Distr.
GENERAL
E/ESCWA/AGR/1993/13
1 December 1993
ORIGINAL: ENGLISH

United Nations Economic
and Social Commission
for Western Asia (ESCWA)

United Nations Environment
Programme Regional Office
for West Asia (UNEP/ROWA)

THE NATIONAL PLAN OF ACTION

TO

COMBAT DESERTIFICATION

IN

THE SULTANATE OF OMAN

93-0904

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ABBREVIATIONS

1.	ALECSO	Arab League Educational, Cultural and Scientific Organization.
2.	AOAD	Arab Organization for Agricultural Development.
3.	CAMRE	Council of Arab Ministries Responsible for the Environment.
4.	DC/PAC	Desertification Control Programme Activity Centre.
5.	DSP&D	Division of Soil Pollution and Desertification.
6.	ESCWA	Economic and Social Commission for Western Asia.
7.	FAO	Food and Agriculture Organization of the United Nations.
8.	GCC	Gulf Co-operation Council.
9.	GEMS	Global Environment Monitoring System.
10.	Ha.	Hectare.
11.	JIKA	Japan International Cooperation Agency.
12.	MAF	Ministry of Agriculture and Fisheries.
13.	MMDI	Mott Macdonald International.
14.	MRM&E	Ministry of Regional Municipalities and Environment.
15.	MWR	Ministry of Water Resources.
16.	NaDeCC	National Desertification Control Commission.
17.	NCS	National Conservation Strategy.
18.	NCPP	National Community Development Programme.
19.	NGO	Non-Governmental Organization.
20.	NPACD	National Plan of Action to Combat Desertification.
21.	PACD	Plan of Action to Combat Desertification.
22.	RO	Omani Riyal.

23.	UN	United Nations.
24.	UNCED	United Nations Conference on Environment and Development.
25.	UNCOD	United Nations Conference on Desertification.
26.	UNDP	United Nations Development Programme.
27.	UNEP	United Nations Environment Programme.
28.	UNEP/ROWA	UNEP Regional Office for West Asia.
29.	UNSO	United Nations Sudano - Sahelian Office.

EXECUTIVE SUMMARY

This report "The National Plan of Action to Combat Desertification (NPACD) in the Sultanate of Oman" is the result of a joint effort by the Economic and Social Commission for Western Asia (ESCWA), the Food and Agriculture Organization of the United Nations (FAO), and the United Nations Environment Programme (UNEP). Two missions were mounted at the request of the government of Oman. First, a one-man mission (1) visited the Sultanate in October 1991 and prepared **Part One**, the Background Section of the NPACD in March 1992. In September 1992, a three-man mission (2) visited the Sultanate for three weeks and prepared **Part Two**, the plan, programmes and projects of the NPACD, in April 1993.

PART ONE

THE BACKGROUND SECTION consists of four chapters, (81 pages) and 7 appendices (in 13 pages).

Chapter I: Inventory and Potential of Natural Resources, presents data and information, in 48 pages of text and 16 figures, on physiographic regions, climate, land resources, water resources, natural vegetation, oils and minerals. The overall picture is that of aridity with pronounced scarcity of water and productive soil.

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Chapter II: **Presents the Socio-Economics Setting** under three sub-headings: economics development, social setting and agricultural potentialities. The Sultanate with its moderately small population (about 2.0 million) has a GDP estimated at 3230.6 million RO (at current prices) in 1989. Nearly 46% of this figure came from mining and crude oil. The Sultanate agricultural potential is limited; of a total land area of 31.4 million ha. about 55,000 ha. were under cultivation in 1990.

Chapter III: **"The Status of Desertification"** gives a background and causes of desertification. Physical and socio economic factors driving the processes of desertification are discussed, highlighting the role of faulty agricultural practices leading to salinization, overgrazing and felling of trees. This brief presentation is supplemented by descriptive sections in **PART TWO**.

Chapter IV: **Gives a Review of Past and Current Efforts for Combating Desertification**. The national efforts to combat desertification are reported under three main headings:

1. Development and conservation of water resources.
2. Efforts for improvement of land capability.
3. Rehabilitation of rangeland in the Southern Region.

In each of the three categories there were several studies and concrete actions.

PART TWO

THE PLAN-PROGRAMMES AND PROJECTS OF THE NPACD, also comprise four chapters, (covering 120 pages) plus three appendices. They are numbered V to VIII. This volume which follows the **Background Section** deals with the substantive part of the Plan: its strategy, content and the institutional capabilities for implementation.

Chapter V: National Plan of Action to Combat Desertification presents the plan in six sections:

1. The Magnitude of the problem;
2. National participation towards preparation of the plan;
3. National Goals;
4. A long-term strategy for desertification control (1994-2020);
5. Elements of the strategy.
6. Remarks.

The proposed long-term strategy sets a horizon for 1994-2020 and suggests 10 programmes. Within this long-term horizon, a short-term horizon is set for 1994-1996. During this period priority programmes and projects will be approved and implemented. Twenty-four priority projects are proposed.

Considering the size of the proposed programmes and the priority projects in the Plan, their implementation and proper coordination requires the creation of a competent institutional

set up. This has been dealt with in Chapter VI. Chapter VII presents the 24 priority projects in a brief form and mentions over 30 projects from the Fourth Five Year Development Plan which have a direct effect on desertification control. The presentation in Chapter V and VII recalls the proposals in the draft National Conservation Strategy and highlights those which have a direct influence on controlling desertification or minimizing its risk.

It is worth noting that the recommendations, programmes and projects in the Plan are not only supported by relating them to the Recommendations of the UN Conference on Desertification Plan of Action, but also to the revised set of Recommendation presented in the Report of the Executive Director of UNEP to the UN Conference on Environment and Development in 1992. This is important for monitoring and follow-up as well as for logical development and expansion of the work in desertification control in the Sultanate along and in relation to the internationally recommended steps and procedures.

Chapter VIII: The last in the document is entitled "Concluding Remarks and Follow-up". It recapitulates the highly significant facts and pieces of information as well as important conclusions. It tells how similar or different this Plan is from those formulated for other dryland countries. An important difference is the **Uniqueness of Oman's Environment** which is pronounced in Dhofar - the primary site of desertification action and spread in the Sultanate. Concern about this uniqueness

motivated inclusion of a priority project on "Advisory services in environment and sustainable development".

An additional significant difference is the serious concern of the State with the environment and its protection combined with an advanced stage of public awareness about environmental matters.

The ESCWA/FAO/UNEP second mission discussed its findings and general recommendations with the government representatives in a roundup meeting attended also by Mr. Kassum, the UNDP resident coordinator. Details were not discussed, but the government representatives emphasized the need to refer to several projects in the current Five Year Plan which have strong bearing on desertification control. With this note there was general agreement on the main findings and the principal recommendations.

Preparation of this Plan is the start of a colossal task and a lot depends on active follow-up. The responsibility for follow-up is given in Chapter VIII which describes four essential steps. The prime step of these four is the **responsibility of the proposed Division of Soil Pollution and Desertification in the Directorate for Environmental Affairs for follow-up action**.

Finally work and project formulation should be accorded priority if further and critical degradation is to be avoided, and the Sultanate of Oman is to succeed in halting desertification spread.

INTRODUCTION

1. HISTORICAL

The Sultanate of Oman, by virtue of its geographical position has enjoyed a long history of contact with several races and cultures. The extended relations with close and far neighbours had its fingerprints on its indigenous civilization and modes of livelihood. Against this background a national renaissance came to being in the early 1970s in Oman with the reign of Sultan Qaboos after a somewhat long period of a closed life.

Evidence of this renaissance, as far as the purpose of this document is concerned is found in:

(a) The high degree of state concern with the environment and its protection; and

(b) The advanced level of environmental awareness among the population.

It is, therefore, no wonder that Oman is one of the very few countries which is about to complete possession of a National Conservation Strategy and a National Plan of Action to Combat Desertification (NPACD).

The coming up of this suggested NPACD is the result of cooperative efforts of UNEP, ESCWA and FAO. The three organizations are involved in a chain of joint activities with ESCWA region member countries to assist individual countries, on request, to prepare their national Plans.

In this case the job was done in two stages. First, a one-man mission prepared **Part One** - the Background Section which was presented to the Government of Oman in April 1992. This was followed by a three - man mission in September 1992 for the preparation of **Part Two** - the Plan - Programmes and Projects.

2. CONTENTS OF THE PLAN

2.1 PART ONE: The Background Section

This part comprises four chapters in 81 pages plus 7 appendices. Chapter I - Inventory and Potential of Natural Resources of Oman is a rich chapter which deals with seven sub-titles including: physiographic regions, climate, land resources, water resources, natural vegetation and geological resources.

Chapter II - deals with the socio-economic setting while

Chapter III - takes the status of Desertification. Chapter IV -review past and current efforts to Combat Desertification in Oman.

2.2 **PART TWO**: The Plan - Programmes and Projects

Part Two also comprises four chapters (numbered V to VIII) in about 120 pages plus three appendices. The document does not repeat the numerous figures (maps etc.) which appeared in **Part One** and the reader is advised to refer to Part One for this purpose.

Chapter V deals with the core of the Plan in six Sub-Headings: (i) The magnitude of the desertification problem; (ii) National contribution towards the preparation of the plan; (iii) National goals; (iv) A long-term strategy; (v) Elements of the strategy; (vi) Remarks.

Chapter VI deals with establishing the institutional set up and capabilities for implementing the NPACD. It describes the present set up and the proposed machinery in fair detail.

Chapter VII covers priority programmes and projects for the short-term, 1994-1996. Some 24 project proposals are included.

Chapter VIII which is the closing chapter in the document gives concluding remarks and follow-up steps in four sub-titles. The chapter highlighted important sections, views, results and suggestions or recommendations in the document, as well as in previous important scientific studies in Oman.

3. SIMILARITIES AND DIFFERENCES

UNEP, FAO and ESCWA are cooperating in a programme through which they offer assistance, on request, to ESCWA region countries for preparation of NPACDs. The present plan is similar in many respects to the NPACDs, prepared over the last three years, in its presentation, main divisions of the content and approach. It differs, however, in that it is perhaps the first time a NPACD is set in two separate parts: A Background Section and the Plan. A part from other aspects mentioned in the text, this Plan is also different in that it is not only concerned with combating desertification for the protection of productive natural resources but also for the protection of the Uniqueness of the Omani Environment in its recognized locations.

CHAPTER I

INVENTORY AND POTENTIAL OF NATURAL RESOURCES OF OMAN

1.1 LOCATION AND AREA

The Sultanate of Oman occupies the south-eastern part of the Arabian Peninsula and shares borders with the United Arab Emirates, Saudi Arabia and the Republic of Yemen. It extends along the Gulf of Oman and the Arabian Sea, with coastline of about 1,700 km extending from the Straits of Hormuz in the north to the Yemeni border in the south (Fig. 1.1). The country has an approximate area of 314,00 sq. km. It consists of a main landmass, two enclaves separated from it by territories belonging to the United Arab Emirates, and numerous islands among which Masirah and Kuria-Muria are the largest (Fig. 1.1).

The Sultanate of Oman is divided into eight administrative regions as shown on Figure (1.1), namely Muscat, Al Janubiya, Al Dhahira, Al Batinah, Al Dakhliya, Al Sharqiya, Al Wusta and Musandam. The country is further divided into 44 administrative units called "Wilayat", each governed by a Wali (local head).

1.2 PHYSIOGRAPHIC REGIONS

According to the General Soil Map of Oman (MAF, 1990), Oman is divided into eleven physiographic regions (Fig. 1.2). These are:

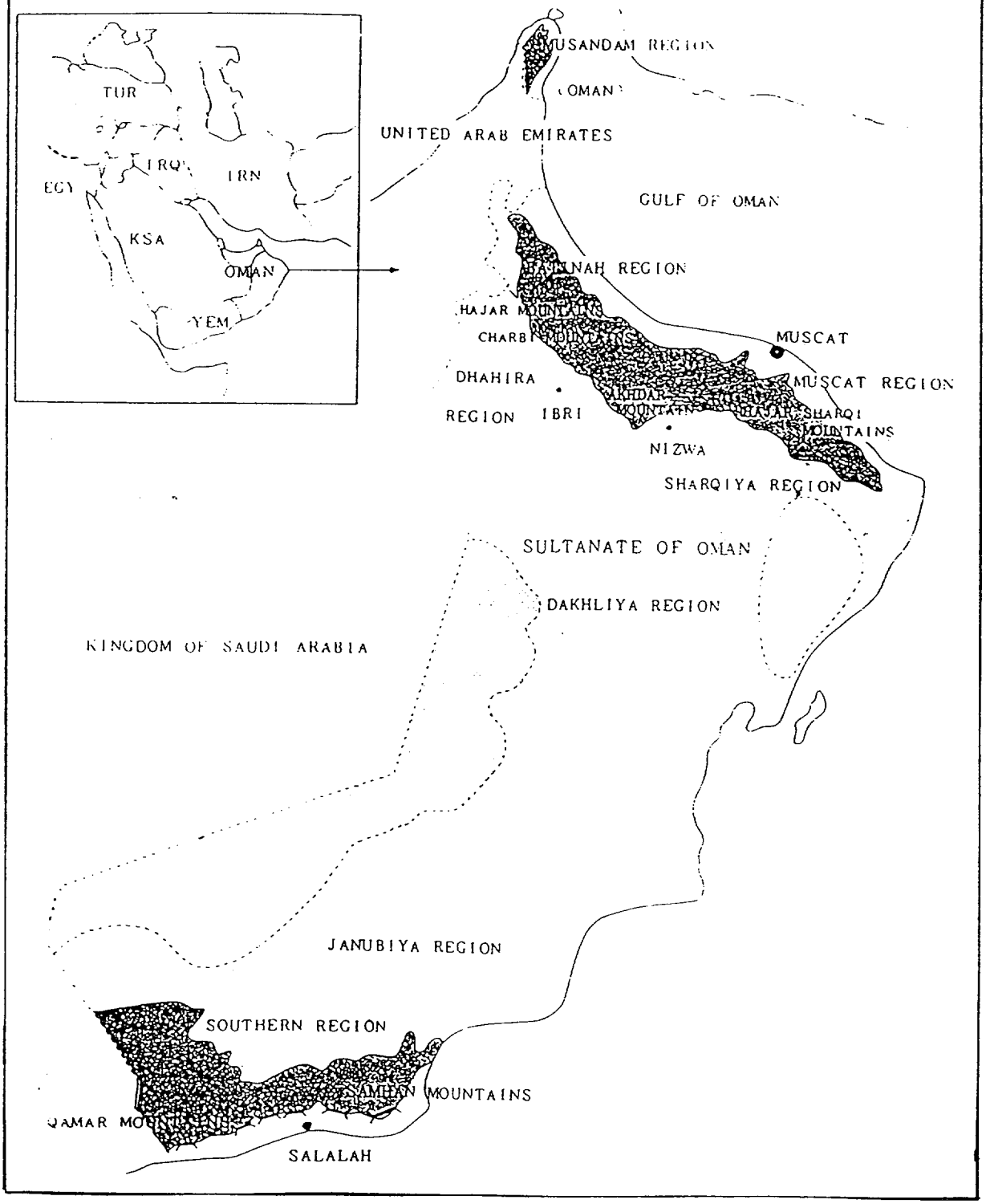
1. Arid mountains;
2. Monsoon affected mountains and plateaus;
3. Arid Dhofar plateau;
4. Accumulation plains;
5. Accumulation/denudation plains;
6. Coastal alluvial plains;
7. Sabkha-dunes-rock outcrop complex;
8. Eastern pediplain;
9. Western pediplain;
10. Umm-As-Samim Sabkha, and
11. Sand dune areas.

1.2.1 Arid Mountains

These are encountered mostly in the Hajar mountains, in northern Oman, including the Musandam peninsula. They also occur to a much smaller extent in the islands such as Masirah and Kuria-Muria. These mountains are mostly steep and barren formations of igneous and sedimentary rocks.

Fig. (1.1):

Map of Oman

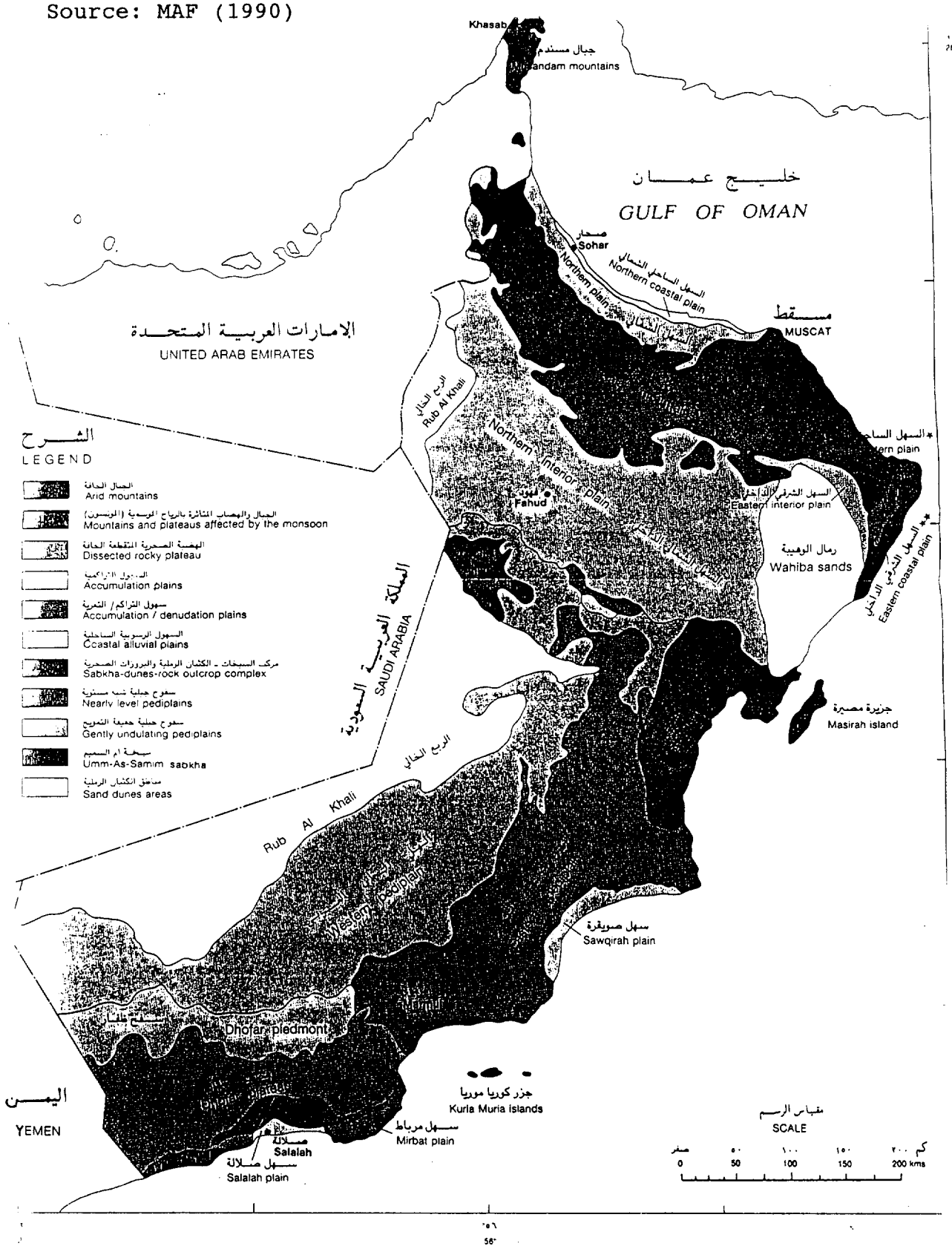


Source: JICA (1990).

The boundaries shown on this map do not imply official endorsement or acceptance by the United Nations

Fig. (1.2):

Physiographic Regions of the Sultanate of Oman
Source: MAF (1990)



The boundaries shown on this map do not imply official endorsement or acceptance by the United Nations

The Hajar mountain range stretches northwest-southeast, along the Gulf of Oman, over about 700 km form Ras-Al-Hadd to Musandam. Its width varies between about 30 to 70 km.

Bare rock outcrop and very shallow soils are dominant on sloping terrain, where very gravelly soils occur in valleys and alluvial fans. With summit nearing 3,000 m above sea level in Jabal Al Akhdar, the Hajar mountains intercept moist air masses, hence receiving relatively higher precipitation than surrounding areas. A dense net work of wadis conveys drainage water north to the Batinah plain, and south to the interior of Oman.

A large number of scattered oases, mostly using falaj irrigation systems, tap local springs or wadis underflow, to grow mostly date palm, limes, alfalfa and vegetables.

1.2.2 Monsoon-Affected Mountains and Plateaus

This kind of landscape occurs only in two separate areas, both in the Dhofar region. One is north of Salalah, the other, along Rakhyut coast.

These areas are strongly dissected. A woody vegetation predominates on steep slopes and gullies, whereas grass and bushes, under heavy grazing, cover most of the relatively flat areas.

Soils are generally shallow in the grazed areas, suggesting that soil erosion is very active in the range-lands. Wooded slopes, protected from erosion by trees and bushes, generally have moderately deep soils.

Rainfed cultivation of beans and sorghum is done by some Jabali in very tiny plots during the monsoon.

1.2.3 The Arid Dhofar Plateau

The Dhofar plateau, which is gently sloping towards the north, is dissected by numerous wadis cutting deep and narrow incisions. Most of the area consists of sedimentary rocks.

Soils are mostly shallow and the meager natural vegetation is under heavy grazing.

1.2.4 Accumulation Plains

There are five accumulation plains in Oman: the Batinah plain, the Northern interior plain, the Sawqirah plain, the Dhofar piedmont and the Salalah plain.

All these plains are bajadas formed by the accumulation of three generations of alluvial fans and terraces. The Sawqirah plain differs somewhat from the other accumulat-ion plains in that the rock floor outcrops in sizeable

areas.

The soils are generally deep and very gravelly to extremely gravelly in all these accumulation plains. In the Salalah plain the soils are not gypsiferous, whereas gypsum accumulations occur in most soils of the other accumulation plain. The quantity of gypsum and the degree of cementation tend to increase with the age of the soils.

Cultivation is generally found in the lower alluvial terraces wherever adequate water resources exit. Most of these cultivated areas are in the Northern interior plain and the Batinah, because water resources are limited in the other accumulation plains.

Date palm, limes, alfalfa and vegetables are the main cultivated crops. Aflaj systems are the main source of irrigation water, but wells are expanding very quickly in and around the oases.

1.2.5 Accumulation/Denudation Plains

These are old accumulation plains where dissection of the landscape by stream erosion has exposed extensive areas of rock outcrop.

The Mirbat plain is mostly rocky, but two levels of alluvial terraces were found in its western part. They are mostly formed of loamy gravelly deposits. No trace of cultivation was seen in that area, probably because of the lack of adequate water resources.

The Northeastern plain in the Sharqiya region is less rocky, but the high alluvial terraces are extremely dissected. Soils are generally gypsiferous, but many of them have very strong salt accumulations. These salts seem to be deposited by droplets of sea water brought by winds.

Cultivation is very limited because of scarce water resources. Date palm and alfalfa are the main crops.

1.2.6 Coastal Alluvial Plains

There are only two such alluvial plains in the Batinah and Salalah areas. Before reaching the sea the wadis, originating in the nearby mountains, become braided and deposit their load of sand and finer particles in depressions behind coastal dunes before infiltrating into shallow aquifers.

These coastal plains have some of the best soils of the country and relatively important water resources.

Nearly half the cultivated area in Oman is in the Batinah coastal plain. Excessive expansion of the cultivated land

has led to sea-water intrusion and salinization of the groundwater and the soils. Crops grown in the Batinah include date palm, limes, mangoes, alfalfa, rhodes-grass, and a variety of vegetables and minor fruit trees.

In the Salalah coastal plain, the main crops are banana, coconut, papaya, vegetables and other minor crops.

1.2.7 Sabkha-Dunes-Rock Outcrop Complex

This landscape occurs extensively in Al Huqf area and in the Eastern costal plain in the Sharqiya region, Hills of rock outcrop alternate with saline basins and sand dunes. Tidal flats are extensive along the coast.

Cultivation is very scarce due to the lack of suitable water resources. It is interesting to note that this area may have some potential for fish farming.

1.2.8 The Eastern Pediplain

It is a nearly leveled monotonous rock plain made of hard carbonate rocks that resist erosion. There is a large number of small depressions caused by dissolution of the carbonates, under a past, moister climate. This landform is deeply incised by wadis near the sea coast.

Soils are generally very shallow and contain secondary lime. Cultivation is very scarce because of the lack of suitable water resources and soils.

1.2.9 The Western Pediplain

It is gently undulated and more dissected by streams. Sulphate rock are more extensive in this area, leading to the concentration of gypsum in the soils which are generally moderately deep to shallow to a gypsum pan and to bedrock.

Cultivation is found in some areas like Dawka where good groundwater is available. Rhodes-grass, alfalfa and vegetables are the main crops.

1.2.10 Umm-Al-Samim Sabkha

This is a large flooded depression collecting drainage waters from the western part of the northern interior plain.

Soils and groundwater are extremely saline, hence preventing any cultivation.

1.2.11 Sand Dune Areas

These are large areas of sand dunes. They occur extensively in the western part of the country in the Rub

Al Khali and in the eastern part as the Wahiba sand area.

Cultivation is very scarce because of unsuitable soils and sand blowing. Grazing is widespread, especially in semi-fixed dunes where a relatively dense bush and tree cover may occur.

1.3 CLIMATE

Except for the Dhofar mountains which enjoy a tropical monsoon climate, the rest of Oman is a subtropical desert. The climate of Oman has a high variability, both spatially and temporally. Two distinct seasons occur, winter (November to April) and summer (May to October). It varies, however, under the influence of three major phenomena, namely the prevailing winds over the region, the up-welling of cold coastal water and the cyclones.

The location of the twelve main weather stations in Oman are presented in Fig. 1.3 and the monthly average temperatures and rainfall recorded in those meteorological stations are illustrated in Figs. 1.4 and 1.5.

1.3.1 Temperature

Annual mean temperature ranges between 17.8^{0}C and 28.9^{0}C (MAF, 1990). Due to the effect of high altitude, mountains like Jabal Al Akhdar in the north and Jabal Al Qairoon Hairiti in the south have the lowest average annual mean temperatures, 17.8^{0}C and 21.6^{0}C respectively. Salalah and Thumrait also have slightly lower mean temperatures than the national average which is 26.3^{0}C because they are affected by the south-westerly monsoon winds which reduce the temperature of the southern region during summer. In other areas mean annual temperatures range form 26.3^{0}C to 28.9^{0}C. In general the annual mean temperature increases from east to west.

The hottest months are June and July and monthly mean maximum temperatures range from 30.7^{0}C in Saiq to 46.1^{0}C in Fahud. The coldest month all over the country is January, with monthly mean minimum temperatures ranging form 9.4^{0}C in Saiq to 24.^{0}C in Mina Raysut. Temperatures below zero are only recorded in Saiq where they occur every year (recorded minimum temperature of -3.6^{0}C).

1.3.2 Rainfall

Only Dhofar mountains, in the southern region, and the Hajar mountains have regular rainy seasons with substantial precipitation. Rainfall in the rest of the country is low and irregular. Heavy rains can occur, sometimes delivering all the precipitation of the year in one single shower, causing violent floods.

Mean annual rainfall is less than 50 mm in the interior

regions, covering two thirds of the country, and is around 100 mm in coastal areas. In the Hajar mountains rainfall ranges between 100 mm to about 300 mm (MAF, 1990). Parts of Dhofar mountains, influenced by monsoons, receive between 200 mm and 260 mm of rainfall annually.

During September to November, very little precipitation is observed in the country (Fig. 1.4 and 1.5).

Rainfall throughout Oman shows not only geographical variations, but also high intra-annual variations. It is not uncommon to have years of very low or even no precipitation. This is evident from Fig. 1.6 which shows annual rainfall at Muscat from 1894 to 1989 (MMDI, 1991_b).

1.3.3 Relative Humidity

Monthly mean relative humidity is highest in coastal areas where it ranges from 50 to 90%. The interior areas are much drier and have mean relative humidity of less than 80% throughout four to five consecutive months. In these areas the absolute minimum relative humidity can be as low as 1 to 2%.

In the northern coastal parts of Oman, high mean monthly relative humidities are recorded in summer and in winter and the lowest values are recorded in May. In Salalah, on the contrary, the relative humidity value peaks in summer and bottoms out in winter.

