly designed and often are not properly located. Due to these facts and to the relatively coarse nature of the soils, the water losses are considerably high.

The Irrigated Farming System and Extension Project has established a demonstration field for improved spate irrigation system. The land was properly levelled and divided into plots of 0.75 ha each, surrounded by 2m high bunds to allow introducing 100 cm depth of flood water. The plots is divided to 3 units each of 0.25 ha. This system has facilitated the use of farm machinery and improved irrigation efficiency. The cost of production is being studied for the new and old techniques, the yield increase due to irrigation improvement and the net income obtained will also be evaluated.

Fields of two farmers using underground water for irrigation were also visited:

- Al Shaheed Nagui farm where vegetables and sorghum are planted.
- Al Amood farm, where small banana, mango and lemon trees were planted. Vegetables were also planted weither separatly or as inter cropping between fruit trees.

The first farm is a typical example of very poor farming and the lack of knowledge of cultural practices is evident. The seed bed was poorly prepared as big soil clods dominated the surface soil. The size of the ridges used for vegetables are unsuitable resulting in low land utilization.
The irrigation canals are not properly prepared and their condition is very poor resulting in great water convieyance losses.
The field is infested with weeds. As a result of the unfavorable conditions prevailing on the farm the vegetative growth is very poor and lots of plants are missing.
Tomato yield is very low and of inferior quality.

On the other hand, the second farm is a typical example of a successful farming and experienced farmer. The soil on this farm is properly levelled and the seed bed properly prepared. Very few weeds were noticed due to good weed control. The vegetative growth of the newly planted banana and the intercropped vegetable (pepper) is excellent. However, the small mango and lemon trees showed tip burning of the leaves and many trees lost a great number of their leaves, while the intercropped vegetable was excellent. It was found after discussing the agricultural practices used with the farmer, that large amount of organic matter (sheep and goat manure) was mixed in the tree pit before planting the trees. It is believed that heat of decomposition of the organic manure along with the hot climate has resulted in the burning of the leaves tip. It was noticed that new small healthy leaves have started growing.

Recommendations

- Large areas of land under spate irrigation were left fallow due to severe water shortage from the low flood in 1983. This leads us to emphasize the importance of studing the possibility of expanding the combined irrigation system "spate irrigation supplemented by underground water"

- Facilities on the farm, particularly farm machinery should be improved

- Extension service should be strengthened as many farmers lack the knowledge of suitable agricultural practices.

- Weed control is extremely important on this farm as numerous fields are severely infested.

- Suitable fertilization programme based on results obtained from El Kod Research Center and in situ trials is important for yield increase.

c) Um-Qooz State Farm

Is an example of the medium altitude region. The farm is located at about 190Km east-north of Aden, at an elevation of 600m, a.s.l.

The area of the farm is about 320 ha, however the cultivated area is only 50 ha (about 15% only). The main reason for the very low land utilization is due to severe shortage of underground irrigation. The farm is equipped with 10 tubewells, however only three are operating and the remaining

seven wells are out of order. Occasionally flood water is also supplied to the farm. The E.C of the groundwater varies between 2.5-5.0 mmhos/cm.

The dominant soil texture is loamy sand, yet the canals are unlined and poorly constructed resulting in large water conveyance losses.

Most of the cultivated area (40 ha) is planted with citrus trees. The trees are stunted (very small size for their age), are drougthy and show deficiency symptoms of micro-nutrient, mainly zinc.

The rest of the cultivated area is planted with vegetables, tomatoes and potatoes. The vegetative growth of the potatoes is relatively good, while that of the tomatoes is poor and lots of plants are missing. According to the farm manager the tomatoes received only two irrigations in over 40 days due to water shortage.

Recommendations

- Due to the fact that there is a severe shortage in irrigation water that the soil is light textured soil and highly permeable, care must be taken to preserve irrigation water by cement lining all irrigation canals.

- All available irrigation water must be directed to the permanent crops which are the citrus trees. Vegetables should not be planted so as not to compete with fruit trees for water.

The total available irrigation water from the three wells is about 40-50 l/sec, is hardly sufficient to irrigate the citrus trees.

- The wells are operating only for a period of 5-6 hours/day. Operation time should be increased to at least 12-14 hours/day to cope with the water needs of the fruit trees. Incentives should be paid to farmers to increase working hours to irrigate the orchard trees.

