GOVERNMENT OF ABU DHABI
PRESIDENTIAL COURT

MARIB DAM
AND IRRIGATION PROJECT

YEMEN ARAB REPUBLIC

ANNEX III
AGRICULTURE

ELECTROWATT
ENGINEERING SERVICES LTD.
ZURICH, SWITZERLAND.

in association with

HUNTING
TECHNICAL SERVICES LTD,
HERTS., ENGLAND.

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ANNEX III

AGRICULTURE

MARIB DAM AND IRRIGATION PROJECT

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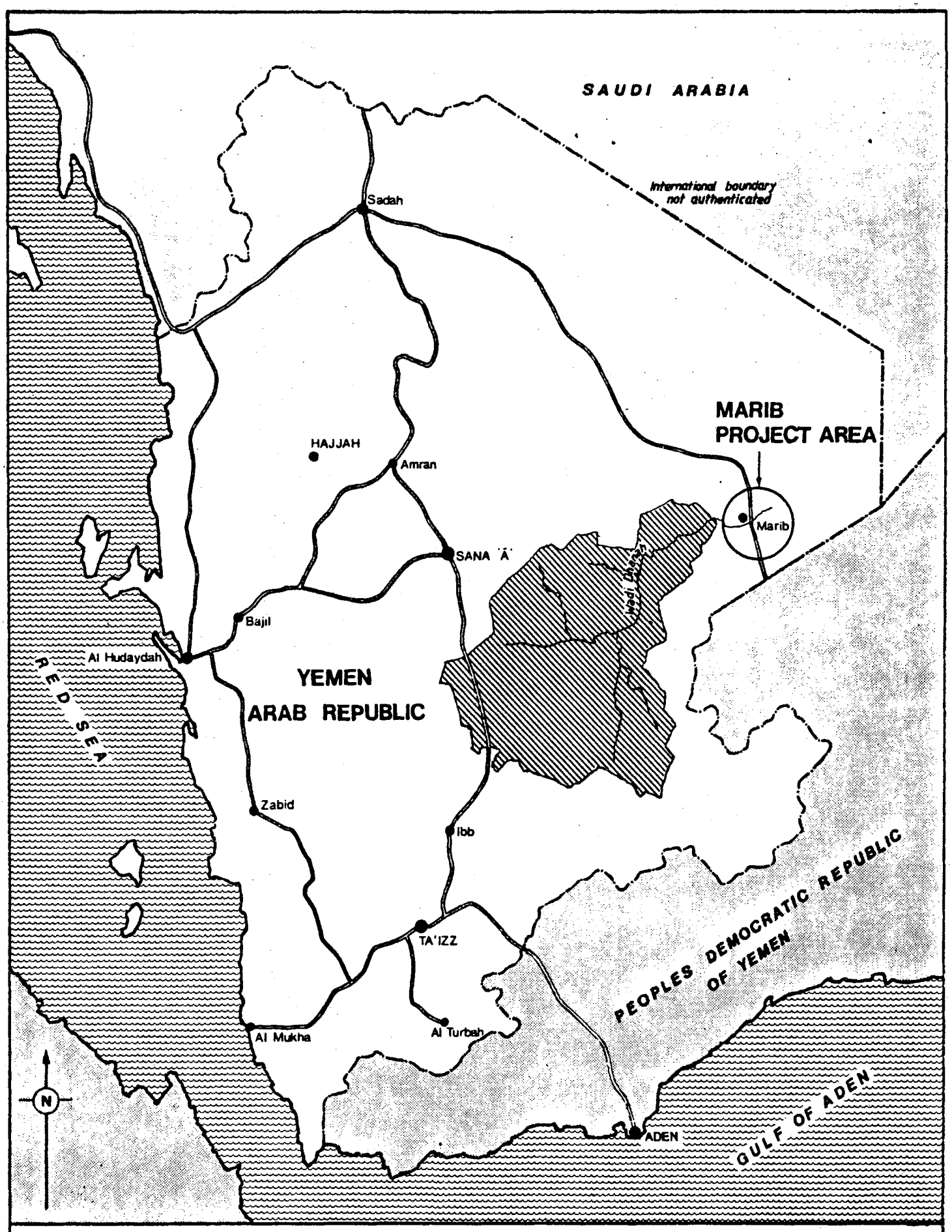

KEY

International boundary

Road

Wadi

Wadi Dhanah catchment area

PROJECT LOCATION

ELECTROWATT ENGINEERING SERVICES LTD.		
DATE	JOB CODE	FIGURE
MAY 1978	4158	

CHAPTER 1

INTRODUCTION

1.1 Objectives

The purpose of this Annex is to present a full report on the findings and recommendations concerning the agricultural content of the Study. Included is an appreciation of the current situation, identification of potential following the provision of perennial irrigation supplies, recommendations covering all aspects of agriculture in the project context and the essential quantification of the inputs, yields and returns.

1.2 The Study Area

A total area of 50 000 ha was covered by the study, from which 22 500 ha were chosen for a reconnaissance soil survey. This indicated that the gross irrigable area is 10 738 ha, refer Annex 1. It is the existing agriculture and the potential of the irrigable area with which this report is concerned. The location of the area is shown in Figure 1.

1.3 Background[1]

Agricultural activity still dominates other economic sectors. It contributes about 50% of the gross domestic product, yet it is still largely of an underdeveloped nature, with low levels of technology and productivity, and with about 73.3% of the workers in the country engaged in this sector. Agricultural products constitute about 80-90% of the gross exports of the country, but the value of imported agricultural products is about sixteen times that of exports. During the Three-Year Programme, this sector obtained investments estimated to be about YR 371 million or less than 13% of the total fixed capital formation.

Cultivated land is estimated to be about 1.5 million hectares or 8% of the area of the country. It is also estimated that

85% of the cultivated land is irrigated by rain water, and about 90% of this land is planted with cereals. Animal products contribute about 27% to total agricultural production. The most salient obstacles and bottlemecks in the Yemeni agriculture are summarized as follows:

- Need for equipment and support by material potentialities.
- Shortage of water and the need for a comprehensive survey for water sources.
- Failure of the road network to link the various parts of the country, although on-going efforts are working to solve this problem.
- Insufficient data and statistics.
- Absence of price and marketing policy.
- Insufficient agricultural credit system to fully meet the needs of the agricultural sector.
- Absentee ownership of agricultural land, since areas that are exploited directly by their owners are estimated to be only about 20% of the total cultivated area. Accordingly, there is a need to organize the relations between land owners and tenant farmers.
- Poor and insufficient use of fertilizers and insecticides. This is in spite of the fact that during the Three Year Programme fertilizer use increased three and a half times and insecticide use increased ten times over previous practice.
- Limited animal production due to the lack of pastures and fodders and because of animal diseases.
- Weak exploitation of fish resources (11 525 tons instead of a potential estimated to be 28 500 tons).
- Increased cultivation of "Qat" due to its relatively high returns per acre and due to increased consumption.

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(1) Extracted directly from "Summary of the First Five Year Plan of the Yemen Arab Republic", Prime Ministers' Office, Central Planning Organisation, November 1977.

- Shortage of agricultural engineers, veterinarians, and extension agents, in addition to the Emigration of farmers to cities and abroad.

1.4 National agricultural strategy(1)

The basic objectives of the agricultural sector are the following:

- Moving towards self-sufficiency in the field of agricultural food products.
- Providing the necessary agricultural raw materials needed by the planned and operating industrial projects.
- Reducing the foreign trade deficit in agricutltural products.
- Improving the quality of agricultural products.
- Increasing the cultivation of food crops.
- Supporting small producters.

These objectives are to be achieved by employment of the following general strategy:

- Completing the establishment of agricultural institutions for guidance and project implementation.
- Completing studies and extending the application of the principle of integrated rural development.
- Carrying out a comprehensive survey for soil and water resources.
- Linking the Plan for agricultural research to the needs of agricultural development.
- Developing agricultural extension services.
- Providing justice and stability in the relations between the landowners and workers in agriculture.
- Realizing rapid development in animal production and fishing capability.

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(1) Extracts from the First Five-Year Plan.

- Building road and increasing transport capacity.
- Providing storage capacity for agricultural products.
- Establishing a plan for agricultural credit to promote plant and animal production.
- Carrying out studies about prices, marketing and taxes in the agricultural sector to determine policies that will further the objectives of the Plan.
- Developing agricultural statistics.
- Coordinating agricultural planning with neighbouring countries.

There are also secondary objectives and strategies.

The Proposed Ma'rib project will contribute to most of the basic national objectives, and is formulated to achieve this by means compatible with the general strategies.

CHAPTER 2

PHYSICAL RESOURCES

2.1 CLIMATE

2.1.1 Transposition of climatic data from neighbouring areas

The project area is at a latitude of 15° 30' and longitude of 45° 40' and centred around the Wadi Abīda as it emerges from its mountainous catchment to flow north east into the Empty Quarter. The altitude of Ma'rib town is some 1 200 m although the chain of mountains, which shadow the area and stretch back to the montane plain of Sana'a, rise to heights of over 3 000 m. Climatic data for the majority of the interior of the Arabian peninsula is very sparse and there are no data from the neighbourhood of the project area, the climate of which is clearly atypical of the majority of Arabia. Correlation with similar areas has therefore been necessary in order to obtain data in an attempt to estimate the climatic conditions that prevail in the Wadi Abīda region.

Meteorological data has been taken from principally two areas (see Annex VII), Wadi Najran which lies approximately 270 km north west of the project area in Saudi Arabia and Wadi Bayhan approximately 70 km south east of the project area in the People's Democretic Republic of Yemen. Both of these wadis emerge from the eastern side of the mountain chain and flow through a fertile agriculture area before disappearing into the Empty Quarter. The type of crops grown and the growing periods are very similar to those of Wadi Abīda.

The Wadi Najran meteorological station, established in 1967, was located at a latitude of 17° 33', longitude of 44° 14' and altitude of 1 200 m. Detailed records are available from 1968 to 1974 and are summarized in Table 2.1. The data from Wadi Bayhan are from two areas, Bayhan al Qasab situated at a latitude of 14° 53', longitude of 45° 42' and altigude of 1 100 m and Muqub latitude 15° 00', longitude 45° 45' alnd altitude 1 050 m. Bayhan al

TABLE 2.1

Najran climate data

Period 1967 - 1974

Month	Temperature °C					Rainfall (mm)	Relative Humidity Mean	Wind Km/day
	Absolute Maximum	Absolute Minimum	Mean Maximum	Mean Minimum	Mean Average			
January	33.5	0.0	24.4	7.8	16.1	1.5	42	185
February	37.4	0.5	26.4	9.2	17.9	5.7	34	196
March	38.4	4.7	29.5	13.9	21.6	11.8	31	202
April	38.0	5.1	31.9	17.1	24.4	33.2	35	210
May	39.3	14.5	35.2	19.5	27.4	4.2	26	217
June	41.5	15.8	38.0	19.7	29.0	0.2	22	213
July	40.4	17.8	38.0	23.3	30.7	8.2	25	249
August	40.0	16.1	37.8	21.7	30.0	2.4	24	246
September	39.0	12.0	34.8	17.2	26.2	1.6	24	226
October	35.0	4.8	30.1	14.9	21.2	0.5	29	179
November	33.0	2.5	26.8	9.2	18.1	2.3	39	163
December	31.8	- 0.9	24.8	6.7	15.9	0.1	47	168
Average			31.5	15.0	23.2	Total 71.7	29	204

Source: Wadi Najran Project, Feasibility Study Appendix A
Binnie & Partners, Hunting Technical Services,
Mander Raikes & Marshall.

TABLE 2.2

Bayhan climatic data

Year	Temperature °C					Rainfall (mm)
	Absolute Maximum	Absolute Minimum	Mean Maximum	Mean Minimum	Average Mean	
1956	-	-	-	-	-	121
1957	-	-	-	-	-	266
Average						193.5
Period 1958 - 60						Rainfall[1] (mm)
Month						3 - 4 Yr Period
January	33.3	2.8	26.6	8.3	17.5	5.1
February	35.0	1.7	29.8	11.0	20.4	7.6
March	37.2	6.1	32.9	14.8	23.8	10.2
April	36.1	11.1	34.0	16.9	25.4	43.2
May	37.8	11.1	35.8	18.2	27.0	2.5
June	39.4	15.0	37.5	19.1	28.3	2.5
July	41.1	17.2	37.3	19.3	28.3	5.1
August	40.6	15.6	38.6	21.2	29.9	53.5
September	38.3	13.3	35.6	18.1	26.8	2.5
October	35.0	6.7	32.4	12.9	22.6	0.0
November	33.3	4.4	29.4	9.6	19.5	0.0
December	31.1	4.4	25.4	7.3	16.3	0.0
Average			32.9	14.7	23.8	132 Total

Source:- Department of Agriculture and Irrigation - Aden Protectorate.

Note (1) Rainfall figures obtained from Greenwood and Bleackley's Report on 'Geology of the Arabian Peninsula' - Aden Protectorate.

TABLE 2.3

Nugub climatic data

Period 1965 - 66

Month	Temperature °C					Rainfall (mm)	Relative Humidity Mean (0900 hrs)
	Absolute Maximum	Absolute Minimum	Mean Maximum	Mean Minimum	Average Mean		
January	32.8	5.0	27.5	10.6	19.0	-	45
February	34.4	7.8	29.1	13.0	21.1	5.0	49
March	36.7	6.7	31.4	14.4	23.0	-	37
April	36.1	14.4	33.3	18.3	26.2	30.5	37
May	38.9	15.6	35.0	21.4	28.2	-	32
June	41.1	18.3	38.0	22.2	30.1	-	24
July	41.1	20.0	38.6	22.8	30.7	0.2	28
August	40.6	20.0	38.0	23.6	30.8	5.8	31
September	39.4	14.4	36.1	20.6	28.3	-	33
October	35.6	8.9	32.5	15.6	24.0	-	43
November	32.8	7.8	27.8	13.6	20.8	-	46
December	29.4	5.0	24.7	10.6	17.6	-	36
Average			32.7	17.2	25.0	Total 41.5	37

Source: Department of Agriculture and Irrigation - Aden Protectorate.

Qasab is higher up the wadi and closer to the mountains and their climatic influences than Nuqub, which is closer to the Empty Quarter. The data available from these areas range from 1956 to 1966 and are shown in Tables 2.2 and 2.3.

The close correlation in the meteorological data taken from the three sites is shown in Table 2.4. As Wadi Abīda is in a similar situation to these sites which are on either side of the project area, it is reasonable to assume and has been assumed for the purpose of this report that the climatic conditions in Wadi Abīda are similar.

2.1.2 Rainfall

The Wadi Abīda area has a low and irrigular rainfall of probably 50 - 100 mm, mainly concentrated around March - May and July - August, with the greater proportion of the annual rainfall falling in the first period. There is virtually no rain in the September - February period. Due to the climatic influences of el Jabal Balaq hills, the areas in the upper part of the wadi receive a higher annual rainfall than areas further down the wadi. Rainfall experienced during the study period typically fell in short storms of moderate intensity covering small areas rather than as prolonged falls of low intensity over large areas. From the rainfall data of Wadi Najran the highest monthly rainfall of 85 mm occurred one April although teh April average is 33 mm and the yearly average is 72 mm for the eight year period. This demonstrates the considerable fluctuations in rainfall pattern that can occur and Wadi Abīda is considered to be no exception.

The catchment area of Wadi Abīda experiences its main rainfall in the same March - May and July - August periods and it is estimated that the average rainfall is in excess of 300 mm per year. Again there are large fluctuations in yearly rainfall which result in large or small amounts of water flowing through Wadi Abīda thus constituting a good or bad year for seil irrigation. An attempt was made to estimate the peak rainfall period in the catchment area

TABLE 2.4

Summary of Climatic data

	Temperature °C					Rain-fall mm	Mean Relative Humidity %	Mean Vapour Pressure	Mean Sun Hours	Mean Radiation Cal/ m^2/day	Mean Wind Km/day
	Absolute Maximum	Absolute Minimum	Mean Maximum	Mean Minimum	Mean Average						
Najran 1967-74	41.5	- 0.9	31.5	15.0	23.2	71.7	30	8.6	9.2	605	210
Bayhan 1956-60	41.1	1.7	32.9	14.7	23.8	162.7	-	-	-	-	-
Nuqub 1965-66	41.1	5.0	32.7	17.2	25.0	41.5	37				

by asking the local inhabitants about peak flows in the wadi but no conclusion could be drawn from their answers.

It is interesting to note that records kept by Yemenite chroniclers[1] indicate that in Sana'a the following years were exceptionally rainy: 1863, 1840, 1846, 1878, 1893, 1913 whereas 1808, 1835, 1894, 1899, 1903, 1914 were exceptionally dry years.

2.1.3 Temperatures

These are typical of semi-desert conditions, with moderate to high midday and afternoon temperatures followed by cool nights. Night temperatures drop to around freezing point but rarely below during December to February whereas maximum day temperatures in these months may rise up to 37°C. Day temperatures reach a maximum of around 41°C in June, July and August although the night temperatures drop to around 17°C. The cool part of the year is October to March with temperatures averaging 20°C whereas April to September is the hot period with temperatures around 28°C.

Skies are generally clear and visibility is good particularly when temperatures are low but during summer months when temperatures are high and the wind is strong there is a dust haze over the area reducing visibility.

2.1.4 Relative Humidity

Humidities are low, averaging around 33% for the year. being highest in the winter and lowest in the summer. There is generally a temporary rise in humidity following rain or during the rainly months.

2.1.5 Wind

Whilst the NE and NW monsoons undoubtedly play a major role in the climate generally, wind directions are variable and no one

(1) Tables and charts summarizing meteorological observations in Yemen FAO/56/8/5826

general direction of low level prevailing winds is readily discernible. During the study period on many days, winds blew from several quarters, north west, north east, south east, veering rapidly at times. Sudden gusts of wings of maybe 40 - 50 km/hour raise quantities of dust and sand into sand devils and can be locally very strong. The general tendency is for winds to rise in the afternoon and die away in the evening. These winds increase from April onwards reaching a peak in July and then decrease until October. The local people reported that these winds could continue all day and sand-storms of four to eight hours were fairly frequent. In view of the wind data from Najran where the peak wind run is 250 km/day in July, which represents a constant wind of over 10 km/hour, the local statements would appear to be accurate. The average wind run for Wadi Najran is 204 km/day and a similar figure can be applied to Wadi Abīda in the absence of more specific data.

2.1.6 Evapotranspiration

From the assumed data it is quite clear that the high temperatures, low humidities and strong winds during the summer months all contribute to a high evapotranspiration rate. Evapotranspiration rates for Wadi Abīda have been calculated using the mean 10 day Penman open water evaporation (Eo) estimates from Wadi Najran taken over a seven year period 1968 - 1974. The 10 day means and monthly totals are shown in Table 2.5.

2.2 SOILS

The soils of the Ma'rib plains described in detail in the Annex I, fall into four broad categories:

(1) Recent alluvial soils still subject to accretion of material during the seasonal floods.
(2) Older alluvial soils above present day flood level.
(3) Aeolian deposits.
(4) Old irrigation deposits.

The older alluvial soils and aeolian deposits have little agricultural potential mainly because of very coarse texture and

TABLE 2.5

Penman open water evaporation estimates
Wadi Najran 1968 - 1974

Month	10 day estimate mm/day	Daily estimate mm/day	Monthly total mm	Month	10 day estimate mm/day	Daily estimate mm/day	Monthly total mm
January	4.3			July	9.5		
	4.9	4.8	148		9.3	9.5	296
	5.1				9.8		
February	5.6			August	9.4		
	5.8	5.9	166		9.0	9.1	281
	6.4				8.8		
March	7.0			September	9.0		
	6.6	7.0	217		8.7	8.6	258
	7.4				8.1		
April	7.7			October	7.3		
	8.0	8.0	240		6.8	6.8	211
	8.3				6.3		
May	8.8			November	6.0		
	9.0	9.0	278		5.6	5.5	166
	9.1				5.0		
June	9.6			December	4.7		
	9.7	9.7	290		4.5	4.5	141
	9.7				4.4		

Source: Wadi Najran Project, Feasibility Study Appendix A
Binnie & Partners, Hunting Technical Services, Mander Raikes & Marshall

Annual 2692 mm

adverse topography. None of these soils is cultivated at present.

It is on the recent alluvial soils that most of the present day cultivation occurs. They are characterised by high contents of silt and very fine sand, and low contents of coarser sand and clay. They are deep and reasonably fertile with good water holding capacity (25 at per cent by volume), but the coarser members have rather low nutrient retention capacity and may give low irrigation efficiences. They are non-saline and non-alkali. Levelling requirements tend to be high because of the presence of sand dunes and coppice mounds, especially where present cultivation is intermittant.

The old irrigation deposits like the recent alluvials have high silt and very fine sand contents, with silt predominating. They are deep soils of reasonable fertility, with good water holding and nutrient retention capacity. Most of the soils are weakly to moderately saline with average ECe of between 10 and 18 mmhos/cm, but with good permeability. They are very calcareous with high pH and induced deficiencies of metallic micro-nutrients like iron and copper may occur in some crops. Chlorosis of young citrus has been noted on these soils.

In the main, the potential of both the recent alluvial and old irrigation deposit soils is quite high. Under irrigation development, the main hazards are likely to be a tendency to form surface caps because of the high silt content and the high erodibility of the soils both to wind and water.

2.2.2 Land Classification

In Annex I are identified three classes of irrigable land which have sufficient potential to justify development. These are:

(1) Class 1

These areas are highly suitable for irrigation farming, being capable of sustaining relatively high yields of a wide range

of climatically adapted crops. They have no, or only minor soil restrictions: low development costs are anticipated.

(ii) Class 2

These areas are of moderate suitability for irrigation farming, and are likely to have significantly lower repayment capacity than class 1 lands. They have specific soil or topographic limitations which restrict the range of crops, or increase the costs of production and/or development.

(iii) Class 3

These areas are only marginally suitable for irrigation farming due to severe restrictions in soil and/or topography, leading to restricted crop adaptability, or to high costs of production and/or development.

The remainder of the study area is Class 6 land, which is considered non-irrigable due to severe topographic or soil deficiencies.

The breakdown of the gross irrigable land is as follows:

Class 1	1 358 ha
Class 2	4 956 ha
Class 3	4 424 ha
Total	10 738 ha

2.2.3 Utilization

Within the plains area studied, 10 738 ha of land is considered to be suitable for irrigation development, of which 3 301 ha are already cultivated leaving a balance of 7 437 ha of new lands suitable for further irrigation development.

2.3 WATER RESOURCES

Average annual rainfall in the Study Area is only 50 to 100 mm

which is not an exploitable resource. The prime source of water is the flow in the Wadi Dhanah, and it is estimated (refer to Annex VII) that the average annual flow is 200 Mm^3 at the point where the wadi emerges from the gorge into the Study Area to become the Wadi Abīda. The Wadi Abīda is not perennial, and the greater part of the annual runoff occurs in flash floods, locally called "seils". The seils are extremely variable and unreliable and last only days or even hours. There are two seil seasons, March/April and July/August.

The seils provide water for agricultural use in two ways. Firstly there is direct diversion of the seils for flood irrigation, and secondly some of the excess water recharges the aquifer which underlies the area, and from which water is abstracted for irrigation. Quantification of the use of the water resources in these ways is presented in Annex IIX, and styles of farming which depend on these resources are described in the next Chapter.

CHAPTER 3

HUMAN RESOURCES

3.1 Population

Annex IX presents the findings on demography from which the following information is obtained. The estimated population of the Study Area is 13 518 persons of which it is estimated that about 10 000 (1) are engaged in settled agriculture.

3.2 Labour availability

In Table 3.1 is presented an estimate of the labour resources in the Study Area which are estimated to total 7 165 man-equivalents (refer to Annex IX). This amounts to 2.64 man-equivalents per household, and in the agricultural sector to 1.61 man-equivalents per ha now cultivated (2).

A feature important to the formulation of development proposals is the absence of many able-bodied males in the 16 to 60 years age group who have left the area to seek work in towns or abroad.

Table 3.1 Age distribution and labour availability

Age Group	0-5	6-15	16-60	60+	Total
CURRENT POPULATION (1)					
Male	1 573	1 436	3 693	137	6 839
Female	1 336	1 202	3 941	200	6 679
Total	2 909	2 638	7 634	337	13 518
MEN EQUIVALENTS (2)					
Male : rate	0	0.33	1.00	0	4 167
men equivalents	0	473	3 693	0	
Female : rate	0	0.33	1.00	0	2 998
men equivalents	0	397	2 601	0	
CURRENT (and 1977) LABOUR FORCE, in man equivalents	0	871	6 294	0	7 165

(1) Eliminating 1 000 nomads, 1 000 refugees and 10% of the remainder who might be engaged in other economic activities, refer Annex IX.

(2) Adopting a figure of 10 000 persons engaged in agriculture, section 3.1, yielding 5 300 man-equivalents who now cultivate 3 301 ha (section 2.2.3) yielding 1.61 man-equivalents per ha.

Source: (1) Amended and updated Census figures, refer Table 1.3

(2) Man equivalents appropriate to the region.

3.3 Social constraints

A summary of the social structures relevent to formulation of the Project is presented in Annex IX. To the agricultural section three elements are of importance: the mobility of labour and the laws governing land tenure and water rights. The mobility of labour appears to be adversely affected by the current disputes over land boundaries and by the parochial attitude to land and water which are discussed in the subsequent two sections. The effect has been to close the many tribal, sheikhdom and even family land boundaries to outsiders, so that the hiring of temporary agricultural labourers is difficult and expensive.

3.4 Land tenure

There is little Government and no religious (Waqf) owned land in the Study Area, and land tenure is typical of the Mishraq region. The ownership of land is ultimately vested in the tribes represented in the area, which for the study are are:

- The Ashraf who occupy an area from the ancient damsite to al Khusayf on the north bank to al Mahtam and Bir Sa'ūd on the South Bank, and who are represented by three tribal sub-divisions.
- The Abīdah who occupy the land downstream of these points and who are represented by five tribal sub-divisions.

The individual Sheiks in conjunction with senior members of the tribe control the land and may allocate it to their followers.

Land for cultivation is available in this way to members of each tribe within their Sheikhdom. In theory it is the use of the land

that is allocated in this way. But in practice, land is in the full ownership of the families concerned. Land so allocated may be inherited and has on occasion been bought and sold, leased or mortgaged. Some of the land held by the Abīdah tribe, for example, has been purchased from the Ashraf, and land has been sold to both individuals and groups.

At the present moment land sales have ceased. The underlying reason is that with the development of groundwater, land has a new potential value, with which the transfer or sale of usufructory rights alone, with ownership reserved, is incompatible. As a result there are numerous outstanding disputes both between and within Sheikhdoms, and the position of families acquiring land across a tribal or sheikhdom boundary is unresolved.

The parochial attitude of the area's population and legacies of past family and group disputes mean that many people are unable to move freely throughout the project area. However, the wadi beds are considered neutral areas along which movement is generally permitted. Other neutral areas include Government land in Ma'rib, the airstrip and Governor's residence, and the town of Husun al Jalah.

3.5 Share-cropping

There are a number of larger landowners in the Wadi Abīda including the three main owners Al Ashraf, Bin Myeli and Bin Jalal. It is estimated that landowners provide 25 - 30 per cent of farmers with land to rent. Rent is based on share-cropping and is almost universally paid in the principal cash crops, wheat and sesame. The tenant pays 25 per cent of his crops to the owner if the farmer provides all the required inputs. These include the provision of labour, the well and pump and its operating cost on well irrigated land, or the costs of bunds on seil alnd. If the owner provides all inputs with the exception of labour the farmer is required to provide the landlord with 75 per cent of his crops.

3.6 Water rights

Water rights in the Wadi Abīda are those laid down under Koranic Law. Under these laws the seil water is first available to persons cultivating land nearest to its source, which in the project area are those closest to the gap in the Jabal Balaq from which the wadi issues, then in succession to those further and further downstream. Once the water needs of the users upstream have been satisfied they are obliged to release water downstream.

The right to extract groundwater accompanies allocation of the land under which it lies. It is customary to allow any person requiring water for domestic or livestock consumption to obtain it without charge from any well. However, water for crop irrigation can be sold, the charge being made for the abstraction of the water rather than for the water itself. A share of the crop is the usual charge.

CHAPTER 4

FARMING SYSTEMS AND CROPPING PATTERNS

4.1 General

During the height of the ancient Sabean civilisation large areas on the left and right banks of the upper part of Wadi Abīda were developed for irrigated agriculture. The lands were flood irrigated through a system of canals originating from the dam which was built to a sufficient height to command the fertile banks. When the dam collapsed in about 575 A.D., there was an exodus of people, but those remaining in the area have used the annual seil run-off to maintain irrigated agriculture by developing a system of bunds to divert and distribute the seil water to the irrigable lands. There also are some old Himyartic wells in the area. These were hand or animal operated to provide water for domestic purposes and for irrigating small plots. The most recent stimulus to irrigated agriculture in Wadi Abīda came with the advent of diesel motors and turbine pumps and the recognition that, with motor powered pumps, crops could be produced throughout the year. In the last ten years the number of hand dug wells has increased from about 20 to about 385. There are, at present, 20 - 35 wells dug each year.

The number of producing wells in the area has been estimated by measuring the total cultivated area from aerial photography and then estimating in the field, farm sizes and percentage of well irrigated land on each type of farm. This method is open to errors but has been cross checked as far as possible. Farm sizes are measurable from the aerial photography and the average farm size is some four to five hectares. The actual area irrigated on a farm may be estimated by irrigation frequency, pumping time and capacity. The resulting estimate of 385 wells is corroborated by records held by the Governor indicating some 327 wells in 1976. This figure probably is conservative because there is no reason why people should declare wells. Further support for the estimate

is provided by the principal pump mechanic in Wadi Abīda who estimates some 406 wells.

Three broad farming systems have been identified:

(a) Seil irrigation only
(b) Groundwater irrigation only
(c) Groundwater and seil irrigation.

The distribution of these three broad systems was determined by aerial photograph interpretation and field checks. Sub-systems are delineated to indicate the relative proportions of the different irrigation systems. The results are presented in Figure 4.1 and Table 4.1.

Areas of land irrigated only by seil lie on the periphery of the main alluvial aquifer. The aquifer underlying these areas is rather unproductive, and well development is difficult and costly. The highly permeable and high yielding alluvial aquifer is patchy and discontinuous in this area; much of the area is underlain either by low yielding sandstone or non-productive basement rock.