In the past five years the relative humidity values varied from 13% in May to 95% in September at Sohar, and 23% in July to 89% in January at Sur. Maximum relative humidity reached 100% for a number of months and went down to 1% at Buraimi and Saiq. At Salalah the variation of the monthly relative humidity values went from 27% in February and November to 98% in August (JIACA, 1990)

1.3.4 Winds

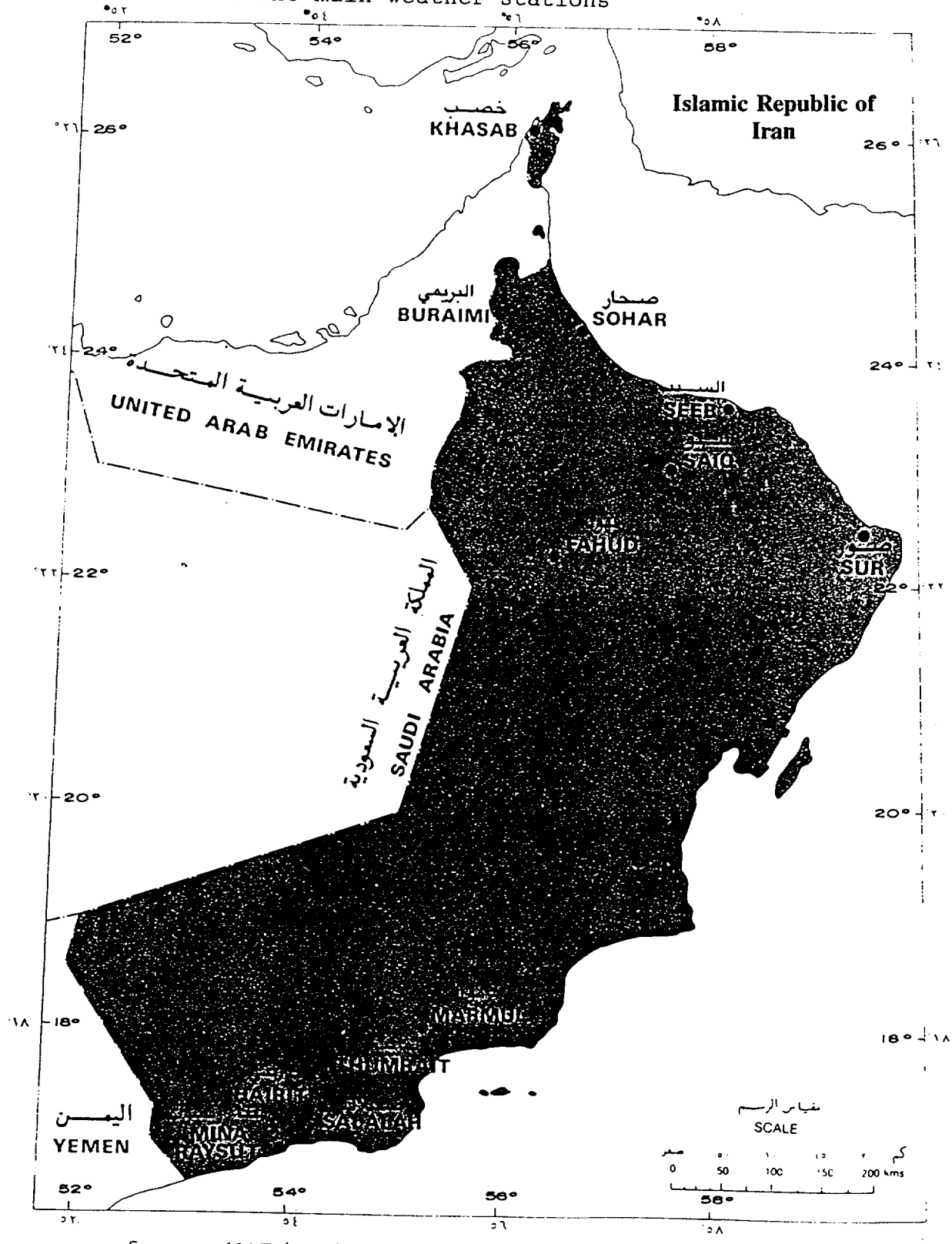
Oman being located in a region between $16^0 37'$N to $26^0 30"$ latitude, and between $51^0 50'$E to $59^0 40'$E longitude is under the influence of the equatorial convergence zone. This is a belt of converging trade wind systems that encircles the earth near the equator (JIACA, 1990). In summer, this system reaches southern Oman and brings monsoon conditions to the Dhofar mountains. In winter, the system moves south of the equator. The predominant wind direction is from the north, while in summer it is from the south.

Average daily wind speeds range between 0.6 $m.sec.^{-1}$ in December to 0.98 $m.sec.^{-1}$ in June at Oman interior, 0.45 $m.sec.^{-1}$ in December to 1.09 $m.sec.^{-1}$ in June at Batinah, 1.6 $m.sec.^{-1}$ in December to 2.33 $m.sec.^{-1}$ in June at Sharqiya, 1.97 $m.sec.^{-1}$ in December to 3.14 $m.sec.^{-1}$ in June

Fig. 1.3: Location of the main weather stations

Fig. (1.3):

Location of the main weather stations



Source: MAF (1990)

The boundaries shown on this map do not imply official endorsement or acceptance by the United Nations

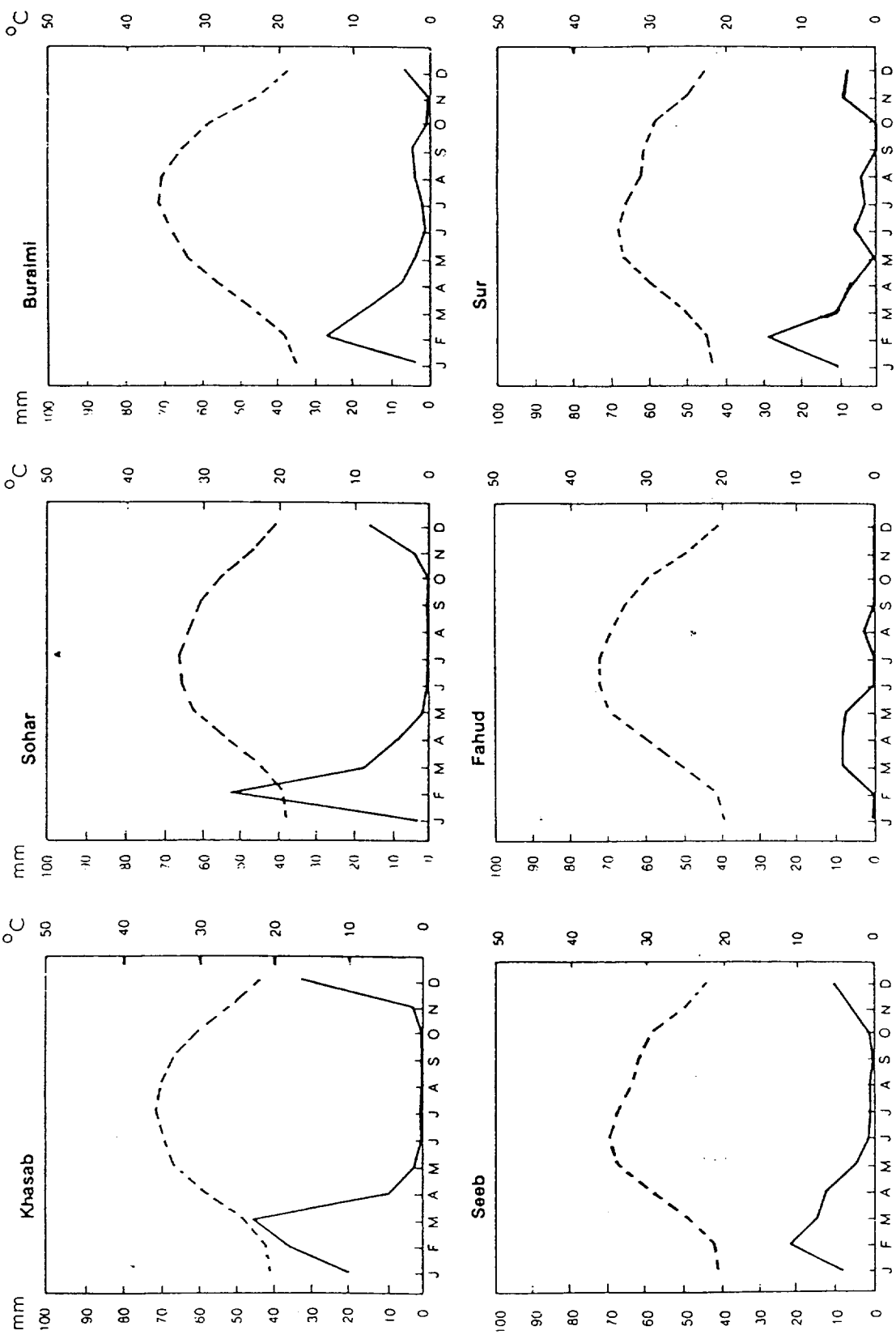


Fig. (1.4):

Monthly average temperatures and rainfall recorded in Khasab, Sohar, Buraimi, Seeb, Fahud and Sur Meteorological Stations (MAF, 1990)

Fig. (1.5):

Monthly average temperatures and rainfall recorded in Saiq, Thumrait, Marmul, Hairiti, Salalah and Mina Raysut Meteorological Stations (MAF,1990)

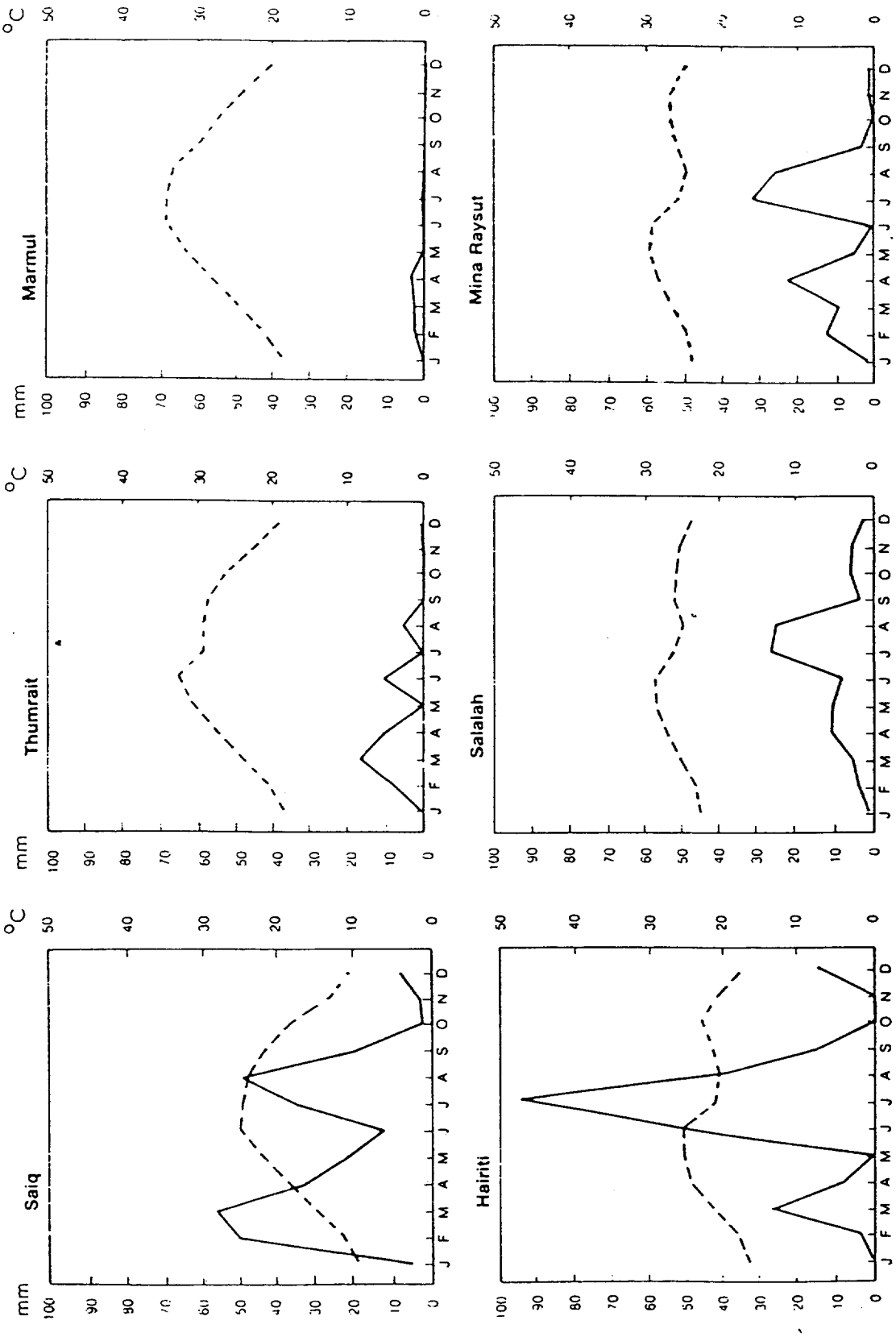
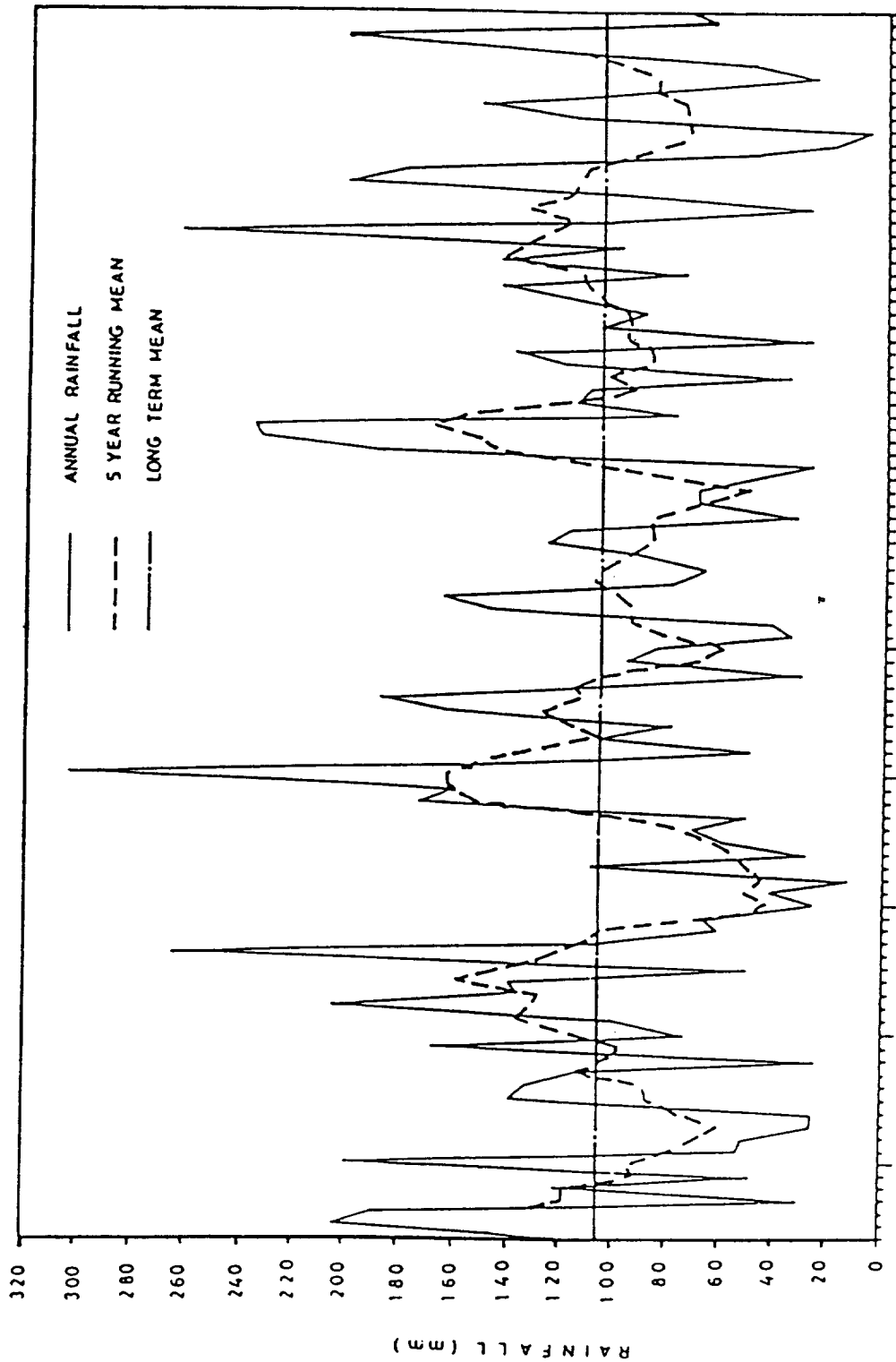


Fig. (1.6):

Annual rainfall in Muscat area during the period 1894 - 1989.



Source: (MAF, 1990).

at Jabal Al Akhdar, and 1.05 m.sec.$^{-1}$ in October to 2.47 m.sec.$^{-1}$ in January at Al Janubiya regions.

1.3.5 Evaporation and Aridity

Evaporation of water from the top soil is affected by a number of factors such as location, time of the year, cloud cover and air relative humidity levels. In Oman evaporation rates usually peak in summer season as temperatures and wind speeds are high and the relative air humidity is low.

The annual open water evaporation rates are 1,411 mm in South Batinah, 2,360 mm at Al Ayn, 2,216 mm at Ibra (JICA, 1990) and about 3,000 mm at Al Wadi-Wahiba sands (Jones et al, 1988). These evaporation figures are 10 - 3 times higher than the mean annual rainfall in the different regions of the country. The least amount of average monthly evaporation was, according to Gibb et al (1985), 168 mm for January (5.4 mm/day). This certainly highlights the degree of aridity the country is exposed to and the critical need for suitable water management systems in the agriculture sector.

1.4 LAND RESOURCES

1.4.1 Geological Regions

The geological formation in Oman ranges from Pre-permian to Recent age, with rock types including volcanic and sediments. The predominant formations which have interest from water resources point of view belong to the Post Nappe Autochthonous and Autochthonous units (Table 1.1)

Oman consists basically of two geological regions. The first is the Oman mountains and their adjacent areas in the north; and the second region is the desert area and the southern mountains. The differences between the two geological groups are clearly identified by topography and climate (JICA, 1990).

The Oman mountains form a part of the Alpine range and are located on the southeastern edge of the arabian sub-continent, adjacent to the Gulf of Oman. Within these mountains, six major rock sequences are found. From bottom to top, they are as follows (see also Fig. 1.7):

(i) A basement of granites and gneisses, partly metamorphosed sediments and meta-volcanic. The basement was folded in the pre-Middle Permian orogeny.

(ii) The Hajar Super-Group and the Aruma Group - a relatively simple sequence of mainly shallow-marine carbonates that range in age from the Middle Permian to the Late Cretaceous.

(iii) The Sumeini Group - local-thrust sedimentary sequences comprising mainly calcareous rocks that range in age from Permo-Triassic to Middle Cretaceous. These sequences are stratigraphically overlain by Middle Cretaceous rocks.

(iv) The Hawasina Group - a complex association of folded and faulted lithological sequences comprising quartz sand and carbonate turbidities, silicified limestone and radiolarian cherts containing fossils from the Triassic through Middle Cretaceous are, and shallow-marine limestone of the Permian and the Triassic ages that are either associated with deeper-water sediments of have a substrate of sheared basaltic pillow lavas.

v) The Samail Ophiolite - a thick sheet of basic and ultrabasic rocks comprising peridotites, gabbros, diabases and spilitic lavas, which overlies the Hawasina nappes with intermittent contact.

vi) The Hadramaut Group and Fars Group - a sequence of mainly shallow-marine carbonates, locally conglomeratic, which overlies all older sequences without conforming precisely to them.

1.4.2 Soils of Oman

Information about the soils of Oman could be extracted from two different soil maps. The first one, "Soil Map of the World", is based on FAO soil classification system. According to this map prepared at a scale of 1:500,000 the soils of Oman were classified in 1977 to two types of soil, Yermosols and Lithosols. Solonchaks and Regosols could, however, be found in certain areas. Haplic yermosols are spread in northern coastal areas, lithosols in the mountainous areas and calcic yermosols in the inland areas. In southern Oman, there are mainly calcic yermosols and some gypsic yermosols in inland areas.

"Agricultural Resources Map" was drawn up in 1988 utilizing LANDSAT imagery (JICA, 1990). Soils of Oman are classified accordingly to seven types, namely:

Yermosols, Arensols, Fluvisols, Regosols, Solonchaks, Solonetz and Lithosols.

In a recent study (MAF, 1990) the soils of Oman were classified according to the Soil Taxonomy, the soil classification system of the United States of America (USDA-SCS, 1975), taking into consideration the revised legend of the Soil Map of the World (UNESCO-FAO-ISRIC, 1988) and using the same concept of the diagnostic horizons. Six diagnostic horizons were recognized in Oman during this soil survey, namely: Ochric epipedon, Calcic

Table (1.1):

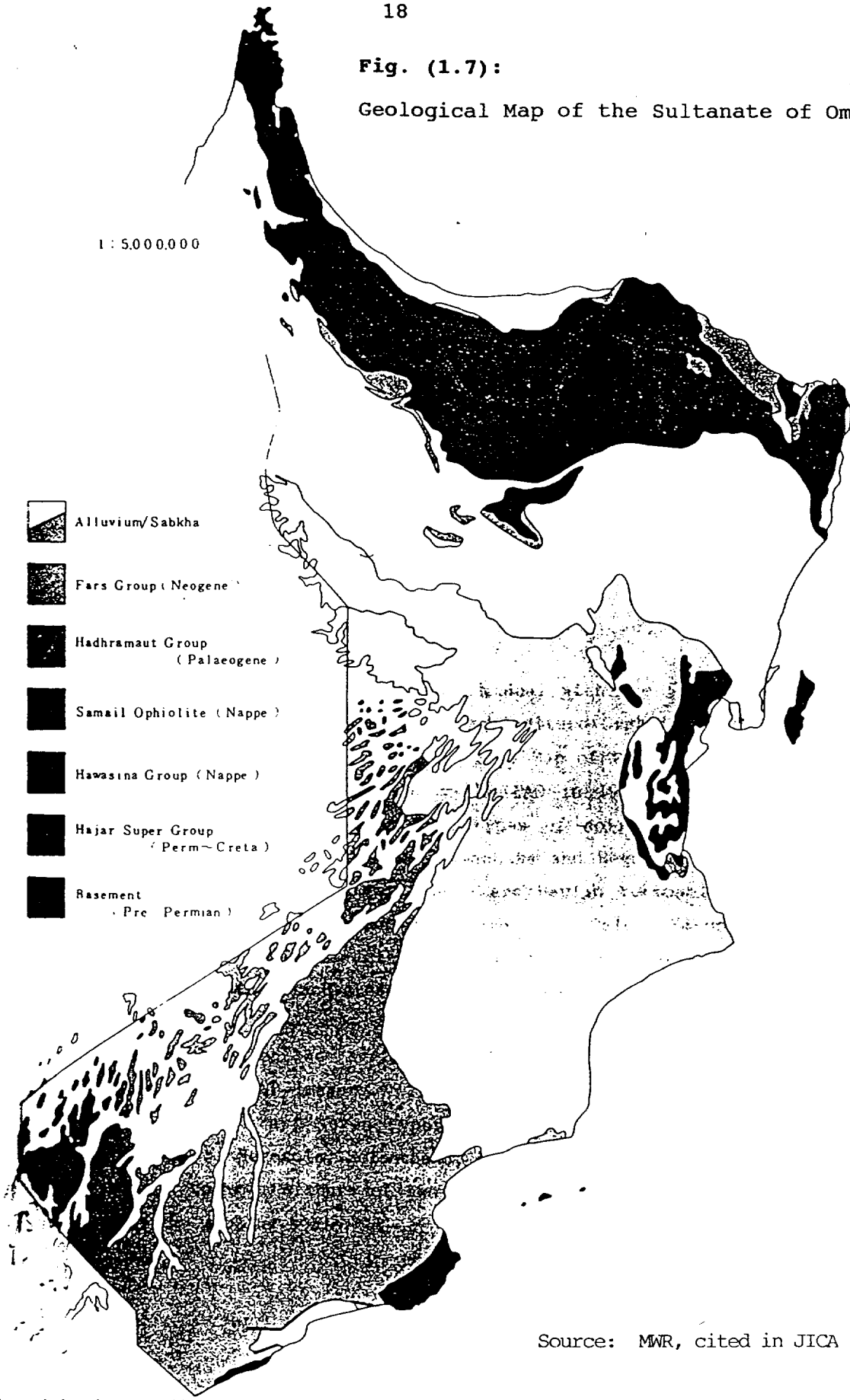
General Stratigraphy and Hydrogeology of Oman

	Era	Age	Stratigraphical Unit	Lithology	Aquifer Potential
POST NAPPE AUTOCHTHONOUS	Q'ARY	Holocene Pleistocene		Carbonate-cemented conglomerates gravels and sands with clasts of basic and ultra-basic rocks, limestone and chert. Aeolian sand and silt, and evaporites. [Terrestrial deposits]	Main aquifer Permeabilities expected to decrease at increasing distances from mountains. Water, in general, fresh
	TERTIARY	Pliocene	Upper Fars Group		
			Folding and Uplift		
		Miocene	Upper Fars Group	Mainly marls and clays with evaporite horizons [restricted basin deposits]	Aquiclude
			Folding of Oman Mountains		
		Oligocene	Taqa Formation	Marls, stratified limestone and massive limestone	Cavernous massive limestone; if recharged may offer fair but varying possibilities
			Erosive unconformity		
		Upper Eocene Middle Eocene Lower Eocene Palaeocene	Dammam Formation Rus Formation Umm er Radhuma Formation	Marls, limestone, massive crystalline limestone, cherts, Gypsiferous horizons possible	Major aquifer within Umm er Radhuma; Dammam and Rus form aquifers of local importance. Water quality variable, may be saline where Rus evaporitic
ALLOCHTHONOUS		Marine transgression over top of allochthonous deposits			
		Age uncertain; probably Upper Cretaceous	Semail nappe	Basic and ultra-basic rocks	Fair possibilities. If fractured, especially in collective zones like weathered zones adjacent to dykes which often function as drain
		Age very uncertain may be many ages	Hawasinah Group	Conglomerate, calcareous shales, limestone conglomerates, cherty limestone, shales and radiolarites	Mainly fractures and cavernous limestones; may offer fair possibilities
		Tectonic unconformity along thrust plane		Thrust zone	May serve as drain if continuous enough and not too clayey (not likely)
AUTOCHTHONOUS B	MESOZOIC	Upper Cretaceous	Fiqa, Muti and Qumayrah Formations	Shales and lime mudstones	Most likely no potential
		Middle Cretaceous Lower Cretaceous	Wasia Group; Mahmah Group;	Limestones Limestones and shales	Fair possibilities if fractured and cavernous
		Jurassic	Sahtan Group	Shales, limestones and sandstones	Most likely no potential
		unconformity			
		Triassic Permian	Mahil Formation Saiq Formation	Dolomite	Fair possibilities if fractured
	PALAEOZOIC	unconformity and major stratigraphical break			
A		Pre Permian	Huaydin Formation Hajir Formation Mistal Formation	Siltstone, sandstone Dolomite chert	Possibilities if fractured, unlikely to be significant

Source: ILACO (1975)

Fig. (1.7):

Geological Map of the Sultanate of Oman



Source: MWR, cited in JICA (1990).

The boundaries shown on this map do not imply official endorsement or acceptance by the United Nations

horizon, Camic horizon, Gypsic horizon, Petrografic horizon and Salic horizon. Some more details about these horizons are given in Appendix (I).

Out of the eleven orders that are defined by Soil Taxonomy, only three exist in Oman. These are the Entisols, Inceptisols and Aridisols. Some more details about the three soil orders existing in Oman are given in Appendix (II).

The characteristics of the soils are presented below according to their presence in the seven main regions of Oman:

(1) North Batinah and South Batinah Regions

The soils of the North and South Batinah are of alluvial types and represent the most suitable soils for agricultural activities. This area comprises yermosols of silt and fine sands. More than half of the cultivated areas in Oman are present in the Batinah plains and hence this region represents the most development potential for agriculture (JICA, 1990).

In areas near to the sea, salt accumulation is observed and the agricultural activities in some farms have been abandoned. This has pushed farmers to search for new farm lands towards the inland area in a search for good soils for agriculture. Accumulation of salt in soils near the sea has been attributed to the intrusion of seawater.

Some of the gravel covered soils of the interfluvial plains are used for agricultural production despite their low suitability. The increased demand for agricultural good and the application of new irrigation method may have made this type of activity economically viable.

(2) Dhahira Region

The soils of the Dhahira region including those of Buraimi region are formed mainly by alluvial and eolian processes. Medium-to-fine textured yermosols found on limestone alluvial fans represent the most important type in these two regions.

(3) Interior and Wusta Regions

Alluvial plains in the north have yermosols derived from the limestone range and represent the agricultural areas in the regions. Flood water brings weathered materials to the plains and forms

the fine textured soils.

(4) Sharqiya Region

The soils of the Sharqiya region are formed mainly by alluvial and Eolian processes. Yermosols represent here also the most suitable agricultural lands and are completely under cultivation. Interfluvial plains with Arenosols are considered to have the highest potential for agricultural development (JICA, 1990).

(5) Southern Region

Salalah plains with their yermosols represent the most important soils for agriculture in the Southern Region. The soils are derived from northern Jabal. In the Jabal areas, soils are of clay and silty type and have well developed structures. These areas are known as the main rangelands grazed by the livestock in the Southern Region.

Yermosols represent the main soil type also in Nejd. Soils suitable for agriculture are entirely yermosols.

1.4.3 Agricultural Lands

The latest soil survey (MAF, 1990) revealed that out of the total area of the country amounting to 31.427 million hectares only 2.223 million hectares are suitable for agricultural activities (Table 1.2) or about 7% of the country area. In another recent study (JICA, 1990) based on analyses of 1982 LANDSAT MSS data, the land area suitable for irrigated agricultural activities was estimated to be only 0.269 million hectares (Table 1.3), located in 10 different regions of the country (Fig. 1.8).