- Farm management should be improved. The assistant farm manager present during the visit needs training as he lacks simple knowledge on agricultural practices.

- The planned trial on drip irrigation should only be implemented on young trees, age of 1-2 years. Old trees with relatively extensive root system will be affected if irrigation system is changed from surface to drip. Fertilizer tank should be used with the drip system to overcome shortage in hand labor and the low efficiency of the laborers working on the farm (many are old women).

3.3.7 General Recommendations for Abyan Delta

- Abyan delta was seriously affected by two extreme floods in two consecutive years. The 1982 flood, which was a very high flood (50 years flood) and caused serious damages washing away the weir, water control orrifices,

bridges and erroding the wadi chanel. The 1983 which was a very low flood that resulted in fallowing most of the areas under spate irrigation. These two extreme floods lead to emphasize the importance of the following:

a) Study of different methods of flood control to reduce damage caused by very high floods.

b) Study the possibility of expanding the mixed irrigation system " groundwater and flood irrigation" to eliminate the chance element or dependence on floods.

- In the Abyan delta it was estimated that the available water resources from flood and groundwater could irrigate annually a maximum are of about 20,000-22,000 ha. The soil survey has shown that the area of class 1 and 2 is over 30,000 ha. Hence it is recommended that land development should concentrate on lands belonging to these two soil classes.

- Salt affected soils in Abyan delta are mainly located in areas irrigated by groundwater. It is important to preserve these soils from salt build up by implementing measures of salinity control. All soils with E.C of more than 4mmhos (in sat. extract), at some depth in the root zone should be included in the leaching programme. Such soils shall be considered to be reclaimed when the E.C is less than 4 mmhos throughout the root zone. Hence the soils which are are slightly saline (E.C 4-8 mmhos) should be leached under normal farming so no special layouts are required for ponding. The amount of water to be allocated for leaching these soils

in addition to the water requirement of the crop grown ranges from 30-60 cm per meter depth of the soil depending on the location. This does not necessarily have to be achieved in one year but may be done over a period of two years. During this leaching period only salt tolerant crops should be planted.

- Moderatly saline soils (E.C 8-16 mmhos), can also be leached under normal farming. The amount of water required for leaching in addition to crop use. Water ranges from 60-100cm per meter depth of soil, which can be given over a period of 2-3 years (20-30 cm/year). Crops grown during this period should be very tolerant to salt.

- In order to keep non-saline soils in their favourable conditions, it is necessary that a general practice of continuous leaching be carried out to maintain E.C of the saturated extract at or lower than 4 mmhos. This is possible through the addition of the leaching requirement water fraction. The slightly saline and moderatly saline soils should be subjected to this continuous leaching, lest they revert to their previous saline conditions. Under Abyan groundwater quality (E.C 1-2 mmhos) the leaching requirement is about 25-50% of the crop water use.

- During the period of initial reclamation of saline to moderatly saline soils salt tolerant crops such as cotton, alfalfa and forage sorghum can be grown. As to vegetables, tomatoes may be grown on slightly to moderatly saline soils: often the period of initial leaching which is

followed by the continuous leaching requirement practice, practically all crops that are adopted to the prevailing conditions in the delta can be grown.

- Land levelling carried in spate irrigated field is inadequate and lack exactitude required for proper irrigation. The development of improved irrigation will require land levelling based on exact surveying techniques which should provide the required slope in the direction of irrigation run.

- Shifting of sand dunes in the south-eastern and north-eastern part of the Abyan delta could present an important problem. Fixation of dunes and planting of windbreaks to prevent the acumulation of surface sand on agricultural lands should be a part of the land development programme of the delta.

4. Agricultural Research Centres

The two Research Centres visited are El Kod in Abyan and Seiyum in Wadi Hadramout. They are organizationally independent but are both responsible to the department of Research and Extension, which was set up in 1980 within the Ministry of Agriculture and Agrarian Reform, Which is responsible for the overall development of research and extension programme. Prior to the establishment of Dept. of Research and Extension, Seiyun was a sub-station of El Kod and research programme were planned at El Kod. To day both research stations are functioning separatly with no administrative links between them. However, both stations aim at achieving the same objectives which are to increase the agricultural productivity and production by improving

the utilization of the land and water resources, introducing high yielding cultivars and developing suitable agricultural practices.