Areas irrigated only by groundwater are underlain by the highly productive alluvial aquifer, and occur for the greater part on land which lies above the command of the seil on the old irrigation deposits of the right bank. The other main area of groundwater irrigation is around Husūn al Jalāl al Jadīdah where groundwater irrigation has fully replaced seil irrigation.

The major part of the area under cultivation at present is served by both seil and groundwater. On some farms the two systems are used conjunctively while other farms are served separately by the two system. Because of the limited access to much of this area, it is not possible to derive reliable estimates of the areas of conjunctive and non-conjunctive use within the groundwater and seil system. For the purpose of estimating cropping patterns and intensities and deriving farm budgets, non-conjunctive use has been taken as applicable to the whole system.

Distribution of farming systems

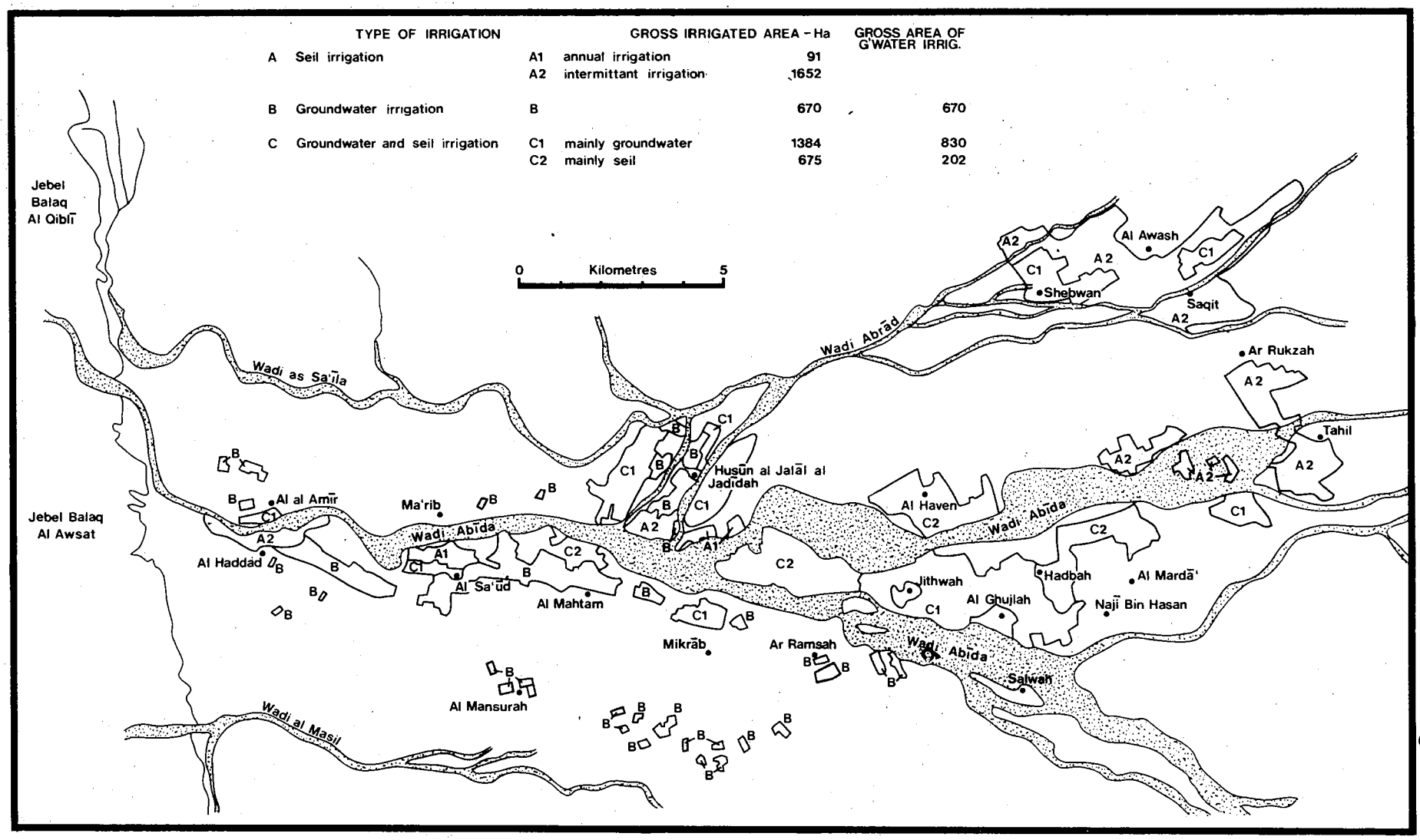

Figure 4·1

Table 4.1

Farming Systems

	Type	Gross irrigated area (ha)	Average (1) farm size (ha)	Net cultivated area ha. Seil	Groundwater
A)					
A1	annual seil irrigation	91	5	77	-
A2	intermittent seil irrigation	1652	5	991	-
B)	Groundwater irrigation only	670	4	-	636
C1	60% groundwater 40% intermittent seil	1384	5	332	789
C2	30% groundwater 70% intermittent seil	675	5	284	192
	Total	4472		1684	1617

Note: (1) Farm size includes seasonal fallow

Source: EWE and HTS estimates

Detailed descriptions of the farming systems are given in Table 4.1 with details of gross areas, net cultivated area and farm size.

4.2 Seil irrigation only

The seil is run-off from the mountainous catchment. The seil accumulates and flows down the Wadi Dhanah which channels it through a gorge in the Jabal Balaq hills where the original Ma'rib dam was sited. After emerging from the gorge the seil flows down the Wadi Abīda, past the old town of Ma'rib to Hasūn al Jalāl, where it splits into three main wadis and several minor ones which eventually terminate outside the project area in the desert.

The seil allows the irrigation of land from April to about November - December. The crops are grown on retained soil moisture and the cultivated area depends upon the volume, and duration of the seil. At present a gross area of 1 743 ha are irrigated solely by flood waters during the periods March - May and August - September. The seil is variable both in volume and time of occurrence with the result that the actual cropped area varies appreciably from year to year; only small areas receive seil water every year.

The principal areas where land is only irrigated through annual or intermittent seils is the north and eastern sections of Wadi Abīda - As Shebwān, As Saqit, Ar Rukzah, Al Tahil and Al Marda. There are smaller areas near Husūn al Jalāl and opposite Ma'rib and Al Manine. The soils contain a higher proportion of fine sand than the old silts but have similar water holding capacity. The silt deposited by the annual seils plays some part in the maintenance of soil fertility and crop production. Without the annual silt deposits, which in areas close to the bunds may amount to 3 to 4 mm, crops could not be continuously grown without some system of rotation or long fallow. Average farm size is five hectares but the cropped area depends upon the amount of water delivered by the seil.

The system of seil irrigation is fully described in Annex IV. Briefly, the system is this: bunds across the wadi bed divert the seils into channels which lead to enpoldered fields where the water is held until it infiltrates. The success of the bunds depends greatly on the skill and knowledge of the farmers. Since the introduction of tractors and caterpillars for building bunds, bunding has become a continuous process during the seil season and bunds are repaired or reconditioned during a break in the seil. This has resulted in less water being available to farm lands downstream as larger bunds are built upstream and repairs are quickly carried out.

In addition to the area of 1 743 ha of land irrigated solely by seil, there are a further 2 059 ha of land in the groundwater and seil system which depend on seil irrigation to a greater or lesser degree. As stated previously, some of this land is irrigated by conjunctive use and some by the separate systems. Table 4.1 gives the areas of land served by the different types of irrigation.

On seil irrigated land the principal crops are sorghum in the summer and, depending on the residual moisture left in the soil following the seil, wheat in winter. The seil of 1976 was very poor and little, if any, wheat was grown. 1975 was a good seil year and a small amount of wheat was grown. Ironically the 1975 seil washed away some farm land in the main wadi near Al Jithwah.

Land cultivation is carried out using a wooden camel plough; sowing, harvesting and threshing are by hand. No vegetables are grown.

In the north and northeastern part of the area served by the Wadi Abrād (Fig. 4.1) encompassing the Al Shebwān, Al Awash and As Saqit areas, the seil is particularly erratic. In these areas the farmers are financially less well off than their counterparts in the main Wadi Abīda area. As the underlying aquifer is relatively unproductive, water is the major constraint to increased productivity rather than labour as in most of the other areas. Many of the farmers are partly nomadic, and are heavily dependent on livestock.

4.3 Groundwater irrigation only

There are an estimated 385 working wells in the area, of which approximately 160 are used to irrigate a net cultivated area of some 636 ha. The wells have an average depth of about 25 m and are typically 1.5 m to 2.5 m in diameter and lined by masonry or reinforced concrete. Wells are sunk by hand to a depth of one to two metres below the prevailing water table. The pumps are normally three or four stage vertical centrifugal pumps, driven by shafts from the surface. The shafts are belt driven from a single cylinder 16 or 20 hp diesel engine. The outlet pipe discharges into a concrete cistern 1.5 m above ground level.

The water discharges from the cistern into a small basin and is led away by a small primary canal elevated 0.5 to 1.0 m above the surrounding field levels. From here it is fed into lower canals or ditches and then into field ditches which serve individual plots of 30 - 40 m^2 by breaching the ditch wall. The plots are divided by low earth bunds.

The areas irrigated solely by wells are the old silts on the left and right banks and mainly lie in Al Ashraf land. Smaller areas, generally consisting of individual farms, lie in Al Masil and around Husūn al Jalāl. The soils are reasonably fertile having been built up from silt carried in the irrigation water during the ancient Sabean civilisation. Within the seil and groundwater irrigated area, the well irrigation system has been accommodated into the older seil system, such that the large (1.5 - 2 ha) fields of the seil system with their 1 - 1.5 m high bunds have been subdivided into small irrigation plots for efficient water distribution. In some instances the larger fields are still used to impound flood water so that land preparation for winter wheat is carried out on moist rather than dry soil. A summer crop of sorghum also may be grown on part of the land using flood water.

The majority of the farmers own their wells and some who are financially more stable and more progressive have a share in other wells. Few of the wells or farms are rented or sharecropped. The

average area under cultivation on each farm is four hectares although the actual farm size may well be in excess of this figure if the adjacent long term or permanent fallow land is counted.

The principal crops are wheat in winter, and sesame with a little maize in the summer. Lucerne is grown as a perennial crop for fresh animal fodder. There is no grain sorghum under groundwater irrigation as the returns do not warrant the additional pumping costs. Vegetables are cultivated for family consumption, as the local demand is negligible. A few grape vines, citrus and fig trees are cultivated for home consumption. There are a few qat plantations, 1/10 to 1/5 ha in size; the bundles of leaves are sold within Wadi Abīda. Most of the cultivation is mechanized and threshing is done by an adaptation of traditional methods; a tractor pulls a length of well pipe over the harvested crop piled on the threshing floor. The separated grain is then winnowed by traditional methods.

4.4 Upper Wadi Abrād area

Excluded from the project formulation is an area of about 500 ha extent in the Wadi Abrād area between Husun and Shebwan. This area is underlain by medium sand deposited by the wadi and is characterised by very uneven topography, the result of aelian erosion and deposition which has formed large coppice mounds up to 3 m in height and 30 m in diameter, and low, 2 m longitudinal dunes.

Within the past two years there has been considerable development in this area. Large impounding and diversionary bunds have been built across the width of the wadi and ten successful wells have been constructed. Further well development is in progress, although several unsuccessful wells were dug where basalt was encountered at depths ranging from 9 to 18 m. The development is being done by the nomadic bedouin and, as yet, there are no permanent settlements.

Present development is restricted to the reasonably level areas within the gross area depicted in Figure 4.1. From examination

of the aerial photography and field transects it is estimated that there are a maximum of 500 ha of land which do not contain the gross relief features described above; even then, micro-relief is sufficiently uneven to require levelling for efficient irrigation. The more level areas occur as small, scattered units through the area.

Because of the combination of coarse textured soils with excessive permeability and low water holding capacity and the very unfavourable topography, this area has been evaluated on the land classification map as unsuitable for irrigation. The cropping of wheat and lucerne that could be examined indicated that the area irrigated per well is considerably less than in areas of more favourable soils and the irrigation interval shorter, about 10 days on average rather than 20. In common with the rest of the area, it was not possible to measure efficiency. Yields were estimated to be lower than in more favourable areas.

In spite of the unfavourable soils and topography it is unrealistic to ignore this area entirely. Cultivation rights have been established in the area and under traditional water rights, the cultivators have a prior right to the water passing through the area to the more favourable lands downstream. Accordingly, provision has been made for water supply to this area, although it is excluded from the project formulation.

4.5 Cropping patterns

The cropping patterns of the three different farming systems are given in Table 4.2, and groundwater and seil irrigated farms are portrayed in Figures 4.2 and 4.3 respectively. The cropping calender is shown in Figure 4.4. Under both well and seil irrigated systems there are two possible cropping seasons, each with a potential cropping intensity of 100% thus giving a maximum possible intensity of 200%. On a well irrigated farm, fallow is a formal, planned part, of the crop pattern; on seil farms, fallow often is enforced because of water scarcity and hence the inability to crop as much land as the labour supply could cope with.

TABLE 4.2

Present Crop Intensities

Farm Type	Crops	% Winter Crops	% Summer Crops	Cropping (1) Intensity %
a) Seil Irrigation only (net cultivated area 5 ha per farm)	Wheat	10	-	10
	Sorghum	-	60	60
	Total	10	60	70
b) Groundwater Irrigation only (net cultivated area 4 ha per farm)	Wheat	50	-	50
	Barley	5	-	5
	Sesame	-	30	30
	Maize	-	10	10
	Lucerne	10	10	20
	Vegetable	-	1	1
	Orchard	2	2	4
	Total	67	53	120
c) Groundwater + Seil Irrigation (net cultivated area 5 ha per farm)	Wheat	40	-	40
	Barley	4	-	4
	Sesame	-	24	24
	Maize	-	8	8
	Sorghum	-	12	12
	Lucerne	8	8	16
	Vegetable	-	1	1
	Orchard	2	2	4
	Total	54	55	109

Note 1. There are two possible cropping seasons, each with a potential cropping intensity of 100% thus giving a maximum possible intensity of 200%

Source: HTS estimates

Present cropping pattern: Groundwater irrigated farm

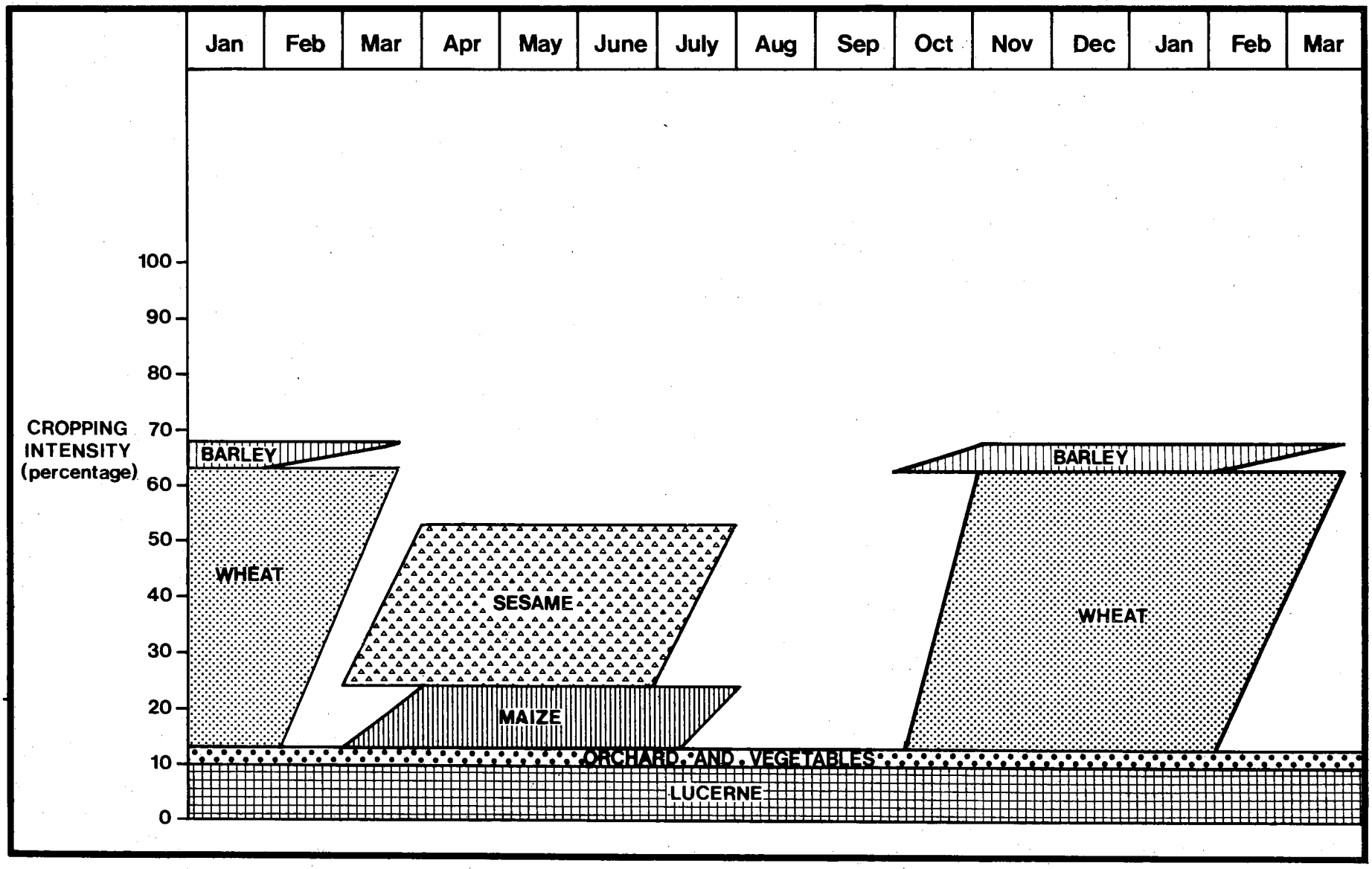

Figure 4.2

Present cropping pattern: Seil irrigated farm

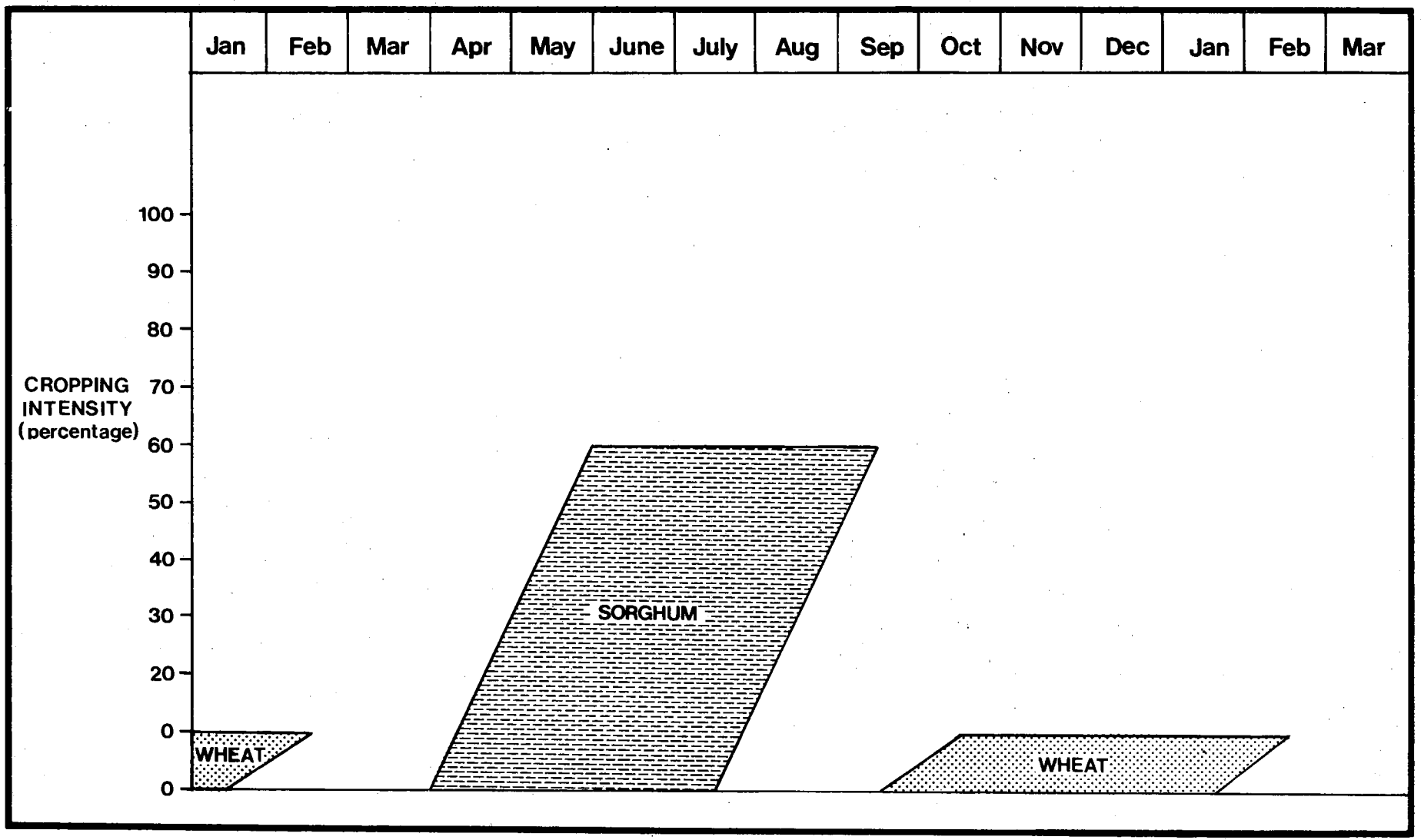

Figure 4·3

Present cropping calendar

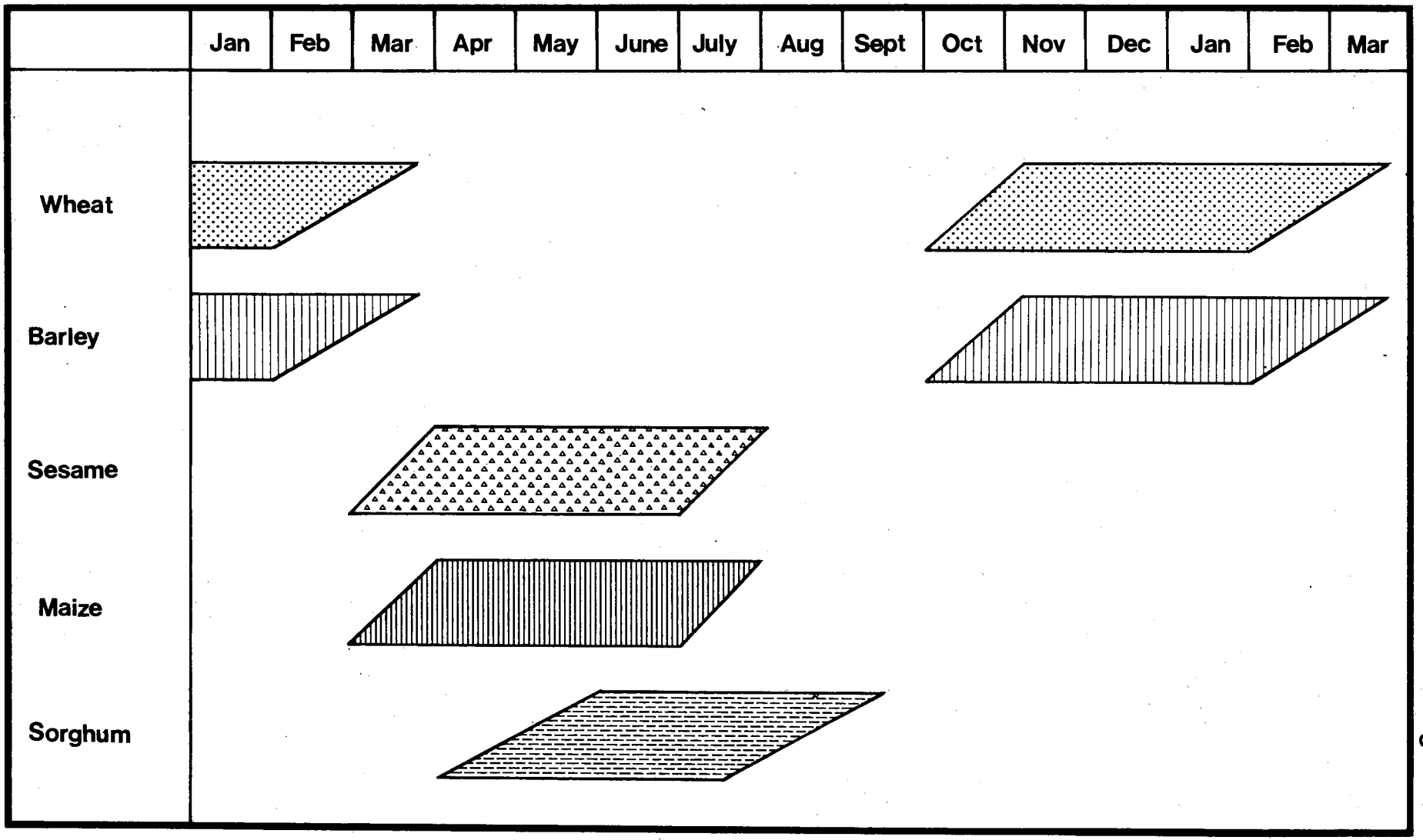

Figure 4·4

CHAPTER 5

CROPS TODAY

5.1 GENERAL

The standard of agriculture and the quality of the crops in the project area is relatively high when compared with other parts of the Republic and the majority of farmers appear reasonably contented with the existing situation. A substantial part (30%) of the cultivated area is commanded by well irrigation and mechanised cultivation using Massey Ferguson 165 tractors, disc ploughs, tyne cultivators and scrapers,is widely practised.

There is no standard land measure for the whole area although different measures exist for different areas and individual parcels of land. Crop yields are calculated on a volume basis, the unit being a kada, and is approximately equivalent to 32 kg for wheat, 27 kg for imported barley, 23 kg for local barley and 29 kg for sorghum, maize and beans. Farmers are reluctant to divulge any information on farm size, crop areas or yields. The crop yields quoted are estimates based on field observations and experience.

The principal crops, wheat, sesame, sorghum and lucerne are generally grown in sufficient quantity to provide for household requirements and the surplus is sold in the villages. Farmers retain adequate seed for planting the following year or buy from a neighbouring farmer with a good crop. Vegetables are grown on a very limited scale, being only for household consumption. The most productive of the tree crops, also grown on a very small scale, are figs and grapes. Citrus trees are grown, but are non productive being either too young or of poor quality stock. At present, no artificial fertilizer is used and use of animal fertilizer is limited. Chemicals for controlling insects, diseases or weeds are not used.

5.2 WHEAT

5.2.1 Varieties

There are two main types of wheat grown in the project area, Triticum vulgare which is a bread making wheat and Triticum durum which is a macaroni making wheat. The local varieties of Triticum vulgare are called 'Maseri' and 'Mesani' and have a growing period of 4½ months. 'Mesani' closely resembles the variety 'Chenab 70' which is a high yielder requiring a lot of water, responds well to nitrogen, is not susceptible to lodging but is unsuitable for poor land. Generally, bread wheats demonstrate good tillering characteristics with a high number of grains in each head and consequently higher yields than the macaroni wheats. The local varieties of Triticum durum are called 'Bouni' and 'Samra' and have a growth period of 3½ and 5 months, respectively. 'Bouni', which shows little response to fertiliser, is adaptable to poor land, reasonably drought resistant but very suspectible to lodging. The 3½ month growing period means that it uses less water than other varieties and thus there is a tendency to plant it in more marginal areas where water supply could be a limiting factor. However, it is a low yielder under these conditions. 'Samra' is a higher yielder and fairly widely cultivated, mainly for selling and not for home consumption.

Normally a stand of wheat in the field will consist of a mixture of varieties although one will be dominant. There appears to be a slight preference for good bread making wheats although the people are not fully aware as to which they are. A definite preference for locally grown wheat exists and imported wheat grain is shunned although much cheaper.

5.2.2 Crop Husbandry

Each of the varieties of wheat described in section 5.2.1 are grown on land principally irrigated by groundwater. However, there is a certain amount of wheat grown on seil irrigated land in the Al Shebwan area and on a small area on the left bank opposite Ma'rib. The wheat obtains water for growth from the residual moisture left in the soil after the last seil. Obviously, the areas cropped with wheat under this system will depend entirely on the date and extent of the last seil but planting often occurs in late September or early

October.

Cultivation is mechanized and the land is ploughed to a depth of 25 cm using a 3 disc plough. One pass of the disc plough is more than sufficient to break up the soil although it has little effect on weed control in the absence of pre-cultivation irrigation which would cause germination of weed seeds. Ploughing is followed by hand broadcasting of the seed. The stands of wheat resulting from the broadcasted seed are of lower plant population than that required for maximum yields; either because the seed rate is too low, or it is adequate but the seed has poor germination properties due to physical or insect damage. A seed rate of 120 kg per hectare is estimated for Wadi Abīda, the average seed rate in the Republic being 120 - 140 kg per ha which should give a reasonable plant population. After sowing the land is harrowed using a spring tyne cultivator. The cultivator buries the seed but at uneven depth causing irregular germination and an extended harvest period. Land is levelled for gravity irrigation by the use of a tractor-drawn scraper. The bunds for the individual irrigation basins are constructed by hand using a single 'T' shaped implement that scrapes the soil plus wheat seed into a bund. In this manner a field is divided up into individual basins of 3-4 m wide and 7-10 m long. The bunds themselves are about 30 cm wide and 20 cm high. After the construction of these bunds the land is irrigated.

The main weeds are Cynodon dactylon ('Wabl', a brassica 'Sunfir' and Chenopodium album ('Barda'). Some weeding does take place when labour is available and weeds, which are either cut or pulled up by the roots, are fed to livestock. Hand weeding is a time consuming task and for this reason most crops suffer badly from weed competition with a resultant drop in yield. Often after growing wheat in the same field for three to four years the weed population is so high that a long fallow period is required to reduce the weeds.