Despite the surveys carried out and the series of investigations made, the present state of cultivated lands is not clear. The figures of land areas of irrigated agriculture show as presented in (Table 1.4) considerable differences between the estimates and ranged between 36,145 and 165,401 hectares according to the source of information (Table 1.4). Factors responsible for such differences include, according to MMDI (1991[b]):

(i) Changes in areas cultivated due to expansion (3.3% annually for the period 1978 - 1988);

(ii) Boundary differences of regions at compilation;

(iii) Seasonal differences in coverage with crops; and

(iv) Differences in definition of agricultural lands.

Table (1.2):

Area by land suitability class for agriculture, selected according to the latest soil survey (1990)

	Area	
Land Class	In Hectares	In Percent
S_1*	791,651	2.52
S_2**	1,431,406	4.55
Total suitable land (S_1 and S_2)	2,223,057	7.07
Total unsuitable land (N)***	29,203,409	92.93
Total land	31,426,466	100.00

*Class S1 (Highly to moderately suitable): Land having no significant limitations or having limitations which in aggregate are moderately severe for sustained irrigated agriculture.

**Class S_2 (Marginally suitable): Land having limitations which in aggregate are severe for sustained application of a given use and will so reduce productivity or benefits, or increase required inputs, that this expenditure will be only marginally justified.

***Class N (Not suitable): Land having limitations which may be surmountable in time but which cannot be corrected with existing knowledge at currently acceptable cost; the limitations are so severe as to preclude successful sustained irrigated agriculture, or, land having limitations which appear so severe as to preclude any possibilities of successful sustained use of the land for irrigated agriculture.

Table (1.3):

Land areas with potential development for irrigated agriculture selected according to the LANDSAT MSS data analysis

Region	Area Surveyed ha.	Land areas according to suitability for irrigated agriculture			
		S_1	S_2	S_3	TOTAL
Batinah	347,000	8,920	11,601	18,276	38,797
Batinah Plain	347,000	8,920	11,601	18,276	38,797
Dahirah	130,000	1,345	11,819	8,613	21,777
Buraimi	60,000	388	361	23	772
Dank	30,000	461	4,267	2,300	7,028
Ibri	40,000	496	7,192	6,290	13,977
Interior	226,000	5,850	4,611	8,170	18,631
Bahlah	70,000	3,880		2,610	6,490
Nizwa-Adam-Izki	156,000	390	2,671	5,560	12,141
Sharqiya	320,000	1,000	22,000	17,000	40,000
Wadi Andam	156,000)				
Jabal Al Qar	164,000)	1,000	22,000	17,000	40,000
Wadi Al Batha					
Southern	220,000	28,340	46,582	75,022	149,944
Salalah Plain and Jabal Al Qara	220,000	28,340	46,582	75,02	149,944
TOTAL	1,243,000	45,455	96,613	127,081	269,149

Source: calculated from data cited by JICA (1990).

Table (1.4):

Areas of irrigated agriculture by region and by source (ha)

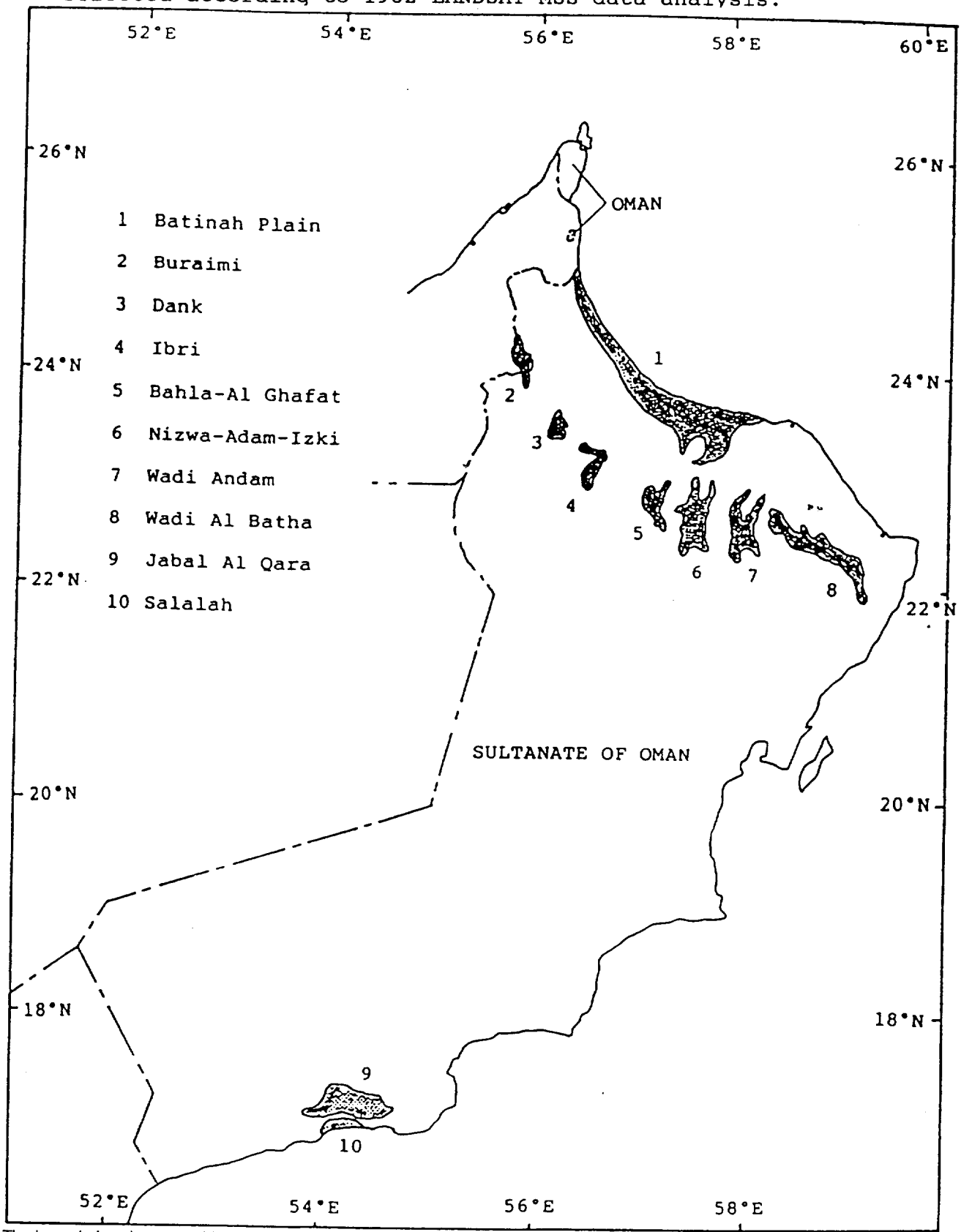
Region	Statistical Year Book (1990) (1978-79 Data) Total Farm-Land	Statistical Year Book (1990) (1978-79 Data) Cultivated Area	ESC (1982) Cultivated Area	JICA (1990) MAF Estimates (1988)	WEC (1) (1988 Cultivated Area
Musandam	1,120	1,030	2,629	N/A	2,550
Batinah	46,126	20,750			94,100
Muscat			14,482	31,207	
Eastern Western Hajar	4,580	3,190			
Buraimi	1,312	885			1,500
Dhahira	7,202	3,303	12,028	5,603	
Dakhliya	14,495	5,167		5,619	20,362
Sharqiya	5,818	4,285	6,034	2,109 8,615	11,015
Janubiah	2,707	2,414	972	1,488	4,462
Total	83,360	41,024	36,145	54,641	165,401

1. Calculation made by MMDI (1991_b) from remote sensing maps.

This overestimated area includes uncropped areas, wadi bottoms, buildings, roads.

Fig. (1.8):

Areas with potential development for irrigated agriculture selected according to 1982 LANDSAT MSS data analysis.



The boundaries shown on this map do not imply official endorsement or acceptance by the United Nations

Source: JICA (1990)

The widely accepted figure for irrigated land area in Oman is in the range of 55 - 60 thousand hectares. This area was cultivated in 1988 to vegetable crops (6,040), field crops (9,647), fruit trees (32,303) and other crops (6,651).

Areas cultivated to different crops by regions are given in (Table 1.5). The most common cultivated crop in the country is the date palm. It occupies 24,170 hectares or about 44% of the entire irrigated cultivated area. The second largest crop area is cultivated to alfalfa, being 8,770 hectares or about 16.1% of the total irrigated crop area of the country.

1.5 WATER RESOURCES

Oman, as mentioned earlier, is arid and characterized by potential evaporation rates (>2,000 mm. $year^{-1}$). Evaporation values of more than 3,000mm $year^{-1}$ are recorded for parts of the interior. In most of the country the rainfall is unreliable.

Surface flow of rain water is usually confined to short periods of few hours or few days after heavy rain storms. This flow is usually towards the sea and does not allow perennial rivers to exist. Wadi Dayqha (70km south of Muscat) is unique in having perennial surface flow over a distance of more than 30km. The flood flows are, however, of major importance for recharge of the aquifers of the coastal and interior plains.

Perennial springs issue from the limestones in the northern mountains and the Dhofar Jabels (MMDI, 1991_a). They remain occasionally as flow at the surface over substantial distance.

1.5.1 Groundwater

The groundwater in the Sultanate of Oman is of utmost importance as it represents the source of most of the Sultanate's irrigation and domestic supplies (MMDI, 1991_a). Water resources are basically equivalent to groundwater resources. Most of the surface flow from catchment areas in the mountains percolates underground at the foot of the mountains.

1.5.1.1 Hydrogeology

The hydrogeology regions of Oman were identified within a project for preparation of A National Water Resources Master Plan which was prepared by Mott MacDonald International Ltd. (MMDI, 1991_a and $_b$). The hydrogeological regions are given in (Fig. 1.9) and the hydrogeology of each has been outlined by MMDI (1991_a) as follows:

Table (1.5):
Areas cultivated to different crops by region (1988), ha

Crops	REGION								
	N.Batinah	S.Batinah	Sharqiya	Wusta	Interior	Dhahira Buraimi	Southern Region	Musandam	Total
Vegetables:	1,354	1,699	998	309	784	759	137	N/A	6,040
Tomato	343	280	202	70	169	125	23	N/A	1,212
Chilli Pepper	148	233	89	28	61	36	15	N/A	610
Onion	109	112	83	32	85	131	8	N/A	560
Garlic	4	8	13	18	63	44	0	N/A	150
Okra	6	33	4	2	4	2	2	N/A	53
Watermelon	257	347	192	38	151	240	25	N/A	1,250
Sweetmelon	209	222	102	14	32	34	12	N/A	625
Cabbage	139	226	94	51	151	79	30	N/A	770
Cucumber	95	171	213	54	64	53	20	N/A	670
Potato	44	67	6	2	4	15	2	N/A	140
Field Crops:	1,879	1,806	2,065	450	1,738	1,388	321	N/A	9,647
Wheat	12	25	85	25	178	143		N/A	468
Alfalfa	1,458	1,781	1,980	425	1,560	1,245	321	N/A	8,770
Tobacco	409	0	0	0	0	0	0	N/A	409
Fruits:	9,155	11,268	4,753	998	2,577	2,906	646	N/A	32,303
Dates	6,392	7,811	4,177	829	2,197	2,689	75	N/A	24,170
Limes	857	901	193	70	213	144	22	N/A	2,400
Mango	1,342	2,012	205	87	67	62	5	N/A	3,780
Banana	564	544	178	12	100	11	216	N/A	1,625
Coconut	0	0	0	0	0	0	328	N/A	328
Other Crops*	2,217	1,829	799	352	520	550	348	N/A	6,651
TOTAL	14,605	16,602	8,615	2,109	5,619	5,603	1,488	N/A	54,641

* Other Crops: Includes papaya, carrot, sweet potato, radish, eggplant, squash, pumpkin, cauliflower, beetroot, turnip, bean, lettuce, pea, barley, sorghum, chickpea, lubia, lemon, sweetlime, fig, guava, grape, pomegranate, almond (not in special order).

Source: JICA (1990)

"The Northern Mountains"

Northern Oman is dominated by an anticline, which forms a mountain chain from Musandam to Sur. The core of these mountains is composed of largely impermeable pre-Permian rocks, overlain on the flanks by shallow marine limestones and dolomites. Tectonic movements resulted in a detached block of oceanic crust and mantle (the Samail ophiolite), and deep water marine sediments being thrust over these formations. A once extensive cover of Tertiary limestone has largely been eroded, but significant remnants especially on Jabal Abyad, North-West of Sur.

Groundwater in hard rocks is found primarily in open joints and fractures, particularly in the limestones, which are the source of several important springs. Water quality is generally good, but highly alkaline springs are associated with certain horizons within the ophiolites.

The alluvium of the wadi valleys on both sides of the mountains usually has a high permeability and contains generally good quality water. It is however, usually of limited extent and the storage may be rapidly depleted in dry periods. The alluvium is recharged by infiltration from surface floods and flow from hard rock aquifers.

Whilst the formations of the Northern Mountains are important sources of water to many existing communities, they do not appear to offer scope for further large scale development. They are either exploited by traditional irrigation systems, or are continuous with the alluvial aquifer systems of the plains described below.

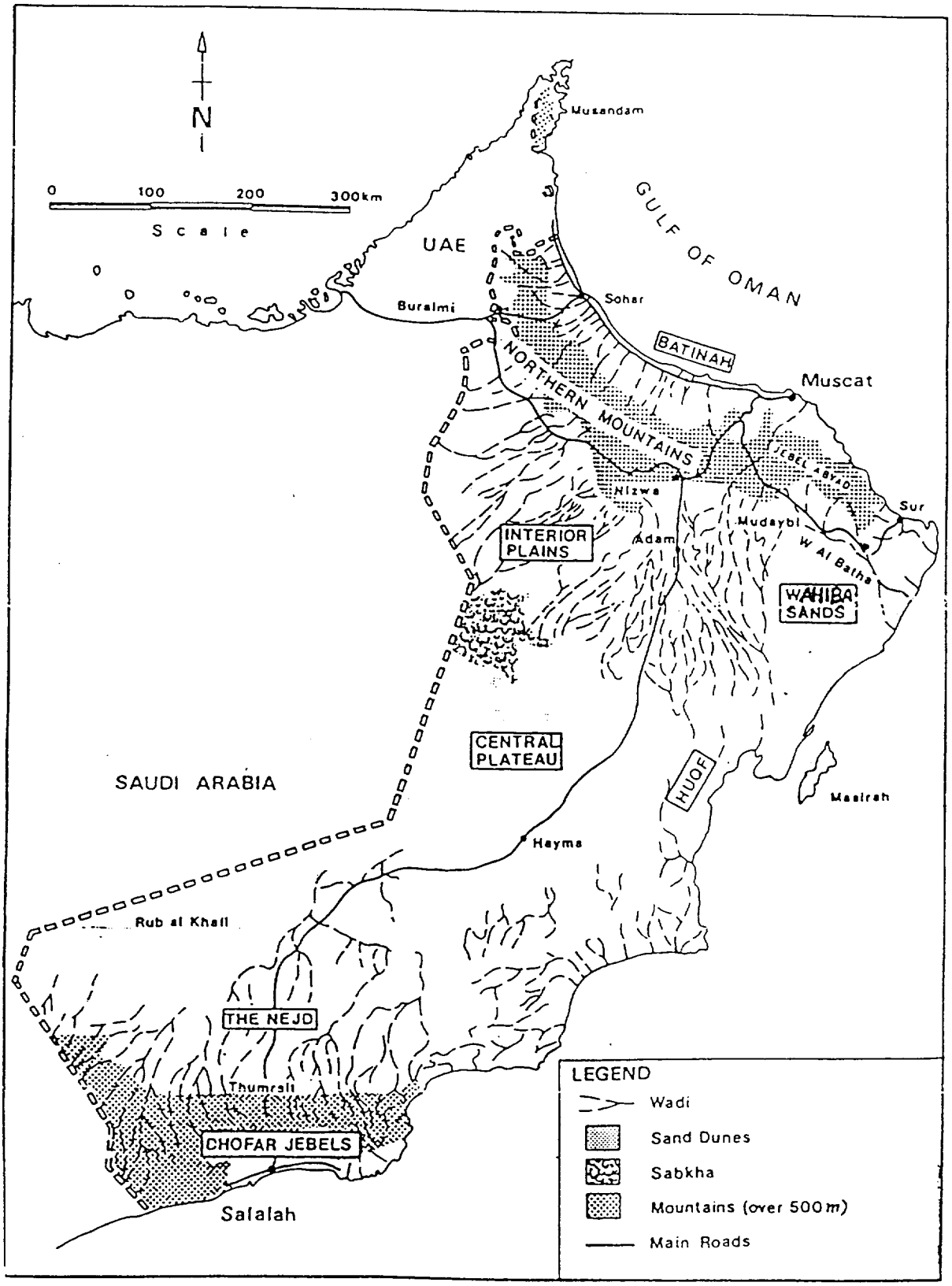
The Batinah Plain

Between the Northern Mountains and the sea lies the coastal plain of the Batinah. The alluvium which forms this plain is up to 600 m thick near the coast and constitutes one of the major aquifer systems of the country. The water resources are heavily exploited for irrigation, especially in the coastal strip. Permeabilities vary according to the clay content of the alluvium and the degree of cementing. The large volume of storage in the alluvium is adequate to maintain supplies during long dry periods. Recharge may occur by; the infiltration of surface run off from the mountains, the transfer of water from hard rock aquifers direct infiltration of rainfall on the plain.

Water quality is generally good, except nea e coast where salinities are high, due to sea water usion, which is increasing over much of the Batinah c st.

Fig. (1.9):

Physical Features and Hydrogeological Regions of Oman



Source: MMDI (1991a)

The boundaries shown on this map do not imply official endorsement or acceptance by the United Nations

The Interior Plains

To the south and south-west of the mountains, a gently sloping plain drains inland. The plain is covered by a thin layer of Quaternary alluvium, underlain by Tertiary sediments. Groundwater is found primarily at shallow depths and good quality resources are mostly associated with alluvial wadi channels. However, near the mountains, large quantities of brackish water (salinity less than 6.400 $mg.L^{-1}$) appear to occur in the uppermost Tertiary sediments. Away from the mountains, groundwater quality deteriorates and becomes highly saline in the sabkha of the Umm-As-Samim.

Wadi Al Batha and the Wahiba Sands

The Interior Plains are bounded in the east by an area of sand dunes, the Wahiba Sands. This prevents surface drainage to the south. Run off from the mountains accumulates in Wadi Al Batha, which flows East and then South-East to the Arabian Sea. The wadi alluvium is an important aquifer, but the saturated thickness is often small and water quality deteriorates to the south. There appears to be a connection to aquifers underlying the Wahiba Sands.

The Central Region (Al Wusta)

The Central Region is underlain mainly by Tertiary sediments of the Hadramaut group. The main aquifer is the Umm er Radhuma formation. Recharge occurs primarily in the south, but flow through the aquifer is low and water quality is generally poor. Localized areas of near potable quality water occur in wadi alluvium and in the Tertiary sediments. Recharge to these areas is presumed to be from local rainfall, probably mainly from occasional cyclonic storms which develop over the Arabian Sea. Therefore, they are unlikely to have significant scope for development, although little is known of the quantity and quality of groundwater resources in the region as a whole.

The Nejd

The Nejd is a gently sloping plain, falling from the Dhofar Jabels towards the sand dunes of the Arub Al Khali. It is underlain by the same sequence of Tertiary sediments as the Central Region, but the Lower Umm er Radhuma formation in this region contains water of near potable quality. The aquifer is confined and flowing artisan wells occur in the north of the region. Recharge is thought to be low, but the large volume of water stored offers significant possibilities for development based on "mining" a non-renewable resource. Other formations may also contain large volumes of water, but generally of poorer quality than the Lower Umm er Radhuma.

The Dhofar Jebels

The Dhofar Jebels form the Southern boundary of the Nejd, with steep scarp slopes to the Salalah Plain and the Arabian Sea. The Jebels are formed from the same Tertiary sediments as the Nejd. They receive a higher rainfall than the plains and are enveloped in fog during the summer monsoon. The Jebels are a major recharge area. Infiltration is believed to flow primarily to the south to the Salalah Plain.

The Salalah Plain

The Salalah Plain lies between the Dhofar Jebels and the sea. It has a mostly thin covering of alluvium, underlain by the limestones of the Taqa formation and the Hadramaut group at depth. The main aquifer is the upper member of the Taqa formation. It is recharged primarily by flow from the Jebels. A broad tongue of fresh water extends across the plain from the Jebels to Salalah. To the East and West of Salalah, groundwater is mostly brackish.

1.5.1.2 Groundwater Resources

Estimates of groundwater resources available in Oman were made by several groups. The JICA group reported in 1990 of 1,239.8mm $year^{-1}$ available groundwater(Table 1.6). This figure was by far higher than the estimates made by the MMDI group in 1991. Estimates of available groundwater carried out within the National Water Resources Master Plan were, according to MMDI (1991_a), only about 850 mm^3 $year^{-1}$ (Table 1.7). Here also more than 50% of the available groundwater resources is in the Batinah and Muscat area. The different estimates of the present groundwater available was attributed by MMDI (1991_a) to one or more of the following factors:

(i) The short period of hydrological records;
(ii) The sparseness of hydrological data; and
(iii) The lack of accurate data on the extent of cropped areas and agricultural water use.

Opportunities to increase groundwater resources, the so-called potential new resources for groundwater seems to be very limited as compared to the available resources at present. According to the Water Master Plan of Oman (MMDI, 1991_a) only about 82mm^3 $year^{-1}$ could be added to the groundwater resources available at present (Table 1.8), representing less than 10% increase.

Enhancement of the recharge of groundwater with present schemes is in the order of 7mm^3 $year^{-1}$ while through the planned schemes an additional 12mm^3 $year^{-1}$ could be recharged to the groundwater and totaling 19mm^3 $year^{-1}$ (see Table 1.7).

Table (1.6):

Groundwater resources in the Sultanate of Oman by region.

Region	Catchment Area Km^2	Mean Annual Participation mm	Mm^3	Runoff Rate (%)	Catchment Runoff Mm^3	Flood Loss Mm^3	Groundwater Recharge Mm^3
N.Batinah	4,860	137	665.82	40.0	266.3	26.1	240.2
S.Batinah	7,757	125	969.63	35.0	339.4	22.5	316.9
Dhahira	7,143	135	964.31	20.0	192.9	56.3	136.6
Dakhliya	4,280	168	719.04	30.0	215.7	58.3	157.4
Sharqiya	10,597	105	1,112.69	25.0	278.2	46.2	232.0
Musandam	693	255	176.72	20.0	35.3	5.3	30.0
Al Janubiya	3,655	156	570.18	25.0	142.5	15.8	126.7
TOTAL	38,985	133	5,178.37	28.4	1,470.3	230.5	1,239.8

Source: JICA (1990)

Table (1.7):
Water Resources in the Sultanate of Oman by source and region, status 1990 ($Mm^3.year^{-1}$)

Region	Water Resources, $Mm^3.year^{-1}$				
	Groundwater				
	Natural Abstraction	Enhanced (Existing Schemes)	Enhanced (planned schemes) 1991-1995	Other Sources (Desalination)	Total Available
Batinah and Capital Area	438	4	9	39	490
Northern Dahira and Dakhliya	217	2	3	-	222
Norther Sharqiya	155	-	-	2	157
Salalah Plain	40	1	-	-	41
Nejd	not known probably low	-		-	
Musandam	not known probably equal to demand			small plant	
Central Region (Al Wusta)	poor quality water			small plant	
TOTAL	850	8	12	41	910

Source: Based on data cited by MMDI (1991).

Water quality is generally good, except near the coast where salinities are high, due to sea water intrusion, which is increasing over much of the Batinah coast.

Table (1.8):
Potential new groundwater resources by source and region, status 1990 (mm^3 $year^{-1}$)

	Potential New Sources, $Mm^3 \cdot year^{-1}$			
Region	Total	Additional Recharge Dam	Recharge of TSE	Wadis Catchments
Batinah and Capital Area	55	20	20	15
Northern Dahira and Dakhliya	25	5	-	20
Northern Sharqiya	2	-	-	-
Salalah Plain	-	-	-	-
Nejd	-	-	-	-
Musandam	-	-	-	-
Central Region (Al Wusta)	-	-	-	-
Total	82	25	20	35

Source: Based on data cited by MMDI (1991_a)

1.5.2 Desalinated Water

Desalination plants are at present limited to Muscat area, Salalah and the Kuria-Muria Islands. Small-scale desalination plants have been installed in some rural areas. The total amounts of desalinated water is in the range of $41mm^3$ $year^{-1}$ (Table 1.7) representing only 4.5% of the Sultanate's total water resources ($910mm^3$ $year^{-1}$, MMDI, 1991_a).

Desalination of seawater in coastal areas as well as of inland brackish water offer unlimited but expensive water source. This limits its use to potable supplies. Reverse osmosis (R.O.) method is appropriate for small and medium sized desalination plants. In muscat area where demand for both water and electric power is large, combined power generation and desalination using flash distillation process is applied.

1.5.3 Treated Sewage Effluent (TSE)

Treated sewage effluent (TSE) represents according to recent studies (Al-Shuriani, 1991) a renewable source of water when properly managed. At present TSE amounts to

about 70,000 m^3 day^{-1} or 25.6mm^3 $year^{-1}$, out of which about 30,000m^3 day^{-1} (11mm^3 $year^{-1}$) are used by the municipality of the capital area for irrigating ornamental plants.

The Potential for increasing both the generated and the consumed amounts of TSE is expected as programmes are to expand both water supply systems and piped sewerage schemes (MMDI, 1991_b). The standards established recently in 1989.

Recent research findings of Al-Shuriani (1991) revealed that tertiary TSE of Dar Seet sewage treatment plant (near Muscat) was as safe as well water when used for irrigation of sunflower oil crop, suggesting reviewing of the present standards and defining several standards to suit the different applications of TSE, i.e. irrigation of ornamental plants, trees for afforestation programmes, controlled cropping, industrial uses and aquifer recharge.

1.5.4 Water Demands

Agriculture is the main water consumer in Oman, representing about 94% of the total water demand of the country. Domestic and industrial water demands, inspite of the recent rapid increase along with Oman's economic development, represent only 6.1% of the country's demand. Out of the 1,231mm^3 $year^{-1}$ total water consumption (MMDI, 1991) only 41mm^3 $year^{-1}$ comes from desalination plants and the rest (1,185mm^3 $year^{-1}$) is pumped from groundwater. Demands of water by sectors and regions are given in (Table 1.9). The differences in water demand values between the JICA (1990) and the MMDI (1991_b) studies indicate the need for accurate estimates of both water resources, demands and uses in Oman. it is also evident that 57.3% (JICA, 1990) to 59.0% (MMDI, 1991_b) of the total agricultural water use was consumed in the Batinah region. Less agricultural water demand is recorded for Dhahira, Dakhliya and Sharqiya regions.

Groundwater is used to irrigate about 54.4 thousand hectares (JICA, 1990) cultivated to date palms (44%), fruit trees (15%), vegetable crops (23%), alfalfa (16%) and other crops (2%).

The cultivated area is irrigated by wells (32,005 hectares), Aflaj (12,410 hectares), springs (121 hectares), irrigated by more than one of the previous sources (2,782 hectares) and by rain (478 hectares).

The Falaj (plural Aflaj) comprises a channel leading from the water source to the irrigation system. Qanat Alfalaj (the channel) consists of a tunnel constructed at low gradients to intersect the water table and exploit the groundwater resource. The Falaj system is managed by the local community to satisfy the domestic use and the irrigation of perennial crops, primarily dates. Annual

Table (1.9):

Water demand in the Sultanate of Oman by source, sector and region ($Mm^3.year^{-1}$)

JICA (1990)					MMDI (1991_B)		
Region	Agriculture	Domestic	Total	Region	Agriculture	Potable Supplies	Total
N.Batinah	321.3	53.9	803.7	Batinah and Capital Area	679	56	735
S.Batinah	428.5			N. Dhahira and Dakhliya	245	5	250
Dhahira	134.5	-	-	N.Sharqiya	165	4	169
Dakhliya	168.6	-	-	Salalah Plain	32.5	7.5	40
Sharqiya	206.8	-	-	Nejd	7	1	8
Musandam	13.4	-	-	Musandam	23	< 1	24
Al Janubiya	35.7	8.0	43.7	Central Region (Wusta)	unknown, but low	5	5*
TOTAL	1,308.8	61.9	1,370.7	TOTAL	1,151.5	79.5	1,231**

* Does not include agricultural demand
** Does not include agricultural demand of the Central Region (Wusta)

crops are grown when the Falaj water is plentiful (MMDI, 1991_a).
Water wells are privately owned and there is no limitation on the abstraction of water. The abstraction of water was limited in the past as human or draught animal power was used to lift water. Large abstractions for irrigation were only possible where the water was at shallow depths. The governmental subsidized introduction of motorised pumps has enabled much larger water abstractions from deeper layers.

Methods of irrigation applied are flood, sprinkle and drip. The areas under each method of irrigation are not known. It is, however, assumed that practically all the irrigated lands apply flood method. The water use efficiency of the traditional irrigation method is very low and ranged between 30 to 45% (Hydro Consult, 1985; Little, 1985; and Atkins, 1989). Improvement of the water conveyance efficiency i.e. through lining of irrigation canals or using piped supply increased the water use efficiency to reach 65-70% (Table 1.10).