Due to the importance of strengthening those two Research Centres which can contribute much to the knowledge needed to overcoming problems faced by production of the agricultural sector in the country, a mission from the World Bank recently visited PDR Yemen (August 1983), to identify and possibly finance project in support of agricultural research and extension within the Ministry of Agriculture. The provision of training, consultants and experts are the major component of the project. Next, is the provision of essential equipment and additional operating costs to allow for the full use of existing facilities and finally in priority over the buildings and rehabilitation of existing ones. The project cost which will be phased over five years is estimated at U.S. 9.7 million dollars.

4.1 El Kod Research Centre

It was originally established by the British in 1955, mainly as a cotton research station with only three sections: agronomy, soils and plant protection. After independance the scope of research broadned to cover most crops grown in the country and related activities. The centre had ten specialized sections in 1981 and are now increased to twelve : soils, irrigation, agronomy, horticulture, entomology,plant pathology, tobacco, forestry, weed control, farm mechanization, food technology and economics.

The centre over a period of time has developed adequate buildings, with laboratory facilities having modern furniture and equipment, library, office and residential buildings.

The present technical staff total 112, comprising 4 PhD, 37 MSc, 16 BSc and 55 technical assistant. The two sections of main concern : soils (1 PhD, 5 MSc, one absent on PhD studies in micronutrient, 7 technical assistant & 10 laborers),

and irrigation (3 MSc, 1 BSc and 7 technical assistant).

Field trials are conducted on a 20 ha experimental farm, some 5 Km from the station buildings. The farm has well laid fields and is tubewell irrigated with relatively good irrigation water. In addition to the rather small experimental farm. There are 8 sub-stations functioning either as local trials, nursery or as a demonstration plot for extension work. Under the 1977-81 UNDP/FAO Improvement of Crop Production Project (PDY/75/019).

Three large demonstration farms were set up to demonstrate improved farming system, on a large scale that can be directly applied to state farms. Two of the farms, Al Arais (125ha, spate irrigated) in wadi Tuban, and El Kod in Abyan (118 ha, groundwater irrigated), were run from El Kod station. The third demonstration farm El Suwairi (85 ha, groundwater irrigated) was run by Seiyun Research Centre.

Main achievements of agricultural research includes release of improved varieties of wheat, maize, medium staple cotton, tomato and patato along with the pachage of agricultural practices needed. In horticulture emphasis was placed on propagation of papaya, banana and citrus trees. In plant protection, doses of pesticides and their methods of application were standardized for farmers use.

Emphasis of activities of soil section was mainly studies of fertilizer and water requirement of crops. Very few experiment were conducted to study leaching of saline soils or salt tolerance of crops. Soil survey activities carried included detailed survey of El Kod farm and the 6th Session farm and reconnaissance survey of some state and cooperative farms. These surveys especially the detailed were useful in revealing the obstacles hindering normal growth and in formulating land use plan for the farm.

However most of the soil survey carried for the major agricultural areas was carried by foreign consulting companies. From research findings general recommendations for fertilizer and water requirements were suggested:

Crop	Nitrogen Kg/ha	P_2O_5 Kg/ha	Water depth cm
Cotton	57-87	-	60
Sorghum	57	30	35
Corn	115	57	50
Wheat	115	57	40
Vegetables	115	57	35 (tomato 50)
Alfalfa	57	57	-

At present the soil section research programme includes studing the NPK effect on the yield of some crops also the application of organic fertilizer. As urea is the main nitrogen fertilizer being used, its transformation under PDRY conditions was studied.

4.2 Seiyum Research Centre

This Agricultural Research Centre, which was up to 1980 a sub-station of El Kod is at present organizationally independent. It is a relatively new Centre as it was established in 1972.

The Centre is carrying its activities through six sections : soils and irrigation, agronomy, horticulture, forestry and range management, plant protections, economics and farm management and Mechanization. Its technical staff total 43, among them 5 MSc, 16 BSc and 22 technical assistants. At present one of the staff is studing for his Ph.D in soils in France. The Centre, has well kept buildings which are adequate for its needs however considerable additional equipments are needed to enable it to function effectively.

Fields trials and demonstrations are conducted on a 25 ha farm which is about 38 Km from the station buildings in Seiyum., which results in loss of some time in driving back and forth and phsical fatigue of the staff especially during the long hot summer season. For this reason, two new sites suggested for an experimental farm were visited. The available information, soil survey data and laboratory analysis were studied. The advantages and disadvantages of each site were assessed and a brief report including some technical recommendations concerning each location was submitted before departure from Seiyum to Mr. Hussein Bamakhrama, Director of Seiyum Research Center.