The incidence of plant diseases is low and is mainly confined to leaf rusts and a very small amount of stem rust, the latter

having a greater effect on yield reduction. All wheat varieties grown in Wadi Abīda are susceptible to rust but due to the low incidence there is little yield reduction. No smut disease was observed.

Insect damage is mainly confined to soil inhabiting insects which damage or kill the young plant after germination. At present the losses are low but could become more serious at a later date if no seed dressing is used. Damage caused by a bird of the weaver type (Quelea spp) is low and losses are about 5%, although greater on lodged wheat. A certain amount of lodging occurs in fields exposed directly to the prevailing wind or dust devils.

5.2.3 Harvesting

Wheat planted in October under groundwater irrigation is harvested from late January onwards until end of March, depending on the variety grown. Soil irrigated wheat is planted in late September or early October and is generally all harvested by the end of February. Most fields have a mixture of varieties resulting in uneven ripening and a prolonged drying period. Harvesting is carried out by family members and/or hired labour and occurs when the plants still have a partial green colour. The stalks are cut by hand using a small serated edge, curved knife, called a 'sharim' or pulled up by the roots. The plants are carried to the threshing floor by hand, camel or donkey and left to dry in the open air for 10 - 15 days. After the removal of the wheat from the fields, the sheep and goats are allowed to graze for one or two days thus removing all remaining plants and weeds and depositing a little animal manure.

When the grain has reached an even degree of dryness threshing is carried out by a tractor travelling around in circles on top of it or by herding animals around or by hand, using flails. A tractor will thresh in about 2½ hours a mound of wheat 40 m square and 70 cm high. The grain is winnowed by throwing it up into the air, allowing the wind to blow away the chaff and then it

is put into sacks for storage on the ground floor of the house. The remaining straw is piled up either by hand or by tractor and fed directly to animals or stored for feeding later or for mixing with mud when brick making. The feeding value of the straw at harvest, when still partially green, is high but due to subsequent treatment it has a lower value when fed to animals. Grain losses through storage pests such as weevils are probably in the region of 5% to 8%.

5.2.4 Yields

The different varieties of wheat grown on different soils and the different levels of inputs, basically water and weeding, result in a wide range of yields. However, under groundwater irrigated conditions, the average top yielder is probably 'Mesani', yielding in some cases 2 500 kg per ha whilst the lowest yielder is 'Bouni' with 1 000 kg per hectare. Wadi Abīda is renowned throughout the Republic for its high wheat yields and an average yield of 2 000 kg per ha has been taken. For wheat grown on seil irrigated land an average yield of 900 kg per ha is estimated. Generally, the wheat in the field appeared to be vigorous in growth habit and of a healthy green colour not showing any mineral deficiency symptoms and is unaffected by disease or pests.

5.2.5 Irrigation Practices

Land that is to be cropped with wheat is not irrigated until it has been cultivated, broadcast with seed and levelled. The first irrigation of 12-15 cm is applied in October as soon as the irrigation basins have been constructed. Subsequent irrigations generally apply 10-12 cm of water. Irrigation frequencies vary but an irrigation about every 20 days is most common. Thus, a 3½ to 4 month wheat crop receives five irrigations totalling around 600 mm and a 4½ month crop receives six irrigations, totalling some 720 mm.

5.3 BARLEY (Hordeum vulgare)

5.3.1 Varieties

Although there is very little barley grown in Wadi Abīda there are two recognised varieties, both two row, 'Biladi' and 'Bacur', the latter having a larger grain. Barley is grown as a source of green animal fodder and as a source of grain principally for mixing with other grains when bread making. It was not possible to identify the advantages of the two varieties or which was most suited to a particular use.

5.3.2 Crop Husbandry

The method of land cultivation, seeding, harvesting and other operations is the same as wheat. Planting takes place in October and harvesting occurs in late January and February, the growth period being four months. The seed rate is around 120 kg per ha, similar to wheat. Weeding is occasionally carried out if there is sufficient labour available. The incidence of disease is low, mainly rusts, and with no indication of covered or loose smut. However, there is some damage to young seedlings by soil inhabiting insects.

5.3.3 Yields

Grain yields are very variable due to differing standards of husbandry and range between 800 to 2 000 kg per ha with an average of 1 500 kg per ha.

5.3.4 Irrigation Practices

The first irrigation takes place after land cultivation and seed broadcasting. Barley is irrigated every 20 days, making five irrigations of 12 cm for the crop, totalling about 600 mm.

5.4 SESAME (Sesamum indicum)

5.4.1 Varieties

There are two varieties of sesame grown locally called 'Tulati' and 'Qumasi'. 'Tulati', which is a white seeded variety, takes three and a half months to reach maturity, whereas Qumasi, which is brown-black seeded, takes four to four and a half months. Generally the white seeded varieties are favoured as the seed is preferred for roasting and also produces a better quality oil. The black varieties produce more oil but of a lower quality. However, the farmers in Wadi Abīda reported that the white seeded varieties gave more oil, which could occur if 'Qumasi' is a poor brown-black seeded variety or if 'Tulati' is an exceptionally good variety.

5.4.2 Crop Husbandry

Sesame is grown on the same land as wheat and is planted in late February and March after the wheat has been harvested. The sheep and goats are generally allowed to graze for one or two days after the harvest and then the field is irrigated. A few days later the seed, sometimes mixed with maize, is broadcast and the land cultivated using a spring tyne cultivator. Levelling follows using a scraper, and then the bunds are made by hand, using a 'T' shaped scraper, thus dividing the field into small irrigation basins of about 4 m by 8 m. The majority of sesame observed growing in fields was irregularly spaced, tending to be in close clusters, thus reducing the yield potential. A few farmers indicated that thinning was practised but this was not observed.

Weed growth is fairly rapid and competition between the weeds and the sesame plants soon develops. The intolerance of sesame to weed competition is recognised and farmers try to achieve a complete weeding of the fields within one month of planting and before the first irrigation. There are small losses of young plants caused by soil inhabiting insects and some slight insect damage to the young shoots.

5.4.3 Harvesting

The sesame varieties are all prone to shattering and harvesting takes place before the pods have fully ripened. Seed losses in the field are thus kept to a minimum. Harvesting takes place in July about four months after planting. The plants are pulled up by the roots and stooked in the field or transported to the threshing floor and stooked. They remain in the sun drying for 15 - 20 days and then the pods are shaken to expel the seeds over a large piece of cloth. Pods which have not burst are threshed on the ground using a flail and the seeds collected. The seeds are then sieved to remove extraneous material and put into sacks for storage.

As the need for sesame oil for cooking or eating arises, some of the stored seed is taken to a 'mill' for grinding. The 'mill' consists of a hollowed out portion of a tree trunk with another piece of wood inside it, set at a slight angle. This angled piece of wood is connected by a wooden shaft, which is weighted with stones, to a blindfolded camel which walks around in circles thus rotating the angled piece of wood in the hollow bowl and expressing the oil. Hot water is added to the seed as it is ground to increase the extraction. The expressed oil is scooped out of the wooden hollow and stored in tins for four to eight months depending on quantity of water added. The remaining oil cake is dried for use as animal feed and is their only source of high protein food. The stalks are also fed to livestock.

5.4.4 Yields

Yields are very variable and tend to be low. Sesame grown alone yields between 350 - 600 kg per ha with an average of 500 kg per ha. Yields of sesame when planted with maize depend on the proportion of sesame to maize and the spacing. In this case an average sesame yield is 250 kg per ha with a maize yield of 800 - 1 000 kg per ha.

5.4.5 Irrigation

Sesame is only grown under well irrigation. After the wheat is harvested but before sesame is planted, the land is irrigated and then again about one month after planting. The crop receives a further two irrigations, thus totalling four irrigations in all, including the pre-plant irrigation, and representing a total application of some 500 mm.

5.5 SORGHUM (Sorghum vulgare)

5.5.1 Varieties

Two varieties of sorghum are grown, which have either red or white grains and both types are locally referred to as 'seif'. They are of the open panicle type, not goose necked, and grow to about 130 cm in height and reach maturity in 100 days. Sometimes a small amount of sorghum is grown as green fodder for livestock. Generally within a field of grain or fodder sorghum there is an even mixture of both varieties.

5.5.2 Crop Husbandry

Sorghum is grown almost entirely on land that is seil irrigated and thus, the area planted to sorghum, the planting time and the yield are completely dependant on the seil. Generally planting takes place in April or May and harvesting follows 100 days later.

A few days after the land has been flooded by the seil, it is ploughed once or twice with a camel-drawn wooden plough with a metal tip. The depth of ploughing can be altered but is normally 12 - 15 cm. The seed is sown by hand through a tube attached to the plough which deposits the seed in the furrow. The furrows are 30 - 40 cm apart.

This procedure of ploughing and sowing requires two people, generally an adult and a child, the adult controlling the ploughing and the child holding the bag of seed and putting them into the

funnel at the top of the tube. After sowing the field is levelled using a camel drawn wooden scraper board. No small bunds are constructed in the fields as sorghum is seil irrigated and thus one field may have a size of up to half a hectare.

Weeding is occasionally carried out when labour is available. There is some incidence of rust disease and some damage to the growing points of the plants probably caused by the sorghum shoot fly, Antherigona varia soccata. Damage by a bird of the weaver type (Quelea spp) occurs especially on lodged sorghum and represents losses of 5% - 10%.

Sorghum grown for fodder is planted on well irrigated land. After the wheat has been harvested, sorghum seed is broadcast on the field and then passed over with a spring tune cultivater. It is then irrigated once and left to grow. At first, wheat seeds germinate with the sorghum, but after a month the wheat seedlings die off because of heat and lack of moisture. The sorghum is cut green after it has headed and used for livestock fodder. Sometimes, after the main crop has been harvested, a ratoon crop is grown for fodder purposes.

5.5.3 Harvesting

Harvesting takes place in July or August. The plant is pulled up by the roots, unless a ratoon crop is required, and the heads are cut off using a small serated edge knife, 'sharim'. When the ground is very hard and it is difficult to uproot the plant, the stalks are cut with the knife. The heads are carried to the threshing floor and left to dry in the sun for 10 - 15 days before threshing with a tractor or by hand. The grain is winnowed by throwing it into the air, the wind blowing away the chaff and the grain falling onto the ground. The grain is put into sacks and transported to houses for storage. A small amount of stored grain from the last season was inspected and there was some damage from storage pests, although the insects were no longer present. The stalks, often slightly green at harvest, are either fed directly to livestock or transported by pick-up truck or camel

to the house where they are stored in special areas, surrounded by brushwood. Later, the dried stalks, mixed with some fresh lucerne, are fed to livestock.

5.5.4 Yields

The yields vary according to the amount of water the crop receives and range between 600 - 1 500 kg per ha with an average of 850 kg per ha.

5.5.5 Irrigation Practices

Grain sorghum is not planted until the land has received one seil irrigation. In a good seil year up to two further irrigations may occur. Sometimes the amount of water applied by the second or third seil irrigation is too great and the sorghum crop is damaged and a certain amount of soil erosion occurs.

Sorghum for fodder on well irrigated land receives one pre-plant irrigation only. Ratoon sorghum on seil irrigated land may receive one or two seil irrigations in August and September.

5.6 MAIZE (Zea mays)

5.6.1 Varieties

Very little maize is grown in the area and it is often planted with sesame or interplanted with melons or a few beans. The varieties grown are yellow grained and have no local names being referred to generally as 'rumi'. This is an indication that not much emphasis is placed on maize.

5.6.2 Crop Husbandry

Maize is a three and a half month crop with planting in March and harvesting in July. The cultivation practices and the planting of large areas are the same as for sesame. When maize is sown in small plots, the cultivation is carried out using a

camel drawn wooden plough. The land is generally ploughed twice and during the second ploughing the seed is sown by hand in the plough furrow, through a wooden tube attached to the plough. The furrows are 30 - 40 cm apart. The planting method is the same as for sorghum.

Weeding is occasionally carried out, the weeds being fed to livestock. There is little insect damage or disease, although some farmers reported losses of young plants from soil inhabiting insects and some insect damage to the growing point of the plants.

5.6.3 Harvesting

At harvest the majority of the cobs are stripped off the plant and placed in the sun to dry, but some cobs are cooked and eaten while still relatively fresh. The seed is threshed from the dry cobs by hand. The stalks when fresh or dried are used as animal fodder.

5.6.4 Yields

Yields are very variable and a pure stand of maize yields between 1 400 - 2 400 kg per ha with an estimated average of 2 000 kg per ha. Maize grown with sesame yields about 800 - 1 000 kg per ha with a sesame yield of 250 kg per ha, depending on spacing and proportion of the crops.

5.6.5 Irrigation Practices

This crop is only grown under well irrigation. Maize inter-planted with sesame receives one pre-plant irrigation followed by a further three irrigations at approximately one month intervals making a total application of 500 mm. Maize grown in a pure stand receives a pre-plant irrigation followed by three or four irrigations at 20 to 30 day intervals, making a total application of 500 - 620 mm.

5.7 LUCERNE (Medicago sativa)

5.7.1 Varieties

The lucerne grown in Wadi Abīda is often erroneously referred to as 'berseem' by the local farmers. There are two types, 'Bāladi' which has a large leaf and grows 50 - 60 cm high and 'Joufi' or 'Gebili' which has a smaller leaf but grows to heights of 60 - 90 cm. Occasionally lucerne seed is bought in Sana'a but normally it is obtained within the area.

5.7.2 Crop Husbandry

A stand of lucerne is kept for three to four years before being replaced by a wheat crop. New stands are sown on wheat land or short term fallow, with planting taking place in September. The land is disc ploughed or harrowed to produce a good seed bed then levelled with a scraper. Bunds forming the small 3 m by 8 m irrigation basins are made by hand using a 'T' shaped scraper implement. The seed is broadcast in the small basins and then irrigated. Where mechanised cultivation is not available two to three passes with a camel drawn wooden plough followed by levelling is sufficient. The first cut can be taken 10 - 12 weeks after planting. A few farmers mix the lucerne seed with a brassica locally called 'Tartar' or 'Hardel' and identified as Brassica juncea (Indian mustard). The seed has a high oil content, 35%, and the plant is very palatable to livestock.

Root nodules were noted on several young plants and the majority of farmers claimed an increase in wheat yields when grown after lucerne, suggesting the presence of nitrifying bacteria. The lucerne is generally thich and lush although in the older stands there is some weed competition from Cynodon dactylon, or 'Wabl', and a brassica 'Sunfir'. Leaf chlorosis was observed locally. There was little evidence of disease, although a few lucerne leaves showed crinkling, which could have been caused by a virus disease. A leaf eating insect, possibly the lucerne weevil, was also observed.

5.7.3 Harvesting

The women cut the lucerne close to the crown by hand using a small knife ('sharim'). A small plot, 3 m by 8 m, is cut over one or two days and the lucerne bundled up and carried to the house for feeding to livestock in the morning and evening. The crop is cut at 30 day intervals during the winter and 20 day intervals during the summer, representing 15 cuts per year. A seed crop, if required, is taken in August.

5.7.4 Yields

The total green matter yield on an annual basis is estimated at 60 t/ha. The green matter yield during winter months when cutting is less frequent, is about 25 t/ha and during summer months 35 t/ha.

5.7.5 Irrigation Practices

The irrigation interval varies according to the time of the year between once about every ten days in the winter and about every seven days in the summer. The depth of water applied in a single irrigation is 7 - 10 cm. During periods of seil, water is allowed to flood the lucerne fields, thereby saving one or more groundwater irrigations.

5.8 VEGETABLES

Vegetables are grown on a very small scale, just a few plants on each farm, for household consumption only. There is no market at present for vegetables in the villages. Generally the plants are grown on the sides of irrigation ditches or sometimes, as is the case with melons and beans, planted with maize. Winter vegetables are mainly chillies and green peppers whereas summer vegetables are peppers, onions, beans, tomatoes, okra, leeks, egg plant, carrots, sweet melon and water melon. The vegetables receive water when the irrigation ditches are used to irrigate other crops. Little attention is given to the vegetables and

yields are low.

5.9 TREE CROPS

Fig, citrus, qat, date, paw paw, pomegranate, banana, grape and apple are grown in the area. However, only fig, citrus, qat and grape are of any significance. Farmers are reluctant to have too large an area planted to tree crops as there is no production for several years and the market is extremely limited, being mainly consumption on the farm.

Most farmers have two or three fig trees, a few grapes and 10 - 12 citrus trees planted near the well. No insect or disease control is practised and irrigation during the summer is at monthly intervals, the application being 12 - 15 cm.

The grape vines are pruned in January or February and trained onto a simple wooden trellis, raised off the ground by wooden or stone supports. Two varieties of grapes are grown, one that produces fruit throughout the summer and the other for one month only.

The citrus trees are mainly tangerine grafted onto rough lemon rootstock and come from Harieb or Saudi Arabia. Most of the trees are two to four years old, there being very few mature fruit producing trees in the area. Some of the trees have chlorotic leaves with dark veins and this could be caused through root nematode infestations or by mineral deficiency, possibly zinc, iron, manganese or copper. Many of the citrus trees are exposed to the full force of the prevailing winds, causing blossom drop and yield reduction.

Qat (Catha edulis) is grown by a few farmers, the plantations consisting of 30 - 60 trees. The quality of the qat is said to be low and may be due to the variety or to the high temperature and lack of shade. The qat grown in Harieb under similar conditions is of good quality and is sold regularly in Wadi Abīda.

5.10 NATURAL VEGETATION

The natural vegetation in Wadi Abīda is varied and ranges from trees and weeds on the irrigated farm land to the more drought tolerant plants found on sand dunes. A collection of the more common plants was made and some of them were later identified. Table 5.1 shows the Arabic and Latin names and the location of the plants.

On cultivated land the principal weeds are Cynodon dactylon, a brassica locally called 'Sunfir' but unidentified and Chenopodium album. Some lucerne fields were heavily infested with Conyza linifolia which has only recently been introduced into the area as none of the farmers could give it a local name. The banks of the irrigation ditches are covered with Cynodon dactylon or Eragrostis aegyptiaca which provide a valuable additional source of grazing for livestock as well as stabilising the canal banks. The only tree found extensively on cultivated land is Ziziphus spina-christi which has a variety of uses. The fruit is eaten by humans and animals, the green foliage is cut off and fed to animals, the branches are lopped for timber, the trunk when large enough is used to make the bowl of the sesame grinding mill, and the tree itself provides shade and acts as a windbreak.

The plants found in the wadi or on the adjacent land are generally more drought tolerant and provide browse for livestock. Tamarix trees are found on the wadi banks and these help to stabilise the banks as well as providing a source of firewood and acting as windbreaks. Acacia trees are found on the drier and stonier parts of the wadi and provide browse for livestock and timber. Calotropis procera grows on the low lying land near the wadi and the young leaves and flowers are fed to livestock when palatable sources of fodder are limited. After the first seil the wetted parts of the wadi banks soon become covered with Cynodon dactylon and Eragrostis aegyptiaca, providing good opportunity grazing for sheep and goats. Two other species of plants, Calligonum comosum and an unidentified species, locally called 'Alga', are plentiful near the wadis and in the drier

sandy areas providing a certain amount of browse throughout the year for sheep and goats.

On the small sand dunes and coppice mounds, Salvadora persica and Rhazia stricta are found in abundance, the latter being poisonous to livestock. The leaves of the Salvadora persica bush provide year-round browse for camels and are in fact their main source of fodder. Some of the bigger clumps are fenced off and browsed on a rotational basis.

TABLE 5.1

Natural vegetation identified in Wadi Abīda

Location	Latin name	Arabic name
Cultivated land	Aerua juvanica	Rehan/Ra
	Blepharis ciliaris	Shoack
	Brassica spp.	Sunfir
	Cassia italica	Isheriq
	Centaurea sinaica	Shoowak
	Chenopodium album	Barda
	Chrozophora plicata	Tannum
	Cleome arabicum	Horman
	Conyza linifolia	-
	Cynodon dactylon	Wabl
	Datura stramonium	Manj
	Eragrostis aegyptiaca	Tafeef
	Fagonia arabica	Derma
	Flaveria trinerva	-
	Farsetia longisiliqua	Hamma
	Helioptropium spp.	-
	Ochradenus baccatus	
	Pulicaria crispa	Githgat
	Solanum nigrum	Obub/Agil
	Sonchus oleraceus	Hurwayra
	Ziziphus spina-christi	Elb
	Zygophyllum simplex	Qarmal

TABLE 5.1 (continued)

Location	Latin name	Arabic name
Wadi land, coppice mounds and sand dunes	Acacia nubica/tortilis/aethbaica	Arufut
	Acacia raddiana	Samar
	Anticiharis linearis	Dubian
	Boerhaavia repens	Sootta
	Calligonum comosum	Abel
	Calotropis procera	Ushar
	Cotoneaster nummularia	Surrah
	Launea spp.	Haweywa
	Lycium barburum	Awsedge
	Leptadaenia pyrotechnica	Myrakh
	Pennisetum divisum	Sarra
	Panicum turgidum	Itmum/Tannum
	Pergularia tomentosa	Halga/Ghalga
	Rhazia stricta	Harmal
	Saccharum spontaneum	Halfa/Hada
	Salvadora persica	-
	Tamarix spp.	Athl

CHAPTER 6

LIVESTOCK TODAY

6.1 GENERAL

Livestock play an important role in the Yemen and the estimated population for the whole country in 1973/74 was as follows:

Cattle	900,000	
Sheep and goats	11,000,000	(possibly 65% sheep)
Equines	300,800	(mainly donkeys)
Camels	150,000	
Poultry	3,000,000	

Arable cultivation at the national level is still largely dependent on animal power in most areas, which accounts for the relatively high numbers of cattle which are kept under generally adverse feed conditions. Although milk and meat form an important sector of the Yemeni diet the currently low levels of productivity fall far short of the demand for animal protein.

All major cultivation in Wadi Abīda is now mechanised. Livestock as working animals have lost their significance at Ma'rib and with the exception of pack donkeys and a few oil press camels, the livestock population is kept for milk, meat and sale, mainly in the form of sheep and goats. Cattle have virtually disappeared.

The development of the livestock industry as a whole is only just receiving official attention through the Livestock Credit and Processing Project (IBRD) and in the longer term through the agricultural and livestock development team in the Ministry of Agriculture. A British Government financed veterinary team has been working in the country since late 1972 on a long term project to investigate the disease situation and assist the Ministry of Agriculture in establishing a veterinary service.

6.2 LIVESTOCK POPULATION

Due to the isolation and independence of the area, there are no official estimates of the livestock population and it is doubtful whether the area is included in the national estimates. Further, under the circumstances in which this study was carried out, it has not been possible to count animals in relation to particular owners or villages and questioning has been limited to a few co-operative farmers. This questioning has been of necessity carried out in an oblique manner and has not led to any clear indication of animal numbers.

It has therefore been necessary to calculate a figure based on counting flocks within and moving around the cultivated areas, observing the penning capacity on villages and 'on-farm' buildings in order to establish an approximation of the average flock size for a farm building. Table 6.1 shows the breakdown of the net cultivated area, farm types and the calculated estimate of the livestock population. Aerial photography offers a reasonable means of estimating the cultivated area. This can be reduced to the number of holdings in two classifications depending on the system of irrigation in use. The classifications are described in detail in Chapter 4 and comprise the following divisions:

(a) Farms - groundwater irrigation.
(b) Farms - seil irrigation.

Two other classes of livestock owner have some influence on the project area as follows:

(c) Immigrants.
(d) Nomadic Bedouin.

The total area downstream of the dam, within which most animal browsing occurs, is 45 000 ha. Within this area the following units carry very little browse:

TABLE 6.1

Calculated estimate of the current livestock population in Wadi Abīda

Farm type	Net cultivated Area (ha)	Average farm size (ha)	No. of holdings or families	Sheep and goats per holding	Total	Donkeys per holding	Total	Camels per holding	Total
Groundwater Irrigation	1 617	4	416	30	12 480	3	1 248	-	-
Seil Irrigation	1 684	5	375	45	16 875	1	375	2.5	937
Immigrants	-		200	5	1 000	0.5	100	0.1	20
Resident total					30 355		1 723		957
Nomadic (1)			50	80	4 000	1	50	11	550
Bedouin			20% influence		800		10		110
Overall total					31 155		1 733		1 067

(1) The nomadic Bedouin find most of their animal fodder outside of the project area and therefore ascribed a partial influence only.

(a)	Cultivation	- 5 000
(b)	Old silts	- 7 000
(c)	Major sand dunes	- 4 000
(d)	Lava	- 3 000
	Total	19 000 ha

This leaves approximately 26 000 ha of browse available for the estimated livestock population shown in Table 6.1. The browse areas are mainly within the area of the recent alluvium and low sand dunes which receive flood water at least occasionally. With an annual rainfall of 50 - 100 mm, little vegetation suitable for browse occurs within areas not subject to replenishment of the soil moisture reservoir by flood water.

Few poultry were observed and they do not appear to be of any great importance to most local inhabitants.

6.3 MANAGEMENT AND NUTRITION

Management is typical of the Middle East in that animals are penned at the homestead during the night and herded on the adjacent browse areas or fallow and stubble grazings during the day. The women and children are generally responsible for the sheep, goats and donkeys while the camels may be in the charge of men or older boys.

Newly born offspring are usually kept at the homestead for the first one or two weeks of life, suckling being limited to the time that dams return for night penning and before going out in the morning. During this period the offspring are offered solid feed, lucerne or 'elb' (Ziziphus spina-christi) leaves, and are subsequently allowed to follow their dams to the day feeding grounds. At this stage the dams, if good milkers are fitted with udder bags and the progeny are only allowed evening and morning suckling in competition with hand milking.

Except in the case of camels there is little if any control on breeding season although there appear to be main and secondary lambing/kidding periods in spring and autumn for sheep and goats.

Many of the dams in these two classes of stock are reported to breed twice a year with regularity. In the short period of the visit to Ma'rib and due to the constraints on questioning it was difficult to confirm or dispute these factors. Observation of the flocks during March, at a distance, were inconclusive as it was not possible to judge the proportion of pregnancy amongst breeding ewes. The proportion of young animals observed in the flocks was low but this may only have been an indication of a high rate of disposal at under six months.

Discussions with workers in other parts of Yemen confirm that two breeding seasons exist but that the erratic availability of feed seriously affects the regularity of breeding. The conditions in Wadi Abīda are not typical of either the upland or coastal areas of Yemen and the fluctuation in availability of animal feed should not be so great as in those parts. Rainfall is below 100 mm per year and therefore of little significance to the local vegetation, which evidently relies on water retained in the silt pockets from the seil. Areas were observed where it was obvious that seil water had failed to penetrate for some time and strong shrub growth was either dead or dying out.

The cropped lands contribute a significant proportion of fodder for all classes of stock in that most farms keep from 8% - 10% of the land for lucerne, grown as a perennial legume, and both straw and stover from wheat, sorghum and sesame are fed to animals. Stubble and grazing from all crops is also used. Small 'elb' plantations are maintained in the vicinity of most settlements within the influence of the seil area, where it is regularly lopped for fuel, the leaves being fed to livestock.

The majority of livestock are out during most of the day either browsing or grazing and are then fed limited amounts of green lucerne in the evening when they are penned for the night. Straw or stover may also be fed at this time if the browse and grazing are in short supply. Although there was some evidence of attempts to store residues, this practice appeared to be limited to keeping

a few bundles of stover in small sheds or leaning against house walls. The need for storage of residues must depend to a large extent on the seasons in that the wheat harvest coincides with late winter (February and March) when the residual effect of the seil on the natural vegetation will be at its lowest. The straw is therefore available at a time when it is immediately required and storage is therefore only of a short term nature. It is probable that supplies will be finished by the time the first seil comes down the wadi in April. The seil should have an almost immediate effect on natural herbage which would then provide the necessary level of bulk feed. Sorghum stover on the other hand would start to become available in the late summer (July onwards) when it is possible that feed from natural vegetation would still be in good supply and the stover would not be immediately required.

The project area was visited during March and observations of the browse situation were therefore made at a period when the growth levels were presumably at their lowest. All the palatable plants available appeared to be in a dormant state and although many retained their green colouring there was little evidence of fresh growth and animals were nibbling at stem terminals and in some areas flower heads. The one exception appeared to be 'raq' (Salvadora persica) which although not in full growth, continued to provide a good supply of leaf browse. The palatibility of this shrub is limited to camels which probably accounts for the strength of its growth. The poverty of the browse situation in late winter is illustrated for the non-farming section of the community where some nomads and refugees are reduced to cutting 'ushar' a species of Calatropis of low palatibility, for animal feed. Animals will reluctantly pick at the flowers and leaves of this plant presumably in the extremes of hunger.

The major source of natural forage for sheep and goats apart from scattered Acacia species, appeared to be a small woody shrub locally known as 'alga'. This plant thrives under a wide variety of conditions and although the strongest and greenest stands are found in the areas influenced by the seil, it can also be found in the rocky desert edges away from the project area in sufficient quantity to support nomadic flocks.

Useful grass is limited to Cynodon dactylon (star grass) which grows along irrigation ditches and in the occasional seepage points. It creates a major weed problem on the groundwater irrigated farms especially amongst the wheat, to the extent that periodic long fallow is necessary to eradicate it. Two or three unidentified specied of coarse grasses were observed but they did not appear to be in sufficient quantity to be significant to the grazing animal.

Some ground legumes, possibly Crotilaria sp., were also observed in a semi-dormant state. These may be of greater significance during the flood period when fresh and active growth is present provided that they are both palatable and non-toxic.

6.4 LIVESTOCK

6.4.1 Camels

These animals are a medium sized dromedary, generally light brown in colour with a few variations to pale or dark. They did not appear to be a particular hairy type and there is no evidence of a camel hair industry.

The vast majority of camels found in the project area are producing and growing females, the males being restricted to adult breeding bulls and immatures.

Although the camel still plays a part in transport and oil pressing, it has lost its place in cultivation power and the need to retain large numbers of castrate males has been obviated. Current high prices both within Yemen and in Saudi Arabia have therefore changed the emphasis from the utility of camels to their breeding potential. The current work demand on the camel is of a light nature and can be adequately carried out by females.

The larger herds of camels are retained by the nomadic Bedou and their influence on the project area is therefore only periodic. The farmer owned camels appear to have been reduced to the minimum number required to keep up a supply of milk and some transport requirements.