Table (1.10):

Water use efficiency of different irrigation methods in Oman

Irrigation Method	Water Use Efficiency by Source %		
	Hydro Consult (1985)	Little (1985)	Atki (198
Flood irrigation, traditional	45	-	30
Flood irrigation, lined canals	65	-	-
Flood irrigation, piped supply	70	-	-
Sprinkle irrigation	75	60	60
Drip/trickle irrigation	80	80	85

Source: (MMDI, 1991).

Farmers tend to overirrigate growing crops to control the build up of salt concentration in the soil within the root zone. The facilitated water abstraction through motorised pumping contributed to the problem. In the Batineh Region, especially in Eastern Batinah, severe overabstraction was reported (MMDI, 1991_a). Water levels have fallen steadily during the last seven years. Salinity of both irrigation water and cultivated soils has increased to an extent damaging to crops of coastal farms. Abandonment of agricultural activities in coastal farms of Batinah Region represents a real threat. Water

balances in this area indicate, according to MMDI (1991_a), abstractions of as much as twice the recharge to the aquifer. The available water resource in the Batinah is estimated to be about 440 $Mm^3.year^{-1}$ (table 1.7) while the present use ranges between 720 (JICA, 1990) and 760 $Mm^3.year^{-1}$ (MMDI, 1991_a).

Financial subsidies are allocated and policies are adopted by the government to encourage farmers to introduce improved irrigation methods aiming at rationalization of water consumption in the agriculture sector. Modern irrigation methods i.e. sprinkle, pivot, drip and bubbler are introduced to some newly established farms and have achieved higher productivity. Shortage of capital, awareness and adequate technical knowledge delay the acquaintance of these irrigation methods by many of the Omani farmers and/or landlords.

1.5.5 Water Balance

Planning for development, especially in the agricultural sector, is based on availability of additional water resources. These resources could be:

(i) Surplus water in some regions;
(ii) Enhanced exploitation of groundwater;
(iii) Savings due to rationalization of present uses;
(iv) New groundwater sources explored; and
(v) Extensive use of TSE or recharge to groundwater.

Calculations made by JICA (1990) indicate that there are few groundwater resources available for development (1.11). General trends of regional balance of groundwater are, according to JCIA 91990), as follows:

(a) Batinah Region indicates serious overdrafting of groundwater amounting to 201.4 $Mm^3.year^{-1}$ over the available groundwater recharge (557.1 $Mm^3.year^{-1}$) or about 36% overdrafting. The overdrafting is mainly seen in salinization areas;

(b) Dhahira Region is reasonably balanced;

(c) Dakhliya Region shows 14.4 $Mm^3.year^{-1}$ overdrafting or about 9% of the rechargeable groundwater;

(d) Sharqiya Region shows a positive balance amounting to 24.1 $Mm^3.year^{-1}$ or about 10.4% of the rechargeable groundwater; and

(e) Salalah Region (Al Janubiya) shows also a positive balance of 91.0 $Mm^3.year^{-1}$. This is a considerable additional water resource, although salinization has unfortunately occurred in the central Salalah plains.

The regional assessments made by MWR are also presented in a map indicating the availability of groundwater to support additional agricultural development (Fig. 1.10).

Table (1.11):
Water resources, demands and balance by region, status 1989 ($Mm^3.year^{-1}$)

Region	Gr.water recharge	Demands of Gr.water			Gr.water Balance
		Agriculture	Domestic	Total	
North Batinah	240.2	321.3	0.0	321.3	-81.1
South Batinah	316.9	428.5	8.7	437.2	-120.3
Dhahira	136.6	134.5	0.6	135.1	+ 1.5
Dakhliya	157.4	168.6	3.2	171.8	-14.4
Sharqiya	232.0	206.8	1.1	207.9	+24.1
Musandam	30.0	13.4	0.2	13.6	+16.4
Al-Janubiya	126.7	35.7	0.0	35.7	+91.0
TOTAL	1,239.8	1,308.8	13.8	1,322.6	-82.8

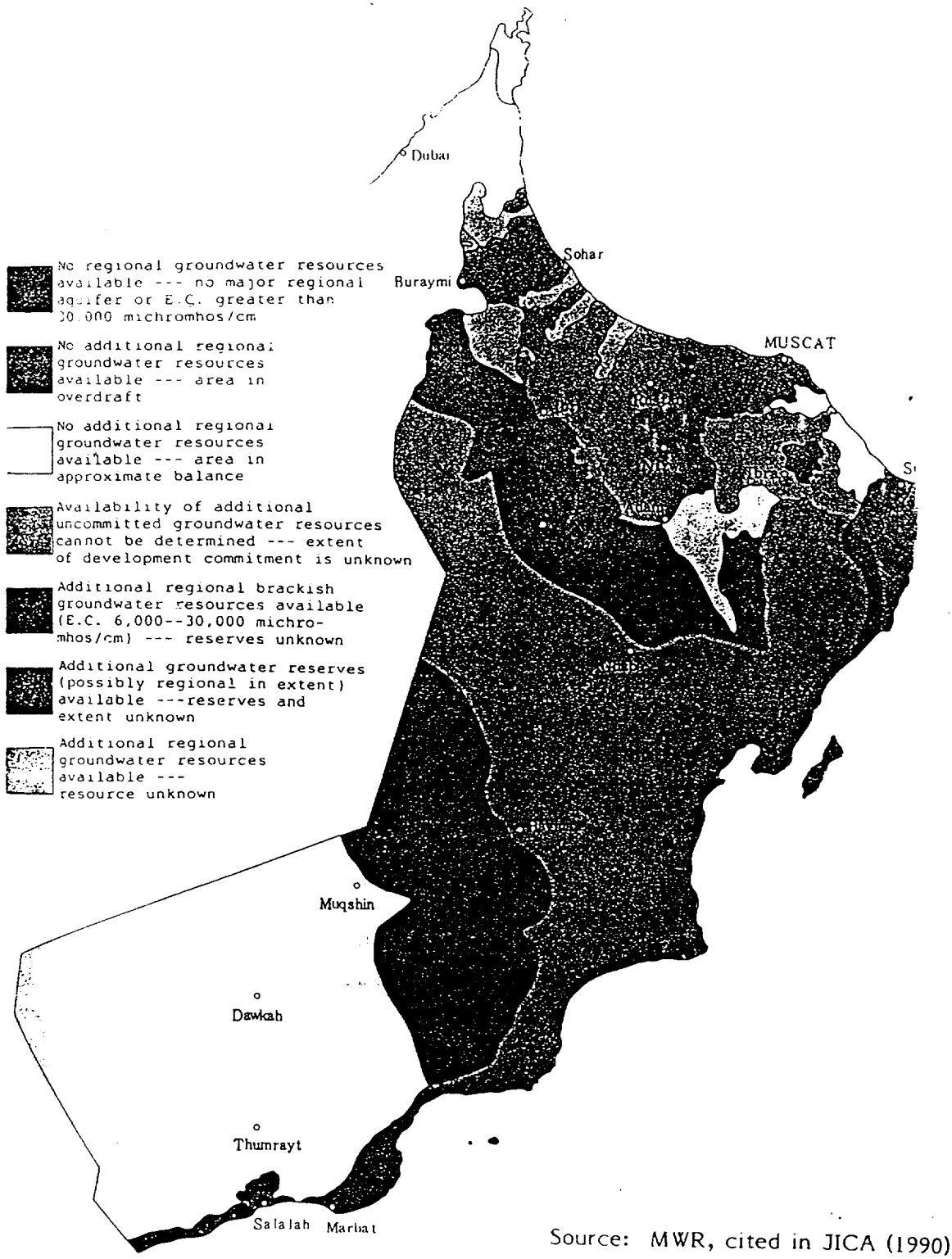
Source: MMDI, 1990.

Assessment of water balance in Oman carried out by MMDI (1991_a) revealed higher water deficit being 286 $Mm^3.year^{-1}$ at present (Table 1.12). Highest amount of water deficits appears in the Batineh and Capital area (245 $Mm^3.year^{-1}$). Potential new resources i.e. additional recharge dams, recharge of TSE and new wadi catchments are expected to provide 82 $Mm^3.year^{-1}$. The estimated deficit could therefore be reduced to 203 $Mm^3.year^{-1}$. The National Water Master Plan prepared by MMDI (1991) for the Sultanate suggests several options for saving of water consumption; especially in the agricultural sector, amounting to 269 $Mm^3.year^{-1}$. Most of the water saving suggested for the Batinah region through improved irrigation efficiency by 5% (saves 30 $Mm^3.year^{-1}$), replacement of date palms in 4,600 ha by winter vegetable crops (saves 55 $Mm^3.year^{-1}$) and reallocating 5,000 ha farmland to alternative uses not dependent on groundwater abstraction (105 $Mm^3.year^{-1}$).

The suggested savings in irrigation water seems realistic as the present water consumption in Oman for irrigating growing crops is more than twice as much as the water requirements estimated for Northern Oman (Table 1.13). Date palms receive 205 - 214% of the net water requirements. Alfalfa, the salt tolerant crop receives 175 - 207% and lime, as many other fruits in Oman, is irrigated with 206% of the required amounts of water. The surplus water applied is much beyond the leaching requirements of salts, usually about 25% of the water requirements. Tomato was the only crop with reasonable excess of water, only 41% over the water requirements. Probably this was due to the winter growth season.

Fig. (1.10):

Availability of Groundwater in the different regions of the Sultanate of Oman



Source: MWR, cited in JICA (1990)

The boundaries shown on this map do not imply official endorsement or acceptance by the United Nations

1.5.6 Water Quality For Irrigation

There is no adequate information about the quality of irrigation water abstracted from the aquifers in different regions of the Sultanate. Information evaluated by MMDI (1991b), however not mentioned, revealed that the available data are either not comparable or of doubtful accuracy. Shallow wells showed increased salinities over the periods 1975 (Gibb, 1976) and 1983 - 1989 (MMDI, 1991b). The changes in groundwater salinity at the coast is taken by MMDI as indication of overexploitation of the aquifer. Similar findings were reported by Weidle plan and Muamir (1989) for the Batinah Region (Fig. 1.11). Due to the extensive agricultural development in the Batinah plain since the early seventies and the extensive motor pumping from a large number of wells due to small farm units, the saline groundwater from seaside intrudes the fresh water aquifer. Soils irrigated with this water have become increasingly saline. Salinization of soils is continuing and the affected area is moving inland. Recent figures of affected areas indicate a 5 to 10 km wide strip of saline soils along the coast of Batinah Region (Fig. 1.12).

Some analysis of Aflaj water, groundwater and TSE are presented in table 1.1.4. The salt content of Falaj water was the lowest and hence presents the best quality for irrigation. Well water and TSE are of similar quality for irrigation.

1.6 NATURAL VEGETATION

The type of natural vegetation coincides with the pattern of water resources in the different physiographic regions of Oman, the variation in the latitudes, the geological formations and the soil characteristics. The variation in such environmental factors is reflected on the plant life and hence, different vegetation types occur in these units, which differ according to Batanouny (1987) in their floristic composition and plant life forms.

The main physiographic regions with distinct floristic composition and plant life forms are:

1. The great sandy regions of the Wahiba Sands and Arub Al Khali;
2. The coastal zone of the Gulf of Oman;
3. The mountains, including the Hajar Mountains, Akhdar Mountains, Qamar and Samhan Mountains of Dhofar.

Each of these habitats contains fairly distinct association of plants under the present prevailing conditions. The vegetation cover, however, fluctuates according to a number of changing environmental factors, especially the short term climatic changes and the increased human pressure on agricultural rangelands.

Table (1.12):

Water Resources in the Sultanate of Oman; Demands, potential new resources and balance by region, status 1990 ($Mm^3.year^{-1}$)

	REGIONS							
	Batinah and Capital area	Northern Dhahira of Dakhliya	Northern Sharqiya	Salalah plain	Nejd	Musandam	Central Region Al Wusta	Total
A. Water Resources	490	222	157	41	not known, probably low	not known, probably equal to demand	poor quality water	910
B. Demands								
Agriculture	679	245	165	32.5	7	23	not known, but low	1,151.5
Domestic	56	5	4	7.5	1	<1	5	74.5
Total	735	250	169	40.0	8	24	5	1,231
C. Present Deficit	245	28	12	1	-	-	-	286
D. Potential New Resources								
1. Additional recharge dams	20	5	-	-	-	-	-	25
2. Recharge of TSE	20	-	-	-	-	-	-	20
3. Wadies catchments	15	20*	-	-	-	-	-	35
Total Potential	55	25	2	-	-	-	-	82
E. Estimated Deficit	190	3	10	0	-	-	-	203
F. Balance as % of Agr. use	28	1	6	0	-	-	-	17.6
G. Possible savings of present uses	190	50	25	4	not known	not known	not known	269

*Brackish water areas
Source: Based on data collected from MMDI (1991a)

Table (1.13):

Water requirements, actual water uses and productivity to water of main crops grown in the Sultanate of Oman

Crop	Net water requirements in North Oman, Annual ETO $m^3.ha^{-1}.year^{-1}$ or $crop^{-1}$	Actual water use (2) $m^3.ha^{-1}.year^{-1}$ or $crop^{-1}$	% of ETO	Productivity to water, Kg. fresh mat.m^{-3} (5)
Dates (Perennial)	17,650 (1) 23,350 (2) 21,040 (3) 25,555 (4) Average 20,660	(Batinah) 42,350 (Interior) 44,300	205% 214%	0.05 0.09
Tomato	7,390 (1) 9,470 (3) 4,830 (4) Average 8,430 ($crop^{-1}$)	(Batinah) 11,900	141%	1.22
Alfalfa (Perennial)	21,180 (1) 24,270 (2) 17,880 (3) 22,230 (4) Average 21,390	(Batinah) 42,350 (Salalah) 37,510 (Interior) 44,300	198% 175% 207%	1.13 0.64 1.37
Banana	- -	(Salalah) 52,690	-	0.46
Fruit (i.e. lime) Perennial	18,390 (4) 18,390	(Batinah) 37,950	206%	0.28
Watermelon	- -	(Batinah) 17,100	-	0.71
Wheat	- -	(Interior) 8,470	-	0.17 (dry)

(1) ILACO (1976) using Blaney Criddle equation (2) Little (1982) using Penman equation (3) MMP (1988) using Penman equation (4) Atkins (1989) using Blaney Criddle equation (5) MAF (1989)

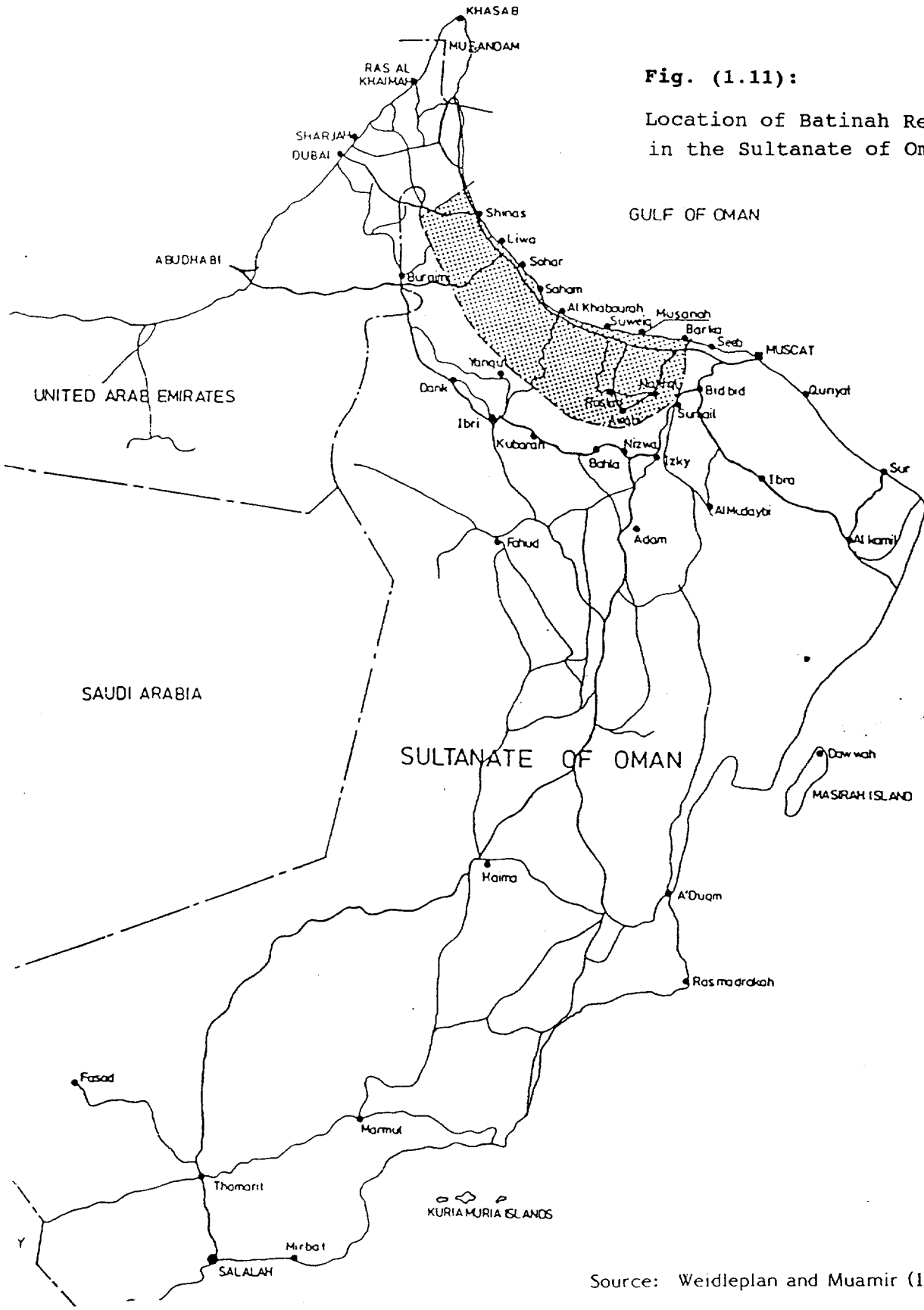


Fig. (1.11):

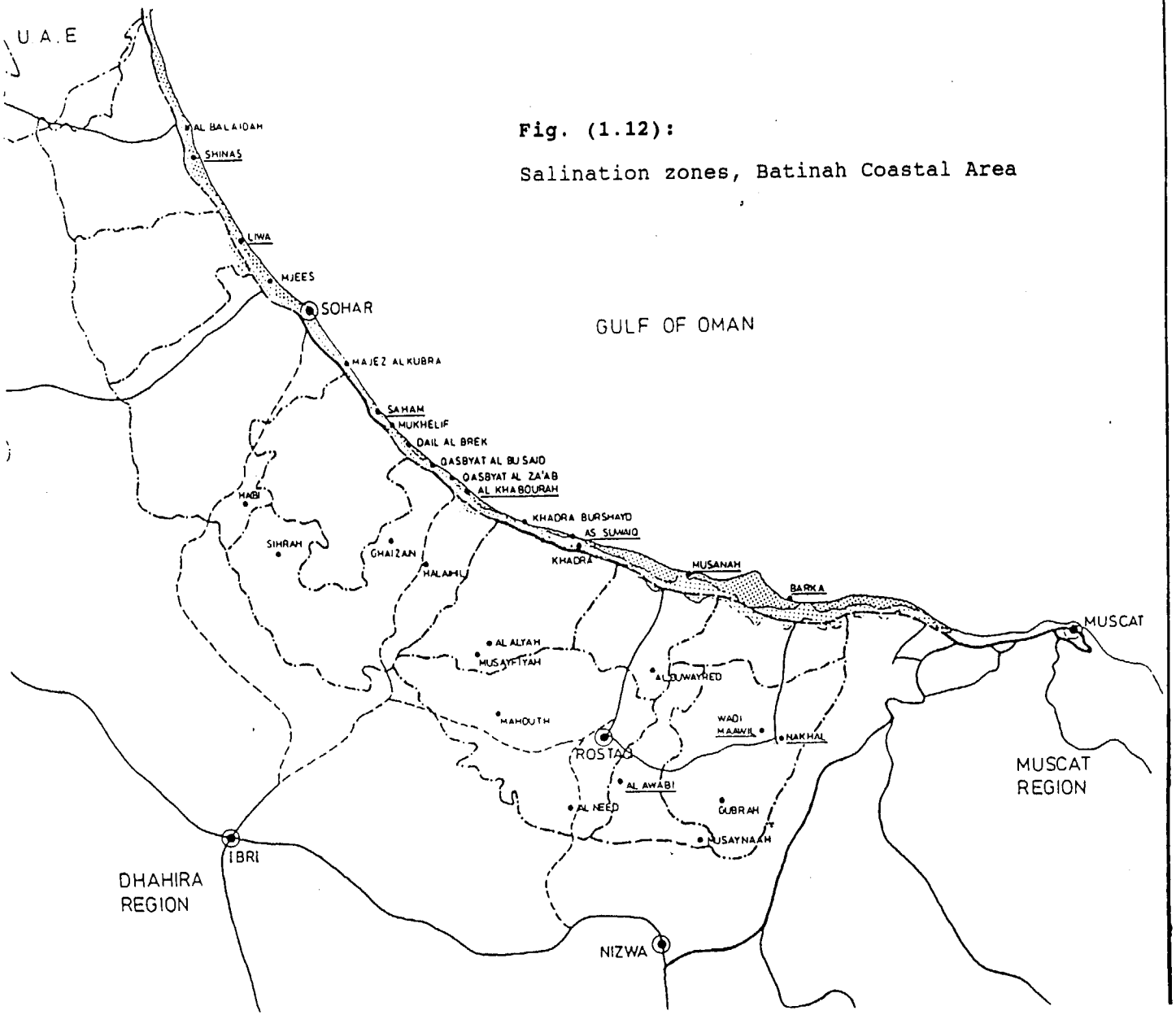
Location of Batinah Region in the Sultanate of Oman

Source: Weidleplan and Muamir (1989)

The boundaries shown on this map do not imply official endorsement or acceptance by the United Nations

Fig. (1.12):

Salination zones, Batinah Coastal Area



LEGEND

- SETTLEMENT
- INTERNATIONAL BOUNDARY
- WILAYAT BOUNDARY
- HIGHWAY
- REGIONAL ROAD (TARMAC)
- TRACKS

SALINITY CLASSES

- GREATER THAN 6000 MICROMHOS
- BETWEEN 2000 AND 6000 MICROMHOS

Source: Weidleplan and Muamir (1989)

The boundaries shown on this map do not imply official endorsement or acceptance by the United Nations

Table (1.14):

Quality of some irrigation water and TSE, by source (1991) (contents in $Mf.L^{-1}$)

	Aflaj Water (1)*	Ground water		TSE		
		(1) *	(2) **	Primary (2)	Secondary (2)	Tertiary (2)
pH	8.0	7.6	8.0	7.5	8.1	7.0
Total sol.salts	680	2000	547	784	796	878
Chlorides	130	810	-	-	-	-
Sulphates	120	270	-	-	-	-
Bicarbonates	250	240	138	228	119	100
Nitrates	2	6	0.1	0.5	0.1	0.1
Ammonia	1	0.06	0.0	28.0	4.0	0.2
Sodium	130	430	220	247	246	258
Potassium	4	17	7	15	16	15
Calcium	39	150	58	46	46	47
Magnesium	51	95	20	29	34	32
Phosphates	-	-	0.3	2.2	2.7	2.7
Fe	30	52				
Mn	1	21	<0.03	<0.05	<0.03	<0.03
Cd	-	-	<0.02	<0.02	<0.02	<0.02
Co	-	-	<0.05	<0.05	<0.05	<0.05
Cu	-	-	<0.03	<0.03	<0.04	<0.04
Ni	-	-	<0.05	<0.09	<0.06	<0.05
Pb	-	-	<0.05	0.16	<0.05	<0.05
Zn	-	-	0.95	0.85	1.34	0.90
BOD_5	-	-	0	118	15	15
COD	-	-	0	294	138	92
Total Alkalinity	-	-	138	228	119	100
Total Bacterial Count	-	-	$1.3x10^1$	$1.0x10^6$	$3.1x10^4$	1.1x10
Coliform Group	-	-	0	$1.46x10^8$	$1.26x10^6$	0
E. Coli	-	-	0	$4.4x10^7$	$1.8x10^5$	0
Faecal streptococci	-	-	0	$12.5x10^6$	$1.0x10^4$	0
Clostridium perfringens	-	-	0	7	3.5	0

(1) ME (1991)
(2) Al Shuriani (1991)
* used for preparation of potable water
** drinking water

The plant associations in the different physiographic distinct regions will be dealt with according to the information available so far.

1.6.1 Natural Vegetation of the Great Sandy Regions

Information is available about the vegetation of the Wahiba Sands. The Royal Geographic Society has conducted an extensive and integrative study about the Oman Wahiba Sands (1985-1987). The results are summarized in a special report No. 3 of the Journal of Oman Studies (1988). Vegetation distribution in Wahiba Sands is illustrated in Figures 1.1.3 (location) and 1.1.4 (plant communities). Although more than 150 species were identified in the Wahiba Sands, plant communities dominating in Wahiba Sands were limited to (a) Panicum turgidum, (b) Zygophyllum qatarense, (c) Halopyrum mucronatum, (d) Tamarix sp. and (e) Prosopis cineraria (Munton, 1988_a).

Under the above mentioned plant communities, following perennial plant species were recorded and are mentioned in order of their frequency in the Sands (Munton, 1988_a):

(i) Calligonum comosum (L.) He'r
(ii) Panicum turgidum Forsskal
(iii) Heliotropium kotschyi Guerke
(iv) Cyperus aucheri Jaub. & Spach
(v) Prosopis cineraria Druce
(vi) Zygophyllum qaarense Hadidi
(vii) Euphorbia riebeckii Pax
(viii) Dipteryginum glaucum Decne
(ix) Lasiurus scindicus Henrard
(x) Stipagrostis plumosa (L.) Murro ex T. Anderson and S. sokotrana (Vierh) de Winter
(xi) Indigofera oblongifolia Forsskal and I.hochstetteri Baker
(xii) Acacia tortilis (Forsskal) Hayne
(xiii) Acacia ehrenbergiana Hayne

The most common ephemeral plant species recorded in Wahiba Sands is Tribulus terrestric L. Other ephemeral species grow if heavy rain falls on the sand and provides a good supplement grazing source for all animals, although it is short lived (Webster, 1988).

The vegetation of Wahiba Sands provides excellent forage for camels as Coligonum comosum are present in large amounts throughout the area of Wahiba Sands and the trees of Prosopis cineraria are accessible at all times. the area is less suited for sheep and goats because of lack of forage in the dry periods.

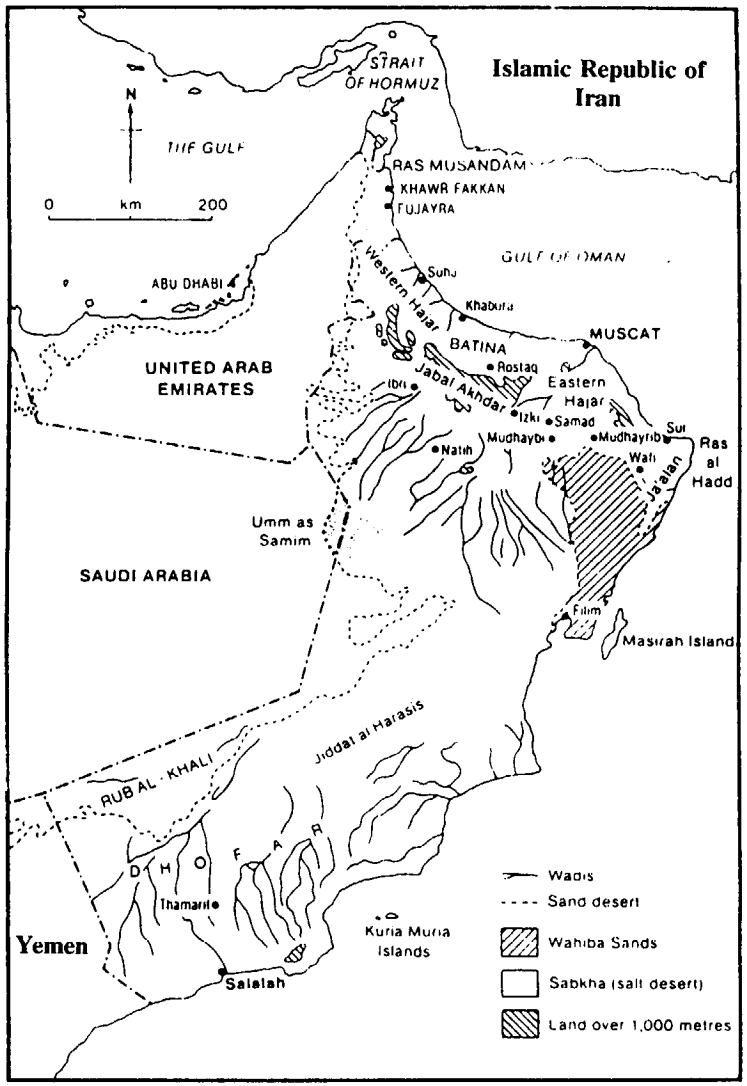


Fig. (1.13)

Location of Wahiba Sands, Rub Al Khali
Source: Munton (1988) .