The soils and irrigation department, is staffed with 2 MSc, 2 BSc and 4 technical assistants. The first activities of the department (1972-1978), concentrated mainly in carrying soil survey of the state farms and analysis of the soil and water on these farms to determine their salt content.

From 1974-1976 some fertilizer trials were conducted on wheat and onion. From 1976 to present both fertilizer and water requirement trials were conducted but on limited scale along with very few (one or two) salt leaching trials.

The soil laboratory is equiped to carry most of routine chemical determinations (EC, PH, cations and onions) and some of the physical analysis (mechanical analysis).

However, some important equipment are lacking and should be provided in case the project being formulated by the World Bank to "Strengthen Research and Extension" does not materialize. These are mainly equipment for soil physical analysis and that for determining the soil fertility status and plant analysis. Some of the present

laboratory equipment (colorimeter, Kejeldahl apparatus, muffle furnace) has not been used yet, as activities related to soil fertility and fertilizer are limited to field trials. Yet it is important that soil analysis should complement in interpreting yield data collected from field trials.

Seiyum Research Center's problems can be summarized as follows:

- Lack of long-term research policy. At present a technical committee has been formed, but a good sound research policy has not been formulated yet.

- Present staff cadre is mainly made up of BSc graduates which lack experience in planning and execution of a sound research programme.

- Lack of fixed skilled and unskilled laboures trained in implementing field trials.

- Poor utilization and maintenance of the laboratory equipment. Repair of broken apparatus may take a very long time.

- Difficulty in obtaining the required inputs needed for the field trials (seeds, fertilizers, pesticibles, chemicals and some equipments ...etc), or obtaining them not at the proper time.

- The library lacks numerous scientific books and Journals. At present the journal are being supplied through subscription by FAO, which is only temporarly and will soon end.

c) General Comments and Recommendations

If strengthened, Research Centers can contribute much to the knowledge needed to overcome problems faced by production of agricultural sector in PDRY.

Despite, undoubted achievements in the past, the research services does not seem to be very active at present. The main reason seem to be the limited availability of operating funds, so work has to be seriously curtailed in particular supplies of important chemicals, other research materials and spare parts for the laboratory equipment. This problem was further aggravated at El Kod station due to withdrawal of most of the farm machinery, vehicules and equipments by the "Farming System Research and Development of Extension Project" which was set up in 1982 as a successor to the 1977-81 UNDP/FAO "Improvement of Crop Production Project". Thus EL Kod Center was deprived from irreplaceable equipments necessary for general research activities.

Another serious limitation to the present research activities, is the human resource element which is not sufficient in number or training to be able to carry out the research programme required for the agricultural development. There is also a lack of in-service training programme for professional staff and technicians. This problem of staff and trained technicians is more serious at Seiyum Research Centre which has not received its share of experts and consultant's services.

However, Iam confident that at the return of the technical staff that was sent abroad for higher degree studies (MSc and Ph.D), along with the present soil staff at El Kod Centre, that with some guidance

from short- turn consultant in various fields (soil fertility, pedology, soil physics ..etc), the soil department can do a good job in covering most of the research aspects urgently needed.

There is no clear long-term research policy existing to deal with the applied research needs in PDRY. The present soil and water research programme provides only general recommendations for soil management and water requirement. The applicability of the general recommendations will vary from one area or farm to another depending on the soil and water characteristics. Such general recommendations are accepted as a first phase, but they need to be followed by more specific recommendations.

4.3 General Recommendations

The following recommendations need to be considered in organizing and strengthening both El Kod and Seiyum Research Centres.

1. It is important to formulate a long-term research policy to cope with the needs of the agricultural development of PDRY and help in achieving the objectives of the Five-Year Plan.

2. Establish an advisory committee to coordinate activities between the two Research Centres (El Kod and Seiyum) and for planning inter-discriplinary research programme and prepare local or national recommendations based on research findings in various fields. The advisory research committee can be assisted by one or more consultants.