There appear to be adequate supplies of camel browse in the area; the major share being provided by Salvadora persica with Acacia and other taller shrubs providing alternate sources. The milking females receive rations of lucerne in the evenings especially if they are working during the day. Camels operating the oil presses are reported to consume considerable quantities of sesame seed cake.

It was not possible to make any accurate assessment of the breeding rate of the local herd but the proportion of young animals appeared consistent with the production of at least one offspring per adult breeding female in three years and a breeding life of up to three or four offspring per female. There are no indications as to the trend in overall numbers but it is possible that the current high prices may encourage overselling which would tend to continue the reduction in numbers that has taken place in recent years due to farm mechanisation. The present population is evidently in reasonable balance with the resources. Stabilisation at this level should ensure that the area will continue to be a viable breeding area and supplier of working stock for other regions of Yemen and Saudi Arabia.

No specific health investigation was possible in the project area and queries met with negative response. Camels on the whole appeared in reasonable to good condition but cases of severe emaciation in adult females were observed as were a number of carcases and skeletons. Discussion with the leader of the British Veterinary Team led to the suggestion that these animals were suffering from advanced cases of mange which is often fatal to camels in other parts of Yemen. External and internal parasites are reported in camels in Yemen as a whole and there would appear to be no reason why infestation should not be present in Wadi Abīda, especially as no control measures of any kind are taken in the area.

6.4.2 Sheep

These are mainly typical fat tail desert sheep, coarse wooled,

black to dark brown with occasional white and of medium size; probably of the 'Nejdi' type. A few larger and less woolly chesnut brown specimens were observed, the exact origin of these was not established but similar sheep were noted in the foothill areas of the western slopes between Taiz and Tihamas.

The ewes are milked fairly extensively and many were observed with bags protecting the udder from suckling. Neither the length of the lactating period nor the quantity of milk produced were established but it is unlikely that more than 500 g per day would be produced at peak of production, as surplus after suckling. Biannual breeding is apparently quite common and it is therefore unlikely that ewes can be milked for more than 3 months after lambing and probably the average is considerably less. A good ewe, lambing twice in the year may therefore produce up to 40 litres per annum but a poorer ewe on the other hand may not produce sufficient surplus over suckling to warrant any hand milking.

It has not been possible to establish other production parameters under the circumstances prevailing. Through observation and very limited questioning it was indicated that sheep are sheared twice a year, the average production per shearing being less than 1 kg of wool; male lambs were not castrated and, except those retained for breeding, are slaughtered between 8 and 15 months at liveweights of between 15 and 20 kg. No factors could be established for birth, weaning or mortality rates although discussion with workers is other parts of Yemen indicated that lamb mortaility is not high in a reasonable season and the lambing rate is also affected by season. The project area enjoys somewhat more consistent conditions and could possibly show a lambing rate as high as 15% with lamb and ewe mortaility rates as low as 10% in a good seil year. An average taken over a period of five years would be unlikely to achieve such optimistic rates.

It was possible to roughly age a few sheep in farm flocks which indicated that breeding ewes tended to be younger than fully mature. It was further noted that adult sheep meat was frequently eaten at entertainments and gatherings. This suggests that production levels and therefore ewe replacement numbers are sufficient

to allow fairly rigorous culling of the poorer breeding ewes especially where their milk production is low.

One well fleshed ram lamb was purchased in the local market, slaughtered and dressed out by the writer. This was the only lamb from amongst some 20 on offer that carried any flesh on the sternum. It was estimated to be in the region of 8 to 10 months and weighed 20 kg live.

The following breakdown after slaughter was recorded:

Liveweight	20 kg	
Hot carcase (with kidneys)	9 kg	
K.O.	45%	
Gut, lungs and contents	4.50 kg)	
Skin (wet with some fat)	3.00 kg)	
Head, feet and fat tail	2.50 kg)	5th quarter
Liver	0.36 kg)	
Other offal (heart, pancreas, testes)	0.31 kg)	
	10.67 kg	
Loss to blood, scale inaccuracies, etc	0.33 kg	
	20.00 kg	

In local practice with the exception of the gut content and skin, the 5th quarter is generally consumed. This would add a further three kilograms approximately to the carcase weight thereby increasing killing-out to 60%. Some of the poorer lambs had liveweights considerably lower than the above example, average about 15 kg, and it is reasonable to assume that killing-out (carcase only) would not exceed 40% - 42%.

Disease levels do not appear to be high although persistent questioning established that major losses occur periodically, indicating epidemics. Close night penning and floor feeding must lead to heavy intestinal worm burdens. Heavy flea infestations common throughout Yemen were observed and although other external

parasites were not seen it is likely that they are present due to lack of any treatments. The present isolation of Wadi Abīda contributes towards what appears to be a relatively disease-free situation but there is evidence that diseases already penetrate the area and are likely to become more frequent as better communications are established.

6.4.3 Goats

These are long haired, generally all black, horned and small to medium in size probably of the 'Hejazi' type. They are sheared along with the sheep and the hair is mixed with wool for a coarse local cloth. The females are extensively milked and locally ascribed better milking qualities than the sheep. It is probable that they are the major suppliers of household milk in the project area. Similar to the sheep they are biannual breeders and generally accepted as more prolific. A good milking female will probably produce at least twice as much milk as a good sheep. The importance of goats' milk is demonstrated in the early age at which kids are slaughtered. Except for replacement breeding males and females, this age rarely exceeds five months and is generally much lower, with liveweights of 9 kg and less.

In common with sheep it is difficult to lay down production parameters but it would appear that similar criteria will apply. The goat is generally accepted as a hardier animal than the sheep and capable of thriving in a poorer feed situation and therefore would be less sensitive to variations in conditions.

The few females that could be aged in farm flocks indicated that the breeding females tended to be older than the ewes. This may indicate a longer and more productive milking life than sheep or possibly only demonstrates the preference for sheep meat over goat meat.

Specific goat diseases exist in Yemen but no evidence was found to confirm their presence in Wadi Abīda. It is probable that the situation is similar to that for sheep with internal and external

parasites being endemic and epidemics causing major losses periodically.

In common with sheep many cases of overgrown hooves were seen in the farm flocks. This is presumably due to the generally short distances moved during the day over soft silt and sand and the soft flooring in the night pens. The animals kept by Nomadic Bedou do not suffer this complaint as they cover much greater distances often on hard and stony ground.

6.4.4 Donkeys

These are small and generally dark coloured animals, although they are not stunted as found in some parts of the Yemen uplands. In general they seem to be in good condition and judging by the number of younsters in evidence, their breeding rate is adequate. They are generally used as pack and riding animals or occasionally for driving oil presses.

Very few carcases or skeletons were observed and no evidence of any specific disease was found. Intestinal parasites (Strongyle sp.) are reported as responsible for loss of condition in other parts of Yemen and it would therefore appear likely that some infestations occur in Wadi Abīda.

Overloading was not observed and the lameness which is prevalent in other districts was not obvious.

6.5 AVAILABLE FODDER

6.5.1 Natural Vegetation

As previously stated, browse forms a major part of the animal diet in the project area.

In the short time available for the study and the circumstances under which it was carried out, it was not possible to quantify

the value of this feed source nor to assess the seasonal changes that may take place in quality.

The farm based animals with alternative sources of feed available are obviously less dependent on browse in the late winter than those animals belonging to non-farming owners. Observations made during this period indicated that the value of the browse, with the possible exception of Salvadora persica for camels, was at a very low level. Apart from offering Calatropis sp., non-farming owners were being forced to purchase or barter for supplementary feed supplies from farmers. Table 6.2 indicates the nutrient content analysis of selected samples of browse collected in the project area during the study. Further observations indicated that the situation for some farmers was being stretched in that extensive lopping of Ziziphus spina-christi trees was taking place to provide supplementary green feed.

The relationship between the current stocking rate and the carrying capacity would therefore appear to be very finely balanced at present. It is probable that the stocking rate is generally too high for the winter period and the failure or even lateness of the seil could cause serious nutritional problems.

There is some potential for improving the situation through control, for better natural regeneration, and possibly through the introduction of new browse species but this would be in the long term and at considerable expense.

The people of Wadi Abīda appear to have a fairly responsible attitude to their environment, as demonstrated in the disposal of their cattle during the process of mechanisation of cultivation, and provided that no major outside influence is applied, then they will probably maintain the current precarious balance between stocking and carrying capacity.

TABLE 6.2

Nutrient analyses of selected browse plants
(collected March, 1977)

Sample	Percentage of green matter		
	Dry matter (air dried samples)	Crude protein	MAD[1] Fibre
Calatropis procera Flowers	68.5	9.6	21.2
Calatropis procera Leaves	90.6	13.6	26.3
Salvadora persica Leaves and stems	82.2	8.5	13.9
Ziziphus spina-christi Leaves	91.2	17.0	13.3

(1) Modified acid detergent

Note: Assuming these plant materials contain no toxic substances they would serve as adequate protein supplements for ruminants being fed mainly on sorghum stalks, maize stover or straw. Ratio of these materials to poor quality roughage would need to be about 1 to 1.5 on a dry basis.

6.5.2 Crops and Crop Residues

The major crops grown which can contribute directly or indirectly to animal feed include lucerne, wheat, barley, sesame and sorghum. No other crops are grown at field scale and any part of these which is useful to animals is of little significance in the overall feed situation. Table 6.3 indicates estimated crop areas and straw yields.

Table 6.4 shows the estimated value of the major crops in terms of Total Digestible Nutrients (TDN) and Digestible Protein (DP) for the estimated current cropped area and levels of production.

The last column converts the TDN value to Livestock Nutritional Units, (LNU), each representing 100 kg of liveweight requiring a basic maintenance level of 546 kg TDN including 43.7 kg DP per year. Conversion to livestock numbers is based on the assumptions that four local sheep or goats equal one LNU. Table 6.5 shows the conversion of the estimated population as shown in Table 6.1 to LNU.

Comparison of total LNU in Tables 6.4 and 6.5 shows that crops and residues provide about 44% of the required nutrition. The remaining 56% must therefore be drawn from natural browse, Salvadora persica plantations and opportunity grazing of stubble and fallow land. This latter category may provide for up to 1 000 LNU per annum which still leaves approximately 48% to be found from other sources.

Assuming that some 26 000 ha of natural browse is available it would be required to supply nutrition for some 6 000 LNU, i.e. a stocking rate of one LNU to 4.3 ha. At a daily intake rate of dry matter in the order of 3% of liveweight, one LNU would require about one tonne per annum. The stocking rate of 1 LNU to 4.3 ha would therefore require an annual edible dry matter production of about 230 kg per hectare which should be relatively easily obtained.

TABLE 6.3

Estimated Crop Areas and Straw Yields

Farm Type	Total Area hectares	Grain yield per hectare tonnes	Total grain yield tonnes	Straw yield per hectare tonnes	Total straw yield tonnes
Groundwater irrigation	1665				
Wheat	832	2.00	1664	2.00	1664
Barley	83	1.50	124	1.50	124
Maize	166	1.50	249	2.50	415
Sesame	500	0.50	250	0.75	375
				seed cake	seed cake
				0.35	175
Lucerne	166	60.00	9960		
Soil irrigation	1878				
Wheat	188	0.90	169	0.9	169
Sorghum	1127	0.85	958	1.75	1972

Source: HTS estimates

TABLE 6.4

Estimated Animal Feed Value of Present Cropping in TDN, DP and LNU

	Total Yield Tonnes	Proportion available to stock per cent	Total available	TDN per cent	Total TDN	DP per cent tonnes	Total DP tonnes	LNU
Wheat Straw	1 833	80	1 466	40	587	0.3	4.4	1 074
Barley Straw	124	80	99	42	42	0.7	0.7	76
Sesame stalks[1)]	375	50	187	20	37	1.0	1.9	69
Maize stalks	415	80	332	50	166	2.0	6.6	304
Sorghum stover	1 972	80	1 578	45	710	1.5	23.7	1 300
Lucerne	9 960	95	9 462	15	1 419	3.5	331.2	2 599
Sesame cake[2)]	175	50	87	71	62	39.4	34.3	114
Total					3 023		402.8	5 536

Source: HTS estimates

Notes on table:

1) Sesame stalks are not generally recognised as a standard animal feed and information on digestibility, palatibility and nutritive value is not recorded. The factors applied assume that it is a low value fibrous material of low palatability similar to groundnut bushes or cotton seed hulls.

2) The proportion available to stock is set at 50% as it is understood that selected material is also used for human consumption.

TABLE 6.5

Conversion of estimated livestock population to LNU

Class	Total Number	Factor	Total LNU
Camels	1 067	2.50	2 667
Donkeys	1 733	1.25	2 166
Sheep and goats	31 155	0.25	7 789
Total			12 622

6.5.3 Protein Balance

The base maintenance ration calls for a TDN/DP ratio of 12.5 to 1. The ratio in the cropping sector, calculated from Table 6.4, shows a surplus of protein where the ratio is about 8 to 1. At most times of the year protein levels in browse will be satisfactory, with the late winter period being the time when deficiencies may occur. This deficiency may be evident amongst animals which do not receive lucerne rations at this period but these will be found mainly amongst the non-farm animals.

This is not seen as a major problem in comparison to the danger of overall fodder deficiency.

6.5.4 Minerals

The British Veterinary Team have found evidence of phosphorus deficiency in other parts of Yemen and preliminary findings indicate low levels of this mineral in soils in Wadi Abīda. Although no obvious clinical signs of the deficiency were observed in the project area during the short visit, there would appear to be a strong possibility that the deficiency is present.

Salt is reportedly given to animals but whether this is in sufficient quantity is not known.

CHAPTER 7

DEVELOPMENT POTENTIAL

7.1 GENERAL

The current gross cultivated ares in Wadi Abīda is some 4 472 ha and the potential gross cultivable area is considered to be 10 738 ha. To achieve maximum development of this potential there must be further mechanisation of agriculture, mainly in the form of seed drills and combine harvesters and the assurance and provision of a regular supply of irrigation water. It is proposed to build a dam with low level release gates across the Wadi Dhanah, above the site of the old Sabean dam, to provide water for seil irrigation from April to November or December, to improve aquifer recharge and to reduce water losses caused by excess water flowing into the desert. The dam will temporarily retain and regulate the flow of the water from the catchment area enabling it to be more fully utilised over an extended period. Further studies regarding the flow periods and quantities of seil water are required, but it is intended, subject to these further studies, to allow a flow of up to 50 m^3 per second of water through the low level sluice gates from April to the middle of August. The flood water will temporarily be retained by the dam during August and September and then released for the irrigation of seil land to be cropped with wheat. Between the old dam and Husūn al Jalāl permanent diversion works are proposed, in similar locations to the present main bunds, to retain the water released from the dam, principally for the seil irrigation of adjacent areas but also to increase aquifer recharge. From the lower bund near Birsaud the seil irrigation water would be canalised to the designated seil irrigation areas. The present system of bunds built in minor wadis will still be required to divert the water onto the land but their construction and maintenance will be facilitated due to the improved control of the seil water. In addition to meeting the aims stated above, the improved water control resulting from the proposed works will lead to reduced erosion of agricultural land and less damage to wadi banks. Only small changes in seil water rights, social organisations and

land rights are required to achieve these improvements in water availability necessary for the full development of Wadi Abīda. The construction and function of the dam, main diversion works and the groundwater development are discussed in appropriate detail in Annexes VI and VII.

7.2 FARMING SYSTEMS AND CROPPING PATTERNS

The proposed dam and seil water distribution will result in various changes in the farming systems enabling greater crop production through provision of a more reliable and regular supply of water.

The land cultivated through seil irrigation only, will gradually be planted with more wheat in the winter and more sorghum and some sesame in the summer. As a result of the controlled flow of water from the dam during the summer months it should be possible to irrigate sorghum more frequently and maybe take an additional ratoon crop in some areas. The seil water retained by the dam during August and September should be released from late September onwards, enabling the soil moisture to be replenished in the seil lands and subsequent planting of wheat. Although the improved supply of seil water from the dam cannot be guaranteed nor the time of supply, the crop yields should be higher than at present especially when the farmers have learnt to control and fully utilize the water. It is envisaged that the cropping intensity of sorghum will rise from its present 60% to 80% just after the dam is operational but reduce to 70% at full development as sesame will become part (up to 15%) of the cropping pattern. Cropping intensity of wheat will similarly rise from its present 10% to 20% and then to 30% at full development.

The land farmed under groundwater and seil irrigation system will also benefit through the improved control of seil water. It should be possible to irrigate the sorghum on the seil land more frequently thus increasing yields and therefore releasing some land for other more profitable crops. It is reasonable to assume that through the increased water control three or four seil

irrigations of a crop will be possible and thus some sesame can be grown. In the event of a bad seil year it would be possible to supplement the seil irrigation with groundwater. It may not be possible to apply the full crop water requirement in such cases but enough water should be available to produce a reasonable crop and thereby avoiding complete failure. Through the improved seil water control and agricultural improvements it is envisaged that the cropping intensity will increase after the dam is in operation from the present 109% to 121% and at full development to 139%.(1)

The effect of the proposed engineering works on farms relying solely on groundwater irrigation will be indirect in that due to increased aquifer recharge it will maintain the reliability of water extraction from the existing wells and also ensure that there is sufficient groundwater supply for new wells. This also applies to the wells on the groundwater and seil irrigated farms. Farms near seil water conveyance structures should be able to take advantage of this alternative water supply and use it during periods of seil water surplus. Through agricultural improvements the cropping intensity on the groundwater irrigated farms is envisaged to increase from its present 120% to 137% when the dam is operational, and then to 155% at full development.

The cropping intensities of the three different farming systems are shown in Table 7.1 for the first year the dam is operational and in Table 7.2 for full development. A typical cropping pattern for a groundwater irrigated farm and a seil irrigated farm at full development are shown in Figures 7.1 and 7.2. A typical cropping calendar at full development is shown in Figure 7.3.

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(1) Reservoir operation studies have shown that the security of the surface supplies is such that no practical difference between the cropping patterns of the groundwater only and mixed supply farms will develop. However, the conjunctive use pattern is included for completeness.

TABLE 7.1

Future Cropping Systems and Intensities
(First year of dam operation)

Farm Type	Crops	% Winter Crops	% Summer Crops	Cropping Intensity (%) (1)
A) Seil irrigation only (Net cultivated area 5 ha per farm)	Wheat	20	-	20
	Sorghum	-	80	80
Total		20	80	100
B) Groundwater irrigation only (Net cultivated area 4 ha per farm)	Wheat	65	-	65
	Sesame	-	35	35
	Maize	-	10	10
	Lucerne	10	10	20
	Vegetables	1	2	3
	Orchard	2	2	4
Total		78	59	137
C) Groundwater + seil irrigation (Net cultivated area 5 ha per farm)	Wheat	50	-	50
	Sesame	-	25	25
	Maize	-	8	8
	Sorghum	-	15	15
	Lucerne	8	8	16
	Vegetables	1	2	3
	Orchard	2	2	4
Total		58	64	121

Note (1) There are two possible cropping seasons, each with a potential cropping intensity of 100% thus giving a maximum possible intensity of 200%.

TABLE 7.2

Future Crop Intensities (Full Development)

Farm Type	Crops	% Winter Crops	% Summer Crops	Cropping Intensity % (1)
A) Seil irrigation only (Net cultivated area 5 ha per farm)	Wheat	30	-	30
	Sesame		15	15
	Sorghum (2)	-	70	70
	Vegetable		2	2
Total		30	87	117
B) Groundwater Irrigation only (Net cultivated area 5 ha per farm)	Wheat	75	-	75
	Sesame	-	40	40
	Maize	-	10	10
	Lucerne	10	10	20
	Vegetables	2	2	4
	Orchard	3	3	6
Total		90	65	155
C) Groundwater & seil irrigation (Net cultivated area 5 ha per farm)	Wheat	60	-	60
	Barley	-	-	-
	Sesame	-	30	30
	Maize	-	8	8
	Sorghum	-	15	15
	Lucerne	8	8	16
	Vegetables	2	2	4
	Orchard	3	3	6
Total		73	66	139

Note (1) There are two possible cropping seasons, each with a potential cropping intensity of 100% thus giving a maximum possible intensity of 200%.

(2) Assumes that through better control of the seil more profitable crops than sorghum can be grown.

Cropping pattern at full development : Groundwater irrigated farm

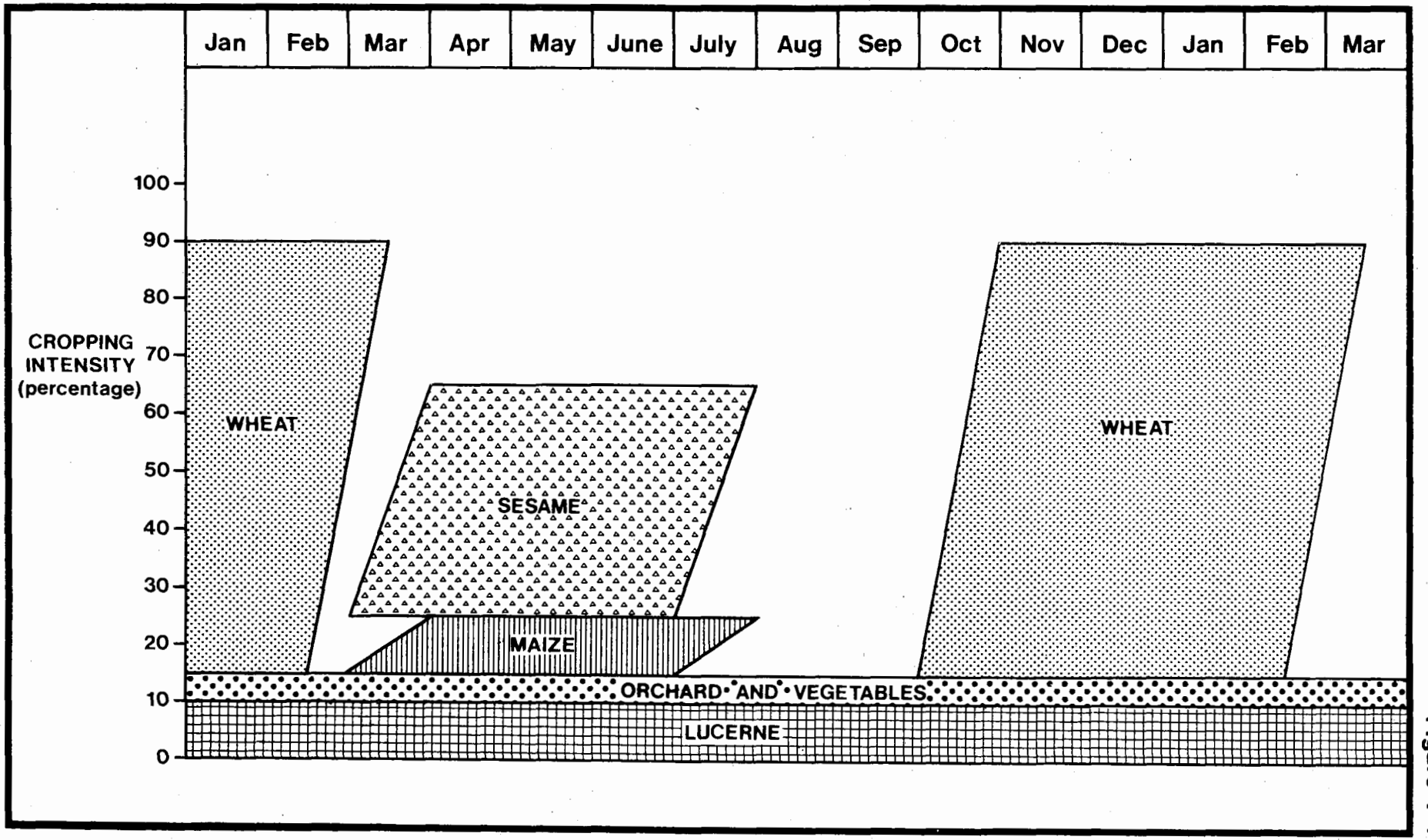

Figure 7·1

Cropping pattern at full development: Seil irrigated farm

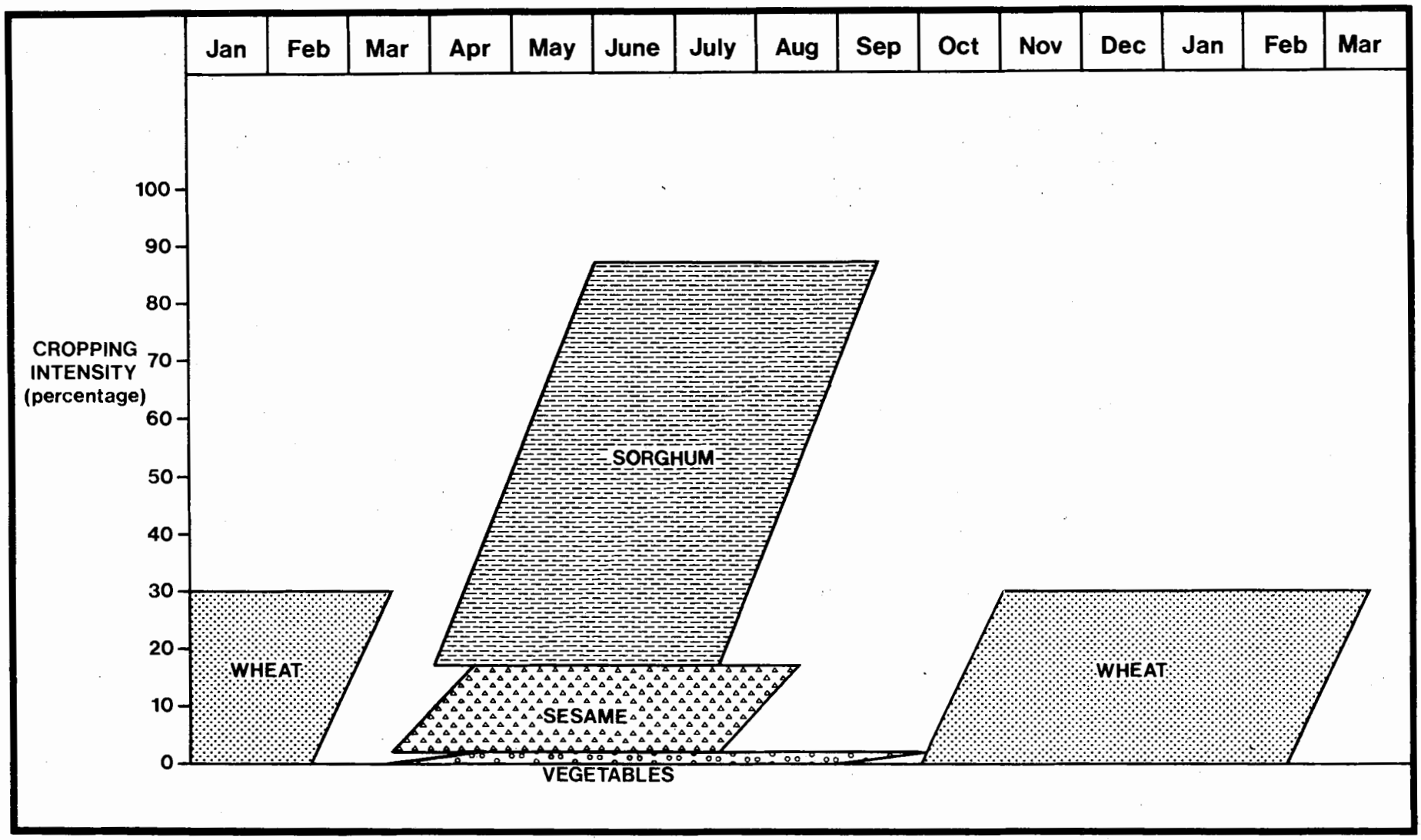

Figure 7·2

Cropping calendar at full development : Groundwater irrigated farm

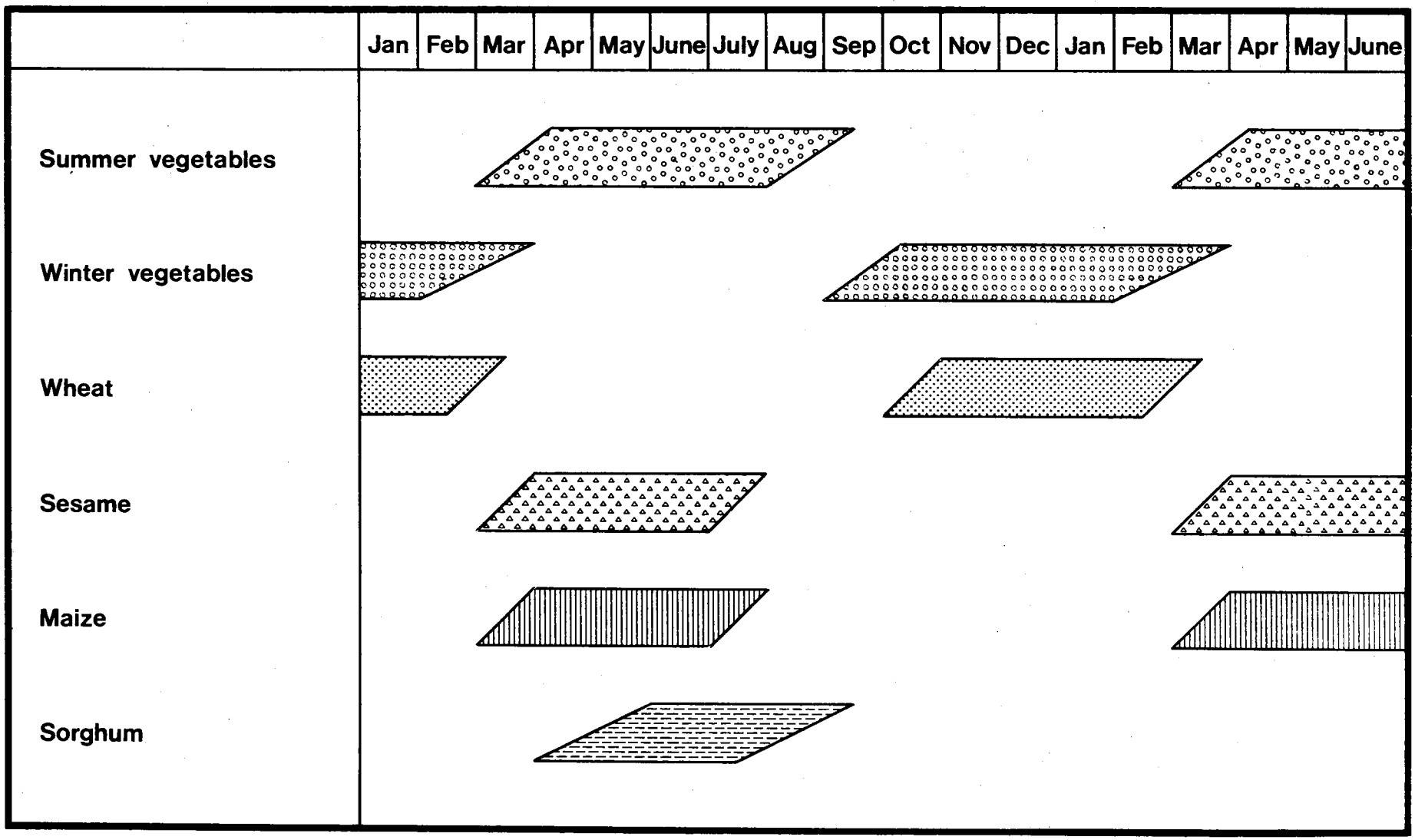

Figure 7·3

7.3 IMPROVEMENTS TO CROPPING

7.3.1 General

The objective of the agricultural improvements is to increase production per unit area and to bring into cultivation additional land, including some of that presently fallow, through methods that will be acceptable to the local people and that do not alter greatly existing social rights or organisations. These improvements consist initially of better cultural methods and the provision of extension services and later, the introduction of new crops, new varieties, harvesting machinery and improved water control from the completion of the dam. The cultural improvements do not have a time limit as they are an ongoing process and will still be continuing when the area reaches full development. Future crop yields are summarized in Table 7.3.