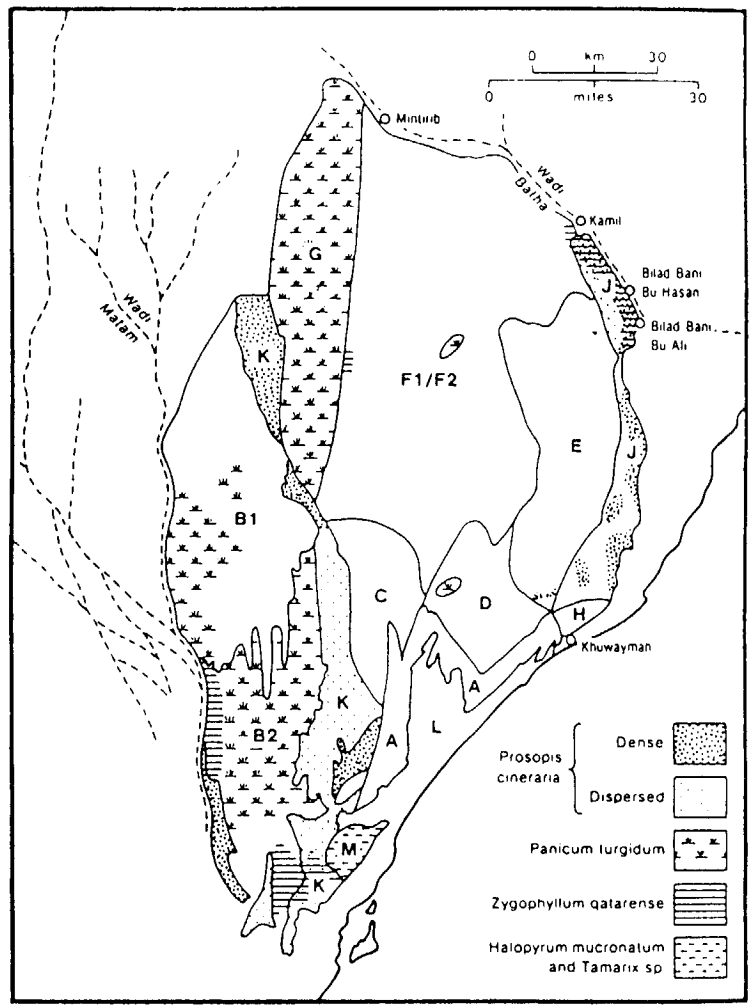


Fig. (1.14)

Vegetation distribution in Wahiba Sands

Source: Munton (1988).

Livestock numbers were estimated by Munton (1988_b) to range between 18.8 thousand sheep and goats in January and 26.3 thousand in March and for camels, between 3340 and 3193 respectively.

Concern is expressed by Muntron (1988_a) because of the overuse of the prosopis woodland especially in Area J (Fig. 1.14). This heavily used area is the priority for action in the Sands. Planting of Prosopis cineraria trees and reduction of Zygophyllum qatarense plants is suggested. P. cineraria trees are reported by Brown (1988) to be resistant to harsh environmental conditions of the Wahiba Sands through their ability to tap permanent underground water reservoirs and to absorb moisture from dew and mist carried from the Arabia Sea. Brown (1988) suggests the afforestation of the deteriorated areas with vegetatively propagated P.cineraria trees.

1.6.2 Natural Vegetation of the Coastal Zone of the Gulf of Oman

The coastal Zone along the Gulf of Oman which includes salt affected areas, lagoons and mudflats, occupies a large area. In addition to the Coastal Zone, soils salinized due to agricultural mismanagement, occupy increasingly large areas. These saline areas harbour halphytic plant communities. These are, according to Batanouny (1987):

(i) Avicennia marina
(ii) Arthrocnemum glaucum
(iii) Halocnemum strobilaceum
(iv) Halopeplis perfoliata
(v) Aeluropus lagopoides
(vi) Suaeda spp.
(vii) Salsola spp.
(viii) Seidlitzia rosmarinum
(ix) Tamarix spp.
(x) Other holophytic plant communities i.e. halopyrum mucronatum, Sporobolus spicatus, S. arabicus, Nitraria retusa and Juncus arabicus.

1.6.3 Natural Vegetation of the Mountains

Among the mountains of Oman the natural vegetation of the mountains of Dhofar (southern Region) received sizeable attention. In an extensive study of the plants of Dhofar published by the Diwan of royal Court of the Sultanate of Oman, Miller et al (1988) reported about over 750 species of plants of which 50 are endemic to Dhofar.

The present natural vegetation present showed distinct bands reflecting climatic and topographical factors dominating along the transect from the coast of the South Arabian Sea inland towards Arub Al Khali. These factors are the distance from sea, elevation, soil type and the amount of precipitation from rain or mist. Each of the six vegetation bands form a distinct zone (Fig. 1.15 and

1.16) namely:

(i) Coastal plain;
(ii) Foothills;
(iii) Escarpment, woods and grassland;
(iv) Dry plateau;
(v) North draining wadis and cliffs; and
(vi) Desert and pre-desert.

The present status of natural vegetation in the different zones are discussed hereafter:

(i) Coastal Plain

The coastal plain is either bare of plants or covered with the trailing stems of beach morning glory - Ipomoea pes-caprae and clumps of Heliotropium fartakense, Limonium axillar, Syperus conglomeratus and the grass Urochondra setulosa. The plain has suffered severe damage to its vegetation as a result of overgrazing, off-road vehicles, construction, tourism and camping activities (Al Kuthairi, 1992). Scattered Acacia tortilis trees can still be seen. A comparison of the present vegetation with that in 1959 in the fenced area at the airport enlightens the severity of the damage to vegetation during the last four decades. The widespread abundance of termite mounds (14 species of Isoptera) also indicates the degree of deterioration of plain habitat. The ants survive by collecting grass seeds and depriving the ecosystem of its natural seed bank.

(ii) Foothills

This area used to be heavily wooded and dominated by the evergreen tree Boscia arabica. Now it is dominated by xerophytic shrubs i.e. Commiphora spp., Grewia spp., Premna resinosa, Croton confertus and Jatropha dhofarica, often with the square-stemmed succulent creeper Cissus quadrangularis sprawling over them (Miller, 1988).

(iii) Escarpment, woods and grasslands

The escarpment is divided into sheltered seaward slopes and heavily wooded southern slopes. The woodlands at lower altitudes (up to 500 m) consist mainly of deciduous bushland and thicket composed of Acaia senegal, Commiphora spp., Mayttenus dhofariensis, Croton confertus and Blepharispermum hirtum. On the open slopes there are few trees of Delonix elata, Anogeissus dhofarica, Sterculia africana, Lennea spp. and Euphorbia smithii. The valleys contain a dense

Fig. 1.15:View of Dhofar showing main ecological zones.

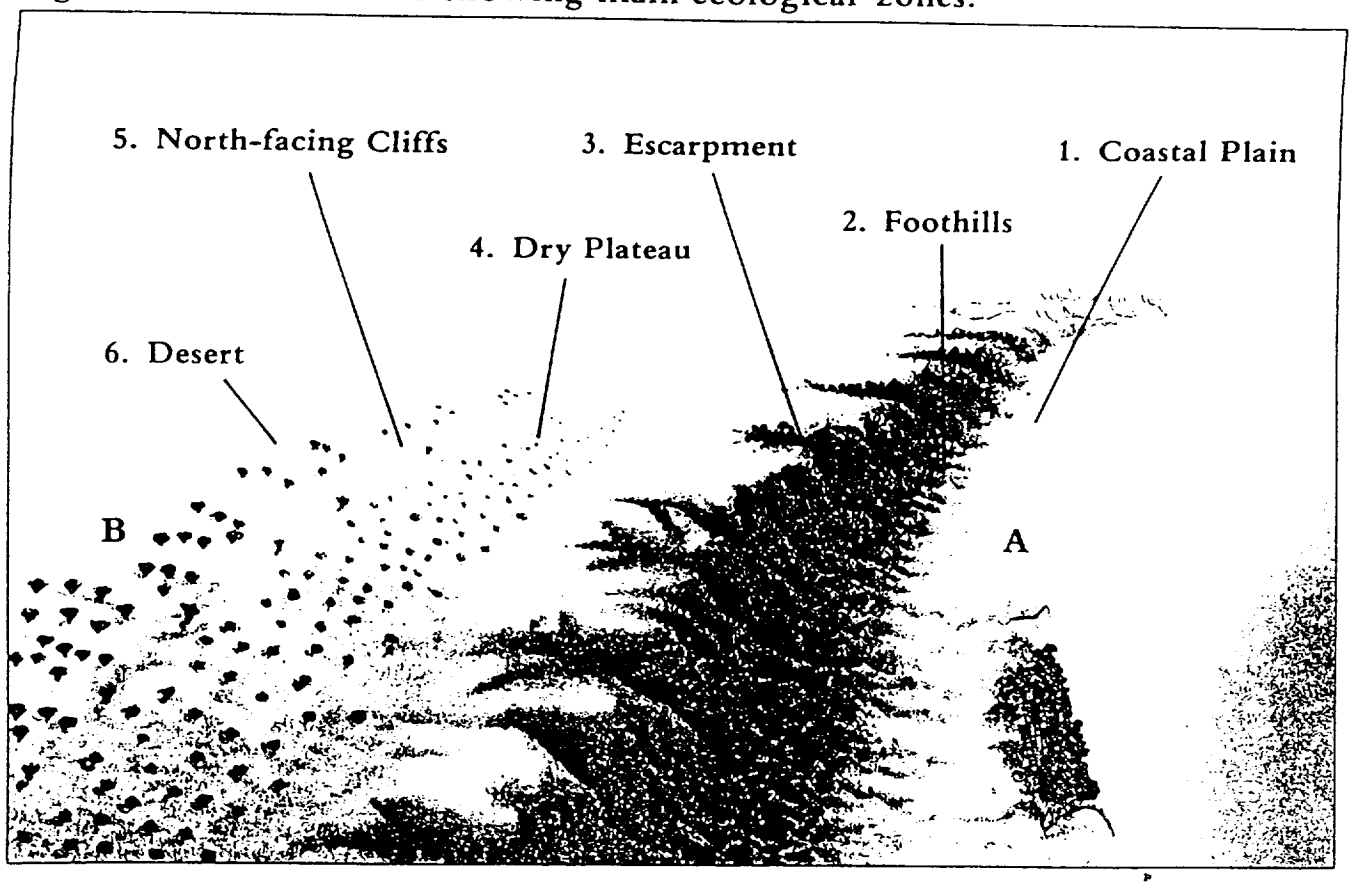
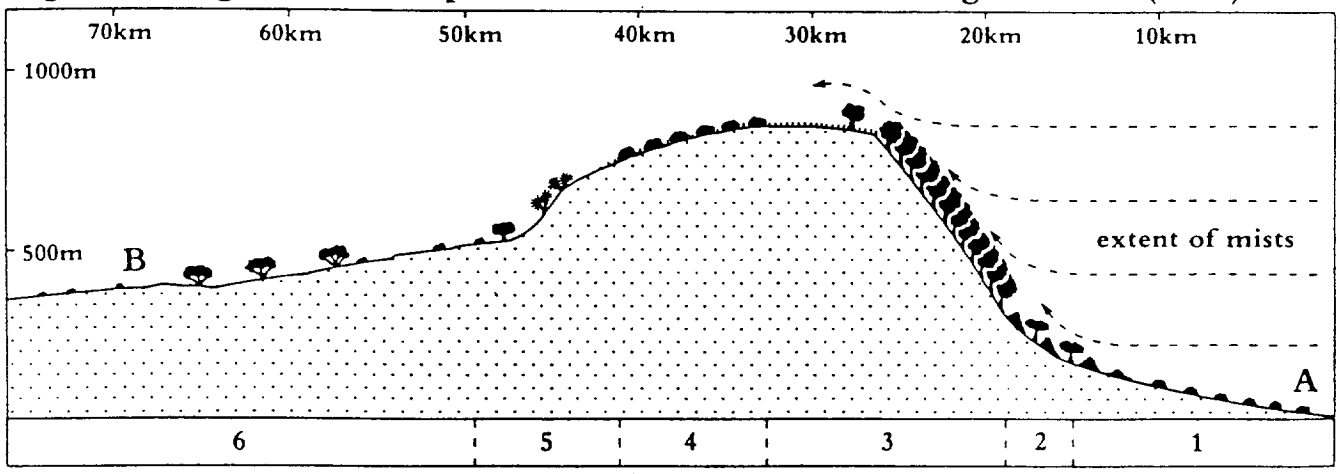


Fig. 1.16:Diagrammatic representation of a section through Dhofar (A-B).



1. Coastal Plain – consists of four main features: J:– 'ḥaǰ' – sand above high tide mark, 'ḥazóg' – areas of soft soil, 'dá'an' – areas of rocky ground, 'šá'ab' – wadis. **2. Foothills,** 'ḥaškík' – belt of termite mounds running along the foot of the mountains dominated by trees of *Boscia arabica*. **3. Escarpment** – consists of two main features: 'fímút' – sheltered seaward slopes of escarpment woodland, 'xóṭem' – heavily wooded slopes and summit grassland cut by deep wadis. **4. Dry Plateau,** 'ḳuṭn' – high, dry plateau dominated by bushes of *Euphorbia balsamifera* and short grassland. **5. North-facing cliffs,** 'moḥúfi' – area in the rain shadow of the mountains generally sparsely vegetated but with *Acacia etbaica* and *Dracaena serrulata* locally dominant. **6. Desert** 'feger', 'negd' – open desert and scattered trees of *Boswellia sacra*.

Source: Miller et al (1988).

riparian woodland dominated by fig trees including Ficus sycamorus, F. vasta, and F. lutea as well as the commonly occurring Tarindus indica. Spiny trees of Zizphus spina-christi and Acacia nilotica are widespread where these valleys debouch onto the plain.

Beneath all trees rich ephemeral communities flourish including many legumes, grasses and the endemic Withania qaraitica. At altitudes higher than 500m semi-evergreen woodland dominates i.e. Olea europaea, Euclea schimperi, Commiphora spp., Dodnaea angustifolia, Carissa edulis and Rhus somalensis.

The grassland forms a belt along the summits and the gentler slopes of the mountains dominated by Apluda mutica, Themeda quadrivalvis, Brachiaria spp., Arthraxon spp. and Cenchrus spp. These grasses can reach a height of 1.5m in good years when mists are at their thickest.

(iv) Dry Plateau

Moving further inland, away from the sea, the effects of the mists decrease gradually. Grasses become shorter and trees thin out. Trees of Olea, Anogeissus and Dodnaea become less common giving way to Euphorbia balsamiphora and stunted Commiphora spp. Under the canopy of Euphorbia balsamiphora several palatable species thrive i.e. Arisaema flava, Ceropegia bubosa, Habenaria myodes, H. malacophylla, Eulophia guineensis and Dorstenia foetida.

(v) North draining wadis and cliffs

In this region of rain shadow of the high escarpment mountains the vegetation becomes gradually sparser and bare ground is much more evident. The common trees in this area are Acacia etbaica, Dracaena serrulata and bushes of Dhofaria macleishii and Cocculus balfourii.

(vi) Desert and pre-desert

Beyond the "north draining wadis" the ground becomes level and represents the beginning of the true desert "nejd". Vegetation becomes scattered with the only tree Bosellia sacra and the less common low bushes of Acacia etbaica. Large areas of this zone are free of vegetation. The succulent Zygophyllum qatarense and the leguminous tree Prosopis cineraria dominate in some localities.

On the very edge of Arub Al Khali in the extreme north of the area, the common vegetation species are:

Calligonum crinitum, Tribulus arabicus, Dipterygium glaucum, Cyperus conglomeratus, Heliotropium kotschyii and Zygophyllum qatarense. Local and scientific names of the most common plants in Dhofar mountains are given in Appendix III.

The forage yields of natural pasture areas of the Dhofar mountain environment was estimated in 18 sites in- and outside enclosures established by the Rangeland Regeneration Project in the Southern Region of Oman (GRMI, 1989). The biomass yield ranged between 0.7 and 3.8 ton.ha^{-1} dry matter outside the enclosures (average 2.139 ton.ha^{-1}), while inside the enclosure the biomass yield was higher and ranged between 1.4-9.4 ton.ha^{-1} dry matter with the average of 3.872 ton.ha^{-1}. Organizing grazing through fencing increased the biomass yield in this area by 81% within one year.

The biomass in the Southern Region is grazed by increasing numbers of animals. The numbers in 1979 of cows, camels and goats in this Region were 77,922; 54,365 and 106,249 respectively. One decade later (1989) the number of animals increased by 40 to 324% to reach 323,333; 76,336 and 450,199 heads of cows, camels and goats, respectively (MAF, 1991).

1.7 OIL, GAS AND MINERALS

1.7.1 Oil

Oil was first discovered in 1962 although the search for it goes back to 1924. The first exports of oil from the Sultanate of Oman began in 1967. Production of oil rose steeply to reach its peak of 600,000 barrels.day^{-1} in 1986. New discoveries of oil are maintaining the level of proven reserves of about 4 billion barrels in 1988. Most of Oman's oil is exported and about 80,000 barrels.day^{-1} are refined in the country.

1.7.2 Natural Gas

Natural gas is playing an increasingly important role in the development of the country since its utilization in 1978. Reserves of associated and non-associated gases were estimated in 1988 to be 2.7 and 6.63 trillion cubic feet respectively. Natural gas is used in the development of the Rusayl Industrial Estate, power generation and desalination of water. Liquid petroleum gas (LPG) plant has also been established to extract and bottle butane and

propane gases for domestic and other uses.

1.7.3 Minerals

Copper, chromite and gypsum are the main mined minerals. Limestone and marble are being exploited for cement plants and for construction works. The government has no plans at present to exploit mineral resources other than copper and chromite. The private sector is, however, encouraged to use the deposits of limestone, gypsum, marble and the iron laterites.

CHAPTER II

SOCIO-ECONOMIC SETTINGS

2.1 ECONOMIC DEVELOPMENT

2.1.1 Gross Domestic Product

The Sultanate of Oman has witnessed drastic economic growth during the period 1962-1989. The Gross Domestic Product (GPD) has risen from 41.3 MRO in 1967 to 3,201.2 MRO in 1989 at current prices (Table 2.1) and from 946.9 MRO in 1978 to 2,246.9 MRO in 1989 at constant prices (Table 2.2.). The country has, until oil production started in 1967, subsided on agriculture and fishery with nearly 35% share of GDP in 1967. Mining and construction activities share of GDP were 38% and 20% respectively.

Oil revenues were used since 1970 to promote economic development in the country. Three development five-year plans have, so far, been executed. The first plan (1976-1980) and the second plan (1981-1985) focused on the improvement of the physical infra-structure and the private economic activities to free the country from its dependence on oil exports. The third five-year plan (1986-1990) continued to support agriculture, industry, energy and water projects. Construction works were reduced drastically from 242.2 MRO in 1985 to 106.0 MRO in 1989.

The GDP share of agriculture and fishery although has risen from 14.3 MRO in 1967 to 117.1 MRO in 1989, the percent GDP share of agriculture and fishery dropped from 34.6% to only 3.6% of the total GDP in 1967 and 1989 respectively, despite the fact that agriculture and fishery still employ almost half of the Omani population (Table 2.1).

The annual growth rate of the agricultural sector was by 9.6% (average of 8 years) outstanding. Variable growth rates of 20.8% and 16.1% recorded for 1980 and 1985 respectively indicate the ambitious development in this sector (JICA, 1990).

The mining and crude oil sector developed from 15.6 MRO in 1967, representing 37.8% of the total GDP, to reach 1,478.6 MRO in 1989 and representing 45.8% of total (table 2.1). The annual growth rate of this sector was about 10.9% between 1980 and 1988, despite the declining oil prices. Compensation was managed by production increases. The successful diversification of the Omani economy decreased the GDP share of this sector from nearly 70% in the 1970% to 45.8% in 1989.

The manufacturing sector has grown considerably over the

past 22 years. The GDP share (table 2.1) increased from 0.2% in 1967 (0.1 MRO) to 4.2% in 1989 (137.1 MRO). Annual growth rate of 27.5% on the average during the period 1980-1989 and surpassed the agricultural GDP share.

Other activities witnessed also considerable growth over the last 22 years, especially after 1970 when oil revenues increased drastically (Tables 2.1 and 2.2).

2.1.2 Exports and Imports

Oman's exports have usually exceeded its imports because of its oil resources. The progress of both Oman's imports and exports during the last decade (1980-1990) are presented in tables 2.3 and 2.4 respectively. Oman's imports increased by 53.1% from 598.2 MRO in 1980 to 916.7 MRO in 1986 due to the increase of imported foodstuffs, chemicals, machinery and other industrial articles (table 2.3). Machinery and transport equipment topped the country's imports during the 1980s, accounting for 39.4% in 1980, 41.2% in 1986 and 36.1% in 1989 of the total imports of the country.

Manufactured goods came second accounting for 16.1% in 1980, 19.2% in 1986 and 18.2% in 1989. Foodstuffs came in third place accounting for 12.2% in 1980, 14.2% in 1986 and 17.1% in 1989 of total imports. West European countries topped the list of exporters to Oman. Their exports accounted for 29.9-44.9% of the total imports of the country during the period 1980-1989. The Middle East Asian countries provided Oman with 20.8% - 28.3% of its imports. Other Asia countries provided 23.1% - 32.8% of Oman's total imports during the last decade. American countries came in fourth place providing 14.3% - 18.7% of the total of Oman's imports.

The United Arab Emirates represent the main exporter to Oman. More than 42% of Oman's imports in 1989 were from the UAE. The shares of South Korea, UK and USA were 15.7%, 11.7% and 8.4% respectively. The large UAE share in Omani imports may be due to the function of the UAE as a trade centre rather than as a production site (re-export).

The non-oil exports of Oman (table 2.4) increased from 4.62 MRO in 1980 to 167.9 MRO in 1989, indicating a growth rate of 404% annually. Machinery and transport equipment represented the biggest part totalling 28.9 MRO in 1989 or 41% of the total non-oil exports. Foodstuffs and livestock followed with 17.6% of Oman's non-oil exports in 1989. Exports of manufactured goods occupied third place with 14.8% (24.8 MRO).

Table (2.1):

Gross Domestic Product (GDP) at current prices during the period 1967-1989 and the share of GDP by Industrial Origin (Million RO)

Activity	1967 MRO	%	1970	1975	1980	1985	1989 MRO	%
Agriculture and Fishery	14.3	34.6	16.6	20.2	2.6	93.7	117.1	3.6
Mining and Crude Oil	15.6	37.8	71.6	486.8	1,280.6	1,683.9	1,478.6	45.8
Manufacturing	0.1	0.2	0.2	2.1	15.6	82.3	137.1	4.2
Electricity and Water	-	-	0.1	1.8	16.0	36.8	48.2	1.5
Construction	8.3	20.1	8.5	70.8	117.8	242.2	106.0	3.3
Wholesale and Retail Trade	0.8	1.9	1.6	38.5	188.3	428.0	393.6	12.2
Transport and Communication	0.3	0.7	0.7	23.5	38.3	99.6	112.3	3.5
Banking and Real Estate	1.3	3.2	2.1	19.1	162.8	295.9	291.5	9.0
Services	0.8	1.9	1.0	8.4	13.0	36.0	49.1	1.5
Public Administration and Defence	0.6	1.5	2.3	53.0	194.6	477.9	548.7	17.0
Less Imputed Bank Charges	-0.8		-1.0	- 2.5	-24.6	-63.6	-81.0	-2.5
Total GDP at prod. values	41.3	100.0	103.6	721.8	2,054.9	3,412.7	3,201.2	99.1
Plus Import Duties	-		-	-	8.6	41.1	29.4	0.9
Total GDP at market prices	41.3		103.6	721.8	2,063.5	3,453.8	3,230.6	100.0
Estimated GDP, RO.Capita^{-1}					2,062.0	2,756.3	2,026.7	

Source: Statistical Year Book (1990)

Table (2.2):

Gross Domestic Product (GDP) at constant prices of 1978 and the growth rate by sectors, Figures in Million RO.

Activity	1978	1980	1985	1989
Agriculture and Fishery	30.7	49.0	81.7	94.6
Mining and Crude Oil	498.3	438.4	775.6	1,032.4
Manufacturing	8.5	12.5	67.3	82.4
Electricity and Water	10.5	16.7	47.5	130.5
Construction	71.4	91.4	239.3	103.4
Wholesale and Retail Trade	104.8	139.0	316.6	228.3
Transport and Communication	20.7	33.2	86.5	90.4
Banking and Real Estate	100.1	125.5	239.6	243.4
Services	7.6	12.1	34.0	43.2
Public Admin. and Defence	109.2	146.6	248.1	227.4
Less Imputed Bank Charges	-14.2	-21.5	-58.1	-45.9
Total GDP at prod. value	942.3	1,040.8	2,078.2	2.230.2
Plus Import Duties	4.6	6.3	27.0	16.7
Total GDP at market prices	946.9	1.047.1	2,105.2	2,246.9
Growth Rate of GDP %	-	6.0	13.1	1.11
Growth Rate of Agriculture %	-	20.8	16.1	-7.05
Growth Rate of Mining %	-	-4.9	20.2	2.76
Growth Rate of Manufacturing %	-	19.8	-0.4	-5.55

Source: Statistical Year Book (1990)

Omani exports depend heavily on crude oil. Revenues from oil exports increased from 1,294.5 MRO in 1980 to 1,344.4 MRO in 1989. Despite this fact, the share of oil in total exports has gradually decreased from 96.2% in 1980 to 88.9% in 1989.

Oman's trade balance (table 2.5) showed increasing surplus, being 224.9 MRO in 1975 and reaching 696.3 MRO in 1980. The trade balance showed thereafter a decreasing tendency, probably due to instability of oil markets. Surplus in trade balance reached 628.4 and 644.2 MRO in 1985 and 1989 respectively.

2.1.3 Balance of Payments

The balance of payments (table 2.5) changed from a surplus of 238.1 MRO in 1980 to an increasing deficit reaching -152.1 and -162.3 MRO in 1985 and 1989 respectively. The reasons for this deficit are the steady increase in recurrent expenditures caused by enlargement of governmental functions, and the decrease of oil revenue by the sharp drop of oil prices in 1986 which continues onwards at low levels.

The average annual growth rate of revenue was 0.6% during the past decade (1980-1990), while that of expenditures was 6.5%, over ten times the revenue. Peak deficit was recorded in 1986, when the annual deficit reached over 600 MRO (JICA, 1990).

2.2 SOCIAL SETTINGS

2.2.1 Population

The estimation of exact number of Oman's population is a difficult task as no census has been conducted so far. Government and international institution estimates for population are not identical as they are prepared independently. Governmental estimates ranged between 1.5 million in 1974 when the First Five-Year Development plan started and 2.0 million in 1985 at the beginning of the Third Five-Year Development plan. The Development Council of Oman decided, however, to set the population at 1.5 million at the end of 1989 and a 10 year fixed annual growth rate of 3.5% as basic figures for the Fourth Five-Year Development Plan (1991-1995).

The concentration of population living in the capital is high. In 1989, more than 23% of the entire Omani population lived in Muscat (333,352 inhabitants). the Batinah Region in which the capital is located holds over 51% of the Omani population (Table 2.6). Urban population is 53.4% of total, while rural population represents only 46.6%.

Recent reports reveal that Oman is alive with children. This is evidenced from the high birth rate (4.5%). While

this is considered to be good for the development of the country, it represents a greater than 55% increase of population within the present decade (Table 2.7). The total number of population will reach 2.5 million inhabitants by the year 2000. No information was available about distribution of population by age and sex.

One of the characteristics of the population structure in the Sultanate of Oman is the large number of expatriates. This number was 234,000 in 1988 representing about 14.7% of the total population (table 2.7). Higher figures (278,405) were given by JICA (1990). The tendency, however, is to reduce their numbers through Omanization of jobs.

2.2.2 Education

Education actually only started in the 1970s. Until 1969/1970 school year the education system of Oman had only 3 schools where 909 male pupils were taught by 30 teachers mostly from neighboring countries. The government has, since then, developed the educational system drastically. Table 2.8 reflects the development in the education sector so far. The number of schools has increased steadily from 3 in 1969/1970 to reach 801 in 1989/1990. The numbers of students and teachers increased within two decades from 909 and 30 in 1969/1970 to 333,286 and 17,570 in 1989/1990 respectively. The development of Omani education culminated with the opening of the Sultan Qaboos University which started activity in the 1986/1987 academic year. About 2,550 students were enrolled for studies at the university in 1989/.1990 while 1,101 students are studying at universities outside Oman.

2.2.3 Employment and Labour Force

The only recorded information available is about the Omani labour force employed in governmental activities and foreign labour force employed by both governmental institutions as well as by private enterprise.

The number of Omanis employed by the government has increased drastically from 1,750 in 1970 to 47,785 in 1989 (table 2.9). The number of expatriate labour force increased also rapidly from 120 in 1970 to 302,440 in 1985 in both government and private sectors. Omanization of labour force was successful in decreasing the numbers of foreign labourers to 287,840 in 1989 despite the high economic growth in the Sultanate during this period.

Construction, wholesale and retail trade and the combined construction and trade employ the highest numbers of expatriates (60.7% of total). Agriculture employed increasing number of labour. In 1980 only 4,660 (3.5%) were employed in agriculture while in 1989, the number reached more than fourfold (21,200) representing 8.2% of the foreign labour force.