3. Allocate the necessary funds needed to strenthen the two Research Centres through:

   3.1 Developing the capabilities of the laboratories to undertake the desired research programme.

   3.2 Purchase the needed field equipment, vehicules and in-put required to execute the field trials.

   3.3 Develop library facilities to contain basic text books and important scientific Journals.

4. Strengthen the research staff with special emphasis to staff for Seiyum Centre. The staff should include at least one Ph.D in each section, capable of preparing a sound research programme, supervising its implementation, evaluating the data obtained and preparing the technical recommendations.

5. It is very important to recruit and train technicians in the use, maintenance and minor repair of laboratory equipments and also in execution and monotoring of field trials and operation and maintenance of field machinery and equipment. Recruitment and training of permanent skilled labourers is also very important for execution of field trials.

6. Establish in-service training programme for the staff (including laboratory and field technicians), to assure their continual up-dating and that they acquire the necessary skills for their research activities.

7. Organizational changes need to be studied with the objectives of strengthening the inter-disciplinary team approach in showing some agricultural problems.

8. Some experts or consultants should be recriuted to assist in certain fields where no expertise is available (in soil dept. soil physics, soil pedology, soil micro-nutrients, soil micro-organism). They will assist in planning the research programme needed in these fields,propose the methodology of work and suggest the training requirement of local staff.

9. If possible make more provision for staff housing to increase the time research staff are on the job (about two and half hours are daily lost), and save the operating cost of transporting staff to and from Aden.

10. Avoid undue depletion of local staff from research centres to other department in the Ministry of Agriculture. It is extremely important that all staff with high degrees (MSc, Ph.D) either present or will return from abroad, remain in their department and work in the field of their expertise and training (Dr. Said Al Mokhtary who recently returned from U.S.A after receiving his Ph.D in soil fertility was transferred to the state farm dept.).

11. Agriculture research need a link with other research academic institutions, including university of Aden and Nasser Collage of Agriculture.

12. There must be a closer link between the research centres and staff from extension service. In fact some of the present research staff could assist in extension service.

13. It is important that experimental farms research programme will gradually shift to production oriented activities through linking of research with extension to assume an impact on increasing agricultural production in the country.

4.4 Reccommendations for Some Future Soil Research Studies

Bites and pieces of information have been accumulated regarding soil and water research and their effect on crop productivity. The present research findings provides only general reccommendations for soil and water management. It is clear that the present level of information of soils of different areas, wadis or farms is not sufficient to plan a sound programme for soil reclamation and improvement or assist yield response of crops grown on them to various fertilization programme. Hence extrapolation of research findings conducted on few sites to cover various conditions is seriously limited.
Therefore it is important to fill the gaps in the present research programme by a long-term research policy with inter-descipliancy team approach.

Some requirements should be taken into consideration in implementing the field trials such as :

- Experiments should be conducted for more than one year until results obtained are conclusive
- The site of the experimental farm or station need to represent as much as possible the dominant soils and water conditions in the wadi if results obtained can be quickly and safely applied to similar soils.
- Concentrate research on major crops whether they are field, vegetable or fruit crops.

The following soil research and studies are recommended

4.4.1 Soil Reclamation and Improvement

Saline Soils

Most of the underground water resources used for tubewells irrigation in PDRY can be classified in class 3,4 or unsuitable for irrigation according to U.S. Salinity laboratory system and has led not only to low productivity but to salt built-up in the soil due to its improper utilization and consequently large area are rapidly deteriorating and being abandoned.

The research programme to establish scientific basis for efficient and practical methods for salinity control can include the following :

1. Study leaching doses and methods for reclamation of saline soils, with different texture and initial amounts of salinity. The amount and quality of water needed for leaching, doses of leaching water and its frequency, method of leaching (continuous vs intermittent leaching or intermittent + ploughing), suitable time for leaching and agricultural practices should be studied.

2. Study leaching requirement for salinity control, using irrigation water with different salinity levels and applying different leaching requirement equations to test their suitability under the prevailing soil, water and climate conditions of the different wadis. Also the amount and frequency of irrigation and method of addition of water leaching either on multiple small doses with every irrigation or heavy pre-planting irrigation according to water availability.

3. Improve the basic recommended cultural practices for the main crops covering land preparation and method of planting (basin, furrows, including shape of furrows and ridges), seed rates and spacing.

4. Study of different irrigation system on rate of soil salinization and its control when using saline water for irrigation.

5. Study on the effect of different quality irrigation waters on yield reduction of major crops. This study will provide some scientific basis on the economy of use of such irrigation water and guideline for its classification according to local conditions.