Table 7.3 Crop yields

Crop	Yield kg/ha		
	Present	Intermediate[1]	Full development
Wheat (well)	2 000	2 700	3 500
Wheat (seil)	900	1 000	2 500
Sorghum (seil)	850	1 000	2 000
Maize (well)	1 500	2 500	3 000
Sesame (weel)	500	800	1 200
Sesame (seil)	-	-	1 000
Vegetables (well)	1 500	9 000	15 000
Vegetables (seil)	-	-	11 000
Orchard (well)	1 500	3 000	6 000
Lucerne (well) (Green matter)	60 000	70 000	80 000

Note: (1) Intermediate stage assumes that all cultural improvements have been implemented, and coincides with the first year of dam operation.

There are many husbandry improvements that are common to all crops and these are as follows:-

a) Improved land levelling in the fields thereby establishing a more even application or irrigation water which will result in a more even crop stand.

b) Through improved land levelling bigger individual irrigation plots can be introduced thus reducing labour requirements for bund making and irrigation attendance time. At present the typical 30 to 40 m^2 irrigation plot takes six to ten minutes to irrigate and if this size is increased to 120 - 160 m^2 then the irrigation time will be 25 - 40 minutes, possibly allowing sufficient time for the person in attendance to carry out another useful job such as weeding. The exact plot size will need to be determined by trials carried out at the field trial-demonstration farm.

c) The introduction of a pre-cultivation irrigation followed by cultivation a few weeks later will improve weed control and facilitate cultivation. The irrigation also helps to build up the available soil moisture content.

d) The introduction of row cropping by use of a seeder attached to a tyne cultivator will greatly reduce seeding time, improve plant populations and facilitate weeding.

e) The labour demand for weeding will be reduced by the use of a hand hoe especially amongst crops sown in rows. Weeding by hoe, apart from being more effective, breaks up the soil surface thereby preventing soil capping.

f) From the irrigation trials conducted at the demonstration farm it will be possible to make recommendations to the farmers on irrigation techniques, timing and application rates. Correct irrigation applications will not only result in a higher yield but also in more economical use of water.

g) The introduction of seed dressings will help prevent losses from soil insects. However, great care must be taken to explain to farmers that dressed seed cannot be eaten and must not be sold unless suitably marked and then only to farmers or merchants for seed purposes.

h) Most farmers use their own seed for planting and better methods of seed selection will improve crop stands and reduce the quantity of seed required to achieve such stands. Possible methods of improving seed selection are selection of seed from the healthy high yielding stands, exclusion of weed seeds, careful threshing avoiding physical damage and storage of low moisture content seed in a suitable place where insect or rodent damage is minimal.

7.3.2 Wheat

The cultural improvements outlined should give a 25% yield increase over the first few years on well irrigated land. A seed rate of about 150 kg per ha should be used. During this time tirials can be conducted on new wheat varieties, planting dates and fertilizer response. Promising new varieties of wheat have been grown in Ibb and Yarim under guidance from the Central Agricultural Research and Training Centre, Taiz (CARTC)[1] where a 25% yield increase was experienced. The German Project (Sana'a) claims yields of up to three tonnes per hectare from farmers' fields using new varieties. These new varieties (Kalyan Sona, Sonalika and Chenab 70) respond to nitrogen fertilizer and CARTC made tentative recommendations for a split application of 90 kg of N on irrigated land and 60 kg of N on rain fed land. When improved varieties are introduced to the farms in Wadi Abīda and small applications of nitrogen fertilizer are used, a further yield increase of 25% - 30% is expected bringing the yield to about 3500 kg per ha. The new varieties will be rust tolerant but old varieties grown in the area are not, and therefore it is likely that the incidence of rust on the existing varieties will increase

(1) Talaat, E.H., Wheat and Barley Breeding and Agronomy Programme 1976 Central Agricultural Research and Training Centre, Taiz - Ministry of Agriculture, Yemen Arab Republic.

possibly causing a reduction in yield. The situation must be monitored closely and if rust disease becomes prevalent, then a special effort by the extension service will be necessary to persuade the farmers to change rapidly to the new rust tolerant varieties.

As wheat production increases and new areas are brought under cultivation, harvesting by hand will become increasingly more difficult and more labour consuming. The introduction of a combine for harvesting will alleviate this labour shorage and enable the crop to be harvested in a few weeks. At full development the whole wheat crop will be drill seeded in the first two weeks of Octover and harvested by combine about four and a half months later in February. To achieve a cropping intensity of 155% on groundwater irrigated farms at full development it is very important that all wheat is harvested by the middle of March so that the land can be cultivated and sown with sesame and maize during the same month. The introduction of a small thresher with a capacity of about one ton per hour will reduce labour demand and give cleaner, better seed, and improve straw quality. The thresher being relatively small can be moved easily from one threshing floor to another or to different areas.

Wheat on seil irrigated land can be expected to reach a yield of 1 000 kg per ha with improved cultural methods, mainly increased plant population and weeding. No further increases can be expected until seil water control is improved, thereby providing a higher residual soil moisture content for the plants to draw on.

7.3.3 Barley

Barley in Wadi Abīda is low yielding and it is proposed to replace the small area, some 83 ha, by wheat which is more profitable. However, areas with high soil salinity or which development high salinity will be better cropped with barley than wheat as it is more tolerant under such conditions.

7.3.4 Sesame

It is stongly recommended that sesame be sown in rows and grown in pure stands and not mixed with maize. This will enable a more even stand of a higher plant population to be achieved and will facilitate the singling and weeding operations. Optimum seed rates and spacings will need to be determined through trials but should be in the region of 6 - 8 kg of seed per ha at a row spacing of 30 - 40 cm. Trials should be conducted with new non-shattering types, preferably white seeded, as the borwn seeded variety is undesirable for industrial purposes. Response to fertilizer from the local varieties is likely to be very small and therefore not recommended. These cultural improvements are expected to raise the yield from 500 kg to 800 kg per ha. Further yield increases will depend on new varieties and fertilizer response, although experimental yields of up to 1 200 kg per ha have been obtained in teh Tihama[1] using local varieties with no fertilizer. A simple motor driven oil press should be introduced to replace the existing camel press thus increasing the rate of extraction and the percentage of oil expressed from the seed. The camel used on existing presses would be released for other work or for breeding purposes.

7.3.5 Sorghum

The potential to greatly increase sorghum yields is limited by water availability. With existing varieties the yield can be expected to reach 1 000 kg per ha, mainly through row planting and better weeding. The optimum seed rate is a matter of individual judgement as the seils are extremely variable but shouls be in the region of 15 - 20 kg per ha. Experimental yields of 3 000 to 4 000 kg per ha have been obtained in the Tihama with new varieties but with an irrigation interval of 15 days. Such an irrigation interval under weil irrigation conditions, even with improved water control through the dam, appears unlikely. Average

(1) Shehata A.H., Muqbal A.H., Shuja'a A.H., Abdel-Hamid F.A., Technical Bulleting No 6 1977. Tihama Development Authority, Ministry of Agriculture, Yemen Arab Republic.

yields using new varieties are expected to rise to 2 000 kg per ha.

Threshing by machine should be considered as it is likely that a single thresher could be economically run off the pump motor.

7.3.6 Maize

Present maize yields are low mainly due to intercropping with sesame and therefore it is strongly recommended that maize be grown in a pure stand. Monoculture should be achieved within three years and yields are expected, with existing varieties, to rise to an estimated 2 500 kg per ha. Two new varieties, Tihama Composite 1 and Tihama Composite 2[1] bred in the Tihama, have in field trials yielded 3 000 - 6 000 kg per ha using a recommended seed rate of 30 - 35 kg per ha and a row spacing of 60 - 70 cm. It is recommended that trials should be started immediately with these two varieties in Wadi Abida and the husbandry recommendations put forward by the Tihama Development Authority,[1] where applicable, followed closely. Trials to determine optimum planting dates, plant populations and fertilizer requirements should be carried out. In the Tihama, ammonium sulphate at 100 kg of active nitrogen per ha is recommended. It is likely that Tihama Composite 1 will be preferred locally as it is yellow grained similar to existing varieties grown. Tihama Composite 2 is white grained. Using new maize varieties and fertilizers, yields are expected to rise to 3 000 kg per ha.

A simple mechanised maize sheller should be considered especially when yield increases become apparent and the labour demand for hand shelling increases.

7.3.7 Pulses

The free draining soils of the area with their inherent fertility and the general climatic conditions are suitable for pulses. Beans unlike some pulses are not drought-tolerant and require moisture throughout the growing period. Pulse crops are particularly

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(1) Shehata A.H., Muqbal A.H., Shuja'a A.H., Abdel-Hamid F.A., Technical Bulletin No. 6 1977. Tihama Development Authority, Ministry of Agriculture, Yemen Arab Republic

sensitive to irrigation during critical response periods which occur at flowering and pod development. No pulses are grown on a field scale at present but it is strongly recommended that trials should be started. If the results prove satisfactory the pulses should be introduced into the cropping pattern to increase crop diversification and to improve crop rotations. Pulses, being legumes, form root nodules in the presence of the specific nodulating bacteria. Atmospheric nitrogen is fixed in these nodules and made available to the legume plant thus improving the nutrient availability. The nitrogen fixed in the nodules will be of benefit to a closely following crop such as wheat. Pulses are easily dried and transported but if consumed locally they will improve the protein content of the local diet. The haulms, providing they are not too dry, are palatable to livestock and will become an additional source of fodder.

From the many types of pulses it is recommended that trials should start with Haricot beans (Phaseolus vulgaris), chick pea (Cicer arietinum) Lentil (Lens esculenta) green gram (Phaseolus aureus) and black gram (Phaseolus mungo). The most suitable types and varieties for planting in March - April and harvesting in July/ August should be identified first and then more detailed trials concerning plant spacing, water requirements, irrigation frequency and cultural practices should be carried out before they are fully recommended and released to farmers. The plants should be sown on the ridge in pure stands and initially it may be necessary to innoculate the seed with the specific Rhizobium bacteria. Where legumes have not previously been used in a rotation a response to innoculum can be expected. Various legume trials have been conducted at CARTC Taiz, but no data are available on yields obtained at farm level. Yields in Wadi Abīda are initially expected to be 500 kg per ha rising to about 1 200 kg per ha at full establishment. Pulses should be introduced before groundnuts.

7.3.8 Groundnut

It is proposed that field trials should be conducted with

groundnuts as apart from being a source of food wither raw or roasted, they can be processed for oil and the haulms are nutritious and palatable to livestock. The husks from the nut are also a source of roughage for use with other animal feeds. Groundnuts, being a legume, have root nodules fixing atmospheric nitrogen for plant use. In Wadi Abīda it should be rotated with wheat which should benefit from the residual fixed nitrogen. Groundnut requires a warm climate and grows well on light reasonably fertile soils such as found in the area. Soil moisture must be maintained throughout the growth period or poor yields result. At harvest, dry conditions are required although the soil should be sufficiently moist to allow the nuts to be pulled without too many remaining in the ground. The Spanish or Valencia type of groundnut are erect and bunched in growth habit and mature in about four months. This type is more suitable for the area due to the shorter growing season than the Virginai groundnut, which is branching in growth habit and has a growth period of five to six months. The Spanish-Valencia groundnut produces a higher quality oil but has a lower yield.

Trials should be conducted with the Spanish-Valencia groundnuts to determine suitable varieties, planting dates, spacing, water requirements and cultural practices. Very few groundnuts are grown at present and the optimum planting date without rrials is difficult to determine. However, planting in April and harvesting in August is envisaged. Groundnuts grown in Taiz and Tihama have been severely damaged by termintes and it is possible that similar damage could be experienced in Wadi Abīda. However, during the short study period no evidence of termite existence or damage was seen. Chemicals are available for termite control but must be used with caution as the cheaper chemicals cause tainting of the nuts. Generally it is not economic to use the expensive, non-tainting chemicals for termite control. Groundnuts do not like standing water and therefore planting on the ridge is recommended. The optimum seed rate will probably be in the region of 40 kg per hectare. Applications of phosphate fertilizers are likely to increase yields. A yield of 750 kg of shelled nuts per ha is expected initially rising to 1 500 kg per ha after a few years.

7.3.9 Lucerne

Lucerne is an extremely important source of animal fodder and yield increases will help to reduce the browsing of natural vegetation and provide a more nutritious diet. Yield increases can be attained through sowing lucerne in rows thereby facilitating weeding and helping to maintain a pure stand. Lucerne should be cut above the crown and not at ground level. This will increase the recovery rate of the plants resulting in higher yields per cut or more cuts per year. Present yields are tentively estimated at 60 tommes green matter per year per ha and increases to 80 tonnes should be possible with 12-15 cuts annually. In Saudi Arabia[1] green matter yields of 120 tonnes per ha have been achieved experimentally using fertilizer and good irrigation management.

7.3.10 Vegetables and tree crops

Both summer and winter vegetables can be grown in Wadi Abīda, however local attitudes and lack of easily reachable outside markets limit the expansion. Vegetables production will increase slowly at first, although a more rapid increase can be expected after completion of the Sana'a-Ma'rib road. Many types of vegetables can be grown and are presently grown in ones and twos on individual well irrigated farms. Production should be concentrated on onions, peppers, egg plant, tomatoes, garlic, carrots, cabbage, beans, sweet melon and water melon. Pidgeon pea, should be mentioned because if planted on farm perimeters or irrigation ditches it not only provides a wind break but also a source of human and animal food. It is grown in the area but not fully utilized because the pods are not picked for local consumption nor are the leaves widely used for animal fodder. Young plants yield best and should not be grown beyond three to four years.

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(1) Farnworth, J. 1976 Irrigated forage production under extreme arid zone conditions in Saudi Arabia. Experimental Agriculture 12, 177-187 (Great Britain).

Improved and more suitable varieties of vegetable seed should be made available as local vegetable varieties appear poor and seed brought from Sana'a is not ideally suitable. Under improved husbandry techniques, yields should be higher and of better quality. Experimental trials conducted by teh Tihama Development Authority have shown water melon[1] to yield 38 tonnes per ha and tomatoes[2] 20 tonnes per ha without fertilizer.

The climate appears suitable for the production of citrus and other fruits such as grape pomegranate, and fig but husbandry techniques need to be improved. Apricots should be considered and preliminary trials carried out to determine suitability and yield potential. Establishment of orchards is long term and capital involvement is high as there is no financial return for the first few years. Initial returns, however, can be achieved if the rows between the trees are intercropped with vegetables or lucerne.

Citrus appears to be the most promising commercial crop and considerable interest has been shown by local farmers in attempting to establish fruit bearing citrus trees, although so far unsuccessfully. Care should be taken to establish trees in places sheltered from the wind or to establish windbreaks. Citrus is easily damaged by wind, producing scars where rubbing occurs and loss of leaves, blossom and small fruit in strong winds. Oranges which grow on the outside of the leaf canopy are liable to suffer from sun scold during the high summer temperatures whereas grepefruit which grow on the inside of the leaf canopy are less affected and therefore more suitable for the area. Rough lemon rootstocks are generally used but these are not tolerant of saline soils anmust be avoided under saline conditions. The high PH of the soils in the area could cause mineral deficiencies but can easily be adjusted using granular fertilizers or foliar sprays. Trials should be conducted using improved rootstock and compared with

(1) Shehata, A.H., Muqbel, A.H. Shuja, A.H. Technical Bulletin No. 5 Tihama Development Authority 1976 - Yemen Arab Republic.

(2) Shehata, A.H., Muqbel A.H., Shuja A.H., Abdel-Hamid F.A. Technical Bulletin No. 6 1977 Tihama Development Authority - Yemen Arab Republic.

local ones which do not appear to be of good quality. Rootstocks that have been successful elsewhere and have performed well under cold winter conditions are 'trifoliate orange' and 'troyer citrange'. Rootstock is brought into Wadi Abīda from many different places at present and if citrus production becomes established some form of control maybe required to prevent the spread of virus diseases from infected trees brought into the area.

7.3.11 Pests and Diseases

Plant damage or loss resulting from diseases or pests is at the moment low but as yields and cropping intensities increase so too will the incidence of disease. The opening of the San's-Ma'rib road could also bring into the area new diseases or strains to which local crop varieties are not tolerant. New varieties or crops introduced must be accompanied with the respective cultural improvements, fertilizers and disease control practices necessary to achieve optimum yields otherwise the true potential will not be realised. No chemical control is used at present and an increase in pests and diseases should be controlled by improvements in cultural methods, seeds and crop hygiene and judicious use of pesticides. The potential dangers of chemical control should be explained to the farmers, especially concerning seed dressings, and they should only be introduced as requred. The control of weeds by the introduction of expensive hervicides into a community not accustomed to chemical methods of control could be potentially dangerous due to misuse and spray drift caused by the almost perpetual windy conditions. The benefits of crop rotation for increasing yields, reducing weeds, pests and diseases and in maintaining soil fertility are generally recognised but should be further stressed as crop production increases and more land is brought under cultivation.

7.3.12 Mechanisation

The introduction of tractors and equipment to the area over the last decade has almost completely replaced the camel ploughs

traditionally used. Camel ploughs are however still used on seil irrigated land mainly for sorghum production. Farmers or contractors own the equipment and it generally consists of:

1) Tractor - Massey Ferguson 165
2) 3 furrow disc ploughs - Massey Ferguson 765, 25 inch disc
3) Cultivator - Massey Ferguson - nine types in two rows giving width of six feet
4) Grader - Massey Ferguson - six feet wide.

Land preparation and cultivation is fully mechanised bu improvements can be achieved in planting and harvesting both of which are still by hand. A simple seeder attached to the tyne cultivator or tractor drawn drill will speed up the planting operations ans assist in establishing well spaced optimum plant stands of crops in rows. The rows allow easier weeding and the more even plant stands and crop ripening, enable harvesting to be carried out by combine. Harvesting by combine, especially of wheat, will reduce the labour requirement and make labour available for other work. Farmers are accustomed to paying contracotrs for the hire of machines and combines and, if available, they will be much in demand. Some alteration in farm layout will be necessary for combining. The width of the irrigation plots when made should be a multiple of the combine cutter blade width and the length should be as long as possible but consistent with good irrigation practices. The cross bunds should be gently sloping and no higher than required to retain irrigation water. Initially the bunding operations will need to be organized so that the irrigation strips are larger and more regular and that the major bunds follow the contour. The present system of bunding is haphazard giving irregular irrigation basins with different shapes and sizes. The rate of combining will be slow because of the bunds and small areas, but one combine with a reasonalbe driver should be able to harvest at least 100 ha.

There is some indication that the present method of ploughing using 25 inch discs is causing soil erosion. The soils of Wadi

Abīda, with their very high content of silt and very fine sand, once broken up and exposed to the wind, are very easily eroded. Disc ploughing is only practised for wheat cultivation and trials should be conducted using a tyme cultivator instead of the disc plough. It may be necessary to use a chisel plough every few years in conjunction with the tyme harrow to break up the sub-soil.

7.4 LIVESTOCK PRODUCTION

The new road, currently under construction, from Sana'a to Ma'rib will reduce the present isolation of the area. It may also initiate a number of changes of which some will be of benefit to livestock and others detrimental.

In the long term better access will no doubt improve the chances of establishing beneficial infrastructure, such as extension and animal health services. It will also open a new market outlet for all agricultural procude including livestock. There is little doubt that the high price of firewoood in Sana'a will encourage tree and shrub destruction, which will have serious effects on the natural browse situaion and aggravate the already present problem of erosion and dune encroachment. New settlers will be attracted to the area and inevitably will bring in animals and therefore threats of more disease. Unless carefully supervised such addition livestock may upset the existing fine balance between stock and feed resources.

It has already been stated that there is opportunity for making significant and rapid improvements in the cropping sector through increasing yield levels, increasing crop intensity and expansion of cultivated area. Progress in livestock production would be in pace with the crop development and would largely depend on the introduction and expansion of extension and health services to ensure that the greater availability of animal feed was more efficiently used.

There seems to be little potential for any large scale livestock enterprises in view of ineffective rainfall and the need to use groundwater for continuous production of fodder.

The present mix of animals is ideally suited for the future. Camels should continue to exploit their specific browse with the object of producing milk and sale stock. Goats should continue as the major milk producer and through breed and management improvement take over milk currently supplied by sheep; levels of milk production could be raised sufficiently to allow for an overall reduction in goat numbers. Sheep development should be concentrated on improved meat production with some attention to better quality wool; the numbers retained could be increased considerably if the goat population were to decline. Cattle should not be reintroduced into the area.

A nucleus poultry industry is currently being developed in Yemen centred on Sana'a. In the short term there may be an opportunity to establish a small commercial unit in the project area to replace the present supplies of imported eggs. Under more propitious conditions it might have been possible to have carried out a more detailed investigation into this sector but a demand for eggs does exist and local grain is available for basic rations.

Dune encroachment is a slow but progressive danger to the project area. Effective measures must include the exclusion of livestock from areas where retaining vegetation already exists and where new fixing vegetation and windbreakers are to be planted. Under present conditions this would be hard to enforce unless the people are persuaded to co-operate for their own benefit. This persuasion might require the provision of an alternative fodder source which could only be provided through irrigated fodder either for cutting or grazing. It is stressed that the introduction of medium or large scale irrigated fodder production could not be justified on the grounds of a livestock project alone, the social necessity associated with dune fixation would be essential.

7.5 TREE BELTS AND SAND DUNE STABILISATION

7.5.1 Tree Belts

The planting of tree belts as sources of timber or as windbreakers should be carried out in conjunction with the sand dune stabilisation programme since they are complimentary and required in the same areas. The areas where trees are to be established for windbreak purposes would need to be subjected to the same strict controls as the dune stabilisation programme regarding cutting, pollarding, browsing, grazing and protection.

Timber is not plentiful and the available supply is of poor quality being brought down annually by the seils or lopped from the few existing trees in the area. The planting of trees would serve three purposes (a) windbreaks, (b) timber for building, and (c) firewood.

(a) Windbreaks: These can be either trees (Tamarix spp, Eucalyptus spp) in non-cultivated areas and on the edges of the farms or useful bushes (Cajanus cajan) and tall grasses (Saccharum and Pennisetum spp) within the boundaries of the farm. The use of quick growing trees as windbreaks provides an excellent opportunity for integration of wood production and agriculture. The effect of a well established windbreaks is to reduce wind velocity by about 50% over an area two to three times the height on the leeward side. A windbreak should consist of one to three rows of tall trees, 5 m apart between the rows and 3 - 4 m within the rows. Several rows of shrubs should be planted on the down wind side of the trees. By a reduction in wind velocity the harmful effect of wind blown soil particles on crops is lessened and due to reduced air movement the evapotranspiration is cut down, whilst the relative humidity is increased. These effects result in an improvement in crop quantity and quality, which is especially important for vegetables and tree crops. Also, the general living conditions for the inhabitants are improved.

(b) Timber for buildings: Building timber needs to be straight and of reasonable strength unlike wood used for fires. Timber from the mature windbreak trees could be used assuming the felling and replanting of such trees is controlled.

(c) Firewood: From the windbreak trees there would be a certain amount of timber wastage that could be used to supplement the existing firewood supply from local vegetation and the seil. The pressure for firewood is likely to increase as the area develops. Introduction of gas cooking stoves would help to alleviate the shortage, thereby protecting living trees from exploitation and would also improve cooking conditions.

Trees planted within farm boundaries should be multi-purpose varieties like Ziziphus spina-christi which is a source of timber, animal fodder, edible fruit and shade. The advantages of planting more trees should be explained to the farmer by the extension service and encouragement given by the provision of tree planting material. Acacia and Ziziphus are planted by direct sowing of the seeds while Tamarix is planted by unrooted cuttings and Eucalyptus by nursery grown stock. Trials concerning the most suitable tree varieties and methods of establishment should be carried out through the field trial-demonstration farm but the variety trials should be conducted with locally adapted trees at first rather than exotic varieties.

Areas where tree belts are to be planted could be controlled on a community basis through agreement with the land owning Sheik. With the introduction of a community water supply it may be possible to persuade the Sheik to set aside land close to the community wells for the establishment of tree belts and for the provision of subsequent protection.

7.5.2 Sand Dune Stabilisation

There is relatively little sand dune movement in Wadi Abīda, the

main areas of dune movement being north of the main wadi and, in particular, near Al Shebwān, Al Awash and the perimeter of the project area. The natural vegetation on these elevated sandy areas is dying off through lack of water which is probably a result of the bigger seil bunds that are being built between Husūn al Jalāl and Al Shebwan. The removal of this cover exposes the sand to the wind thus causing sand movement. During the summer months when the wind is strong there is even a small amount of sand/soil movement in areas where there is reasonable natural vegetation cover. The blown sand that accumulates in the wadis during the dry windy period of the year is swept away when the seil water flows down the wadi, thus avoiding the build up of sand dunes in the wadi which, if left undisturbed, would eventually encroach into the cultivated areas.

The balance between the natural vegetation as a source of browse for livestock and total livestock numbers appears at present to be in equilibrium. This means that the consumption rate of this browse is approximately the same as the regrowth rate of the plants. However an increase in livestock numbers without an adequate increase in available fodder sources would upset the delicate balance and through the increased grazing pressure, a rapid deterioration of the natural vegetation would occur. Over the last ten years through the advent of mechanized cultivation and transport coupled with the high prices for horses and camels in Saudi Arabia there has been a decline in livestock numbers. With present high animal prices and apparent boom economy in Wadi Abīda there could be a reversal in this trend over the next few years leading to further sand dune encroachment.

Sand dunes consist mainly of medium to coarse sand which moves almost entirely by saltation and surface creep and stabilization depends on reducing wind velocity at the surface or establishing a vegetative cover. Suitable plants must be ones that are well anchored, able to hold sand, catch the wind borne load and keep aerial parts above the accumulated sand. They must also be able to withstand abrasion.

Before any vegetation cover can be established on dunes it is imperative that the particular area be protected from all livestock browsing and that there is no pollarding or cutting of scrub bushes, or trees, or vegetation, that becomes self established.

A programme for sand dune stabilization needs to be established and should include investigations into:

(a) Area identification:

The location and extent of areas requiring sand dune stabilization should be identified and a list of priority areas drawn up.

(b) Selection of suitable species:

Trials should be set up to find the most suitable species of trees, bushes and grasses and should start with already established species in the area. Successfully established species of trees which would be suitable are Acacia, Tamarix, Eucalyptus and Ziziphus spina-christi. Other suitable plants are Salvadora persica, Calligonum commosum, Rhazia stricta and Leptadaenia pyrotechnica although the first two plants are a source of animal fodder especially for camels.

(c) Selection of appropriate planting and protection methods:

Before sand dunes can be permanently stabilized, temporary stabilization by artificial means needs to be achieved first. This could be done by covering the dune surface with plant residues, brushwood or mulching with special petroleum by-products and enclosing the whole area with barbed wire fence. For planting methods see section on Tree Belts. The water requirement for the establishment of the plants needs to be determined, probably five or six good waterings for the first year would be sufficient. After establishment the waterings could be reduced but this would be dependant on the trial results. In the majority of the areas a well would need to be constructed to provide the water necessary for irrigation of the plants. The number of wells would depend on the area to be irrigated and the water requirements.

(d) Local attitudes towards protection of the selected areas:

The views of the local people would have to be assessed regarding the value they would attribute to such protected areas and whether they are prepared to abide by the control regulations for protection and future browsing of the area. A community based system of control and protection would be most effective and acceptable and possible methods for setting up such control groups, may be through the Land Development Association, should be investigated. Selected areas would need to be in blocks within one sheikdom and control would have to be exercised by each sheikdom over its respective blocks.

The establishment of an efficient extension service would reflect in the success of the sand dune stabilization programme.

7.6 EXTENSION AND RESEARCH

7.6.1 General

Agricultural extension and research services are the responsibility of the Ministry of Agriculture. National coverage is uneven and at present confined to the central and south highlands and the Tihama coastal belt. The Ministry has only recently been established and although its budget increased from R1.71 million in 1973/4 to R10.4 million in 1975/6 expansion of its activities is limited by the human resources available.

The Ministry employs a total of 420 people (1975) of which only 54 are university graduates and a further 51 have secondary or post secondary education. Farmer level extension officers under present policy are selected from the areas in which they will serve, for a nine month course at Wadi Zabid in the Tihama. They then return to their areas and provide the essential link in the development process.

Government policy is to expand such services to the higher potential areas first and in line, as far as politically possible, with the Ministry's resources. The relatively low potential eastern areas of Yemen (the Mishrag) have very low priority for attention both for crop and for livestock husbandry.

Agricultural research for the Republic is co-ordinated by the Central Agricultural Research Organisation at Taiz. This organisation, supported by the Food and Agricultural Organisation of the United Nations, has already undertaken valuable work in several parts of the country.