Table (2.3):

Development of Oman's Imports during the period 1980 - 1989

Commodity Classification	1980 MRO	19 86 -000-ton	MRO	19 89 -000-TON	MRO
0 Foodstuffs and Livestock	72.9	536.4	129.9	518.7	148.5
1 Beverages and Tobacco	14.8	33.5	16.9	25.4	17.5
2 Raw Materials, Inedible (except Fuels)	9.9	174.6	12.0	156.2	10.0
3 Mineral Fuel and Lubricants	64.6	69.6	26.3	121.8	16.6
4 Vegetable and Animal Oils and Fats	3.2	23.4	2.3	17.7	3.7
5 Chemicals	20.8	87.9	42.7	77.7	53.5
6 Manufactured Goods	96.3	982.2	175.7	327.0	157.5
7 Machinery and Transport Equipment	235.7	168.5	377.3	108.5	313.3
8 Miscellaneous Manufactured Articles	45.1	44.3	107.3	26.0	117.1
9 Non Classified Commodities and Transactions	34.8	1.6	26.3	14.4	29.5
TOTAL	598.2	2,122.0	916.7	1,393.4	868.0

Source: Statistical Year Book (1990)

Table (2.4):

Omani Domestic Exports during the period 1980 - 1989

Commodity Classification	1980 MRO	19 86 -000-ton	MRO	19 89 -000-TON	MRO
0 Foodstuffs and Livestock	4.6	58.3	20.7	61.5	29.5
1 Beverages and Tobacco	0.02	2.0	1.1	10.7	3.5
2 Raw Materials, Inedible (except Fuels)	0.0	49.0	1.9	54.3	1.8
3 Mineral Fuel and Lubricants	0.0	3.3	1.3	0.9	0.4
4 Vegetable and Animal Oils and Fats	0.0	0.4	0.1	0.1	0.1
5 Chemicals	0.0	4.8	1.7	1.8	2.5
6 Manufactured Goods	0.0	39.7	13.1	27.2	24.8
7 Machinery and Transport Equipment	0.0	31.4	59.2	26.7	68.9
8 Miscellaneous Manufactured Articles	0.0	2.4	3.9	2.2	8.5
9 Non Classified Commodities and Transactions	0.0	6.3	8.7	153.5	27.9
SUBTOTAL	4.62	197.4	111.7	338.8	167.9
Oil exports	1,244.6	-	981.0	-	1,344.4
Re-export	45.3	-	-	-	-
TOTAL	1,294.5	-	1,092.7	-	1,512.3

Source: Statistical Year Book (1990)

Table (2.5):

Balance of Payments Estimates during the period 1975 - 1989 (MRO)

Activities	1975	1980	1985	1989
Exports				
Crude Oil	488.1	1244.6	1,597.0	1,344.4
Non-Oil Exports	1.1	4.6	22.9	66.6
Re-exports	not determined	45.3	97.4	101.2
Total Exports	489.2	1,294.5	1,717.3	1,512.2
Total Imports	264.3	598.2	1,088.9	868.0
Total Trade	753.5	1,892.7	2,806.2	2,380.2
Trade Balance	224.9	696.3	628.4	644.2
Total Revenues	-	1,187.9	1,776.2	1,481.8
Total Expenditures	-	949.8	1,928.3	1,644.1
Balance	-	238.1	-152.1	-162.3

Source: Statistical Year Book (1990)

Table (2.6):
Population of the Sultanate of Oman by Region (1989)

Region	Wilayat	Villages	Population	%
Muscat	2	139	333,352	22.22
Al Batineh	12	594	436,476	29.10
Al-Dhahirah	5	302	135,585	9.04
Al-Dakhliyah	9	255	190,263	12.68
Al-Janubiyah	1	64	164,410	10.96
Al-Sharqiyah	11	371	218,089	14.54
Musandam	4	172	23,825	1.59
TOTAL	44	1,897	1,500,000	100.00

Source: JICA (1990)

Table (2.7):
Population changes in the Sultanate of Oman during the period 1988 - 2000.

Year	Omani[1] Nationals -000-	Expatriates[2]	TOTAL -000-	% change* over 1988
1988	1,360	234	1,594	0.0
1989	1,418	230	1,648	3.5
1990	1,478	226	1,704	7.0
1991	1,541	225	1,766	11.0
1992	1,606	224	1,830	15.1
1993	1,675	222	1,897	19.4
1994	1,746	221	1,967	23.8
1995	1,820	220	2,040	28.5
1996	1,898	219	2,117	33.4
1997	1,979	218	2,197	38.6
1998	2,063	217	2,280	43.9
1999	2,151	216	2,367	49.4
2000	2,242	215	2,457	55.2

Sources: 1) World Bank (1988) 2) GRMI (1988)
* Based on birth rate of 4.5% and overall mortality rate of 1.3%.

Table (2.8):

Development of Education in the Sultanate of Oman (1967/70 - 1989/90)

Description	School or Academic Year				
	1969/70	1974/75	1979/80	1984/85	1989/90
Students, -000-	0.91	49.7	96.2	197.3	333.0
Primary	0.91	48.6	83.7	155.4	250.2
Preparatory	-	0.57	10.2	28.3	61.7
Secondary	-	0.08	0.94	9.2	19.5
Religious	-	0.35	0.33	0.74	0.90
Technical	-	-	0.03	0.59	0.70
Schools (Total)	3	183	382	273	801
Primary	3	163	237	308	432
Preparatory	-	11	114	195	286
Secondary	-	2	12	38	72
Religious	-	7	8	8	8
Technical	-	-	2	4	3
Classrooms (Total)	n.d.	1387	3214	6297	10241
Primary	n.d.	1350	2677	4575	7351
Preparatory		29	434	1132	2116
Secondary	-	5	41	333	710
Religious	-	n.d.	5	38	39
Technical	-	-	2	26	24
School Teachers, Technical & Admin Staff	30	2138	5007	9776	17570
University Studies					
Students	-	-	-	-	2550
Teaching Staff	-	-	-	-	337
Gov.exp. on education (MRO)	n.d.	n.d.	n.d.	102.3	127.4

Source: Statistical Year Book (1990). n.d. not determined

Table (2.9):

Employment in governmental institutions and in private enterprise (1970-1989), numbers in thousands

	1970	1975	1980		1985		1989	
Governmental Institutions								
Omanis	1.63	13.62	23.45		39.19		47.79	
Expatriates	0.12	5.51	15.36		27.46		29.48	
Total	1.75	19.13	38.84		66.65		77.27	
% of Omanis	93.10	71.20	60.40		58.80		61.80	
Private enterprise, by sector (expatriates only)								
				%		%		%
Agriculture and Fisheries	-	-	4.66	(3.50)	10.25	(3.60)	21.20	(8.20)
Mining and Quarrying	-	-	2.27	(1.70)	3.62	(1.30)	3.71	(1.40)
Manufacturing	-	-	3.88	(2.90)	7.15	(2.50)	27.59	(10.70)
Electricity, Gas and Water	-	-	0.72	(0.50)	0.14	(-)	0.43	(0.20)
Construction	-	-	33.39	(25.20)	67.27	(23.70)	78.08	(30.20)
Wholesale and Retail Trade	-	-	43.69	(32.90)	60.85	(21.40)	78.90	(30.50)
Construction and Trade combined	-	-	26.55	(20.00)	100.91	(35.50)	-	-
Restaurants and Hotels	-	-	1.52	(1.10)	4.21	(1.50)	-	-
Transport, Storage and Communication	-	-	2.85	(2.20)	2.93	(1.00)	3.11	(1.20)
Financing, Insurance and Real Estate	-	-	3.03	(2.30)	5.14	(1.80)	5.03	(2.00)
Community, Social and Personal Services	-	-	2.06	(1.60)	13.26	(4.70)	32.73	(12.70)
More than one Activity	-	-	3.68	(2.80)	7.89	(2.80)	7.58	(2.93)
Activities not stated	-	-	4.32	(3.30)	0.65	(0.20)	-	-
*Net total employment in private enterprise	-	-	130.60	(100.0)	274.98	(100.0)	258.36	(100.0)
Net total expatriate labour force	0.12	5.51	145.96		302.44		287.84	

Source: Statistical Year Book (1990)

* Number of labour who left Oman deducted

The number of Omanis employed in agriculture is not known. It was, however, felt everywhere visited that the dependence on foreign labour in the agriculture sector is dominant and represents a problem in the continuity of acquired agricultural techniques.

2.3 AGRICULTURAL POTENTIALITIES

2.3.1 Farming Systems

Although agricultural activity is carried out by private farmers and private enterprise, land distribution to Omanis for agricultural purposes, as for other activities, is controlled by the Ministry of Housing (MH). MH is by law the executor of the Royal Decree prescribing land utilization including for agricultural purposes. During the period between 1970 and 1988 the government distributed 27,436 ha to farmers or companies who qualified and intended to use it for agriculture.

The area allocated to each applicant since 1970 was 3 feddans (1.68 ha) and increased then to 5 feddans (2.1 ha). Recently, after 1986 the limit was set up to 10 feddans (4.2 ha) except in plain areas of the Southern Region where 5 feddans, due to limited land resources, still represents the upper limit.

The entitled area is first leased for three years for RO $3.feddan^{-1}.year^{-1}$. The title of the area is then transfered to the farmer at a rate of RO $50.feddan^{-1}$ (about RO $120.ha^{-1}$), upon cultivating 75% of the area within three years. Each farmland holding is allowed to drill only one well. No subsidy is made available for purchasing farmland. Expanding the farm area up to 10 feddans is possible by purchasing land from neighbours. Areas larger than 10 feddans follow the rules of commercial farms including submission of a feasibility study acceptable to MAF. Farmland distributed can be used or traded only for agricultural purposes.

The areas distributed during the period 1970-1986, the number of holdings and the area under cultivation are given in table(2.10). About 57% of the agricultural land is concentrated in South and North Batinah. The area of land holding was 2.22 ha in North batinah, the highest of all regions. Holdings of very small areas are the common feature in the Southern Region. Farm area of only 0.15 ha is the average for 17,468 land holdings in this region. The overall average for the country is about one hectare per land holding.

The total area under cultivation has increased from 41,024 ha in 1978/1979 to 54,641 ha in 1988. This increase by 13,600 ha in the last decade represented a rate of 3.32% annually over the last ten years. The principal crop is dates accounting for 44% of the total cropped area. Other

major crops are alfalfa, vegetables and fruits (table 1.5).

2.3.2 Agricultural Production and Self Sufficiency

Although some of the Omani production of fruits and vegetables i.e. limes, dates, watermelons and tomatoes are exported, the self sufficiency in agricultural food products in 1988 ranged between 0% for rice, beans, sugar and plant oil and 105.1% (5% surplus) for dates and 408% for some other fruits (Table 2.11). The local production of cereals in 1988 provided only 0.4% self sufficiency. It is projected to keep it at that level until the year 2000. Locally produced vegetables provided about 64% self sufficiency in 1988. Projected development is to improve production and increase its area to meet the demand of increasing population at 65% self sufficiency until the year 2000. MAF is projecting the increase of tuber production to improve 100% in 1995 and through to the year 2000.

Fruit production provided the country with 93.3% of its demand and dates provided 5.1% surplus in 1988. The government is planning to achieve surplus in fruit and a larger surplus in date production by the year 1995 and through to the year 2000.

Animal products in Oman show, however, a large deficit. Self sufficiency was only 26.0% in 1988 for animal products. This was variable according to the product i.e. it was 28.6% and 29.9% for red meat and milk products, while it was lower for eggs (18.8%) and much lower for poultry (6%). Future plans are to achieve 100% self sufficiency in local poultry and egg production by the year 2000. Increase of self sufficiency in red meat is projected to reach 36.1% in 1995 and 46.6% in 2000. Local milk products on the contrary are going to satisfy only 23.2% and 22.4% of Omani demands in 1995 and 2000 respectively. The projected increase in animal products is accompanied by an increase in area cultivated to fodder crops of 10,174 ha in 1988 to reach 12,007 ha in 1995 and 14,412 ha in 2000 and putting along with the increases of cultivated areas excess pressure on the already exhausted water resources.

Fish caught during the period 1982 - 1989 varied between 90,253 and 161,108 tonnes.year^{-1} (table 2.12). The Sultanate of Oman has, so far, self sufficiency in this commodity. Part of Omani fish caught is even exported to GCC countries. No fish farming has yet been exercised.

Table (2.10):

Area of Farm Land distributed, Number of Holdings and Area under Cultivation

Region	No. of Wilayat	Farm Land Distributed 1970- 1986 ha	Holdings of Farm Lands 1978/1979			Area under Cultivation, ha	
			Number	Area, ha.Holding^{-1}	Area, Total ha	1978/1979	1988
South Batinah	10	12,469	16,720	1.39	23,198	10,246	16,602
North Batinah	5	4,520	12,188	2,22	27,073	13,274	14,605
Sharqiya	10	4,607	14,696	0.43	6,253	4,705	8,615
Dakhliya	6	3,367	6,842	1.60	10,920	3,054	5,619
Wusta	3	1,243	4,444	0.80	3,575	2,112	2,109
Dhahirah	3	1,230	6,402	1.13	7,202	3,303	5,603 (including Buraimi)
Buraimi	2	NA	2,024	0.65	1,313	886	
Musandam	3	NA	2,420	0.46	1,121	1,030	NA
Janubiya	1	NA	17,468	0.15	2,707	2,414	1,488
TOTAL	43	27,436	83,204	1.00	83,360	41,024	54,641

Source: JICA (1990)

Another projection for foodstuffs demand of 3 million Omani population in 2010 was made by MMDI (1991_b) assuming that (1) the population is now 1.5 million and the overall growth rate is 3.5% annually; (b) no dietary changes will take place over the next 20 years. The estimated demands on foodstuffs and land requirements to meet self sufficiency according to this assumption are presented in table (2.13). By the year 2010 self sufficiency in all commodities except rice, sugar and oils will require an eightfold increase in the area of irrigated lands at their present yields. With the anticipated improvement in yields after successful execution of JICA 10-year plan, a fourfold increase in cropped irrigated land would be needed (MMDI, 1991_b). Excluding wheat production and importing 100% of the needs (as it is at present) doubling the cropped area at higher production yields will be necessary by the year 2010.

Table (2.11):

Demand Local Production and Self Sufficiency of Agricultural Products in Oman (ton.year^{-1})

Commodity	1989			1995			2000		
	Demand	Local Prod.	% self sufficiency	Demand	Local prod.	% self sufficiency	Demand	Local prod.	% self sufficiency
Cereals	191,765	744	0.4	264,455	1,020	0.4	314,077	1,320	0.4
Vegetables	209,599	133,909	63.9	262,785	172,950	65.8	312,767	204,005	65.2
Tubers	17,016	5,900	34.7	19,382	19,382	100.0	22,754	22,754	100.0
Beans and nuts	2,279	0	0.0	1,285	0	0.0	1,526	0	0.0
Fruits	179,390	167,442	93.3	245,227	248,768	101.5	284,346	286,500	100.8
Dates	95,195	100,000	105.1	114,75	126,651	110.4	132,892	145,020	109.1
Others	16,531	67,442	408.0	36,834	122,117	331.6	43,253	141,480	327.1
Sugar	38,322	0	0.0	40,439	0	0.0	48,026	0	0.0
Oil	20,541	0	0.0	32,340	0	0.0	43,406	0	0.0
Sauce, Spices	8,689	5,553	63.9	11,667	7,934	68.0	14,041	9,777	69.6
Beverages	8,971	0	0.0	49,690	0	0.0	59,485	0	0.0
Other foods	9,516	0	0.0	9,006	0	0.0	10,695	0	0.0
Fish	82,770	NA	-	127,905	NA	-	151,905	NA	-
Animal products	199,139	51,717	26.0	277,221	95,004	34.3	329,626	130,387	39.6
Milk products	139,437	41,638	29.9	192,698	44,562	23.2	228,107	51,151	22.4
Red meat	22,885	6,549	28.6	34,172	12,348	36.1	41,692	19,409	46.6
Poultry	26,443	1,580	6.0	36,901	27,294	74.0	43,827	43,827	100.0
Eggs	10,374	1,950	18.8	13,450	10,800	80.3	16,000	16,000	100.0

Source: (MMDI, 1991).

Table (2.12):

Quantity of Fish caught in the Sultanate of Oman during the period 1982 - 1989

YEAR	Quantities in tonnes landed by			
	Traditional Fishermen	Korean Fishing Company	National Fishing	Total
1982	83,274	3,473	3,506	90,253
1983	95,968	7,389	5,168	108,525
1984	99,973	7,231	1,980	109,184
1985	81,525	9,339	4,029	94,893
1986	82,778	9,791	3,770	96,339
1987	104,055	8,094	2,861	115,010
1988	148,167	10,175	2,766	161,108
1989	98,000	*2,292	9,993	110,285

* The contact of the Korean Fishing Company was terminated in February.

Source: ME (1991)

Table (2.13):

Current Consumption and Projected Demand for Foodstuffs and Cropped Areas Required.

Commodity	1987			2010				
	Consumption ton.year^{-1}	Local prod. ton.year^{-1}	Required area of cultivation, ha.year^{-1}	Projected demand ton.year^{-1}	Yield[1] ton.ha^{-1}	Required Area ha.year^{-1}	Yield[2] ton.ha^{-1}	Required Area ha.year^{-1}
Wheat	124,000	0	0	248,000	1.5	165,000	2.4	103,000
Rice	83,000	0	0	166,000	-------	--------	----All	imported----
Dates	80,000	80,000	19,500	160,000	4.1	39,000	6.0	27,000
Fruit	61,000	42,000	3,600	122,000	11.8	10,300	17.2	7,100
Vegetables	41,500	24,000	1,300	83,000	18.4	4,500	25.4	3,270
Sugar	29,000	Negligible	0	58,000	-------	--------	----All	imported----
Dairy[3]	74,000	33,000	16,700	148,000	3.0	49,300	6.0	24,700
Fish	90,000	88,000	-	180,000	-	-	-	-
Meat	46,000	7,500	7,500	92,000	1.0	92,000	2.0	46,000
Eggs	207,473	39,500	-	415,000	-------	------All	imported	(feeds or
Vegetable Oils	12,700	0	0	25,000	-------	--------	----All	eggs)--
								imported-----
Total land requirement			48,600			360,100		211,070
Total excl.wheat						195,100		108,070
Total excl wheat and animal prod.			-			53,800		37,370
			-					

(1) Actual average yields of Oman at present.
(2) Target yields according to JICA plan after 10 years.
(3) Prediction with cereal importation of 22,000 tonnes.

Source: MMDI (1991_b)

CHAPTER III

THE STATUS OF DESERTIFICATION IN OMAN[1]

3.1 BACKGROUND

Desertification is the man-made process of the degradation of land so that it loses its capacity to provide economic returns under cultivation or grazing. In other words, desertification leads to the increase of the deserted area and the decrease of the fertile and productive land.

The process has recently been recognised internationally as a world-wide problem with the United Nations Conference on Desertification held in Nairobi, Kenya in 1977. Accordingly, desertification commonly appears as the deterioration of land, water and other natural resources under ecological stress. Deterioration implies that activities in an area have been unsuitable, either in degree or in kind. Such activities may have been pursued because of lack of environmental knowledge or experience, because alternatives were lacking or, in an attempt to maximize short-term gain at the expense of long-term productivity. Education, social and economic advancement and the adjustment of population growth to the development resources are the key elements responsible for initiation of desertification for successfully combating it.

"While water, soil and other material and biological resources are often the limiting physical factors, social, political and other human systems for making decisions and implementing plans, and the inadequate availability of financial resources, may constitute the major constraints to development, prevention of desertification and rehabilitation of desertified lands. (United Nations 1978)."

3.2 CAUSES OF DESERTIFICATION

In the Sultanate of Oman, desertification could be attributed mainly to physical factors and socio-economic factors.

3.2.1 Physical Factors

Physical factors leading to desertification in the Sultanate of Oman are mainly:

(i) The climate in the Sultanate of Oman is

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[1] The notes in this chapter are supplemented with information on the status of desertification in Part-Two-Chapter V.

characterized, as discussed in Chapter I, by low and erratic rainfall over most parts of the country and high temperatures as well. The country occasionally is hit by storms leading to sand drifts, desert encroachment and soil erosion.

(ii) Water scarcity makes it by far the most critical resource in the Sultanate of Oman at present and in future. The way water is being used at present does not give the impression that water scarcity is appreciated. Water misuse is happening everywhere, especially in the agricultural sector. Over-exploited aquifer through thousands of wells supplied with diesel pumps (no information was available about numbers of wells) has led to severe salinization of the cultivated lands in Batinah Plain. No information, however, is available about the area of salinized lands, but one should consider the magnitude of this problem as over 57% of the cropped area of Oman is located in Batinah Plain.

Over-abstraction of groundwater leads t salinization of water as a direct consequence to sea water intrusion in the coastal plains i.e. Batinah. This worsens the situation (MMDI, 1991_b). Changes of salt concentration in irrigation water need, however, to be monitored so as to outline the magnitude of the problem. Exact information about the dynamics of the aquifers in the different regions of Oman need to be generated.

(iii) Sand drifting represent serious problems especially over areas adjacent to Wahiba Sands and in the plains and wadis of Dakhliya, Wusta and Janubiya Regions.

The rate of advance of dunes of Wahiba Sands is hazardous to roads and other installations placed near them (Warren, 1988). There is, however, no information about agricultural and grazing areas affected with sand burial.

(iv) Type of agriculture practiced is characterized mainly with very large numbers of small farm holdings (<1 to about 1 ha each) cultivated to low yielding varieties, under-fertilized and over-irrigated traditional crops. The small holdings hinders mechanization which along with the low yields increases the cost of production. Productivity of crops is evaluated according to unit area (feddan or hectare) and neglecting the productivity of irrigation water used, which is given zero value. Soil fertility is expected to deteriorate after successive cultivation following single or double crop rotation system. The rate of mineral fertilizers applied is very low. Recent figures (ME, 1991) indicated that fertilizers are applied at the

annual rate of 13.4 Kg $N.ha^{-1}$, 6.0 Kg $K_2.ha^{-1}$ and 6.77 Kg $P_2O_5.ha^{-1}$. This worsens the situation of soil fertility. The absence of organic manuring of soils with high rate of organic matter decomposition in Oman will indeed reduce the level of soil fertility.

(v) Overgrazing has become the general trend everywhere in Oman. This is true for the rangelands with low carrying capacity as in Wahiba Sands and for the forests of Dhofar Mountains in the Southern Region where two thirds of Oman's cattle graze. Increasing demand for red meat and milk products as a direct result of both the increase of population and the rapid improvement of the living standard of the Omanis during the last two decades has encouraged pastrolists to raise larger numbers of cattle, sheep and camels. This was much beyond the carrying capacities of the rangelands grazed.

Desertification processes i.e. deterioration of vegetation composition and biomass productivity of rangelands were accelerated by providing pastoralists with subsidized feed. This encouraged pastoralists to keep larger numbers of animals. Increasing the availability of surface fresh water for the watering of livestock disturbed the balance between animals and plants which existed for many generations (GRMI, 1989).

The deterioration in quality is evidenced by the increasing abundance of annual grasses and poorer quality species ie. Arthraxon spp. and the increase of undesirable woody shrubs i.e. Calotropis procers, Dodonaea spp. and Solanum spp. (GRMI, 1989). Livestock owners talk of Themeda quadrivalvis which grew so tall that cows and even men could hide in it (Al-Kuthairi, 1992).

The current desertification in Dhofar mountains is summarized by GRMI (1989) to be due to one or more of the following:

- Heavy over-stocking;
- Little application of rangeland management practices; and
- Significant deterioration in rangeland quality and productivity.

3.2.2 Socio-Economic Factors

Exact data concerning the population of Oman, their distribution according to sex, age, trend of growth, labour force and their distribution according to area of activity are not available yet. A national census is planned for 1993. Until then, the evaluation of socio-economic factors

affecting desertification processes in Oman will be limited and difficult. However, following factors contribute to the desertification process in Oman:

(i) The type of farming practiced in Oman which is characterized by very small holdings (about one hectare and less) operated traditionally becomes profitable only when cultivated to high water consuming corps i.e. vegetables and forage crops (alfalfa). The average net profitability of vegetables, forage and fruit crops for small farms operated traditionally was 1,460; 752 and -829 Ro.ha^{1} year respectively (Table 3.1.).

The average annual profitability of such farms is only 196 Ro.ha^{-1}. In new farms higher annual profitability was achievable through the increase of vegetable area share. Average net profit of RO 985.ha^{-1}.year^{-1} in these farms. Here also negative balance of fruit cultivated areas were evident (RO - 758 ha^{-1}.year). Modern farms of larger areas (40 ha) generated much more income as the share of vegetable crops increased to more than 60% of total area, double cropping of vegetables (higher water consumption) and avoidance of cultivating field crops. Net profit from vegetables more than double (RO 3,253.ha^{-1}.year^{-1}) and the fruits brought profit for the first time (RO 85.ha). The average annual profit of the 40 ha farm was by RO 2,054.4 ha^{-1} more than ten times the wide spread traditional farms (only RO 196.2 ha^{-1}.year).

It is quite evident from the above-mentioned example that the type of farming is of crucial importance to Oman. Modern farming leading to reduction of water use (sprinkle and drip irrigation) to increase of yields and hence leading to increased net profitability of agricultural lands can help combat desertification caused by traditional subsistence farming. The improvement will need however skilled labour, active extension service, financial supporting system and organized marketing of products.

(ii) Employment in agriculture represents one of the major constraints for agricultural development. The number of Omanis employed in agriculture is unknown, however it was felt everywhere that young Omanis show unwillingness to work in agriculture because of one or more of the following:

(a) Misconception of prestige;
(b) Hard working conditions;
(c) Long day work;
(d) Lower money reward as compared to governmental and other jobs.

The number of foreign agricultural labour has therefore increased from 4,660 in 1980 to 21,200 in 1989. Many of them had no experience before. After one or two years training they usually return to their home countries. The continuity of acquired agricultural techniques is not sustainable unless Omanis get attracted to agricultural work.

Table (3.1):

Profitability of vegetable, forage and fruit crops in traditional farms, new small farms and modern large farms.

	Crops Cultivated			
	Vegetables[1]	Field Crops[2]	Fruits[3]	Total
a) Traditional farm				
Area cultivated (ha)	1.04	0.75	1.69	3.48
Average net profit ($RO.ha^{-1}.year^{-1}$)	1,460.10	752.3	-828.50	196.2
b) New farm (small)	3.26	1.78	1.11	6.15
Area cultivated (ha)	1,647.40	859.40	-757.60	985.30
Average net profit ($RO.ha^{-1}.year^{-1}$)	25.0[4]	-	15.00	
c) Modern farms (large)	3,235.1	-	85.40	40.00 2,054.40
Area cultivated (ha)				
Average net profit ($RO.ha^{-1}.year^{-1}$)				

(1) 10 vegetable crops at least.
(2) 4 field crops, mainly forage crops.
(3) 6 fruit crops.
(4) Crop area is 37.4 ha with 49.6% double cropping.

Source: calculated from JICA (1990).

(iii) The zero value of water has encouraged farmers to the extent of overusing this scarce resource. This overuse has contributed to increasing salinization.

(iv) Governmental efforts to combat deterioration of rangelands of the Southern Region (Dhofar Mountains) through the destocking programme in 1984 was aiming at protecting this national resource from overgrazing. Encouraged subsidized purchase of Dhofari cattle to decrease their numbers has, on the contrary, stimulated the livestock holders to increase the number of cattle for higher prices and/or profits. Al-Kuthairi (1992) found that the number of cattle has nearly doubled (98% increase) within 6 years of applying this policy (1983-1989). The number of camel decreased by 12% while the number of goats remained unchanged high during the same period (Table 3.2).

Table (3.2):

Changes in Livestock Numbers in Dhofar Region during the period 1979-1989.

Animal	19 79		19 83		19 89	
	Number	%	Number	%	Number	%
Cattle	77,932	100.00	163,687	210.0	323,333	44.9 197.5
Camel	54,365	100.0	97,982	180.2 100.0	76,336	140.0 77.9
Goats	106,249	100.0	450,191	423.7 100.0	450,191	423.7 100.0

Source: calculated from data by al-Kuthairi (1992).

The government programme to decrease cattle numbers from 163,687 in 1983 to reach the number recorded in 1979 (77,932) or less has resulted in further increase and at the same rate (about 16% increase annually). The number of cattle in 1989 was 415% of that in 1979 despite the destocking programme, through which 62,409 cattle were purchased by the government within 5 years (1984-1988) and 6.223 MRO were spent on purchase subsidy (JICA, 1990).

(v) Touristic activities represent additional threat to both the coastal plain and the foothills of the Dhofar Mountains in the Southern Region (Fig. 1.16). The plain had suffered damage to its vegetation as a result of the indiscriminate use of off-road vehicles used by the increasing touristic activities in this area. Camping for several days as well as sporadic visits has developed from nearly no activity before the 1970s to be visited by 11,300 and 19,000 in 1988 and 1989 respectively, mainly from GCC countries (Al-Kuthairi, 1992). The trend of increase is alarming (Table 3.3).

Within one year (1988-1989) the number of visitors increased by 68.1%. The rate of increase was much higher for visitors discovered the beauty of the region. Rates of increases ranged between 86.8% for Saudis to 329.4% for foreign visitors within one year. The leftovers after enjoyments have serious effects on camels (broken glass, tins etc.) and on goats (plastic bags). Migration of pastoral and agricultural labour to the tourism sector may also affect these activities in future.