6. Study the fertilizer treatment and efficiency on crop yield response in salt affected soils. This will help determine the interaction between soil salinity and the different levels of crop nutrients (N,P,K), and will help evaluate the ecomomy of production of different crops on soils of different levels of salinity.

7. On saline-alkali or alkali soils (as on 6th Session farm), study of types of soil amendments, doses and methods of addition to control alkalinity.

4.4.2 Soil Fertility

More fertilizer trials are needed to refine the first approximation of data obtained but not verified on which is based the present recommendations for fertilization of various crops.

1. To study the relationship between yield of major crops and nutrients level required of NPK at different selected sites in major agricultural areas.

2. To study the amount of fertilizer applied, its doses, time and method of application under both spate and tubewell irrigation.

3. Interaction between nitrogen fertilizer and different water regines and its chemical composition.

4. Compare use of foliar application of phosphorus fertilizer on calcareous soils to overcome its fixation with other methods such as band placement, placement in pockets or drilled with the seeds during planting.

5. More studies should be conducted on the effect of organic manuring using different types of organic matter (compost, plant residues, city compost, sheep or goat manure .. etc), on soil improvement and crop yield.

6. To assess levels of micro-nutrients in PDRY soils and crop needs. Special attention should be given to needs of perennial crops and fruit trees when grown on calcareous soils. Most citrus trees showed zinc and iron deficiencies.

4.4.3 Soil Physics

1. Effect on use of different farm machinery during seed bed preparation on soil structure, soil aggregates and infiltration.

2. Depletion of soil moisture by the major crops grown different soil texture under spate irrigation and on irrigated land.

3. Study on soil crust formation on heavy texture calcareous soils and methods to overcome it (use of organic manure, green manuring, plant residues or by special irrigation frequency).

4. Study the effect of erosion in areas subjected to wind and or water erosion on the physical and chemical characteristics of the surface soil to evaluate extent of damages and suggest means of control.

5. Some General Recommendations

Specific recommendations were given at the end of each part. However it was thought of interest to emphasis in the following general recommendations some of them or give new ones:

5.1 Soils and Soil Salinity

1. Survey and studies of soil and water resources of the major wadis in PDRY, should be completed to assist in the preparation of a sound realistic Five-Year plan for land reclamation and development. Results of such surveys will determine the extent and location of potential agricultural areas cals-sified according to their quality characteristics, suitability for irrigation methods and their crop-ping system.

   A set of LANDSAT photos (satellite photos)covering the entire country, can be of great use as base maps. Moreover it can help delineating the correct boundaries of cultivated areas.

2. It is important to plan a detailed or semi-detailed survey programme along with the water studies of th present agricultural areas and farms to provide som basis for proper land use, farm planning and site selection criteria for different crops.

3. Close monitoring of soil and groundwater salinity in areas irrigated by tubewells. This could be done by choosing some bench marks (about 4-6) in each of

the major agricultural areas representing as much as possible the different soil types.

In areas close to the sea, monotoring of ground-water extraction and its effect on increase in water salinity and danger of sea water intrusion if extraction exceeds safe yield must be studied.

4. It is important to establish in each of the major agricultural areas a small soil laboratory with limited staff and equipment (mainly pH. meter, electrical conductivity bridge and some chemicals and glassware). These laboratories will assist the main research centres in monotoring both soil and water salinity. A salinity map delineating as closely as possible the extent of areas affected by salinity and the degree of salinity, can be easily prepared before the cropping season. This map will guide both the responsible in state farms or cooperatives in planning the method of soil amelioration (leaching or leaching + amendments), and selecting the proper crops suitable to the soil and water salinity conditions.

5. Planting of salt tolerant crops. Seed collection can be obtained from specialized organizations such as SEMIT or ICARDA for some major crops (wheat and sorghum) for selection of varieties with high salt tolerancy and relatively high yield. Those seeds will be propagated in salt affected areas and areas using saline to highly saline irrigation water

5.2 Soil Fertility and Fertilization

1. A general policy for improving soil fertility through better fertilization programme, salinity control, soil conservation from water and wind erosion must be implemented. This policy should be based on land use maps prepared for the various farms (state and co-operatives).

2. Increasing the fertilizer use is one of the major inputs required in achieving the planned vertical agricultural development. The present nitrogen fertilizer used is actually way below the recommended rates for most of the crops. Moreover the lack or low phosphorus used may limit the benefit from the applied nitrogen.