7.6.2 The Project Area

The Wadi Abīda in common with the rest of the Mishrag receives no extension or research services. The proposed developments will be dependent upon an effective extension programme supported by field trial experiments to select suitable crop varieties and new crops.

There is good justification for extending the Ministry of Agriculture's coverage to the project area immediately in contrast to the very low priority given at present:

(a) The Wadi Abīda has a population of about 13 000 largely dependent upon irrigated crop husbandry. The population is in a compact area with easy internal physical access for staff.

(b) Investment in developing agriculture in the area, particularly water extraction and field cultivations, is substantial. It clearly illustrates farmers' interest in improving production. Crop yields are however often not high enough to justify the investment levels though they could be made so if husbandry was improved.

(c) The Yemen is a net importer of basic foodstuffs. The project area is renowned for producing good quality wheat as well as sorghum, sesame and other crops. Increasing the total output of these crops and expanding into vegetable production will help to reduce the trade deficit. The completion of the new Ma'rib - Sana'a road will open up the urban markets of Sana'a and Taiz making crop diversification practical. The present trade in wheat from the area to Saudi Arabia can also be expected to be diverted to the home market.

(d) The proposals in this report show that there is potential to increase the area's output. For social reasons this output can only be achieved by increasing the productivity of the present resident population rather than by any rapid expansion of the arable area or introduction of new settlers. This requires access to extension staff for the provision of advice on improved husbandry techniques.

(e) The area's present livestock population is in a delicate balance with the resources available. Education and practical advice are needed to ensure that this balance is maintained as the human population and farmed area grows.

(f) Practical assistance to the people of the Wadi Abīda, if undertaken without initial haste should extend Government's overall influence in the region. The community's loyalties to the Republic and participation in its affairs would be extended. The area is of importance in the Mishrag and and developments within it can be expected to have a stabilising influence on the region as a whole.

(g) Establishment of the Ministry in the Mishrag at the Governorate Capital in the project area will provide a good basis for the extension of activities to Harieb, Jawbah and Wadi Jawf.

7.6.3 Project Requirements

To implement the proposals made in this report Government and other agencies will need to provide the following services:

(a) Credit facilities through the Yemen Agricultural Credit Bank (See Chapter 9).

(b) Basic crop and livestock husbandry advice.

(c) Advice and co-ordination on sand dune stabilisation and tree planting.

(d) Field trials on new crop varieties and types and experimental work to assess the effects of "improved" husbandry practices.

(e) Advice on human nutrition and home economics. This activity will give the project a chance to influence developments through the women of the area.

7.6.4 Staff

The staff required to provide the extension and research services would be:

1 x local graduate agricultural officer, to take charge of the Ministry's work in the project area. The officer would be responsible for the formulation and implementation of the extension programme as well as for the operation of the proposed experimental - demonstration farm. This officer will most likely be a young graduate with little field experience in view of the scarcity of personnel with this level of education. He should therefore be able to rely upon support from Ministry headquarters particularly in the formulation of the extension programme.

1 x expatriate graduate agricultural officer to provide support for the officer-in-charge and to have special responsibility for field trials. This officer should have previous experience in irrigated agriculture including practical extension work or agronomic research or in both of these fields.

1 x diploma level agricultural officer to support the officer-in-charge particularly in the group's extension activities.

1 x female graduate or diploma level home economist for work specifically with women in the fields of nutrition, home economics and, where necessary, agriculture.

11 x agricultural demonstrators. These officers to be selected by the people of the area in which they are to work in conjunction with the Ministry of Agriculture for training at the Wadi Zabid training centre. The numbers to be built up over two years, or longer, depending upon the willingness of each area to agree to the idea and select suitable candidates.

Demonstrators to be selected as follows:

Ma'rib al Ashraf	2	Ar Ramsah and Ar Rukzah	1
Husūn al Jalāl	2	Al Jithwah and Al Hānī	3
Al Masal	1	Al Mardā	2

Staff should be of "all round" ability and able to provide extension relating to crops, livestock and resource management.

Work should be confined, during the first years especially, to the introduction of improved cultural techniques and crop varieties. No attempt should be made to cover aspects such as the redesign of farm layouts which could lead to misunderstandings and disputes. Considerable patience and an initial low-key approach will be needed since the officers will be Government personnel and as such their motives will be suspect until sufficient trust and goodwill has been built up.

7.6.5 Field Trial/Demonstration Farm

The extension service would be based upon a 10 - 15 hectare field trial/demonstration farm. The aims of the centre to be:

(a) To provide for field trials of new varieties and crops and improved husbandry techniques before introduction into the area's farming systems.

(b) To provide a small demonstration area.

(c) To provide a physical base including offices and houses for extension staff, and a seminar room for teaching and discussions.

Demonstration work should principally be carried out on individual farmer's lands and not solely upon the Government farm.

There is no Government or Waqf land in the project area. It could be obtained by direct Government purchase, by leasing a suitable area from an individual or by leasing from the Local Development Association after it had purchased land from an individual. The latter method might be preferred in that it would help to establish the centre as a community service in the minds of the population. However the land is obtained, it is essential that the Sheik and people of the area in which it is situated agree to its use and give firm assurances that it will be treated as a neutral area and that people from all other areas will be given free, unhindered access to it.

The introduction of new planting material should follow the quarantine recommendations of Government specialists in Plant Pathology and Pest Control. Evaluation trials should lead to demonstration/source material plots for the successful introductions. These should include the following.

(a) Introduction of new varieties of present arable crops. Some very good work on improved varieties has been carried out at Taiz and at the Wadi Zabid Research Centre and it is probable that some of these improved varieties can be distributed to the farmers after only short evaluation.

(b) Introduction of improved citrus and grape rootstocks.

(c) Introduction of new crops - initially limited to beans, groundnuts, vegetables, citrus and apricots.

(d) Seed selection, storage and dressing.

Improvements in animal husbandry should be an extension exercise only, adapting and making use of research results for elsewhere. Introduction of animal health services could later but only in line with suitable attitudes towards and facilities for marketing.

7.6.6 Field Trials

The field trials and demonstration plots must be planned and managed at the highest standards to be of any scientific value and to be convincing as demonstrations to local farmers. All experiments must be properly designed and systematically recorded so that the results can be statistically analysed. Trials with field crops should receive basal management at the anticipated optimum level, including thorough control of pests, diseases and weeds and the use of fertilisers, in order that each experiment tests the variable in question and is not limited by an uncontrolled constraint. Maximum use should be made of results of experimental work in other areas with similar conditions.

Crop experiments should be designed, directed and analysed by staff of the Ministry of Agriculture's Research Centre at Taiz. The agronomist based at the Field Trial/Deomonstration Farm would be responsible for day-to-day supervision of the trials and the recording of data. The initial research programme should not be over-ambitious.

Experimental programme should eventually cover the following:

(a) Cultural techniques to increase crop yields and reduce soil erosion and labour requirements - plant density and spacing; planting dates; weed control; crop rotations; mechanisation of planting, harvesting and threshing; fertiliser usage.

(b) Irrigation layout and methods - irrigation frequency, timing and application rate; the possibility of furrow irrigation for some crops.

(c) Methods of stabilisation of sand dunes - leading to a conservation programme.

CHAPTER 8

IRRIGATION WATER REQUIREMENTS

8.1 GENERAL

The water requirements of a crop can be determined from meteorological data in conjunction with various factors or co-efficients. There are many methods using climatic data the principal ones being those of Penman, Blaney Criddle, Thornwaite and Lowry Johnson. Penman's method, based on open water evaporation (Eo), is used in this report as factors like wind speed, air temperature, relative humidity solar radiation and sunshine hours are taken into account in the calculations and it has been successfully used in Wadi Najran which is 270 km northwest of the project area and in a similar location and altitude (see Chapter 2). Climatic observations and records were collected in Wadi Najran between 1968 and 1974 and in view of the similarity between the two locations and the non-existence of any form of weather data in Wadi Abīda the Penman monthly open water evaporation estimates from Wadi Najran have been used to calculate the crop water requirements.

8.2 POTENTIAL EVAPOTRANSPIRATION

Potential evapotranspiration (Et) refers to the water used for growth processes by crops grown under ideal conditions where available moisture, crop cover and leaf area are not limiting and also to the water evaporated from adjoining soil surfaces. In these conditions Et is related to open water evaporation (Eo) by a specific crop factor which varies according to crop growth stage, height, roughness and albedo.

At present the cropped areas tend to be isolated fields or blocks of fields. The hot dry air blowing in from the Empty Quarter over these irrigated areas will cause the actual evapotranspiration to be somewhat higher than Et estimates, especially on the field boundaries facing the prevailing wind. With the establishment of larger cropped areas and adequate windbreaks this edge effect will be reduced or eliminated.

The crop factors (f) used (Table 8.1) were obtained from experience in Pakistan, Nigeria, Australia and Ethiopia and adapted to local conditions.

8.3 ACTUAL EVAPOTRANSPIRATION

Actual evapotranspiration (Ea) refers to field conditions where the available soil moisture varies from a maximum immediately after irrigation or rainfall to a lower value prior to the next rain or irrigation. Potential evapotranspiration represents the potential demand for water by the crop and if this exceeds the potential transmission rate, the plant must either reduce the transpiration rate or become temporarily wilted. In either case the water used by the plant is reduced to below the potential evapotranspiration rate, the reduction increasing as the open water evaporation values increase. Therefore, by the introduction of a soil moisture factor (P) the variations in the rate of water uptake by the plant caused by the high evaporation rates are taken into account in calculating the water requirements. The report uses the soil moisture factors proposed by Fleming[1] which approximate to the Ea/Et curves of Denmead and Shaw[2] (Table 8.2).

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(1) Fleming, P.M. 'A water budgeting method to predict plant response and irrigation requirements for widely varying evaporation conditions'. VI Congress of Agricultural Engineering, Lausanne, Switzerland. 1963.

(2) Denmead, O.T. and Shaw, R.H. 'Availability of soil water as affected by soil moisture content and meteorological conditions'. Journal of Agronomy, 54, 385-390. 1962.

TABLE 8.1

Adopted monthly crop factors
(f)

Month	Wheat Barley	Sesame	Sorghum	Maize	Beans	Groundnuts	Summer vegetables	Winter vegetables	Lucerne	Grapes	Citrus
January	1.10							0.80	0.95	0.30	0.65
February	0.75							0.65	0.95	0.30	0.65
March		0.45		0.45			0.45	0.50	0.95	0.40	0.65
April		0.70	0.45	0.75	0.50	0.45	0.55		0.95	0.50	0.70
May		1.0	0.70	1.10	0.80	0.70	0.65		0.95	0.65	0.75
June		0.75	1.00	1.00	1.10	1.00	0.75		0.95	0.80	0.80
July		0.50	0.90	0.70	0.95	0.90	0.80		0.95	0.75	0.80
August			0.50		0.60	0.50	0.70		0.95	0.70	0.75
September							0.65	0.45	0.95	0.55	0.75
October	0.50						0.50	0.55	0.95	0.50	0.70
November	0.80							0.65	0.95	0.30	0.65
December	1.15							0.75	0.95	0.30	0.65

Source: HTS estimates.

Note: As lucerne is cut once per month the growth stages go from 0 to 100% per month with crop factors ranging from 0.45 to 1.20, giving an average crop factor of 0.95.

TABLE 8.2

Soil moisture factors

Available soil moisture per cent	Factor P for each range of Eo in mm/month			
	0-92.9	93 - 122.9	123 - 184.9	185+
100 - 75	1.0	1.0	1.0	1.0
75 - 50	1.0	1.0	0.8	0.6
50 - 25	1.0	0.7	0.5	0.35
25 - 0	0.5	0.3	0.25	0.15

Thus $Et = Eo \cdot f$

$Ea = Et \cdot P$

$Ea = Eo \cdot f \cdot P$

where Eo is open water evaporation, Et is potential evapotranspiration, Ea is actual evapotranspiration, f is a crop factor and P is a soil moisture factor.

The estimated monthly actual evapotranspiration totals for all crops are given in Table 8.3 and individual crop calculations including pre-irrigation amounts are given in Tables 8.4 to 8.14.

8.4 CROP COVER

The crop cover refers to the total percentage of any one crop growing in the project area in a particular month. The planting of a crop is not limited to a few days but is usually spread over one month as is the harvesting. Most of the crops have a fixed growth cycle dependent on crop variety, soil fertility and available moisture. For vegetable and fodder crops a staggered production is desirable.

TABLE 8.3

Estimated monthly actual evapotranspiration

m^3/hectare

Month	Wheat Barley	Sesame	Sorghum	Maize	Groundnut	Beans	Vegetables Summer	Vegetables Winter	Lucerne	Grapes	Citrus
January	1 470							1 070	1 270	400	870
February	840							730	1 420	450	970
March		390	430	390			390	430	1 650	690	1 130
April		1 340	1 560	1 440	650	480	1 060		1 820	960	1 340
May		2 220	2 320	2 450	1 560	1 780	1 450		2 110	1 450	1 670
June		1 740	2 130	2 320	2 320	2 550	1 740		2 200	1 860	1 860
July		590	560	830	2 130	2 250	1 890		2 250	1 780	1 890
August					280	670	1 180		2 140	1 570	1 690
September							340	230	1 960	1 140	1 550
October	630							930	1 600	840	1 180
November	1 200							970	1 420	450	970
December	1 460							950	1 210	380	820
Total for growing season	5 600	6 280	7 000	7 430	6 940	7 730	8 040	5 310	21 050	11 970	15 940

Source: HTS estimates.

TABLE 8.4

Estimated net monthly water requirement for wheat and barley

Wheat 4½ month crop grown over 5 months. Effective rooting depth 80 cm.
Barley Available soil moisture 25% volume. Total soil moisture available to crop 200 mm.

Month	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Total
Evaporation Penman Eo (mm)		211	166	141	148	166	832
Crop cover (%)		75	100	100	100	75	
Crop factor (f)		0.50	0.80	1.15	1.10	0.75	
Soil moisture factor (P)		0.80	0.90	0.90	0.90	0.90	
Actual evaportranspiration (Ea)		63	120	146	147	84	560
Soil moisture storage, pre-irrigation (mm)	100	50	50	-	-	-	200
Soil moisture deficit (mm)		-	-	-	66	84	150
Net water requirement (mm)	100	113	170	146	81	-	610

Source: HTS estimates.

TABLE 8.5

Estimated net monthly water requirement for sesame

Sesame 4 month crop grown over 5 month. Effective rooting depth 60 cm.
Available soil moisture 25% volume. Total soil moisture available to crop 150 mm.

Month	Feb.	Mar.	Apr.	May	June	July	Total
Evaporation Penman Eo (mm)		217	240	278	290	296	1 321
Crop cover (%)		50	100	100	100	50	
Crop factor (f)		0.45	0.70	1.00	0.75	0.50	
Soil moisture factor (P)		0.80	0.80	0.80	0.80	0.80	
Actual evapotranspiration (Ea)		39	134	222	174	59	628
Soil moisture storage, pre-irrigation (mm)	75	40	35	-	-	-	150
Soil moisture deficit (mm)		-	-	-	53	59	112
Net water requirement (mm)	75	79	169	222	127	-	666

Source: HTS estimates

TABLE 8.6

Estimated net monthly water requirement for maize

Maize 3½ month crop grown over 5 months. Effective rooting depth 80 cm.
Available soil moisture 25% volume. Total soil moisture available to crop 200 mm.

Month	Feb.	Mar.	Apr.	May	June	July	Total
Evaporation Penman Eo (mm)		217	240	278	290	296	1 321
Crop cover (%)		50	100	100	100	50	
Crop factor (f)		0.45	0.75	1.10	1.00	0.70	
Soil moisture factor (P)		0.80	0.80	0.80	0.80	0.80	
Actual evapotranspiration (Ea)		39	144	245	232	83	743
Soil moisture storage, pre-irrigation (mm)	100	50	50	-	-	-	200
Soil moisture deficit (mm)		-	-	-	67	83	150
Net water requirement (mm)	100	89	194	245	165	-	793

Source: HTS estimates

TABLE 8.7

Estimated net monthly water requirement for sorghum

Sorghum 3½ month crop grown over 5 months. Effective rooting depth 80 cm.
Available soil moisture 25% volume. Total soil moisture available to crop 200 mm.

Month	Apr.	May	June	July	Aug.	Total
Evaporation Penman Eo (mm)	240	278	290	296	281	1 385
Crop cover (%)	50	100	100	100	50	
Crop factor (f)	0.45	0.70	1.00	0.90	0.50	
Soil moisture factor (P)	0.80	0.80	0.80	0.80	0.80	
Actual evapotranspiration (Ea)	43	156	232	213	56	700
Soil moisture storage, pre-irrigation (mm)	150	50	-	-	-	200
Soil moisture deficit (mm)	-	-	-	94	56	150
Net water requirement (mm)	193	206	232	119	-	750

Source: HTS estimates

TABLE 8.8

Estimated net monthly water requirement for groundnuts

Groundnuts 4½ month crop grown over 5 months. Effective rooting depth 60 cm.
Available soil moisture 25% volume. Total soil moisture available to crop 150 mm.

Month	Mar.	Apr.	May	June	July	Aug	Total
Evaporation Penman Eo (mm)		240	278	290	296	281	1 385
Crop cover (%)		75	100	100	100	25	
Crop factor (f)		0.45	0.70	1.00	0.90	0.50	
Soil moisture factor (P)		0.80	0.80	0.80	0.80	0.80	
Actual evapotranspiration (Ea)		65	156	232	213	28	694
Soil moisture storage(1), pre-irrigation (mm)	75	75	-	-	-	-	150
Soil moisture deficit (mm)		-	-	-	84	28	112
Net water requirement (mm)	75	140	156	232	129	-	732

Source: HTS estimates.

Note (1) Soil moisture storage is brought up to full capacity by end of April to reduce overall water demand in May.

TABLE 8.9

Estimated net monthly water requirement for beans

Beans 4 month crop grown over 5 months. Effective rooting depth 60 cm.
Available soil moisture 25% volume. Total soil moisture available to crop 150 mm.

Month	Mar.	Apr.	May	June	July	Aug	Total
Evaporation Penman Eo (mm)		240	278	290	296	281	1 385
Crop cover (%)		50	100	100	100	50	
Crop factor (f)		0.50	0.80	1.10	0.95	0.60	
Soil moisture factor (P)		0.80	0.80	0.80	0.80	0.80	
Actual evapotranspiration (Ea)		48	178	255	225	67	773
Soil moisture storage[1], pre-irrigation (mm)	75	75	-	-	-	-	150
Soil moisture deficit (mm)		-	-	-	45	67	112
Net water requirement (mm)	75	123	178	255	180	-	811

Source: HTS estimates

(1) Note soil moisture storage is brought up to full capacity by end April to reduce overall water demand in May.

TABLE 8.10

Estimated net monthly water requirement for summer vegetables

Summer vegetables Average effective rooting depth 60 cm.
Available soil moisture 25% volume. Total soil moisture available to crop 150 mm.

Month	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Total
Evaporation Penman Eo (mm)		217	240	278	290	296	281	258	1 860
Crop cover (%)		50	100	100	100	100	75	25	
Crop factor (f)		0.45	0.55	0.65	0.75	0.80	0.70	0.65	
Soil moisture factor (P)		0.80	0.80	0.80	0.80	0.80	0.80	0.80	
Actual evapotranspiration (Ea)		39	106	145	174	189	118	34	804
Soil moisture storage, pre-irrigation (mm)	75	40	35	-	-	-	-	-	150
Soil moisture deficit (1) (mm)		-	-	-	-	-	34	41	75
Net water requirement (mm)	75	79	141	145	174	189	77	-	880

Source: HTS estimates

Note: (1) Soil moisture deficit has been taken as 50% of total soil moisture available.

TABLE 8.11

Estimated net monthly water requirements for winter vegetables

Winter Vegetables — Average effective rooting depth 40 cm.
Available soil moisture 25% volume. Total soil moisture available to crop 100 mm

Month	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
Evaporation Penman Eo (mm)	258	211	166	141	148	166	217	1 307
Crop cover (%)	25	100	100	100	100	75	50	
Crop factor (f)	0.45	0.55	0.65	0,75	0,80	0.65	0.50	
Ooil moisture factor (P)	0.80	0.80	0.90	0,90	0.90	0.90	0.80	
Actual evapotranspiration (Ea)	23	93	97	95	107	73	43	531
Soil moisture storage, pre-irrigation (mm)	50	50	-	-	-	-	-	100
Soil moisture deficit[1] (mm)	-	-	-	-	-	7	43	50
Net water requirement (mm)	73	143	97	95	107	66	-	581

Source: HTS estimates.

Note: (1) Soil moisture deficit has been taken as 50% of total soil moisture available.

TABLE 8.12

Estimated net monthly water requirement for lucerne

Month	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Evaporation Penman Eo (mm)	148	166	217	240	278	290	296	281	258	211	166	141	2 692
Crop cover (%)	100	100	100	100	100	100	100	100	100	100	100	100	
Crop factor (f)	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	
Soil moisture factor (P)	0.90	0.90	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.90	0.90	
Actual Evapo-transpiration (Ea)	127	142	165	182	211	220	225	214	196	160	142	121	2 105
Net water requirement (mm)	127	142	165	182	211	220	225	214	196	160	142	121	2 105

Source: HTS estimates

TABLE 8.13

Estimated net monthly water requirement for grapes

Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Evaporation Penman Eo (mm)	148	166	217	240	278	290	296	281	258	211	166	141	2 692
Crop factor (f)	0.30	0.30	0.40	0.50	0.65	0.80	0.75	0.70	0.55	0.50	0.30	0.30	
Soil moisture factor (P)	0.90	0.90	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.90	0.90	
Actual evapo-transpiration (Ea)	40	45	69	96	145	186	178	157	114	84	45	38	1 197
Net water requirement (mm)	40	45	69	96	145	186	178	157	114	84	45	38	1 197

Source: HTS estimates

TABLE 8.14

Estimated net monthly water requirement for citrus

Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Evaporation Penman Eo (mm)	148	166	217	240	278	290	296	281	258	211	166	141	2 692
Crop factor (f)	0.65	0.65	0.65	0.70	0.75	0.80	0.80	0.75	0.75	0.70	0.65	0.65	
Soil moisture factor (P)	0.90	0.90	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.90	0.90	
Actual evapo-transpiration (Ea)	87	97	113	134	167	186	189	169	155	118	97	82	1 594
Net water requirement (mm)	87	97	113	134	167	186	189	169	155	118	97	82	1 594

Source: HTS estimates

8.5 FIELD CAPACITY AND WILTING POINT

Field capacity is the maximum amount of water the soil can hold once the gravitational water has drained away. Normally field capacity is determined one or two days after an irrigation or heavy rain. Permanent wilting point is reached when the plant can no longer extract sufficient water from the soil to maintain transpiration and growth processes and permanent wilting occurs. The difference in moisture content of the soil between field capacity and permanent wilting point is called the available water capacities (AWC).

Tests carried out in the project area have shown that the available soil moisture is slightly lower for the old silts than for the more sandy soils in the Al Awash and Al Shebwān area. An average AWC of 25% by volume has been taken because approximately 70% of the soils in the cultivated and potentially cultivable area are silts.

8.6 ROOTING DEPTH

The effective rooting depth of a plant governs the depth to which moisture can be extracted from the soil. The following effective rooting depths were assumed:

Lucerne	- 120 cm
Wheat, Barley, Maize, Okra, Sorghum	- 80 cm
Sesame, Groundnut, Egg Plant, Pepper, Melon, Tomato, Pulses, Beans)	- 60 cm
Onion, Cabbage, Carrots	- 40 cm

8.7 PRE-PLANTING IRRIGATION

The moisture content of the soil before cultivation for planting arable or field crops is probably close to permanent wilting point and a pre-cultivation irrigation is necessary to restore soil moisture. Generally a pre-cultivation irrigation of 50% of the total available soil moisture is adequate to moisten the soil causing the germination of the weed seeds which are subsequently

destroyed by cultivation practices. The irrigation also provides sufficient available soil moisture for satisfactory germination of the planted seeds. The pre-cultivation irrigation should be applied two to three weeks before planting, allowing time for cultivation practices. The remaining 50% of the total available soil moisture should be applied with the scheduled irrigations but within the first six weeks after planting thus obviating any possibilities of water stress on the plants.

8.8 RAINFALL

The rainfall has not been taken into consideration because although it is thought to be in the region of 50 - 100 mm per year and falling between March-May and July-August, there is no information on the rainfall intensity, duration or peak rainfall months. It is likely however, due to high air temperatures and short duration rainstorms of moderate intensity, that the effectiveness of the rainfall is low. Rainfall records from other parts of Yemen show that the rainfall is very variable and cannot be guaranteed.

8.9 IRRIGATION INTERVAL AND EFFICIENCY

The irrigation frequency is determined by daily crop water use, rooting depth, allowable degree of soil moisture depletion, water holding capacity of the soil and rainfall. It has been assumed that there is no capillary rise of water from the water table as this is approximately 20 m to 30 m deep. The allowable degree of soil moisture depletion has been taken as 60% for all crops and 50% for vegetables with irrigation application depth ranging from 5 cm to 12 cm. Towards harvesting or maturity of the crop, irrigation applications are reduced to encourage even ripening and it has been assumed that 75% of the available soil moisture content will be taken up by field crops and 50% by vegetable crops.

Water conveyed by irrigation ditches from the well head to the fields is subject to losses by evaporation, seepage and water use by plants growing in or near the ditches. These ditches although reasonably short are unlined and often wind their way to the fields

but present transit losses are thought to be low. Irrigation losses in the field are mainly through run-off and deep percolation. Current field losses are low as the irrigation plots are small, some 30 - 40 m square, and someone is in constant attendance during irrigations. Farms under good management with straight irrigation ditches built with puddled silt and straw will achieve higher irrigation efficiencies than the farms with winding, unlined ditches. Future irrigation losses have been estimated at 10% transit loss and 15% field loss giving an overall irrigation efficiency of 75%.

It has been shown in Annex I that to maintain a low salt equilibrium in the root zone would require a leaching fraction of 5% - 9%, depending on groundwater quality. Obviously this will be adequately met within the assumed field loss of 15%.

The estimated net monthly crop water requirements are summarized in Table 8.15 and the number of irrigations required on a monthly basis are shown in Table 8.16.

TABLE 8.15

Estimated net monthly crop water requirements

(m^3/ha)

	Wheat Barley	Sesame	Sorghum	Maize	Beans	Groundnut	Vegetables Summer	Vegetables Winter	Lucerne	Grapes	Citrus
January	810							1 070	1 270	400	870
February		750		1 000			750	660	1 420	450	970
March		790		890	750	750	790		1 650	690	1 130
April		1 690	1 930	1 940	1 230	1 400	1 410		1 820	960	1 340
May		2 220	2 060	2 450	1 780	1 560	1 450		2 110	1 450	1 670
June		1 210	2 320	1 650	2 550	2 320	1 740		2 200	1 860	1 860
July			1 190		1 800	1 290	1 890		2 250	1 780	1 890
August							770		2 140	1 570	1 690
September	1 000							730	1 960	1 140	1 550
October	1 130							1 430	1 600	840	1 180
November	1 700							970	1 420	450	970
December	1 460							950	1 210	380	820
Total	6 100	6 660	7 500	7 930	8 110	7 320	8 800	5 810	21 050	11 970	15 940

Source: HTS estimates.

TABLE 8.16

Estimated irrigation intervals

Crop	Effective Rooting depth (D) (mm)	Permissible level of drying off (P)	Maximum[1] calculated water to replace per irrigation (mm)	Average field application (incl. field losses 15%) (mm)	Average evapo-transpiration during irrigation interval (mm)	Number of irrigations per month including pre-irrigation J	F	M	A	M	J	J	A	S	O	N	D
Wheat	800	0.60	120	120	93	1	-	-	-	-	-	-	-	1	1	2	1
Sesame	600	0.60	90	98	78	-	1	1	2	3	1	-	-	-	-	-	-
Sorghum	800	0.60	120	110	94	-	-	-	2	2	3	1	-	-	-	-	-
Maize	800	0.60	120	117	93	-	1	1	2	2	2	-	-	-	-	-	-
Groundnut	600	0.60	90	96	77	-	-	1	2	2	2	2	-	-	-	-	-
Beans	600	0.60	90	95	77	-	-	1	2	2	3	2	-	-	-	-	-
Summer Vegetables	600	0.50	75	86	67	-	1	1	2	2	2	3	1	-	-	-	-
Winter Vegetables	400	0.50	50	53	45	3	1	-	-	-	-	-	-	2	3	2	2
Lucerne	1 200	0.60	180	118	100	1	2	2	2	2	2	2	2	2	2	1	1
Grapes	1 500	0.50	187	117	100	-	-	1	1	2	2	1	2	1	1	1	-
Citrus	1 500	0.50	187	117	100	1	1	1	1	2	2	2	2	2	1	1	-

Source: HTS estimates.

Note: (1) Available soil moisture (A) = 25% by volume Calculation: $\frac{D \times P \times A}{100}$

CHAPTER 9

AGRICULTURAL CREDIT

9.1 SOURCES OF CREDIT

Funds for investment in the Yemen Arab Republic are most generally available from the savings of private individuals and from the private commercial sector. The banking system only extends back to 1962 and for the subsequent eight years the country's civil war effectively impeded its expansion. In 1962 the Yemen Bank for Reconstruction and Development was established to act both as an independent economic agent and as the agency for Government policy. The latter function was taken over in 1971 by the Central Bank of Yemen established in that year. Four other banks were established in 1970 and 1971 but were concerned overwhelmingly with the industrial and commercial sectors. In 1969 and 1971 attempts were made to form a national credit institution to serve the agricultural sector. These failed because of insufficient funds and the absence of adequately trained staff. In 1974 Government authorised the formation of the Agricultural Credit Fund (AFC).

The Yemen Agricultural Credit Bank was established in 1975 as a national organisation with a wider eventual coverage than the AFC.