Table (3.3):

Number of Tourists to Dhofar Mountains (1988-1990)

Country	1988	19 89		1990*
		Numbers	% increase over 1988	
United Arab Emirates	8,356	9,726	16.3	6,596
Kuwait	415	1,086	161.2	498
Saudi Arabia	340	635	86.8	189
Qatar	199	750	276.9	431
Bahrain	122	254	108.2	434
Local tourists	1,332	4,210	216.0	4,780
Foreign tourists	578	2,482	329.4	1,568
TOTAL	11,300	19,000	68.1	14,500

* The Iraq/Kuwait conflict hit the peak season of tourism in this region (July-September), but numbers are still very high for the start of the 1990's season.

Source: calculated from data by Al-Kuthairi (1992).

CHAPTER IV

REVIEW OF PAST AND CURRENT EFFORTS TO COMBAT DESERTIFICATION IN OMAN

The people of Oman have adopted, through long experience, conservationally sound ways of exploiting their local resources. They have evolved economic and social systems in keeping with their environment. The Bedu of Wahiba Sands and the pastoralists of Dhofar Mountains knew how to make use of their self-imposed regulations governing the use of natural pastures available in the regions. Farmers everywhere in Oman knew how to adapt their production to the Aflaj water levels within the so-called subsistence economy.

In recent years, however, the outside world has imposed itself on the sands' inhabitants, mountain pastoralists and village farmers through the oil wealth. The rapid social change and development that took place in Oman from subsistence to a highly commercialized economy over the last two decades has inevitably led to the creation of increased pressure on both the land and limited water resources. The population growth at a high net annual rate of 3.5% has, along with the improvement of Omani standard of living, further strengthened the pressure on those resources.

The improvement in agriculture production methods i.e. soil tillage, irrigation, seeds and fertilization have, however, failed to cope with the increased demand. Over-exploitation of both water and land resources inevitably led to deterioration of groundwater quality, soil fertility and hence the sustainable productivity of the system.

Realizing the above mentioned factors and considering the consequences of the continuing desertification processes on Oman's economy and environment the government of Oman has been putting much effort to combat desertification. In the following the current efforts to combat desertification in Oman are highlighted.

4. NATIONAL EFFORTS TO COMBAT DESERTIFICATION

Realizing the impacts of desertification on Oman's overall development and on agricultural development in particular, the government has started several activities to help improve ant conserve water resources, improve capabilities of land for agricultural purposes, rehabilitate rangelands, set up of capable research facilities and increase the public awareness of desertification. Considering the fact that the Sultanate is in its early years of organization and administration renaissance, the government's current efforts to combat desertification indicate awareness of the problem and high degree of determination to take necessary measures to combat desertification in the country. Allocating

budgets in the second, third and fourth five- year plans for related activities, initiation of institutions to deal with major aspects and promulgation of legislation necessary to prevent or minimize causes of desertification are good examples of such determination.

4.1 DEVELOPMENT AND CONSERVATION OF WATER RESOURCES

The utmost importance of water to the inhabitants of arid regions, Oman is not an exception in this respect, has caused the Omani Government to pay great attention to water resources development and conservation in the country. This was reflected in many governmental efforts implemented all over the country to explore water resources available and to optimize water use. In the following, the current efforts are summarized:

- The establishment of a Ministry for Water Resources (MWR) acting as central authority for water resources development, conservation and management. The structure of MWR (Appendix IV) allows for good interaction with other concerned bodies. The linkages between MWR and other organization are given in Appendix V.

- Preparation, for the first time in Oman, of a National Resources Master Plan, completed by the end of 1991. The studies were carried out by Mott MacDonald International Ltd. In association with Watson Hawkesley (MMDI, 1991$_a$ and $_b$). The Master Plan envisaged:

  (i) The strengthening of the institutional and legal framework to provide effective management of water resources in the interests of the Sultanate's long term development.

  (ii) Giving priority to domestic and industrial water supplies, but using desalinated seawater, despite the high cost, to minimize the impact of new potable water supply schemes on existing agriculture.

  (iii) Policies to curb demands for potable water and improve the efficiency of agriculture without increasing water use.

  (iv) Restricting agricultural development strictly in accordance with the available resource and reducing agriculture where resources are presently overdrawn.

  (v) Controlled development of non renewable resources.

  (vi) Augmenting the resource wherever possible.

- Adoption of a research plan in 1989 to be carried out by

the Ministry of Agriculture and Fisheries (MAF) with special emphasis on water use by crops, improvement of yield/Water relation and salinization problems. Improvement of irrigation methods is given high priority.

- Establishment of several meteorological stations covering the different regions of the Sultanate. The development of a network for agrometeorological data collection and processing is also considered (MAF, 1989).

- Strengthening of the programme for construction of recharge dams through the construction of 27 recharge dams until 1985 (MMDI, 1991_b) and additional 8 dams until 1992 (MWR, 1991).

- The Sultan Qaboos University contributed recently to the research on Siltation and Storage efficiency of Recharge Dams (Saleh, 1992).

- Allocation of 42 MRO in the fourth Five Year Development Plan (1991 - 1995) for priority projects at MWR and 45.7 MRO in the same plan for the irrigation sector at MAF. The total budget allocated for water resources development and conservation will amount to 87.7 MRO to be spent in the coming 5 years to help combat desertification through water management (Development Council, 1991).

- Preparation of "A Master Plan for Agricultural Development" by Japan International Co-operation Agency (JICA). This comprehensive study (5 volumes) is giving both 5 and 10 year plans for development in the agricultural sector. Improvement of irrigation methods is highly emphasized.

- Water resources of Wahiba sands were also studied. Hand dug wells contained water of 35 to 1,000 years of age. Deeper water reached by boreholes entered the ground 4,000 to 8,000 years ago (Gibb, Sir Alexander and partners, 1985). This study is very important for agricultural projects as it indicates the depletable nature of the groundwater in the Wahiba Sands.

Further work is, however, still needed to compile data on rechargeability of groundwater in the different regions. Changes of piezometric levels and salinity of groundwater need to be monitored. This information as well as crop water requirements are inevitably important for successful actions to combat desertification.

4.2 IMPROVEMENT OF LAND CAPABILITY

Many studies have been carried out by MAF in the field of agricultural development. Land resources were explored for future development Plans. Productivity of vegetable, fruit and field crops as well as livestock raising have been the aim of continuing efforts to improve it aiming at increasing

both farmer's income and the degree of self sufficiency in foodstuffs. In the following the major efforts are highlighted:

- The preparation of two surveys for land resources. The first generated the soil map (1977) and the second one "Agricultural Resources Map" in 1988. It is now known where and how much land is available for agricultural development, provided there is enough water available for irrigation.

- A ten year Master Plan for Agricultural Development has recently been prepared (1990) by the Japan International Co-operation Agency (JICA). This comprehensive study contains detailed working plans to develop land productivity, maximize water returns and increase profitability of agricultural farms. Options are given when considered along with the water master plan (MMDI, 1991_a and $_b$) to combat some desertification factors in the different regions of the Sultanate.

- Establishment by MAF of several research stations to deal with problems related to plant, soil, water and animal. These stations present in Rumais, Interior and Salalah (southern) provide a very important tool to improve land productivity through generating of:

  (i) Research finding for appropriate agricultural procedures including tillage, cultivation, irrigation, pest control, harvesting, marketing and processing.

  (ii) Extension services to farmers.

  (iii) Training of their young staff, agricultural engineers, extension personnel and farmers.

  (iv) Providing pest control services.

- MAF has in 1989 developed a very ambitious research plan to improve productivity of major vegetable, fruit and field crops. Improvement of irrigation methods is also one important goal. The plan foresees the establishment of data banks for agrometeorological data, water resources and requirements and other information leading to more accurate planning for resources development and conservation.

- Survey of forests of Oman using remote sensing techniques (LANDSAT imagery) and ground truth data was carried out by MAF and Sultan Qaboos University in Oman and Durham University, U.K.

- A joint work on "The use of sewage water for irrigation of sunflower in Oman" was carried out jointly between Arabian Gulf University Bahrain, Sultan Qaboos University

and the Ministries of Agriculture, Health and Environment (Al-Shuriani, 1991).

- Promulgation of legislation to control land use, land distribution for agricultural purposes and organizing drilling of wells and the use of treated sewage effluent was done when deemed necessary.

4.3 REHABILITATION OF RANGELAND IN SOUTHERN REGION

The development of the Southern Region of Oman (Dhofar) has received special attention from the Omani Government. Rehabilitation of the deteriorating forests and rangeland of Dhofar mountains has been the focal point of many activities during the last decade. The efforts were directed towards the identification of the magnitude of the problem, suggesting options for solution, execution of one or more of the options suggested and evaluation of the actions taken by the government and the response of Dhofari people. A great deal of effort was made among which the following are worth mentioning:

- The MAF had conducted through GRMI a rangeland revegetation project in the Southern Region (1987 - 1989). This comprehensive study investigated the status of biomass of the different rangelands of Dhofar Mountains, change of flora composition and the effects of reseeding, protection and fertilization of soil and the re-establishment of traditional rangeland management practices. One of the major outcomes of the project (GRMI, 1989) was that organized grazing (through fencing) increased the biomass productivity by 11 - 395% with the average of 81% within one year (average of 18 sites each). Some more details are given in Appendix VI.

- Forest resources of the Southern Region (Dhofar) were also the subject of a study carried out by FAO/MAF in 1990 (Seif El-Din, 1990) aiming at elucidating causes of deterioration of pastoral potentiality of Dhofar Mountains and suggesting measures to combat. The study concluded the following recommendation:

  1. Full support of the plans aiming at reducing the livestock number in Dhofar, through regular marketing channels as suggested in the regional development plan by PCDE-SR.

  2. Establishment of Range and Forestry Department within the Ministry of Agriculture and Fisheries as soon as possible.

  3. Recruitment and training of forestry staff so that the new department would have specialists trained at pos-graduate levels in the fields of (a) Planning and Forest Management, (b) Forest Ecology, and (c) Silvicultural Research. These should be supported by appointment and

training of technicians at post-secondary school levels.

4. In order to formulate sound planned management programmes, the forest resources must be surveyed, inventoried and mapped.

5. While the above programmes are being implemented the Ministry of Agriculture and Fisheries, within a five-year development programme, should secure professional assistance to undertake the following tasks:

   (a) Development and standardization of nursery techniques.

   (b) Development of tree establishment techniques appropriate to the conditions in Dhofar.

   (c) Species elimination trials involving indigenous and selected exotic tree species in the various ecological zones aiming at optimum utilization of the sites for the production of fodder, wood and other benefits.

   (d) Testing of systems for the management of natural forests for browse production and watershed management, and

   (e) Development of extension messages, in the light of these research findings, for use by the range and forestry staff in their dealing with the livestock owners.

6. Conduct research on water collection from the fog prevailing during monsoon times and develop methods for exploitation.

- Considering the impacts of socio-economic factors i.e. land tenure, land use pattern, social habits in the pastoral living areas the Omani Government (MAF) in collaboration with FAO carried out a field study (Janzen, 1990) to evaluate the present status of pastoral habits and efficiencies and to develop a suitable pastoral management programme to help improve the productivity of this region, taking into consideration the traditional and present tribal structure, its spatial land-use and pastoral migration pattern as well as the land property regulations on which the whole system is based.

- The Government is currently reviewing the farmer subsidy programmes formerly applied in the region to help destocking of livestock by 50% that have, on the contrary, led to nearly doubling the numbers of cattle within 5 years of application. The search is continuing and at all levels for socio-economically sound measures to help reduce the number of animals to the 1970s

levels.

- A strategy for rehabilitation of Dhofar forest and for rangeland management has recently been suggested by Jebbali, national young scientist (Al-Kuthairi, 1992), who was assigned to research this problem as the subject of his M.Sc. thesis at the Arabian Gulf University. Within this study he documented the efforts of MAF to combat desertification of the valuable Dhofar Mountains including afforestation of large areas and the establishment of large nurseries to provide natives with suitable trees.

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APPENDIX I

Diagnostic Horizons Recognized in Oman During Soil Survey (MAF, 1990)

1. **Ochric epipedon:** It is a light coloured horizon that is low in organic matter. Most soils in Oman, unless they are covered by fresh aeolian or alluvial sediments, have such a surface.

2. **Calcic horizon:** It is a subsurface horizon of accumulation of calcium carbonate or of calcium and magnesium carbonates. It is encountered in Calciorthids, in some Gypsiorthids and in Tropepts.

3. **Cambic horizon:** It is a subsurface horizon that is weakly developed. Rock structure is largely obliterated and the horizon has redder or greyer colours, or has lost part of its carbonates through leaching. In Oman the cambic horizon in encountered in Camborthids and Tropepts.

4. **Gypsic horizon:** It is a subsurface horizon of accumulation of calcium sulphates (gypsum) that is not strongly cemented.

5. **Petrogypsic horizon:** It is a cemented subsurface horizon of accumulation of calcium sulphates (gypsum). Many of the Gypsiorthids in Oman have a petrogypsic horizon.

6. **Salic horizon:** It is a subsurface horizon of accumulation of salts more soluble in water than gypsum. Sodium chloride is the dominant highly soluble salt in most saline soils in Oman. Salic horizons are encountered in many types of soils in Oman but are only diagnostic in Salorthids.

APPENDIX II

Soil Orders and Great Groups in Oman According to the Latest Soil Survey (MAF, 1990)

Soil Orders and Great Groups in Oman

Out of the 11 orders that are defined by Soil Taxonomy, only 3 exist in Oman. These ar the Entisols, Inceptisols and Aridisols.

A. **Entisols** are soils that have little or no evidence of development. They have no other diagnostic horizon than the ochric epipedon. In Oman Entisols are found in young alluvial deposits, aeolian sands and strongly eroded landforms.

Psamments, Orthents and Fluvents are the 3 great groups of Entisols presents in Oman.

1. Psamments are Entisols that formed in sandy aeolian deposits or young sandy alluvium. Torripsamments are psamments that have a torric moisture regime as defined by Soil Taxonomy. They are mostly non-saline and slightly saline, slightly to strongly calcareous, deep soils. Moderately deep and shallow Torripsamments were also encountered locally wherever thin young sandy deposits over bedrock occur.

2. Fluvents are Entisols that formed in young alluvial deposits that are subject to flooding. They have various textures but they always include at least one loamy or finer layer. They occur extensively in the coastal plains, such as those of the Batinah and Salalah. However, their proportional extent in Oman is rather limited.

3. Orthents are Entisols that formed on strongly eroded landforms, which are often strongly sloping or in very gravelly sandy alluvial deposits.

   a) Toriorthents are Orthents that have a torric moisture regime as defined by Soil Taxonomy.

   b) Ustorthents are Orthents that have a ustic moisture regime as defined by Soil Taxonomy. They occur in strongly sloping humid areas of the Dhofar plateau, affected by the monsoon. Overgrazing and the destruction of the natural vegetation play an important role in their formation. The proportional extent of Ustorthents in Oman is very limited.

B. **Inceptisols** are soils that show limited evidence of soil development. In Oman they have a cambic and/or a calcic horizon and a Ustic moisture regime as defined by Soil Taxonomy.

Ustropepts are Inceptisols that have a high saturation in exchangeable bases and have a warm temperature regime. They occur in the monsoon-affected humid areas of the Dhofar regions. They usually occur on karstic calcareous rocks. They have a shallow and irregular contact with the underlying rocks.

C. **Aridisols** are soils that do not have water available to mesophytic plants for long periods of time. They have at least one subsurface diagnostic horizon and an aridic moisture regime as defined by Soil Taxonomy. However, the Salorthids may have an aquic moisture regime. The suborder of Orthids is the only Aridisols suborder encountered in Oman. Its subdivisions (great groups) are Salorthids, Gypsiorthids, Calciorthids and Camborthids.

1. Calciorhids are the Orthids that have a calcic diagnostic horizon and do not have a gypsic horizon. The great group of Calciorthids is quite extensive in Oman. The Calciorthids form on residuum and on alluvium. They are generally strongly calcareous, non-saline to strongly saline, gravelly and deep to moderately deep. However, shallow Calciorthids do occur on eroded landforms and in alluvial deposits. The Calciorthids are frequently buried under recent stratified alluvium.

2. Gypsiorthids are the Orthids that have a gypsic horizon. The great group of Gypsiorthids is the most extensive type of Aridisols in Oman. The Gypsiorthids are mostly encountered on old landforms such as old alluvial fans and alluvial terraces. However, they may also be encountered in active depressions among sulphate rocks. The gypsiorthids often have a compact layer more or less cemented by gypsum, called a gypsum pan. Strongly cemented and hardened gypsum pans are called Petrogypsic horizons. These are frequently encountered in Oman.

3. Camborthids are Orthids that have no other subsurface diagnostic horizon than cambic and salic. Those that were encountered during the course of the soil survey are extremely saline and have a very hard and compact horizon of accumulation of sodium chloride. They occur mostly on high, old alluvial terraces in the Sharqiya regions. However, we suspect that non saline or slightly saline Camborthids may cover small areas in the Southern Dhofar and in Jabal Al Akhdar. Camborthids, in general, are not extensive soils in Oman.

4. Salorthids are very salty soils that form in wet depressions where capillary rise and evaporation concentrate highly soluble salts in a salic diagnostic horizon. Salorthids occur extensively in the Um-As-Samim Sabkha, in the Sharqiya region and in the Batinah coastal plain.

APPENDIX III

Local and Scientific Names of Common Plants of Dhofar Mountains

Scientific Name	Local Name
Acacia arabica	قـــرض
Acacia etbaica	صـــعب
Acacia tortilis	ســـمر (طلع)
Acacia senegal	هشاب (ثمر)
Anogeissus dhofarica	ســـغات
Adenium obesum	اسفيـــد
Adansonia digitata	انكيجـــي
Acridocarpus orientalis	اثبـــوت
Azima tetracantha	ظيشـــي
Allophyllus rubifolius	زركيـــن
Boswellia sacra	مغيـــروت
Blepharis dhofarensis	عليلـــوب
Boscia arabica	ســـير
Blepharispermum hirtum	خفـــوت
Carissa edulis	فلـــق
Calatropis procera	عطـــب
Cordia perrottettii	شبحيـــط
Commiphora foliacea	عقبـــاب
Comiphora gileadensis	شفيـــوف
Commiphora hebessinica	عقـــر
Commiphora wightii	عقريـــت
Capparis cartilaginea	لـــوصف
Croton confertus	حـــور
Caesalphinia erianthera	قيطيـــر
Cissus quadrangularis	عطـــراء
Cordia pupurea	ســـحل
Cordia Spp	عيـــتيـــت
Dracaena serrulata	عيـــروب
Delonix viscosa	اريـــر

Source: Al-Khuthairi (1992)

Scientific Name	Local Name
Dodonea viscosa	شـيراز
Dyerophutum indicum	ملـحلـح
Euphorbia cactus	طشـوق
Euphorbia chimperi	زغـــر
Euphorbia smithii	امبطـوت
Euphorbia schimperi	هبشنـوت
Ficus carica	كيليـت
Ficus salicifolia	ايلـوس
Ficus sycamorus	اثيـــب
Ficus vasta	غيضيـت
Ficus carica	طيـــق
Flueggea virosa	اثـــف
Ficus lutea	ظريفيـت
Hildebrandtia africana	اطبيـن
Hybanthus durus	اطبيـن
Hypoeste forskalei	اروت
Jatropha dhofarica	زبـرات
Jasminum grandiflorum	مطبطـب
Lannea triphylla	اينـور
Lawsonia inermis	حيـنا
Maerua crassifolia	سبرشحريت
Maytenus dhofarensis	شربيـث
Nannorrhops ritchieana	عرفيـت
Olea europaea	ميـطان
Ormocarpum dhofarense	خيـــر
Pavetta longiflora	عاصبيـى
Ricinus communis	عشعشـة
Rhus somalensis	زريفيـت
Ruttya fruticosa	مغليف
Salvadora persica	ايهريـك
Sansevieria ehrenbergii	شوبتـا

Source: Al-Kuthairi (1992).

Scientific Name	Local Name
Sterculia africana	اكثورة
Solanum incanum	حلـقوت
Tamarindus indica	صبـــار
Woodfordia uniflora	طـوب
Zizphus leucodermis	حيضيـت
Ziziphus spina-christi	ضيـد (علب)

Source: Al-Kuthairi (1992).

APPENDIX IV

Forage Production in and Outside the Sites of the Stock Exclusion Demonstration Areas (SEDA) in the Southern Region Jabals, Dhofar, Oman

SEDA Sites	Water Received in mm 1986	Forage Production, Dry Weight ha^{-1} Tonnes.		% Increase due to enclosure
		Outside enclosure	Inside enclosure	
1. Tawi Atiar (1)	191	2.8 ± 0.3	4.5 ± 1.4	61
2. Tawi Atiar (2)	191	3.1 ± 0.8	4.4 ± 1.4	58
3. Jallop	102	1.3 ± 0.5	2.4 ± 0.6	85
4. Shihait	130 - 170	1.5 ± 0.3	2.4 ± 0.5	60
5. Medinat Al Haq	-	1.2 ± 0.4	2.7 ± 0.3	125
6. Al Saan	205	1.4 ± 0.3	2.0 ± 0.3	43
7. Zeak	106	2.8 ± 0.5	4.3 ± 1.4	54
8. Shair	136	1.9 ± 0.1	3.5 ± 0.7	84
9. Qairoon Haritti	119	2.5 ± 0.3	4.4 ± 3.2	76
10. Ambushaq	119	2.5 ± 0.3	3.3 ± 0.3	32
11. Jahneen	257	3.8 ± 0.6	4.2 ± 0.8	11
12. Hagaif	257	1.4 ± 0.2	2.3 ± 0.7	64
13. Teetam	46	0.7 ± 0.1	1.4 ± 0.3	100
14. Ghadow	46	2.2 ± 0.3	3.6 ± 0.7	64
15. Shabah Asieb	92	3.4 ± 0.1	6.3 ± 0.9	85
16. Rayqut	200 - 250	2.5 ± 0.3	5.2 ± 0.8	108
17. Dhalqut	200 - 250	1.9 ± 0.4	9.4 ± 0.8	395
18. Khadrafi		1.6 ± 0.3	3.4 ± 0.3	113
Range		0.7±0.1 - 3.8±0.6	1.4±0.3 - 9.4±0.8	11-395
Average		2.139	3.872	81

Source: calculated from data cited in GRMI (1989).

APPENDIX V

Persons Met During the Course of the Visit to Oman

1. Ministry of Environment (ME)

   (a) General Directorate for Technical and Supporting Services

   - Dr. Sadik Abdulhassan Almaskati, Director General.

   (b) General Directorate for Environment Affairs, Muscat

   - Mr. Ahmad Ben Ali Alshuriani, Acting Director General.
   - Mr. Ali Ben Aamer Alqayomi, Head, Dept. National Strategy for Conservation of Environment (NSCE).
   - Mr. Said Ben Ahmad Almoqaddam, (NSCE).
   - Mr. Paul Menten, Expert (NSCE).
   - Dr. Ali Eltom, Consultant (NSCE).

   (c) General Directorate for Environment, Dhofar Governorate, Salalah

   - Mr. Salem Ben Farag Abdoon, Director General.

2. Ministry of Agriculture and Fishery (MFA)

   (a) General Directorate for Agriculture, Muscat

   - Mr. Suliman Ben Amer Almoharrazi, Director General
   - Mr. Tariq Ben Mousa Alzidgali, Director of Research Dept.
   - Mr. Saleh Ben Mohamed Alabri, Counterpart during the visit.
   - Mr. Hafeedh Ben Ahmad Alghessani, Director, Agricultural Statistics Dept.
   - Mr. Salem Mohd. Alghumari, Deputy Director, Agricultural Statistics Dept.
   - Mr. Mohd. Slahuldeen Mabrook, Agricultural Statistics Dept.

   Agriculture Extension Centre, Al-Seeb

   - Mr. Hamad Ben Seif Al-Qunoti, Director
   - Mr. Kamel Ameen Mohamed, Extension Eng.
   - Mr. Salah Mostafa Saleh, Agric. Statistics.

   Barkaa Agricultural Centre

   - Mr. Rashed Ben Khamees Al-Maamary, Director.
   - Mr. Samir Anwar Ahmad, Extension Eng.
   - Mr. Nagdi Abdul Aleem Mohamd, Agric. Statistics.

(b) Directorate of Agricultural Planning

- Mr. Salem Ben Seif Alabdali, Director.
- Mr. Mohamed Haitham El-Hurani, Adviser (FAO).
- Mr. Mohd. Wazir Hassan, Expert.
- Mr. Salem Ben Yousef, Counterpart to FAO Expert.

(c) General Directorate of Irrigation

- Mr. Seoud Alharithy, Director General.
- Dr. Hassan Wahbi, Irrigation Consultant.
- Mr. Hassan Nabhan, Head of Department of Dams.

(d) General Directorate for Agriculture, Livestock and Fishery, Dhofar Governorate, Salalah

- Mr. Saleh Mohd. Amer Alshanfary, Director General.
- Dr. Ahmad Mohd. Abdullah, Agric. Economist.
- Dr. Mohad. Awad Bashir, Head, Studies Coordination Section.
- Dr. Nicholas Clarke, Ecologist, UN Volunteer.
- Dr. Awni Mohd. Hammoda, Researcher, Plant Diseases.
- Mr. Ahmad Mustaheel Al-Kuthairi, Forest and Rangeland Project.

3. Ministry of Water Resources (MWR), Muscat

General Directorate of Water Resources

- Mr. Philip Gohnson, Assistant Director General for Water Resources Evaluation.
- Mr. John Key, Expert.

4. Ministry of Housing

General Directorate to Town Planning and Planimetry (Muscat)

- Mr. Salem ben Said Alghattami, Director General.
- Mr. Ali Mohd. Almazrooi, Deputy Director General.

5. Development Council

(a) General Directorate of Planning

- Dr. Taha Sultan Al-Mugheiry, Deputy Director General.
- Mr. Hamdan Ben Mohd. Alwahibi, Director of Agric. and Fishery Planning Dept.

(b) General Directorate of Follow-up

- Dr. Issa Jumaa Ibrahim, Economic Expert

(c) General Directorate for National Statistics

- Mr. Salem Ben Hamad Al Tauqi, Acting Director General.

6. Ministry of Regional Municipalities (MRM)

General Directorate of Municipalities for Technical Affairs

- Shaikh Helal Ben Nasser Al-Kindi, Director General.
- Dr. Suliman Ben Djbaer al-Farisi, Expert.

7. Council for Planning for Development and Environment (Salalah)

- Mr. Azzam Ben Hamax Al-Shanfari, Technical Coordinator.

8. Sultan Qaboos University (Muscat)

(a) College of Science

- Dr. Reginald Victor, Acting Chairman, Biology Department.
- Dr. Keven Brown, Biology Department.
- Dr. Abdul Kader El-Shafie, Biology Department.
- Dr. A.S. Gardner, Biology Department.

(b) College of Literature and Arts

- Dr. Taha A. Radwan, Chairman, Geography Department.
- Dr. Ahmad Salem Saleh, Geography Department.

9. United Nations Development Programme (UNDP), Muscat

- Mr. Stephen Brown, Programme Officer.

THE NATIONAL PLAN OF ACTION

TO

COMBAT DESERTIFICATION

IN

THE SULTANATE OF OMAN

PART TWO

THE PLAN - PROGRAMMES AND

PROJECTS

CHAPTER V

NATIONAL PLAN OF ACTION TO COMBAT DESERTIFICATION

5.1 THE MAGNITUDE OF THE DESERTIFICATION PROBLEM

5.1.1 General

The Sultanate of Oman is part of the mass known as the Arabian Peninsula which is classified according to the World Atlas of Desertification (UNEP, 1992) as mostly hyperarid and arid in some parts. According to a study prepared by ECWA (HIRMIZ, 1983) 95.8% of Oman is either climatic desert or more than moderately affected with desertification.

The Desertification Map of the world (FAO & UNESCO, 1977) depicts the degree of desertification hazards (in zones likely to be affected by desertification) for Oman as moderate or high. Desert and desertified lands in Oman could also be calculated from the latest soil survey (MAF, 1990) as almost equal to the total unsuitable land for agriculture which is about 93%.

5.1.2 Definition of Desertification

The definition of desertification adopted by the United Nations Conference on Desertification (UNCOD) in 1977 was found inadequate and a more precise definition was required in the face of several suggestions put forward by individuals and institutions.

Taking into consideration the results of additional studies and consultations undertaken by UNEP, the following was finally adopted in the consultative meetings of UNEP for its 1991 assessment of the status of desertification and preparations for the United Nations Conference on Environment and Development (UNCED).

"Desertification is land* degradation in arid, semi-arid and dry sub-humid areas resulting mainly from adverse human impact" (UNEP, 1991).

This definition however, in 1992 was somewhat modified by UNCED in its agenda 21 as follows:

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* Land in this concept includes soil and local water resources, land surface and vegetation or crops." (UNEP 1991).

"Desertification is land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variation and human activities.

5.1.3 Perception of Desertification

Among the early reports which touched on the type of land degradation that leads to, or is related to desertification are Lamprey (1976) and Lawton (1978). Both conducted surveys in the Dhofar Region. By 1977 the Sultanate of Oman was conscious of the spreading land degradation and interested in controlling it and in the newly spreading environmental problem, called "desertification".