3. A substantial increase can be achieved through soil improvement increase of land productivity by increasing the organic matter content of the soil. This can be achieved either by adding animal manure (its quantity is quite limited and its availability still restricted) farm and city compost, or by increasing the acreage of legume crops, as it present acreage in the cropping system is very limited.

4. It is important to conduct a survey of the micronutrient status of the major soil types in different regions to be used as a base in preparing a micronutrient fertilization programme to correct the dificiency of such nutrients especially in calcareous soils. Priority must be given to perennial crops and fruit trees as citrus trees showed severe deficiency symptoms of iron, zinc and sometimes manganese, in most of the areas visited (Hadramout, Abyan area and Mudia).

5. It is important to ensure the timely supply of inputs, particularly making fertilizer available in the rural areas for farmers to buy. At present a major constraint of expanding agricultural production is the capacity of the institutions to supply inputs due to tight financial situation.

5.3 Irrigation

1. It is important to improve irrigation efficiency either under spate irrigation or tubewell and endeavor to increase it from the present less than 50% to 60% or more.

2. Seriously study the possibility of expanding the combined dual spate and tubewell irrigation systems whenever possible in the largest possible areas to overcome the disadvantage of each of the two systems when used by itself.

3. Improvement of actual agricultural practice using small unlevelled basins to improved well levelled plots 100-250 m. long x 10-20m width. This will result in improved irrigation efficiency and use of farm machinery.

4. Rehabilitation of irrigation schemes whenever possible or construction of new one. On coarse and medium texture soils all main and secondary canals should be cement lined.

5. Topographic survey maps should be prepared prior to rehabilitation of irrigation schemes or reclamation of both spate and tubewell irrigated project, to properly estimate the amount and cost of levelling and to properly locate and alignment of irrigation canals.

5.4 Cropping System

1. Optimize the land and water use for production of suitable crops within the natural limitations and the present technology. This will ensure that only suitable crops being grown on land where their productivity will be the highest. For example planting of citrus trees on medium to heavy texture calcareous must be discouraged.

2. Different crop rotations need to be studied for different areas in the mainwadis taking into consideration, the prevailing climate, soils,and water condition also the economy of production of each rotation. At present no notations are being followed.

3. Coordinating cropping pattern to different agricultural areas to the national cropping pattern with the purpose of increasing export of some crops that can be produced in some seasons. Specialized areas for production of such crops and training of farmers on methods and practices of their production is important.

4. State farms with suitable irrigation water should be exploited for high cash crops, mainly for vegetables and fruit production. Crop intensity on those farms should reach 150-200%. Farms with lower quality irrigation water could be used for production of fodder and field crops which are salt tolerant.

5. Areas cultivated by state farms (about 7000 ha.) can be appreciably increased by about 20-30%, if the present on farm irrigation efficiency of less than 50% is increased to 55 or 60%, and cropping intensity is increased from the present 40-80% to 100-150%.

6. Study of cost of different items for agricultural production of major crops grown on state and cooperative farms. Results can be used as a guide for recommendations for improving farm management and reducing production cost.

7. It is important that immediate measures be taken for weed control. Weed propagation on certain farms is becoming quite serious affecting both soil fertility and crop production.

8. At the present time, it is strongly recommended NOT to grow citrus trees on medium to heavy texture calcareous soils. The proper management and fertilization needed is at the moment difficult under PDRY conditions.

5.5 Follow-up and Training

1. Establish a follow-up and evaluation department at the Ministry of Agriculture and Agrarian Reform. It is clear from the different reports reviewed that similar recommendations were given in some of them as such recommendations are the only and practical solutions to some problems. However, such recommendations have not been implemented uptil now. Hence, it is important to establish the follow-up and evaluation dept., to follow implementations of important recommendations and also the execution of the Five-Year Plan. Monthly report should be submitted on the progress of the work achieved, rate of work, persent of work completed, problems encountered and possibly suggest means and ways of overcoming those problems.

2. In-service training programme for state farm supervisors and staff extension officers and soil staff on reclamation and management of salt-affected soils, must be established. Areas of salt-affected soils are rapidly increasing in farms irrigated by tubewells.

   Two fellowships should also be provided for training abroad of two of the soil staff: one from El Kod and the other from Seiyum research centres, to study the chemistry and management of saline soils.