9.2 PRIVATE SECTOR CREDIT

Government sponsored credit for the agricultural sector has been recently established and its coverage is only gradually being extended. In most areas, including Ma'rib, credit is only available from private individuals and merchants. Funds for development have been made available from earnings of individual family members working outside the Republic, in particular, in Saudi Arabia. Private transfers to the Republic have grown from R563.6 million in 1972/3 to R2363.3 million in 1975/6 and show no sign of reducing. In the project area, as elsewhere in the Yemen, individuals have used such monies for investment in their own farming operations. In particular funds have been invested in wells, engines and pumps, new and often more permanent housing

and to a lesser extent in farm machinery. Savings from outside the Yemen are, however, commonly supplemented by loans from local merchants, the suppliers of these new inputs, and from landlords. Merchant and landlord credit is generally short term, repayable over four months to two years depending on the amount and use. As a result of the Islamic stigma relating to usury, interest on loans, although charged, is not specified as such. The availability of credit to individuals depends upon their standing in the community, their record, if any, of settling previous debts and the lender's personal knowledge of the person. Figures obtained in the project area indicate rates of interest of 12% to 15% on loans repayable over one to two years. Excessive rates are undoubtedly prevented by the Islamic tradition relating to loans. The availability of credit to individuals varies a great deal and the non-repayment of a loan within the stipulated period can lead to repossession and a drying up of all future credit.

Short term credit is only in demand for fuel and the hire of machinery. For the farmer interest is high. For example diesel fuel can be obtained for R104 per 220 litres for cash, for credit this increases to R195 (+88%). For tractor hire a charge of R25 per hour is made for cash, R30 per hour for seasonal credit (20%). (Fuel prices vary according to availability and the figures above are lower than those prevailing during April, 1977). Such short term loans are generally repayable when the crop is harvested, a period of three to four months. Repayment may be in cash or in kind. Where in kind the crop is valued at the current Husūn Al Jalāl buying price. In at least one area, however, the value of crop is decided in advance between the Sheik and the merchant supplying credit, thus reducing the uncertainty prevalent in such transactions. In some cases credit is provided for the purchase of machinery under an agreement whereby the buyer repays by providing the seller with 25% of his crop during the payment period. The supplier in such cases is responsible for repairs and maintenance during the repayment period, the farmer being responsible for the provision of fuel and lubricants only.

9.3 AGRICULTURAL CREDIT FUND (ACF)

The Agricultural Credit Fund is financed by the Yemen Bank for Reconstruction and Development through an arrangement with Central Bank of Yemen. The International Bank for Reconstruction and Development and the Kuwait Fund use the ACF as a channel for investment. The ACF has offices in Sana'a, Wadi Mawr and Wadi Zabid confining its activities to the Tihama and Southern Uplands Development Projects. Short term production and medium term capital loans are provided including credit for the development of processing and marketing ventures. Borrowers are expected to provide 20% of the development cost and are charged interest at 8% to 9% per annum according to the type of loan.

9.4 YEMEN AGRICULTURAL CREDIT BANK (YACB)

In 1975 Government established the Yemen Agricultural Credit Bank with the objective of providing credit facilities for the sector throughout the Republic over a five year period. It is early yet to assess the degree of success obtained. Offices have been opened in Sana'a, Taiz and Ibb. In the Tihama coastal belt the Bank operates through the Agricultural Credit Fund's offices. Care is taken to ensure that services are not duplicated between the ACF and the YACB. The YACB's policy is to staff its branches as far as possible with people from the areas in which they are situated. Its policy of gradual expansion has been thought out bearing in mind the various region's possible potential for credit absorbtion and Government control. Ma'rib as a result is scheduled to receive a branch only during the last year of the five year period. However, the plan is flexible and the Bank would be willing to consider operating in the project area providing certain safeguards were assured. These include the provision of funds from government or other sources for the area which could be on-lent at the minimum of risk. Ideally the repayment by farmers of such funds would have to be guaranteed by the funding body, the Bank merely acting as a servicing, not a risk taking, agent.

The principle difficulty foreseen by the YACB is that of security. Generally this is in the form of land and the Bank fears possible problems in areas of little Government control such as the Wadi Abīda. Repayment levels to date have however been good in the areas now covered.

The YACB provides a comprehensive set of loan types both to individuals and to Local Development Associations and co-operatives. Short term credit is available for periods of less than twelve months at an annual interest rate of 9%.

Medium and long term credit for machinery, buildings and other farm improvements is available at 8% annual interest.

Loans are available for all farming, livestock, forestry and fisheries activities. Credit is as far as possible provided in kind, very little cash being disbursed and each branch employs staff sufficient to adequately supervise loans.

The interest rates are attractive to borrowers compared to those charged by merchants and landlords and the Sana'a branch has already been approached by a number of producers in the Ma'rib area for loans. These cannot be granted, however, until the YACB is operational in the Governorate.

9.5 CONCLUSIONS

Development in the project area will increase the demand for credit at reasonable interest levels. The expansion of seasonal credit can be expected in particular as growers are encouraged to purchase improved seed and extend mechanical cultivation and harvesting.

The Yemen Agricultural Credit Bank should be induced to open a branch in the project area as soon as the project commences. The YACB will require some degree of guarantee against losses that might arise as a result of the independent nature of the area. However, this could only be justified for a limited period, the

first three years at the most. During this period it is reasonable to assume that Government control will have been sufficiently extended to bring the levels of risk into line with those now in areas where the YACB operates.

Initially the YACB branch will be small, operated by one loans-supervisory officer and a clerk.

CHAPTER 10

AGRICULTURAL TAX

10.1 SYSTEM OF TAXATION

In common with all other parts of the Republic farmers and livestock owners in the Wadi Abida are subject to agricultural taxes, collectively known as Zakat. This traditional system of taxation has a religious origin and is still generally viewed as a religious obligation, particularly in the more traditional areas such as Ma'rib. Revenues are now collected by Government where it is in a position to do so.

Income under the Zakat system accrues from crops, livestock and from individual wealth.

National revenues from this source totalled R19 million in 1975/76 of which R12 million was from crops and R1.5 million from livestock. Since the end of the recent civil war collection of Zakat has increased substantially as shown in Table 10.1, an indication of Government's increased acceptance throughout the country.

Table 10.1 Zakat revenue accruing to Central Government 1971-1976

R million

Source	1971/2	1972/3	1973/4	1974/5	1975/6
Crops	6.68	0.65	7.99	8.40	12.00
Livestock	0.82	0.80	1.08	1.40	1.50
Wealth	1.03	1.71	2.15	0.75	2.00
Pool	2.23	2.98	4.53	4.10	3.50
Total Zakat	10.76	6.14	15.75	14.65	19.00
Total Revenue	151.27	199.02	275.20	379.60	485.30
Crop and livestock Zakat as proportion of total revenues %	7.1	3.1	5.7	3.9	3.9

Source: Statistical Year Books 1974 - 75 and 1976 Yemen Arab Republic Central Planning Organisation Sana'a.

There are however still areas from which very little or no revenue is obtained. Zakat as a proportion of total Government revenue has been falling as income from other sources increases, particularly indirect taxes including import tax and customs duties. Zakat now stands at almost 4% of total revenue.

10.2 LEVEL OF ZAKAT

Zakat under the Republic's previous regime was assessed for each individual by specially appointed officers. At present however the tax is self-assessed by each individual on the basis set out in the Koran. There are no Government checks on the assessment levels.

The tax is levied at rates stipulated in the Koran which are uniform throughout the country. Crops are assessed on total production including that used by producers for subsistence. Crops derived from well irrigated lands are subject to Zakat at 5% of their value, from seil irrigated and dryland areas at 10%.

In the Ma'rib Nahiyat livestock is assessed on the basis of the Nesab system. This results in the following levies:

Camels	-	R100 for every five head
Sheep, goats	-	R100 for every forty head
Cattle	-	R100 for every ten head

There are no owners in the Governorate who qualify for Zakat on cattle. The tax is not payable in respect of poultry or livestock products.

The tax is payable to the Government's office within one month of harvest. It must be made in cash for livestock but can be in cash or in kind for crops. The cash value for crops is determined by the general price level prevailing in Husūn Al Jalāl during the harvest periods.

Zakat collected in each Governorate is shared on an equal basis

between central Government and the area itself. 50% of the tax can be retained in each Governorate for expenditure on community projects. The dispersal of these funds is decided by a small committee under the chairmanship of the Governor. In most areas this group includes strong representation from the Local Development Association which is often the body responsible for the implementation of community projects.

10.3 MA'RIB ZAKAT INCOME AND EXPENDITURE

Government's presence in the Ma'rib area was only established in 1973 and is still nominal in a number of areas including those in the project area. Cash submitted to Government from crops and livestock in the whole Governorate amounted to R300 000 in 1976. In addition 1 300 kada (42 900 kg) of wheat, 300 kada (9 900 kg) of sesame and a very small quantity of sorghum was paid to Government. In 1973 the Zahat collected amounted to only 250 kada (8 250 kg) of wheat and 70 kada (2 310 kg) of sesame.

Despite the steady improvement in Zakat collection there are still many who do not pay the tax to Government or who only pay the 50% of their assessment they feel is Government's due. Such people, and they include many who farm close to the Governorate capital, pay the tax themselves but in the form of direct contributions to the area's needy.

The bulk of monies paid to the Government that are kept in the area, R150 000 in 1976, are dispersed in the form of supplementary payments of R200 per annum to the 300 teachers in the Governorate. In 1976 R20 000 was provided to initiate the building of a school at Husūn al Jalāl in the project area.

There is considerable scope for the improved collection of Zakat in the Wadi Abīda area as well as the Governorate as a whole. The experience of the period since 1973 suggests that improved coverage will occur in the future though only gradually.

CHAPTER 11

MARKETING

11.1 FOREIGN TRADE

The Yemen Arab Republic has suffered a growing foreign trade deficit for many years as illustrated in Table 11.1.

Table 11.1 Summary of foreign trade, Y.A.R. (1969-77)

R'000

	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76	1976/77[1]
Exports	19323	13498	24701	25269	55382	52966	50063	3759
Imports	166629	174562	204428	410666	444980	981004	1706894	363465
Trade deficit	147306	161064	179727	385397	389598	928038	1656831	359706

Source: Financial Statistical Bulletin. Vol. 4 No. 1 Central Bank of Yemen, Sana'a.

(1) July to September 1976, only.

The deficit has grown by over 1 000% during the period 1969/70 to 1975/76 even though the value of exports more than trebled during the same period. As shown in Table 11.2 imports of food and live animals accounted in 1975/76 for 43% of the value of total imports as compared with 45% in 1971/72.

During 1975/76 almost one third of this category of imports were cereals and cereal products, second in value only to sugar. Animals and animal products and fruit and vegetables represented 6.5% and 9.5% of those imports respectively.

Table 11.2 Value of certain imported commodities, Y.A.R. (1971-77)

R'000

Item	1971/2	1972/3	1973/4	1974/5	1975/6	1976/7 (1)
Total imports	204428	410666	744980	981004	1706894	363465
Food and live animals	90942	176337	364377	418631	741569	111759
Live animals	220	6	49	1357	9513	2176
Meat and meat products	81	733	618	829	3831	1156
Dairy products and eggs	2183	7346	14586	20359	34627	9107
Cereals and cereal products	45013	74313	154350	165142	235126	46881
Vegetables and fruits	9105	18625	32310	43546	70407	16090
Coffee, tea and spices	5931	16387	23392	24680	48055	6512
Sugar and sugar products	20744	40832	101663	119403	242141	15948
Animal feedstuffs	-	16	69	25	664	41
Vegetable oils	2314	5366	2833	3565	2398	756

Source: Financial Statistical Bulletin. Vol. 4 No. 1. Central Bank of Yemen, Sana'a.

(1) July to September 1976, only.

The Republic's exports during 1976/76 were predominantly cotton and cotton seed (52% by value), hides and skins (16%) and coffee (15%) as illustrated in Table 11.3.

Table 11.3 Value of main exports, Y.A.R. (1971-77)

R'000

Item	1971-2	1972-3	1973-4	1974-5	1975-6	1976-7(1)
Total exports	24701	25269	55382	52966	50036	3759
Live animals	341	768	643	443	6	-
Fruit: fresh & dried	161	197	56	88	164	180
Coffee	5534	5496	6461	4972	7588	1030
Qat	2327	247	31	-	395	226
Cotton & cotton products	10899	13138	37378	32544	25967	118
Raw hides & skins	3271	3325	6241	4404	8040	918
Potatoes	239	392	115	141	135	1

Source: Financial Statistical Bulletin. Vol. 4 No. 1
Central Bank of Yemen, Sana'a.
(1) July to September, 1976 only.

It is Government policy to reduce the present dependency on food imports, in particular, by encouraging the proudction of cereals, vegetables, fruits, vegetable oils and livestock products.

The project area produces surpluses of wheat and sesame at the present time.

11.2 PROJECT AREA CROPS

In addition to wheat and sesame, sorghum, maize and small quantities of barley and vegetables are now produced in the Wadi Abīda. For rotational purposes rather than cash profitability

it is suggested that some beans and groundnuts be grown in the future.

11.2.1 Cereals

Table 11.4 provides a breakdown of cereal and flour imports for the calendar years 1973 to 1975.

Table 11.4 Cereal and floor imports (1973-1975

	1973		1974		1975	
	Quantity	Value	Quantity	Value	Quantity	Value
	tonnes	R'000	tonnes	R'000	tonnes	R'000
Wheat	71216	46690	74690	93171	119774	135774
Rice	2145	2565	4424	14132	6278	17482
Barley	3	7	n.a.	4	-	-
Millet	-	-	27061	20900	-	-
Maize	18118	8705	2139	2783	6249	6241
Sorghum	-	-	-	-	6	5
Flour	75859	49616	35589	35211	55797	62972
Total	167341	107583	143903	166201	188104	222474

Source: Yemen Arab Republic Statistical Year Books 1974-5 and 1976. Central Planning Office, Sana'a. Foreign Trade Statistics. 1975. Central Bank of Yemen.

The Republic's resident population presently require about 1.3 million tonnes of grain annually and imports provide 15% of this. In order to achieve import substitution by 1980 local production will have to be raised by 60%. While sorghum and wheat will become in greater demand as incomes increase.

Imports have continued at high levels since 1975 even though local output has increased during the past two good growing seasons.

Wheat: Wheat grain and flour are a major import and Government is placing emphasis upon increasing local production both by encouraging wider plantings and increased yields. The project area has a reputation for producing local wheats of the quality much in demand in the Republic. It was estimated by the study team that production from the 1 020 ha in the project area totalled almost 1 833 tonnes in 1976 - 77 with a value to producers of about R4.6 million. Wheat is considered a cash crop and a good proportion is sold to local merchants. The crop is thereafter exported to Saudi Arabia which is close and of easy access and where very high prices prevail. Present production valued at import price levels would, if consumed within the Republic, be worth over R2.1 million less the value of the grain utilised presently within the Wadi Abīda.

The price of imported and domestic wheat has been falling since the high levels of 1974. This has not however affected the project area where levels are governed by those in Saudi Arabia and by the high quality of grain, which is in much demand. During 1976 and early 1977 producer prices in the area have varied from R3 100 to R2 300 per tonne at Husūn al Jalāl.

Barley: As it is not in great demand, barley is only produced on a small scale in the project area, an estimated 124 tonnes from 83 ha, locally valued at about R186 000 in 1976-77. It is likely that this crop will be replaced by wheat within a few years. Local prices vary from R2 000 to R1 400 per tonne in the project area.

Sorghum: The principal subsistence crop in the project area is sorghum which is planted on some 1 130 ha of seil irrigated land. Over 960 tonnes were produced in 1976 with a local value of approximately R1.0 million. Little of this grain is traded but Husūn al Jalāl prices are said to have been from R1 140 to R850 per tonne in 1976. Demand is for white sorghum rather than the red variety and can be expected to increase. Only small quantities are imported into the Republic.

Maize: Imports of this grain have been growing and in 1975 totalled 6 249 tonnes at a value of almost R1 000 per tonne. The value per tonne has decreased since, but local prices remain high and as with some other crops especially so in the project area with its easy access to Saudi Arabia. Nevertheless maize is not generally considered a cash crop in the area where some 166 ha of well irrigated lands produced about 249 tonnes in 1976 with a median local value of R448 000. Much of the crop is grown as a mixed stand with sesame.

Local preference is for the cob roasted whole rather than for maize flour. The latter is however consumed on occasions. The local Ma'rib market for maize will probably remain small though in due course some demand, probably on an 'own production' basis, may arise for its use as animal feed. There is scope, however, for sales to other parts of Yemen at prices that will be considerably lower than presently prevail in the Wadi Abīda. Husūn al Jalāl prices in 1976 were reported as varying from R1 700 to R1 995. Cobs fetch about R1.30 for four.

11.2.2 Sesame

This important cash crop is the only oilseed grown in the area. An estimated 500 ha produce 250 tonnes of seed representing 75 tonnes of sesame oil at local extraction rates. Imports into the Republic of sesame seed have grown from 376 tonnes in 1973 to over 1 000 tonnes in 1976. Most of this is used by the Yemen Biscuit Company in Taiz for the manufacture of compressed sesame cake. Unreliable local supplies and high prices have forced the company to rely upon imports. Large quantities of vegetable oils are also imported as shown in Table 11.2. Imports fluctuate but averaged R3.3 million between 1971/72 and 1975/76 representing some 1 700 tonnes annually.

Sesame oil is extracted in the project area by camel powered traditional presses with an estimated yield of 30% oil. Millers charge one tenth of the seed brought in for extraction as well as keeping the cake. Local prices are generally high though

extremely variable. In 1976 they reached over R5 000 per tonne of seed and R22 per litre for oil. More realistic levels however would be R10 per litre for oil and R3 000 per tonne seed.

Demand at these prices is very localised and total consumption in the Republic unknown for lack of data. If the crop can be grown more economically than at present then the market which does exist in Yemen and neighbouring Saudi Arabia will be worth exploiting. This will mean considerably higher yields than the estimated 500 kg per ha at present.

11.2.3 Fruit and Vegetables

Production of fruit and vegetables in the Wadi Abīda is small and confined to the well irrigated farms. 50 ha are devoted to these crops producing a possible total of 75 tonnes. Imports into the Republic have increased in value since 1971/72 by 770% to over R70.4 million in 1975/76. Table 11.5 sets out the latest figures available for quantities imported during the calendar years 1973 to 1975.

Table 11.5 Fresh fruit and vegetable imports (1973-1975)

		1973	1974	1975
Fresh fruit:	tonnes	3371	3327	3782
	value R'000	4920	4854	7346
Fresh vegetables:	tonnes	12	147	391
	value R'000	20	291	554
Total:	tonnes	3383	3474	4173
	value R'000	4940	5145	7900

Source: YAR. Statistical Handbook 1976. Central Planning Organisation, Sana'a. Foreign Trade Statistics 1975. Central Bank of Yemen.

Fruit imports include substantial quantities of apples, oranges, dates and bananas. Vegetables include potatoes, tomatoes and a range of others. Whilst fruit imports have grown moderately, imports of vegetables have risen very substantially indeed.

Local fruit is confined to grapes, figs, water and sweet melons. Vegetables grown include beans, tomatoes, onions, okra, egg plant and peppers.

None of the locally grown crops are traded except in very small quantities, indeed onions from Harieb are commonly to be found for sale in Husūn al Jalāl.

There are reasonable prospects for increasing the production of these crops once the new road to Sana'a is completed. Local vegetable yields are difficult to assess but yields of 10 to 15 tonnes per ha should easily be realised and would be a substantial increase on present levels.

Other crops that are considered for future production in the Wadi Abīda include pulses and groundnuts.

11.2.4 Pulses

Production in the project area of pulses is very small and is confined to beans for use green. The local population is not inclined to consume pulses except for small quantities of fenugreek.

Imports into the Yemen of dried pulses appear to be variable, as shown in Table 11.6.

Table 11.6 Imports of dried pulses (1973-1975)

		1973	1974	1975
Dried pulses:	tonnes	335	1417	796
	value R'000	439	1751	1484

Source: YAR Statistical Handbook 1976. Central Planning Organisation, Sana'a. Foreign Trade Statistics. 1975 Central Bank of Yemen.

Market prospects are good for a variety of pulses in the Yemen including kidney, haricot, broad and other beans and lentils.

11.2.5 Groundnuts

As shown in the section on sesame, vegetable oil imports into north Yemen are substantial and recently an oil extraction plant has been established at Taiz. In addition groundnuts are popular in the main consumption centres.

Production of both pulses and groundnuts would however depend upon good yields. Nevertheless legumes could be justified on a small scale for rotational purposes and would reduce the need for nitrogen fertiliser.

11.3 PROJECT AREA MARKETING

Private commercial activity is well established in the Republic's main centres and most rural areas have access to the commercial sector to a greater or lesser degree.

The project area is physically isolated from the main consumption centres and trade is directed mainly to Wadi Najran in Saudi Arabia. This applies both to exports, particularly wheat and

imports including vehicles, fuel and machinery. At Husūn al Jalāl there are four principal merchants who operate independently though three are brothers. There are in addition a number of small scale shopkeepers most of whom were originally from outside the Wadi Abīda, where the activity of trading tends to be despised. The level of commercial activity is not high and the quantity and range of goods retailed is at present limited. As illustrated in the section on farm budgets net, disposable income is not substantial, despite the high investment of recent years and the high prices paid for cash crops.

Very few items are sold directly by producers who generally deal with the local retailers or, for larger quantities, with the merchants. The trading pattern in the area does provide for a reasonable degree of competition though merchant credit for capital and operating costs does mean that there is a tendency for producers to regularly deal with one or other of the merchants. It is possible however to settle debts in cash rather than in kind. The merchants have over a period of time established a range of contacts in both the Yemen and Saudi Arabia.

Wheat is mainly traded with other merchants in Wadi Najran and sesame seed and oil tends to be sold to Sana'a and Taiz in the Yemen itself. Other grains, fruit and vegetables are not handled except in the smallest quantities almost all for local consumption. The bulk of produce sold is done so within a month of harvest to allow for credit payments, Zakat tax where paid to Government and to provide for immediate cash needs. Wheat is traded mainly during February and March, sesame during July and August. The farmers met by the study team nevertheless did show an awareness of the value of selling later when local prices were higher, and said they did so as far as possible. The area's dry climate and freedom from any serious pests of stored grain makes this possible and storage losses would appear to be very slight. Merchants do not collect produce from farms but

producers bring their surpluses to the main centre of Husūn al Jalāl.

Records of quantities and prices of produce traded in the area do not exist. It would appear, however, that prices vary considerably from season to season and within each season. There are no price differentials for the various qualities of wheat though it is conceded that some varieties are preferred to others.

The crop prices already quoted were derived from information supplied by local merchants and a small number of farmers local Prices are high and are, in some cases, two or three times world prices. The large difference between local prices and world market prices of certain crops is not solely limited to Wadi Abīda but is found throughout most of the country. The Sana'a to Ma'rib road is scheduled for completion in 1978 thus providing good communications with the capital, greater availability of goods and more competitive pricing. This easy access to the capital coupled with increased crop production in Wadi Abīda will tend to lower price levels regardless of whether there is or is not a project. The price levels given in Table 11.7 are an attempt to establish realistic crop values for farm budgets and the project analysis but still maintaining a premium over world market prices for local produce.

Table 11.7 Crop prices in Wadi Abīda (1976-1977)

	Rials per tonne	
Crop	Local Merchant price range	Price used in farm budget
Wheat	2 325 - 3 100	1 500
Barley	1 400 - 2 010	1 300
Sorghum	850 - 1 140	1 000
Maize	1 700 - 1 995	1 200
Sesame Seed	2 500 - 5 400	2 500
Sesame Oil R/Litre	10 - 22	15

Source: Information from local merchants and farmers.

Sesame prices in particular are extremely variable possibly reflecting large fluctuations in supply. Wheat prices have been falling during the past three years, in common with those in other parts of the country and in the world markets, although the falls have been less than elsewhere.

Prices for other crops were not available with the exceptions of:

Maize cobs:	R1.30 for four
Onions (from Harieb):	R1 600 per tonne
Water melons:	R2 to 10 each.

Merchants indicated that they would welcome and be able to dispose of larger quantities than at present in particular of wheat and other grains and of sesame.

There is very little trade in lucerne although it was reported that small quantities are sold to the Bedouin.

11.4 LIVESTOCK MARKETING

As stated in the chapter on livestock the present population of animals is in a delicate equilibrium with the natural resources and arable fodder available. Any significant increase should be in conjunction with increased output from the agricultural sector and therefore the prospect of increasing output from the Wadi Abīda for sales is limited. Cash sales at present are confined to camels and small numbers of sheep and goats. Prices are high as elsewhere in the Republic. Camels used mainly for breeding may fetch from R2 000 to R9 000 each, sheep in early 1977 were being sold for R230 to R400 each and goats from R100 to R300. Young stock are predominantly used for home consumption and this is reflected in the prices used for the farm budgets of R250 for sheep and R150 for goats.

11.5 CONCLUSIONS

The present marketing system does appear to operate well both for

imports to and exports from the project area. There would appear to be little need for interference in the system with the exception of providing an alternative source of credit, from the Yemen Agricultural Credit Bank, as recommended in Chapter 9.

CHAPTER 12

FARM BUDGETS

12.1 INTRODUCTION

Farm budgets are calculated for three farm models:

- 4.0 ha farm irrigated from groundwater only,
- 5.0 ha farm irrigated from seil-water only,
- 5.0 ha farm comprising 4.0 ha irrigated by groundwater and 1.0 ha irrigated by seil-water.

There are likely to be wide variations from these models, but they are considered to be sufficiently typical to form a basis for an examination of farm budgets. For reasons given elsewhere in the report it was not possible to undertake a farm survey in the project area. Indeed certain important areas of production were closed entirely to the study team. The data used are therefore only approximate and the figures arrived at can only provide a very general idea of the present and future levels of farm income.

Crop prices received by producers in the area vary considerably. The data collected shows that local prices are considerably in excess of world prices, which is thought to be a reflection of the comparative isolation of the Study Area. It is assumed that with the completion of the Sana'a to Ma'rib road,local prices will fall into line. Prices have been adopted, therefore, which are based on world prices with a correction for local transportation and handling charges. These prices which are presented in Chapter 11 are used throughout the Report for evaluations of both present and future conditions.

Livestock are sold only in small numbers in the project area, and the value of production for all output, including home consumption, is set at the prevailing local level. Animals used for home consumption are generally young stock which command a lower marketable value and this is reflected in the average price used, refer Chapter 11.

In the following Sections the disposable incomes of farmers operating in the three identified farm models is calculated for the present situation and the future "with-project" and "without-project" situations.

12.2 PRESENT SITUATION

12.2.1 Inputs

The basis of the estimates of the agricultural inputs which have been quantified for inclusion in the calculation of the crop gross margins are presented below.

(i) Tractor work

A figure of YR 41 per tractor hour is adopted. This is in contrast to the present rates for tractor hire of YR25 per hour for cash and YR35 per hour for seasonal credit, and represents the real cost as derived in Table 12.1.

Mechanical cultivations are presently confined to land preparation and threshing by running a tractor and heavy pole over the crop after it is cut. Three furrow disc ploughs are used to prepare ground for the winter crop followed by one spring tyne cultivation to provide a finer seedbed. Summer crops commonly receive only one spring tyne cultivation. Levelling is also carried out on seil irrigated fields. The small basins used in well areas are constructed and levelled by hand. Table 12.2 sets out the figures assumed for tractor use and cost for each crop.

(ii) Irrigation water

Pumped water in the Wadi Abīda is relatively expensive at 11.4 fils per m^3[1]. The use of unnecessarily high powered

(1) Adopting a cost that excludes replacement, refer Annex IV. The reason is that the wells are largely financed by remitted income for which at present there is little alternative investment opportunity.

Table 12.1

Tractor costs

Item	Cost in YR/hr/ha
Tractor	
Depreciation R 61 400 - 8 000 hours (1)	7.68
Interest 10%	4.09
Fuel 8.2 litres/hours - R0.65/litre	5.33
Oil, filters and fan belts	0.75
Tyres, 1 set per 1 500 hours - R5 910	3.94
Repairs 100% value - 8 000 hours	7.68
Sub-total	29.47
Driver	
25% of present R25 hire rate	6.25
Implements	
3 furrow disc plough, 9 tyne cultivator, scraper blade:	
Depreciation R20 5000 - 9 000 hours	2.28
Interest 10%	1.37
Repairs + maintenance 5% value p.a.	1.37
Sub-total	5.02
TOTAL	40.74

Source: HTS estimates

Notes: 1) As tractors are shared and hired and have a comparatively short life their full cost including replacement is included.

Table 12.2

Duration and cost of tractor operations

Crop	Duration of tractor use in hours/ha					Unit Rate	Cost
	plough	cultivate	level	thresh	Total	YR/hr	YR/ha
Wheat (well)	2.0	1.5	-	1.0	4.5	41	185
Wheat (seil)	2.0	1.5	1.5	1.0	6.0	41	246
Barley	2.0	1.5	-	1.0	4.5	41	185
Sorghum (seil)	2.0	1.5	1.5	-	5.0	41	205
Maize	-	1.5	-	-	1.5	41	62
Sesame	1.5	-	-	-	1.5	41	62
Vegetables	2.0	1.5	-	-	3.5	41	144
Orchard	1.0	-	-	-	1.0	41	41
Lucerne (1)	0.5	0.4	-	-	0.9	41	37

Source: HTS estimates
(1) over a four year crop life.

engines and large capacity pumps contributes to the relatively high cost. It is assumed that crops receive less water than the figures given for crop usage in Chapter 8, but no accurate water application measurements were possible. The cost of water from the seil can only be guessed at present. A flat rate charge of YR150 per ha has been used in these farm budgets. The cost arises from payment for the construction of the main holding and diversion bunds in the Wadi. Charges are levied on all who benefit in proportion to the area of land they cultivate which uses water from the seil. Tables 12.3 and 12.4 present the assessment of current water useage and costs.

Table 12.3

Expenditure on seil irrigation

Crop	Rate(1) YR/ha	Cost YR/ha
Wheat	150	150
Sorghum	150	150

1) Refer Section 12.2.1 and Annex IV

Table 12.4

Expenditure on groundwater irrigation

Crop	Abstraction m^3/ha(1)	Rate YR/ha	Cost YR/ha
Wheat	7625	0.114	869
Barley	7625	0.114	869
Sesame	8325	0.114	949
Maize	9913	0.114	1130
Lucerne	26313	0.114	2300
Vegetables	11000	0.114	1254
Orchards	17450	0.114	1989

Notes:-

1) Assuming abstraction of 1.25 x consumptive use, which allows for provision. 0.7 of consumptive use at an overall efficiency of 56%. Figures from Ch. 8.

(iii) Containers

Crops are stored when fully dry in sacks of generally good quality, and storage losses are low. A 90 kg sack costs YR3.90 and it has been assumed that they have a life of three years. Tables 12.5 and 12.6 show the quantities and costs of containers for seil and well irrigated crops respectively.

Table 12.5

Cost of containers, seil irrigated crops

Crop	Number of containers per ha	Rate YR	Cost YR/ha
Wheat	10	1.3	13
Sorghum	10	1.3	13

Table 12.6

Cost of containers, well-irrigated crops

Crop	Number of containers per ha	Rate YR	Cost YR/ha
Wheat	23	1.3	30
Barley	17	1.3	22
Sesame	6	1.3	8
Maize	17	1.3	22
Lucerne	-	-	-
Vegetables	-	-	-
Orchard	-	-	-

(iv) Seed

No costs are included for seeds. The current practice is for farmers to retain a proportion of their crop for next year's seed. It is anticipated that this practice will continue and the yield figures contain an allowance for retention of an

appropriate proportion for seed.

(v) Fertilisers and agricultural chemicals

No fertilisers or chemicals are used at present so no costs are included in the present farm budgets.

(vi) Labour

No labour costs have been included since in most cases labour is provided by the family alone. Hired labour is both expensive, at YR35 for six hour day, and extremely difficult to obtain.

(vii) Zakat

Zakat is a tax of religious origin which is levied on the basis of crop value. It is customarily 5% for well irrigated land and 10% for seil irrigated crops. It is tax theoretically payable in cash or kind to Government, but producers often pay directly to the poor areas instead. Zakat tax is self assessed and no checks are made on these assessments. It is also chargeable on livestock at the following rates:

YR100 for every 40 sheep and goats
YR100 for every 5 camels

The farm budgets have not taken Zakat into account, it being considered here as a payment out of the farmers' disposable income.

12.2.2 Gross crop revenue

Crop yields are derived from the study team's estimates (Chapters 5 and 7), and though there is variation between the seasons, the figures used are considered to reflect the present position. Price data are scanty and there is without doubt considerable variation between and within seasons. The derivation of the prices used in the farm budgets is discussed in Chapter 11.

Table 12.7 presents the yield and price data and the estimate of gross revenue for each crop and irrigation method.

Table 12.7

Crop gross revenue

Crop	Yield tonne/ha	Price YR/tonne	Gross Revenue YR/ha
Seil irrigation			
Wheat	0.900	1500	1350
Sorghum	0.850	1000	850
Well-irrigation			
Wheat	2.000	1500	3000
Barley	1.500	1300	1950
Sesame	0.500	2500	1250
Maize	1.500	1200	1800
Lucerne	60.000 (1)	(2)	(2)
Vegetables	1.500	2500	3750
Orchard	1.500	3500	5250

Notes:

1) Green matter

2) Not valued in farm budgets as it is only an intermediate crop used as fodder for the livestock.

12.2.3 Crop gross margins

Table 12.8 presents the gross margins for the crops grown under both irrigation methods. Input data is derived from 12.2.1 and revenue from 12.2.2.

Table 12.8

Crop gross margins

Crop	Production costs YR/ha					Gross Revenue YR/ha	Gross Margin YR/ha
	Tractor	Water	Con-tainers	Ferti-lisers	Total		
Seil irrigation							
Wheat	246	150	13	0	409	1350	941
Sorghum	205	150	13	0	368	850	482
Well-irrigation							
Wheat	185	869	30	0	1084	3000	1916
barley	185	869	22	0	1076	1950	874
sesame	62	949	8	0	1019	1250	231
maize	62	1130	22	0	1214	1800	586
lucerne	37	2300	-	0	2337	(1)	-2337
vegetables	144	1254	-	0	1398	3750	2352
orchard	41	1989	-	0	2030	5250	3220

Notes:

1) Lucerne is an input to livestock through which its value is derived.

Table 12.9

Livestock values for each farm model

Livestock/Farm type	Well	Seil	Well and seil (1)
Sheep			
Flock size no.	12	18	16
Annual offtake no.	6	9	8
Value at R250 ea.	1 500	2 250	2 000
Goats			
Flock size no.	18	27	24
Annual offtake no.	11	16	14
Value at R150 ea.	1 650	2 400	2 100
Camels			
Flock size no.	-	2.5	1.0
Annual offtake no.	-	0.25	0.10
Value at R4 000 ea.	-	1 000	400
Total value of live-stock production, R	3 150	5 650	4 500

Source: HTS estimates

Note: (1) The livestock numbers on the well and seil irrigated farms are an approximate average of the numbers on the other two types of farms.

12.2.4 Livestock

In common with the rest of Yemen Arab Republic, livestock prices are very high. High incomes from employment, especially in Saudi Arabia, and a distinct preference for mutton account for this. In the project area sheep prices vary from YR200 to YR500 and from YR100 to YR300 for goats. The average figures assumed are sheep YR250 and goats YR150. Camel prices vary between YR2 000 and YR9 000 and a median price of YR4 000 has been assumed. Flock sizes and offtake figures, which are derived from the data available and probable birth and mortaility rates, are set out in Table 12.9 for the three farm models.

Although no lucerne is grown on seil farms they have larger flocks than well irrigated farms because of their closer proximity to natural browse. Well irrigated farms are generally situated in areas where there is little natural browse closeby, and therefore they are mainly dependant on the lucerne and crop residues produced for animal feed.

12.2.5 Present farm income

Tables 12.10, 12.11 and 12.12 show the estimates of the present farm incomes for the three farm models. The incomes for each are:

- 4.0 ha well-irrigated farm : YR7085/an (YR1771/an/ha net CCA)
- 5.0 ha seil irrigated farm : YR7567/an (YR1513/an/ha net CCA)
- 5.0 ha well and seil irrigated farm : YR 8724/an (YR1745/an/ha net CCA).

These figures exclude Zakat and depreciation of pumps, motors and wells and labour. Zakat is self-assessed, and it is not necessarily rigorously paid. Most farmers operating holdings similar to these models would be liable to a Zakat tax of about YR500/an. The depreciation cost of a typical well is about YR6500/annum, refer to Annex IV. Clearly the farmers are not budgeting for this as

the net returns would then be negligable.

Table 12.10

Present income, 4.0 ha well-irrigated farm

Farm enterprise					Farm Income YR/annum
CROP PRODUCTION[1]		Area %	Area ha	Gross Margin YR/ann/ha	
Wheat	W	50	2.00	1916	3832
Barley	W	5	0.20	874	175
Sesame	S	30	1.20	231	277
Maize	S	10	0.40	586	234
Lucerne	P	10	0.40	-2337[2]	-935[2]
Vegetables	S	1	0 04	2352	94
Orchard	P	2	0.08	3220	258
Sub-total, crops		120	-	-	3935
LIVESTOCK PRODUCTION		Annual Offtake No.		Value YR/animal	
Sheep		6		250	1500
Goats		11		150	1650
Sub-total, Livestock		-		-	3150
TOTAL FARM INCOME					7085

Notes:

1) W: Winter crop, S: Summer crop, P: Perennial crop

2) Lucerne is produced for livestock consumption only, and the cost of production is here internally charged to the crop enterprises.

Table 12.11

Present income, 5.0 ha seil irrigated farm

Farm enterprise				Farm income YR/annum
CROP PRODUCTION[1]		Area %	ha	Gross Margin YR/ann/ha	
Wheat	W	10	0.5	941	471
Sorghum	S	60	3.0	482	1446
Sub-total crops		70	-		1917
LIVESTOCK PRODUCTION		Annual Offtake No.		Value YR/animal	
Sheep		9		250	2250
Goats		16		150	2400
Camels		0.25		4000	1000
Sub-total livestock		-		-	5650
TOTAL FARM INCOME					7567

Notes:
1) W: Winter crop, S: Summer crop.

Table 12.12

Present income, 5.0 ha well and seil irrigated farm

Farm enterprise					Farm income YR/annum
CROP PRODUCTION (1)		Area %	Area ha	Gross Margin YR/ann/ha	
Wheat	W	40	2.00	1916	3832
Barley	W	4	0.20	874	175
Sorghum (2)	S	12	0.60	482	289
Sesame	S	24	1.20	231	277
Maize	S	8	0.40	586	234
Lucerne	P	8	0.40	-2337 (3)	-935 (3)
Vegetables	S	1	0.04	2352	94
Orchard	P	2	0.08	3220	258
Sub-total crops		109			4224
LIVESTOCK PRODUCTION		Annual Offtake No.		Value YR/animal	
Sheep		8		250	2000
Goats		14		150	2100
Camels		0.1		4000	400
Sub-total livestock					4500
TOTAL FARM INCOME					8724

Notes:

1) W: Winter crop, S: Summer crop, P: Perennial crop

2) Sorghum grown on seil irrigated area only

3) Lucerne is produced for livestock consumption only, and the cost of production is here initially charged to the crop enterprises.

12.3 FUTURE "WITH PROJECT" SITUATION

Incomes have been estimated for the three farm models at full development of the project. These budgets take into account the increased production per unit area resulting from better cultural methods and the introduction of new crops and varieties as suggested in Chapter 7. Further mechanisation, which will lead to increased production per unit area and will also free labour for other activities, is assumed a necessary feature of the future situation.

12.3.1 Future inputs "with project"

The cost and price estimates are the same as those used for calculating the farm gross margins in the present situations except where the more efficient use of machinery can be expected to reduce costs.

(i) Machinery

Costs and usage are given in Table 12.13 exclusive of pumping machinery. During development of the project tractor usage is reduced by the replacement of the disc plough with the tine cultivator now used after ploughing. Two runs of this equipment is assumed for wheat and one for the crops planted in the summer. To reduce the labour peaks and to facilitate later weeding, row planing is proposed. Improved threshing equipment is assumed, though at no extra tractor input. At full development it is assumed that wheat is combine harvested. Tractor costs remain at R41 per hour and combine costs are set at R100 per hour.

Table 12.13

Mechanisation Requirements and Costs at full development

Crop	Tractor operations, hours/ha (1)				Combine Harvesting hrs/ha (2)	Total Cost YR/ha
	Cultivation	Level & ridge	Threshing	Total		
Seil-irrigated						
Wheat	3.0	1.5	-	4.5	2.5	435
Sorghum	1.5	1.5	1.0	4.0	-	164
Sesame	1.5	1.5	-	3.0	-	123
Vegetables	3.0	1.5	-	4.5	-	185
Well-irrigated						
Wheat	3.0	-	-	3.0	2.5	373
Maize	1.5	-	1.0	2.5	-	103
Sesame	1.5	-	-	1.5	-	62
Vegetables	6.0	3.0	-	9.0	-	370
Orchard	1.0	-	-	1.0	-	41
Lucerne	0.9	-	-	0.9	-	37

(ii) Irrigation water

Groundwater abstraction will continue to be the responsibility of the farmers who will still employ the current technology. Thus the cost of water will remain at 11.4 fils/m^3. The surface supplies will be the responsibility of the Project, who will charge for the water. The economic charge for the water is discussed in the Main Report, and is largely a matter of Government policy. Consequently no costs are included for surface water at this point. It is also assumed at this point that no groundwater abstraction is necessary in the conjunctive use areas, which is the usual case, and thus no water costs arise here either.

Table 12.14 shows the expenditure required for groundwater abstraction in the groundwater only areas.

Table 12.14

Expenditure on Groundwater Irrigation

Crop	Abstraction m^3/ha (1)	Rate YR/m^3	Cost YR/ha (2)
Wheat	8133	0.114	927
Maize	10573	0.114	1205
Sesame	8880	0.114	1012
Vegetables	19480	0.114	2221
Orchard	18607	0.114	2121
Lucerne	28067	0.114	3200

Notes:
1) Assuming application of the crop consumption use at an overall efficiency of 75% which means that more water will be applied to the crops in the future, but that the efficiency of application will have improved.
2) Adopting a cost that excludes replacement, Annex IV.

(iii) Containers

At full development more sacks are required for cereal storage because of the increased output. Allowance is also made for containers for fruit and vegetables as some of the output will be sold. The costs of containers are shown in Tables 12.15 and 12.16.

Table 12.15

Costs of Containers for Seil Irrigated Crops

Crop	Number of containers per ha	Rate YR	Cost YR/ha
Wheat	29	1.3	38
Sorghum	23	1.3	30
Sesame	12	1.3	16
Vegetables (1)			2200

Note:
1) Includes elements for labour and other packing costs

Table 12.16

Costs of Containers for Well Irrigated Crops

Crop	Number of containers per ha	Rate YR	Cost YR/ha
Wheat	40	1.3	52
Maize	34	1.3	44
Sesame	14	1.3	18
Vegetables (1)			5200
Orchard (1)			500
Lucerne	0	0	0

Note:
1) Includes elements for labour and other packing costs

(iv) Seed

The regular purchase of high quality seed of improved varieties of crops and of seed and other planting material of new crops will be required at full development. Estimated costs are shown in Table 12.18 for the calculation of crop gross margins.

(v) Fertilisers and agricultural chemicals

Some fertilisers and chemicals for seed dressings and pest and disease control will be required to achieve the expected output. Final recommendations will result from field trials but estimated costs, based on world prices plus transport and handling charges, have been included in Table 12.18.

(vi) Labour

No labour costs have been included since it is expected that labour will continue to be provided mainly by the family. Labour savings resulting from increased efficiency and mechanisation, will be balanced by increased labour inputs for vegetable crops and other activities.

(vii) Zakat

Zakat tax is considered to be a payment out of the farmers disposable income and hence does not figure in the calculation of crop gross margins.

12.3.2 Crop gros revenue "with project" situation

The same price levels that were used for estimating present gross margins have been taken for calculating future gross margins. Yield levels are in accordance with expected increases outlined elsewhere in this Annex. Table 12.17 presents the yield and price data and the estimate of gross revenue for each crop and irrigation method.

Table 12.17

Crop Gross Revenue at Full Development

Crop	Yield tonne/ha	Price YR/tonne	Gross Revenue YR/ha
Seil irrigation			
Wheat	2.5	1500	3750
Sorghum	2.0	1000	2000
Sesame	1.0	2500	2500
Vegetables	11.0	2500	27500
Well irrigation			
Wheat	3.5	1500	5250
Maize	3.0	1200	3600
Sesame	1.2	2500	3000
Vegetables	26.0	2500	65000
Orchard	6.0	3500	21000
Lucerne	80.0 (1)	(2)	(2)

Notes:
1) Lucerne yield in tonnes green matter.
2) Lucerne not valued in farm budgets as it is only an intermediate crop used as fodder for livestock.

12.3.3 Crop gross margin "with project" situation

Table 12.18 presents the gross margins for the crops grown at full development by seil well irrigation and by conjunctive use. Input data is derived for 12.3.1 and revenue from 12.3.2.

Table 12.18

Crop Gross Margins at Full Development

Crop	Production costs in YR/ha/ann						Gross Revenue	Gross Margin
	Machinery	Water	Combiners	Seed	Fertilisers Chemicals	Total	YR/ha/ann	YR/ha/ann
Seil irrigated								
Wheat	435	0	38	225	200	898	3750	2852
Sesame	123	0	16	62	150	351	2500	2149
Sorghum	164	0	30	60	150	404	2000	1596
Vegetables	185	0	2200	300	350	3035	27500	24465
Well irrigated								
Wheat	373	927	52	225	300	1877	5250	3373
Sesame	62	1012	18	62	250	1404	3000	1596
Maize	103	1205	44	103	350	1805	3600	1795
Lucerne	37	3200	0	19	0	3256	(1)	-3256
Vegetables (2)	370	2221	5200	600	800	9191	65000	55809
Orchard	41	2121	500	100	250	3012	21000	17988
Conjunctive use								
Wheat	373	0	52	225	300	950	5250	4300
Sesame	62	0	18	62	250	392	3000	2608
Maize	103	0	44	103	350	600	3600	3000
Sorghum	164	0	30	60	150	404	2000	1596
Lucerne	37	0	0	19	0	56	(1)	-56
Vegetables (2)	370	0	5200	600	800	6970	65000	58030
Orchard	41	0	500	100	250	891	21000	20109

Notes:
1) Lucerne not valued as it is only an intermediate crop used as fodder for livestock.
2) Two crops per year.

12.3.4 Livestock production "with project"

Actual adult flock sizes are assumed to remain static, however an increase in offtake is envisaged. Crop residues and lucerne fodder production will increase and this in turn should give better feeding, resulting in increased lambing/kidding percentages and heavier adults for sale. At full development an increase in offtake numbers of 30%, over the present situation is expected. Further, heavier animals are anticipated and the prices used are therefore also higher than for the present situation.

The value of livestock production is given for each farm model in Table 12.19.

Table 12.19

Livestock Values at Full Development

	Well	Seil	Well and Seil
SHEEP			
Flock size	12	18	16
Annual offtake	8	12	10
Value at YR 300 ea.	2400	3600	3000
GOATS			
Flock size	18	27	24
Annual offtake	14	21	18
Value at YR 180 ea.	2520	2780	3240
CAMELS			
Flock size	0	2.5	1.0
Annual offtake	0	0.33	0.13
Value at YR 4000 ea. (1)	0	1320	520
Total value of livestock production, YR	4920	8700	6760

Notes:
1) No change in price assumed

12.3.5 Future farm income "with project"

Tables 12.20, 12.21 and 12.22 show the estimates of the future incomes of the three farm models at full development of the project. The incomes for each are:

- 4.0 ha well irrigated farm : YR 23 633/an [1]
  (YR 5 908/an/ha net CCA) [1]
- 5.0 ha seil irrigated farm : YR 22 623/an
  (YR 4 525/an/ha net CCA)
- 5.0 ha well and seil irrigated farm : YR 34 766/an
  (YR 6 953/an/ha net CCA)

These figures exclude Zakat, the cost of labour and certain water charges. Zakat is self assessed, and it is not rigorously paid. Most farmers operating holdings similar to these models would be liable to a Zakat tax of YR 1200 to YR 1500. The annual depreciation cost of a typical well is YR 6500, refer to Annex IV. This cost is excluded from the above figures. In the present situation the farmers clearly do not budget for this cost; but in the future, opportunities for alternative investment may develop leading to a more enlightened approach. At this stage, however, farm revenues will be sufficient to permit replacement. No charges are included for water in the well and seil irrigated farm model, this will be the situation is a good year when there is an average, or better than average, runoff from the catchment.

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1) For comparison with the other models, the farm incomes when water costs are excluded are YR 30,227/an, or YR 7 557/an/ha net CCA.

Table 12.20

Income at Full Development, 4.0 ha, Well Irrigated Farm

Farm enterprise					Farm income YR / annum
CROP PRODUCTION (1)		Area		Gross Margin	
		%	ha	YR/ha/ann	
Wheat	W	75	3.0	3373	10,119
Sesame	S	40	1.6	1596	2,554
Maize	S	10	0.4	1795	718
Lucerne	P	10	0.4	-3256	-1,302
Vegetables	W+S	2	0.08	55809	4,465
Orchard	P	3	0.12	17988	2,159
Sub-total, crops		155			
LIVESTOCK PRODUCTION		Annual Offtake		Value, YR/animal	
Sheep		8		300	2,400
Goats		14		180	2,520
Sub-total, livestock		-		-	4,920
TOTAL FARM INCOME					23,633

1) W = Winter crop, S = Summer crop, P = perennial

Table 12.21

Income at Full Development, 5.0 ha, Seil Irrigated Farm

Farm enterprise				Farm income YR / annum
CROP PRODUCTION	Area		Gross Margin	
	%	ha	YR/ha/ann	
Wheat	30	1.5	2852	4,278
Sesame	15	0.75	2149	1,612
Sorghum	70	3.5	1596	5,586
Vegetables	2	0.1	24465	2,447
Sub-total, crops	117			13,923
LIVESTOCK PRODUCTION	Annual Offtake		Value, YR/animal	
Sheep	12		300	3,600
Goat	21		180	3,780
Camels	0.33		4000	1,320
Sub-total,livestock				8,700
TOTAL FARM INCOME				22,623

Table 12.22

Income at Full Development, 5 ha Well and Seil Irrigated Farm

Farm enterprise					Farm Income YR/annum
CROP PRODUCTION		Area		Gross Margin YR/ha/ann	
		%	ha		
Wheat	W	60	3.00	4300	12,900
Sesame	S	30	1.50	2608	3,912
Maize	S	8	0.40	3000	1,200
Sorghum	S	15	0.75	1596	1,197
Lucerne	P	8	0.40	-56	-22
Vegetables	W+S	2	0.10	58030	5,803
Orchard	P	3	0.15	20109	3,016
Sub-total crops		139			28,006
LIVESTOCK PRODUCTION		Annual Offtake		Value YR/animal	
Sheep		10		300	3,000
Goats		18		180	3,240
Camels		0.13		4000	520
Sub-total livestock					6,760
TOTAL FARM INCOME					34,766

12.4 FUTURE "WITHOUT-PROJECT" SITUATION

In the future, "without-project" situation a certain degree of development may be anticipated, but not to the level that will be achieved with the project present. Without the project, improvements will occur as a result of further mechanisation, adoption of better techniques and improved varieties. The project will provide the following extra benefits for the areas already cultivated:

- release from the flooding hazard;
- improved surface water supplies;
- site-specific agricultural research and development;
- extra, irrigation orientated agricultural extenstion services;
- an extra incentive.

To determine the future, "without-project" farm incomes the following assumptions have been made. On well-irrigated farms it is assumed that the farm income will be 60% that of the with-project value. On seil irrigated farms, where the unchanged regime of the seils will curtail improvement, an increase in farm income of 10% over present levels is assumed. On mixed seil and well-irrigated farms farm incomes of 50% of the "with-project" situation are assumed. These assumptions lead to the following figures for farm income in the future, "without-project" situation:

- 4.0 ha well-irrigated farm: YR 14,179/an
  (YR 3,545/an/ha net CCA)
- 5.0 ha seil-irrigated farm: YR 8,323/an
  (YR 1,665/an/ha net CCA)
- 5.0 ha well and seil-irrigated farm: YR 17,383/an
  (YR 3,476/an/ha net CCA)

These figures exclude Zakat, the cost of labout and certain water charges. Zakat is self-assessed, and it is not rigorously paid. Most farmers operating holdings similar to these models would be liable to a Zakat tax of YR 500 to YR 1000. The annual depreciation cost of a typical well YR 6500, refer to Annex IV. This cost is excluded from the above figures. In the present situation the farmers clearly do not budget for this cost, but in the future opportunities for alternative investment may develop, leading to a more enlightened approach.

CHAPTER 13

PROJECT AREA PRODUCTION

13.1 INTRODUCTION

On the basis of the farm budgets presented in Chapter 12, and the irrigable areas as presented elsewhere in the Report, the net revenue generated in the Study Area is assessed for the present situation and the future "with-project" and "without-project" situations.

The prices used are those adopted in Chapter 12 for the farm budgets. They are based upon world prices with a correction for local transport and handling costs. The current high local prices are considered a temporary distortion of the market which will not survive the completion of the Sana'a to Ma'rib road. Constant prices are used in all assessments.

13.2 PRESENT SITUATION

The current breakdown of farming systems is given in Chapter 4, and the appropriate farm gross margins in Chapter 12. This information is combined in Table 13.1 to show the annual revenue now generated by agriculture in the Study Area to be about YR 2.7 million. In this table the areas are sub-divided into the areas covered by the separate components of the proposed project. This facilitates comparison with the later tables in this Section.

Table 13.1

Present Net Revenue

Area	Farm (1) model/ water source	Area (1) net, CCA ha	Gross Margin YR/ha/an		Net Revenue million YR/an
			without allowance for well replacement (3)	with allowance for well replacement (4)	
(i) First stage area	groundwater	160	1771	146	0.02
	seil	1068	1513	1513	1.62
	gw/seil (2)	1597	1745	445	0.71
sub-total	all systems	2825	-	-	2.35
(ii) Second stage area	groundwater	400	1771	146	0.06
(iii) Area only for ground water development	groundwater	76	1771	146	0.01
Total, Study area	all systems	3301	-	-	2.42
(iv) Areas outside the Study area (10738 ha) but in the general region	seil	200	1135 (5)	1135	0.23
	gw/seil	100	1309 (5)	9	0
Total, all areas	all systems	3601	-	-	2.65

Notes:
1) Refer Chapter 4 and Figure 4.1
2) Includes both classes of mixed system, refer Table 4.1
3) Refer to Chapter 12
4) Assumes one well per farm with an annual replacement cost of YR 6500, refer to Annex IV, which is equivalent to a cost of YR 1625/an/ha and YR 1300/an/ha for groundwater and mixed farming systems respectively
5) Gross Margins of 75% those quoted above are used to allow for the poorer soil conditions as these areas are not in the Class 1, 2 or 3 soils comprising the Study Area

13.3 FUTURE "WITH-PROJECT" SITUATION

With completion of the Project, four classes of area benefitting from the project works will be identified. These are described below.

(i) Areas receiving surface water irrigation supplies in the first stage of the Project.

These areas comprise

- small areas commanded by separate wadi diversions	:	803 ha gross,
- North canal command	:	2170 ha gross,
- South canal command	:	3069 ha gross
Total	:	6042 ha gross
		(5136 ha net)

Reservoir operation studies have shown that the security of surface supplies to these areas in such that no practical difference in cropping pattern will develop between these areas and those replying solely on groundwater, refer to the Main Report. In the following calculation it is assumed that these will use the "groundwater only" cropping pattern developed in Chapter 7 and whose estimate of farm income appears in Chapter 12.

(ii) Areas receiving supplementary surface supplies in the second stage of the Project.

These areas, comprising 3588 ha gross (3050 ha net), are those of good groundwater potential where there will be an initial improvement in recharge characteristics as a result of the project, and where a supplementary surface distribution system will be provided at a later date. Initially private groundwater development is proposed. Cropping patterns appropriate to groundwater only farming will be adopted.

(iii) Areas of groundwater only development

These areas, comprising 1108 ha gross (1053 ha net), are outside the command of the surface distribution systems, but with good groundwater potential. Recharge to these areas will be improved by the project works. Cropping patterns appropriate to groundwater only be adopted.

(iv) Areas outside the Study Area (of 10738 ha gross) which may receive improved seil supplies. Cropping patterns appropriate to seil-irrigation farming will be adopted.

Table 13.2 shows the calculation of the total net revenue generated by agriculture in the Study Area as a result of the project works. This shows an increase from YR 2.7 million/ann in the present situation to about YR 64.2 million/ann with completion of the project.

Table 13.2

Future, "with-project" Net Revenue

Area	Farm (1) model	Area net CCA ha	Gross Margin YR/ha/an		Net Revenue million YR/an
			without allowance for well replacement (3)	with allowance for well replacement (4)	
(i) First stage area receiving surface supplies	groundwater only	5136	7557	7557	38.81
(ii) Second stage area receiving supplementary surface supplies (5)	groundwater only	3050	7557	6257	19.08
(iii) Area only for groundwater development	groundwater only	1053	5908	4608	4.85
Total, Study area	all systems	9239	-	-	62.75
(iv) Areas outside the Study Area (10738 ha but in the general region	seil only	200	3394 (4)	3394	0.68
	conjunctive use	200	5215 (4)	3914	0.78
Total, all areas	all systems				64.21

Notes:

1) Refer to Chapter 12
2) Refer to Section 12.3
3) Adopting costs of YR 1625/an/ha and YR 1300/an/ha for groundwater and mixed farming systems as developed in Table 13.1. That is, assuming well designs are unchanged. Refer Annex IV.
4) Gross Margins of 75% those quoted above are used to allow for the poorer soil conditions as these areas are not on the Class 1, 2 or 3 soils comprising the Study Area
5) Assuming a year in which the surface supplies are adequate

13.4 FUTURE "WITHOUT-PROJECT" SITUATION

Without the project no significant improvements in agriculture can be anticipated.

(i) Groundwater

The construction of new wells is anticipated, but at a reduced rate since the availability of agricultural labour is a constraint on development which will become more apparent. Construction of modern tubewells on a large scale is thought to be unlikely as they are expensive and inappropriate to the current farm holding pattern. An operating extension service is assumed, which will lead to an improvement in yields. Further mechanisation will occur, improved varieties, purer seed and improved techniques will be employed.

(ii) Seil irrigation

The characteristics of the seils will remain unchanged, and no extension of seil irrigated agriculture is therefore possible. In fact, a decrease in the number of farms relying solely on the seils for irrigation is anticipated as wells are developed in this area. Yields are unlikely to improve since agriculture is already mechanised, and further investment seems unlikely for so uncertain a form of agriculture.

(iii) Mixed seil and well-irrigated farms

An increase in the area of mixed farming systems is expected as new wells continue to be constructed in the current seil irrigated areas. Developments in the groundwater and seil areas will be in line with the predictions of the above paragraphs.

Table 13.3 shows the agricultural revenue generated in the Project Area in the future, "without-project" situation to be about YR 7.8 million. The estimate based on the farm revenues from Section 12.4 and the predictions of development outlined in the preceding paragraphs, and it shows nearly a threefold increase over the current level.

Table 13.3

Future "without-project" Net Revenue

Area	Farm (1)	Area (2) net, CCA ha	Gross Margin YR/ha/an		Net Revenue million YR/an
			without allowance for well replacement (3)	with allowance for well replacement (4)	
(i) First stage area	groundwater	260	3545	1920	0.20
	seil	980	1665	1665	1.63
	gw/seil	1942	3476	2176	4.23
sub-total	all systems	3182	-	-	6.06
(ii) Second stage are	groundwater	700	3545	1920	1.34
(iii) Area only for groundwater development	groundwater	200	3545	1851	0.37
Total, Study Area	all systems	4082	-	-	7.77
(iv) Areas of seil irrigation outside the Study Area	seil	100	1249 (5)	1249	0.12
	gw/seil	200	2607 (5)	1307	0.26
Total, all areas	all systems	4382	-	-	8.15

Notes:

1) Refer Chapter 4
2) Refer Section 13.4 for qualitative description of future developments
3) Refer to Chapter 12
4) Assumes one well per farm with annual replacement cost of YR 6500, refer to Annex IV, which is equivalent to a cost of YR 1625/an/ha and YR 1300/an/ha for groundwater and mixed farming systems respectively
5) Gross Margins of 75% those quoted above are used to allow for the poorer soil conditions as these areas are not in the Class 1, 2 or 3 soils comprising the Study Area