In that year the Sultanate participated in the United Nations Conference on Desertification (UNCOP) which was held in Nairobi, Kenya with a delegation from the Ministry of Agriculture and Fisheries (MAF) and the Diwan of Royal Court.

Concern about the environment and the desire to ensure that development, which was to continue in Dhofar Region after peace has returned in 1975, should be based on sound basis and knowledge, was behind the decision to conduct the very successful scientific survey of the flora and fauna of the Dhofar mountains in 1977. Its results (Diwan, Sultanate of Oman 1980) "emphasized the urgent need to prevent irreparable damage to the delicate balance which exists there between man and nature, between land use exploitation and the limited biological resources".

Of particular interest to this study is Sale's (1980) special note of the careful balance between cattle numbers and available nutrition which was a remarkable feature of the Jabal ecosystem. At the same time Sale warns against disruption of this balance by the effect of new developments such as additional water supplies on cattle numbers and distribution and states that increased grazing impact could rapidly destroy the entire grass land - a serious process which unfortunately has already started.

Sale (ibid) alerted about desert formation following heavy grazing of shrubs and bushes by large concentrations of camel or excessive grazing of shrubs and herbs in arid areas by goats. The presence of both camels and goats,' he said, " in the marginal areas does, however, constitute a potential factor in increasing desertification and their numbers and ecological effects require careful monitoring".

Studies on land degradation particularly as caused by wind and water erosion as well as problems of overgrazing and sand movements continued in Oman. In some six or seven years there were several reports and the government became concerned that the process

of development in the Southern Region was, unintentionally, creating new problems in terms of overgrazing, damage to the environment, depletion and pollution of water resources. Consequently an International Workshop on Environmental Aspects of Development in the Southern Region was held under the auspices of the Diwan of Royal Court in September 1983.

Two major recommendations of the workshop were:

(i) "The urgent need for a comprehensive land use plan";

(ii) "The fundamental need for an interministerial authority which can coordinate all aspects of development in the region. Without such a body it is inevitable that there will be conflicts between the development programmes of various ministries and consequent wastage of effort and resources "(Sultanate of Oman, Planning Committee for Development in the Governorate of Dhofar (1991).

In response to these recommendations the Planning Committee for Development and Environment in the Governorate of Dhofar (PCDEGD) was established by Royal Decree in 1984. Its Technical Secretariat has undertaken a number of original studies on natural resources, land use, population etc. These studies were used in the production of a Regional Development Plan and first stage land Use Plans.

Concern and interest of international organizations in environmental issues in the Sultanate were manifested by visits of their representatives and the missions reports which followed. Among this group are included a report by UNEP (1982) which boldly asserted for the first time the threat of desertification by encroaching sands in Badiyah. This conclusion was not accepted by Brunsden (1988). On the basis of his reconnaissance observations he concluded that further work was necessary. Brunsden (ibid), however, admitted the threat of some active dunes to Al Ghabbi, for example, and further stated that "interpretation of the satellite image and air-photographs and ground observations leave little room for doubt that there is sand drift in Badiyah". Among the studies which contributed to advance knowledge on the hazards and processes of desertification is the invaluable document comprising 51 scientific papers on a part of Oman - a sand sea which is unique in the world for the diversity of its character'. This document (Diwan, Sultanate of Oman 1988), records the results of the Wahiba Sands Project, 1985-1987, and remains a principal reference not for the Wahiba sands but also for other desert areas of Oman. The most recent study consulted by

this (UNEP/ESCWA) mission was the National Conservation Strategy - (NCS) Vol III in draft which presents tens of programmes and projects as elements for implementation of the NCS.

The NCS pointed out that the sectoral and regional studies by the Ministries of Agriculture, Housing, Regional Municipalities and Environment and the Governorate of Dhofar have drawn the attention to the growing problem of desertification following expansion in agriculture and construction. Of 25 projects suggested in the NCS 11 have more or less strong connections with desertification control. This, no doubt is an indication, not only of advanced perception of the growing problem of desertification but also of the big magnitude of the problem.

5.1.4 Examples of the Extent of Desertification

(i) **Field Visits**

The mission during its three weeks of stay in Oman, visited Al-Batinah Region, the Governorate of Al-Kamil and AL-WAFI (in Al-Sharqiyah Region), and Dhofar Region. In such a short period a quantified assessment of desertification is not possible. In fact such a task would be part of the priority projects in a plan for desertification control in Oman.

(ii) **Al-Batinah:**

From Al-Khobora village to Wadi Al-Hawsma and wadi Al-Salahi, horticultural farms in the coastal strip along three kilometres showed signs of deterioration. Palm date and mango trees in particular were withering and drying up from the effects of saline water and soil. Desertification was observed at various degrees along almost the whole strip of land between the main highway and the coast. The main cause of desertification in the Batinah plain is the salinization of the groundwater leading to soil salinization, and consequently loss of soil productivity or suitability for economic crops. The salinization of the groundwater in this region is caused by sea water intrusion, which in its turn is caused by aquifer over-exploitation and reversing of the hydraulic gradient due to decline in the water table. With continued overdraft the groundwater salinity will continue to increase, and the area affected will

continue to expand leading to further soil salinization, and deterioration of agricultural production.

In Al-Sagha and Wadi Algazi area the water was too saline to be used for drinking or irrigation particularly after the establishment of the copper factory as reported by the area inhabitants. The withering effects of salinization on horticultural trees was marked and extensive in Masanah, AlBadia and many other locations. Increasing salinity in ground water has been noted since 1975 as reported in the Background Section "Part one" of this study, (Pg 36) and the levels of salinity in ground water have been depicted in a map (Fig. 1:12) of the Background Section. The reduction of soil and aquifer potential as a result of the present levels of salinization is now widely obvious in the agriculturally important Batinah soils. Concern among the Government circles is growing about this form of desertification, because Al Batinah coast is the most important agricultural area in Oman and it produces about 60% of the countries total agricultural production.

(iii) **Al-Shargiyah Governorate of Al-Kamil and Al-Wafi**

The road from Muscat to AlKamil runs for the most part in a south east direction. About 186 kms from Muscat, Wahiba Sands appeared to the west of the road - high dunes at some 5 km on the west of the road. On the east there were low flat sheets of sand. At Al Zhahir village sand encircled the village farms; the dunes were less than 0.5 km in certain sectors. After Al-Mintirib road junction no sand dunes were seen on the east side of the road for some 15 kms; on the west the high dunes were now about 20 km from the road. Sand dunes were then seen on both sides of the road and plenty of sand collected on the slopes of a hill east of the road, (222 kms from Muscat - and close to Jebel Galhat.

At the approach to AL-Kamil (about 260 km from Muscat) the vegetation cover was sparse, scattered scrub and there were isolated low sand sheets; on one farm sand accumulated and almost climbed the southern wall of the farm. The water

resources Administration at Al-Wafi was conscious of the land degradation problem and had good knowledge and data on the situation. They considered sea water intrusion the main problem and the ensuing discussion revealed that several farms in Sur were ruined by salinization. Sand encroachment constitutes a problem in the eastern part.

Al-Kamil- Al Wafi area is known for its high potential for development in view of the availability of land. The alluvium fan in this area is wide and the depth of soil in the higher parts reaches 300 metres, while the water table is around 20 metres.

In the area between Al-Wafi and Abu Ali there are about 5000 wells; cultivated land is about 4000 ha while the farm average size is one ha. Farm crops are palm dates, citrus fruits, melons and fodder. Some wells have gone dry while salinity increases from Abu Ali in the north direction and has affected 80% of the wells in which the level exceeds 3000 millimohs.

The groundwater situation in Wadi Al-Batha (Al- Wafi and Al-Kamil areas) has reached a critical stage based on information gathered from the office of the ministry of Water Resources. Some irrigation wells have dried out. Wells with water salinity above 3000 millimohs have increased from 40% to 80% of the existing 5000 wells (approximately). The salinity increased in these wells to about 7000 millimohs. In addition, the water levels in most of these wells dropped, on the average, about 3m in Al-Wafi and Al- Kamil, and 3-5 m in Bani Bu-Hasan and Bani-Ali area.

As a result of the groundwater salinity built up in this area, about 10% of the presently irrigated area (about 4000 ha.) has been severely affected by salinization. Deserted farms and badly damaged palm trees due to high water table and soil salinity were observed during the field visit. The groundwater salinity build up in this area is attributed to the pattern of groundwater extraction as related to the irrigated land where the irrigation wells are located within the main irrigated areas.

Increased groundwater salinity was also observed in the coastal plain of Sur and Qraiyat as a result of sea water intrusion due to over-pumping. Groundwater salinity in these areas is higher near the coast where it reaches up to 5000 and 10,000 millimohs in Qraiyat and Sur plains respectively.

Groundwater salinity levels up to 10,000 millimohs was also reported in the coastal area of Wadi Maih. Soil salinization in these areas of high water salinity have been progressing and increasing the desertification hazard in these areas, particularly in Sur area, where agricultural productivity of the soil has been seriously affected.

Another form of desertification was observed in the Wahiba sand dunes area and the adjacent Wadi Batha in the east and south east. This form of desertification is related, to overgrazing and deterioration of the natural vegetation cover and has led to active sand movement by wind action. This reactivation of the Wahiba sand dunes have resulted in the advancement of sand dunes towards agricultural lands and oasis. The reactivation of sand and observable sand drift was reported by Brunsden (1988).

In the near past Wadi AL Batha formed the dividing line and barrier for the sands collecting on its west and south west sides - and no sands were found on the east side. But this is no longer true. Sand dunes are now across the Wadi, the road from Falaj Al Mashaikh to Jaanlan Abu Hassan is surrounded by dunes on both sides. Less than two decades this road passed through woodland as depicted on the map sheet No. NF40-8E shown to the mission in the MWR office at Al Kamil.

DHOFAR GOVERNORATE

Six ecological zones in Dhofar have been described in Chapter 1 of the Background section of this study. Following are brief observations on type and extent of desertification in each zone.

(i) **The coastal plain**

Most of the year there is little vegetation cover on the plain . It has suffered severe damage to its vegetation as a result of overgrazing, off-road

vehicles, construction and tourism activities. However, after the rains the whole plain turns green with ephemeral herbs and grasses.

(ii) **Foothills**

A zone, which used to be heavily wooded, has been subjected to heavy pressure by people and livestock is now over-grazed, dominated by xerophytic shrubs and severely degraded.

(iii) **Escarpement, woods and grassland**

A zone of woodland and tall grasses which often reach a height of 1.5 metres. The best known sector here is the Khatem or Kotem. Although under pressure by both cattle and camels little degradation is observed. In certain spots, however removal of trees has resulted in soil erosion.

(iv) **Dry Plateau**

A zone of short grassland with thin tree cover "the Kutn". As a result of overstocking the zone is overgrazed and the land suffers extensive degradation.

(v) **North draining wadis and cliffs**

The vegetation in this rain - shadow zone is naturally sparse and bare ground is much more evident. Degradation is observed in quantity and quality of vegetation which has become mostly unpalatable.

(vi) **Desert and Pre-desert**

Best known as the Nejd, it is mostly free of vegetation, with scattered trees of Bosallia sacra which are badly degraded under extensive pressure by camels and goats.

General Comment

The Dhofar environment has been subjected to increased pressure of the human population, change in animal husbandry practices and of livestock numbers which increased between 1980 and 1990 by 70%. Apart from overstocking leading to overgrazing, the area was subjected to deforestation which led to soil erosion. There was also degradation of rangeland quality as a result of replacement of good varieties by unpalatable and toxic species. All these factors working singly or in combination in the various ecological zones brought almost all ecological zones under increasing degree of desertification hazard.

5.2 NATIONAL PARTICIPATION TOWARDS THE PREPARATION OF THE NATIONAL PLAN TO COMBAT DESERTIFICATION IN THE SULTANATE OF OMAN.

5.2.1 General

This section is included to reflect the importance and significance of the participation of national institutions and experts in the preparation of this plan. The role they played and their contribution whether direct or indirect in the formulation of this plan should be publicised and made known to others and this is one way of doing this.

Secondly this will bring to the notice of those who wish to assist this country (the Sultanate of Oman) in the matter of desertification studies or control the existence of this contribution.

The following record gives details of the work by Omani Institutions and experts which helped directly or indirectly in this study. Of course a lot of this work has not been done in connection with the problem of desertification, nor was it done as preparatory material in anticipation of formulation of a NPACD. Nonetheless it was all useful for the Plan. The following list, however is not exhaustive.

5.2.2 Surveys and Research

(i) Preparation of two surveys for land resources. The first generated the soil map in 1977 the second generated the "Agricultural Resources Map" in 1988.

(ii) Forest resources of the Southern Region (Dhofar) FAO/MAF in 1990 (Seif Eldin, 1990).

(iii) Field study on socio-economic factors in pastoral living areas by MAF & FAO -(Jahnson, (1990).

(iv) A study of rehabilitation of Dhofar forest and rangeland management in Al Kuthairi-1992.

(v) Al- Shuriani, A.(1991): The Use of Treated Sewage Water for Agricultural Irrigation in the Sultanate of Oman (in Arabic). M.Sc. Thesis, Arabian Gulf University Bahrain.

(vi) Saleh, A.S. (1992): Siltation of recharge dams in the Sultanate of Oman - A Geomorphological Study. Dept. of Geography. Fac. Literature. Sultan Qaboos Univ. Muscat, Oman.

(vii) Al-Shenfari, Saleh M.A. & ElHag B. Ahmed (1992): Management of rangeland in collaboration with herder groups in Dhofar. A paper presented at International Conference on Nomadism and Development. Isfahan - Iran, 1 - 6 December 1992. PP 9.

(viii) Al-Kuthairi, A.M. (1992): Forests and Pastoral Activity in Dhofar Mountains: Study of Strategy for Rehabilitation (in Arabic). M.Sc. Thesis, Arabian Gulf University Bahrain.

5.2.3 Other Reports and Studies

Several reports and scientific documents of great importance and relevance to this work have been prepared in Oman. A selected number is listed:

(i) The Journal of Oman Studies, special Report No. 2 (See list of references).

(ii) The Journal of Oman Studies, special Report No. 3 (See list of references).

(iii) The Sultanate of Oman National Report to the United Nations Conference on Environment and Development.

(iv) State of the Environment in the Sultana of Oman (1990).

(v) Annual Report (1991) Ministry of Municipalities and Environment. Directorate general for environmental affairs.

(vi) National conservation strategy - vol III in draft - (1992).

(vii) Sectoral and Regional Planning Studies.

(viii) Selected papers among 120 papers presented to the international Symposium on Agriculture and Fisheries development in Oman. (October 1989).

5.2.4 National Participation in the Formulation of the NPACD.

The interest of the Sultanate in desertification could be traced back to the early seventies when it is found embodied in the concern of the Sultanate with the overall environment protection and with land degradation of which desertification is one form. In pursuance of these important aims the Sultanate organized the Salalah workshop on environmental

aspects of development in the Southern Region in September 1993. Before that and in response to his Majesty Sultan Qaboos bin Said directives a scientific survey of the flora and fauna of the Dhofar mountains was undertaken in 1977 (see 5.1.3). This general concern with land degradation continued but desertification, in particular,was in focus, after a Ministry of Environment was found in 1984 and a division of Soil Pollution and Desertification was created in the Directorate General of Environmental Affairs within the Ministry of Environment. It seems, however, that the division did not go functional.

A request from the Government of Oman to UNEP Regional Office for West Asia (Bahrain) for assistance, was immediately followed by a positive response from UNEP and UNESCWA. An expert was sent in 1991 to the Sultanate to prepare the background section of the Plan.

By September 1992 a three-man mission was mounted to prepare the substantive part of the plan. The mission's programme was organized by the Directorate of International Organization Affairs in the Ministry of Regional Municipalities and Environment.

Omani experts who accompanied the mission and generously offered their knowledge and experience are included in appendix 1.

The contributions of these persons were invaluable. The mission, in its endeavour to collect information and learn about the conditions in the Sultanate met with 86 persons, mostly in group meetings. The meetings were well organized, very informative and allowed wide exchange of views. From a total of 26 meetings 14* were more or less departmental type of meetings attended by the senior decision making staff who spoke with responsibility and confidence and were obviously aware of the intricate inter-relationships between the various institutions who shared responsibility with one aspect or more of the environment. These meetings were very informative and provided unique opportunities for the mission to collect important first hand information.

The second valuable opportunity for gathering useful information was handy when senior national experts accompanied the mission to the field.

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* 1. Introductory meeting, 2. UNDP, 3. NCS; 4. Housing, 5. Ministry of water resources, 6. MAF, 7. Development Council, 8. Qaboos University, 9. Marmul Agricultural Project/ Dhofar, 10. Directorate General of Agric, Animal wealth and Fisheries, 11. Dept of Animal wealth, 12. Regional Municipalities and Environment, 13. Round-up meeting , 14. Planning Committee for Development and Environment.

The third source of information was the individual meeting or personal communication. The details of all these meetings and the list of persons met by the mission appears as appendix 1.

The fourth, but surely the most important source of information was the reports and documents, many of which were either nominated or actually handed over to the mission.

A substantial contribution to the preparation of the plan came through the work done in the preparation of the NCS. This valuable contribution came in the meetings with the director and the consultant on the NCS and the Omani experts. It also accumulated in the wealth of basic data and information prepared for writing up the NCS and finally it is exemplified in several projects proposed in the draft NCS Vol. III.

5.2.5 National Seminar on the Suggested Plan.

5.2.5.1 Steps in the Preparation of NPACD

The essential steps in preparation of a national plan of action to combat desertification are:-

(i) Preparatory works in the country concerned with the plan;

(ii) Visit of the team of experts for some weeks to prepare the draft plan;

(iii) Government initial agreement or preliminary acceptance of the plan outline presented by the expert group to the Government representative in the round up meeting;

(iv) Government approval of the suggested NPACD; and

(v) Organization of a national seminar on the suggested NPACD.

5.2.5.2 Proposed Programme for the National Seminar

The principal aim for holding this seminar, after the government approval or acceptance of the document is to further the involvement and participation of national institutions and cadres, modify and correct as necessary and draw up direction and steps towards which individual projects should be elaborated. The list of invitees to the seminar will include all ministries, universities and institutions concerned or interested in the issue. The list should also include UN and other organizations: UNEP, UNESCWA,FAO, UNDP, AOAD, CAMRE, ALECSO etc..

5.2.5.3 It is proposed that the seminar convenes for three days. The following actions are suggested for the sessions of the seminar:

(a) Presentation of the plan to the participants so as to form a common general understanding of the main contents and to have a common language for discussion.

(b) To define priorities for the programmes and projects proposed in the plan, and consolidate reasons and remarks needed to ensure inclusion of the projects in a revision or a supplement to the Five-Year Plan, for Economic and Social Development (1991-1995).

(c) Fixing a date and method for preparation of Project Fact Sheets. This is the step which follows defining the priorities when essential information for each project are registered. That includes, the geographical position, execution, the duration, the cost, background, the goals (short-or long-term), the expected results, the activities, follow-up, financing and estimated costs for various activities.

(d) Fixing a date for preparation of full-fledged project documents. Normally these documents are prepared by multi-disciplinary teams. The members are selected from experts sent by countries, regional and international institutions willing to cooperate and assist in the execution of the proposed schemes after having studied the papers concerning the projects which were proposed in the previous stage - the project fact sheets.

(e) Deciding on time and organization of a round-table meeting composed of representatives of governments, regional and international institutions with the aim of obtaining their support and assistance in financing the projects which they had previously either shared in preparing its documents or have studied them when called for the meeting.

It is proposed to prepare a working paper for each item of the five items suggested above. It is also suggested that international organizations should be invited to participate in preparing some

of the working papers so that they could be called upon in future for financing part of the costs of activities or meetings or by sending an expert for assisting in the preparatory work of the seminar.

5.3 NATIONAL GOALS

The literature agrees that national renaissance in Oman started in 1970 with the accession of Sultan Qaboos Bin Said to power. A search for the national goals or aims which led the forces of development through the past two decades was focussed on the successive five-year development plans.

5.3.1 Targets in the First Five-Year Plan 1976-1980

The targets of the first Five-Year Development (1976-1980) were summarized in the plan as follows:-

(a) To develop new sources of income to supplement and eventually to replace oil revenues;

(b) To increase the proportion of capital investment expended on income-generating projects, particularly in the sectors of manufacturing, mining,agriculture and fisheries;

(c) To effect a wider geographical distribution of investment in order that the benefits may be shared by different regions of the country, and to narrow the gap in the standards of living in different regions with special emphasis on the least developed regions;

(d) To maintain and develop the existing areas of population and to protect them against the dangers of mass immigration to these already densely populated areas and to protect the environment;

(e) To pay more attention to the development of water resources which are of vital importance to economic progress;

(f) To develop the local human resources in order that they may be able to play a more active role in the national economy;

(g) To continue the development of basic infrastructure;

(h) To encourage trading activities by removing the obstacles which hinder

their progress; these obstacles include problems of transportation, storage and limitations on competition with a view to encouraging competitive practices and keeping prices at reasonable level;

(i) To work to achieve the basic requirements of a free economy in which the private sector plays a leading role on the basis of free competition in a market clear of monopolistic practices. To this end the introduction of incentives including reasonable exceptions, loan with easy repayment terms to finance productive projects and government participation in the capital of important projects are suggested;

(j) To improve the efficiency of the government administration.

Of these 10 long-term targets those covering or related to desertification or land including water degradation are found in the 4th, which specifies protection of the environment, and the 5th which states "to pay more attention to the development of water resources".

5.3.2 Targets in the Third Five-Year Plan 1986-1990

These long-term targets were meant also for future guidance as recalled in the Third Five-Year Development Plan (page 47):

"The long-term development strategy was commissioned in February 1975. It outlined the philosophy which since then has been undertaken by the state and it defined development goals which were derived from the prevailing socio-economic conditions of the Omani Society".

The Third Five-Year Plan (1986-1990) was charged with 13 main targets. Number 6 of them states: to give priority to the development of natural water resources and to the income-generating projects in such sectors as those in agriculture, fisheries, manufacturing, mining and natural gas".

5.3.3 Targets in the Fourth Five Year Plan (1991-1995)

The 4th Five-year Plan (1991-1995) has been formulated on the basis of the goals approved by the Development Council in 1975 for the first and subsequent Five-Year Development Plans.

The Plan's strategy was based on mainly six targets:

1. Achieving an appropriate growth rate for GDP with emphasis on diversifying sources of income.

2. Maintaining the financial balance of the State.

3. Developing human resources and limiting dependence on expatriate labour.

4. Emphasising the regional dimension of development.

5. Supporting the role of the private sector in economic activity.

6. Emphasising the principle of self-reliance. It is noted that for the purpose of this study none of these six targets mentioned environment, land degradation or desertification.

Under the Infrastructure Sector, the plan includes among seven titles, the Environment and Water Resources. The aims of the plan under the environment are summarized as follows:

(a) Monitoring and controlling all possible forms of environmental pollution.

(b) Provision of environmental advice and applying environmental measures and specifications.

(c) Linking development to its effect on the environment to support its positive aspects and reduce its negative aspects to a minimum.

Under water resources the plan, specifically aims to achieve the following:-

(a) Reduce the current shortage in water resources and stabilize the main underground aquifers throughout the Sultanate by the year 2000.

(b) Prepare a programme for the regions which suffer from water shortage to achieve a balance between available resources and the need for them during a specific time

period.

(c) Widen the scope for protection of water resources and reuse of treated drainage water for watering gardens and forestation.

(d) Encourage maximum use of brackish water resources.

The worrying observation that none of the above areas included desertification control among its aims is partly alleviated when it is remembered that desertification has been discussed in regional and sectoral plans; but this was not reflected in the five-year Plan (Abd El Rahman, 1992)*. One of the NCS project proposals mentioned that sectoral studies by the Ministries of Agriculture, Housing, Regional Municipalities and Environment and the Dhofar Governorate Regional Study have all drawn attention to the spreading desertification disaster and overgrazing problem as a result of vast extension in agriculture and construction (NCS Vol. III in draft).

Furthermore the PCDE in the Government of Dhofar prepared a study "Land Use Plan in the Southern Region" in which the issues of desertification, water resources and livestock were adequately dealt with (Al Ghassani, 1992)*. According to the Secretary General H.E. Al Ghassini desertification control in the Southern Region will be accorded top priority.

5.4. A LONG-TERM STRATEGY FOR DESERTIFICATION CONTROL (1994-2020)

5.4.1 Guidance from the Long-term National Goals

The National goals during the last two decades have been extracted and reviewed under section 5.3. All through the targets in four Five-year Development Plans have been formulated on the basis of principles and philosophy from the long-term development strategy which was commissioned by the Development Council in

* Personal communication, during discussion in the Development Council, General Secretariat.
* Statement by H.E. Al Ghassani in his brief to the meeting of 19.9.1992.

February 1975. Since a principal directive in the United Nations Conference on Desertification (UNCOD) Plan of Action - Recommendation 22, calls for integration of anti-desertification programmes into development plans, it becomes imperative that the long- term strategy for desertification control should anchor its roots into the long-term development strategy of 1975 and ensure that its objectives are in line and supportive of those in the current development plan. In this way integration of programmes formulated for desertification control will naturally be easily achievable.

Desertification is an environmental problem. When left to spread unchecked it will, no doubt, develop into an environmental disaster. Control of desertification which is known to have spread in Batinah, Al Sharquiyah and extensively in Dhofar region is meant to be covered under the goal or target (d) in the National long-term strategy of (1975), protection of the environment " and target (e) to pay more attention to the development of water resources".

5.4.2 Target Dates

One of the main principles which from the basis of the global anti-desertification strategy, according to the external assessment (UNEP, 1991) requires that "NPACD for all the countries effected by desertification should be fully incorporated into national programmes for development, including appropriate financial and institutional provisions". The current Five-year Development Plan (1991-1995) has about two more years. As the suggested NPACD for the Sultanate of Oman would have a long-term horizon and a short-term one, it appears that two years would not be appropriate for the short-term horizon. It is therefore suggested that the short-term horizon be for 1994-1996. The long-term horizon would be set for 2020. This last date is chosen to coincide with the date set in the second assessment (UNEP,1991) to complete execution of a set of practical steps proposed for implementation to combat desertification at the national, regional and international levels (ibid).

5.4.3 Aims of Strategy for Desertification Control.

Guiding Policies/General

A National Plan of action to combat Desertification whose primary function is to halt desertification in the country concerned is at the same time a building block in the design to implement UNCOD/PACD. It is therefore recommended that it should be prepared on the basis of the general policy guidelines as directed by UNEP (1991).

The principal aim, as spelled out in UNCOD/PACD, (UN,

1978); "is to prevent and to arrest the advance of desertification and, where possible, to reclaim desertified land for productive use". Under its objectives and principles the plan (ibid) (paragraph 10) stipulates that:

"The ultimate objectives is to sustain and promote, within ecological limits, the productivity of arid, semi-arid, sub humid and other areas vulnerable to desertification in order to improve the quality of life of their inhabitants. A campaign against desertification should take its place as a priority among efforts to achieve optimum and sustained productivity. For the countries affected, {and the Sultanate of Oman is one of them} the implementation of this Plan of Action implies more than a campaign against desertification; it is an essential part of the broad process of development and the provision of basic human needs".

With this quotation from the plan, which was unanimously endorsed by the General Assembly in December 1977 and whose validity was upheld at the conclusions of the two general assessments in 1984 and 1991 the argument for taking up the issue of desertification control in the Sultanate of Oman and the need for assigning the highest priority to it does not require further reasoning or justification. To accomplish this principal aim the following targets/objectives are set for the year 2020*.

(a) Raising the percentage of self sufficiency in food production and improving the status of food security.

(b) Anti-desertification programmes and projects should be in conformity with national goals and contributing towards their success, improvement of the quality of life of the inhabitants of lands affected by desertification and protection of the environment.

(c) Ensure, in accordance with the need and potential of country's natural resources, the sustainable development of the two limiting factors-water and land; through interalia, sound integrated water resources management and land reclamation projects.

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* These targets are formulated along the lines of the 16 targets suggested in UNEP (1991) to be addressed nationally, regionally and internationally.

(d) Ensure public participation in design and implementation of the programmes side by side with developing and improving public perception of the desertification problem.

(e) Achieve development of indigenous national and regional scientific research and technology capabilities (through the implementation of programmes designed to bring about this result).

(f) Establishing national institutional and technical facilities for assessment and monitoring of desertification.

(g) Contribute to strengthening of regional programmes and international cooperation in the campaign against desertification.

5.4.4 Basic Assumptions

(a) The Sultanate of Oman long known concern with environment protection and development will continue through out.

(b) Fighting desertification, as an environmental undertaking will remain supported by a strong political will of the Government and with full realization that the fight is a long-term undertaking.

(c) The validity of desertification control projects should not solely be judged by standard methods of economic and financial feasibility. Some of the parameters important to this issue cannot be measured by these yardsticks.

(d) The proposed long-term and short-term programmes, including projects, would be subject to frequent revision and changes in view of the dynamic nature of the phenomenon.

(e) There will be close co-ordination and mutual support among all the national projects, irrespective of geographical location, and also between this group of national projects and other regional projects.

5.4.5 Elements of Strategy: A Long-term Programme (1994-2020)

The UNCOD/PACD was formulated and adopted by the UN General Assembly in 1977. One of the basic principles

in the Plan states that "ideally all (28) recommendations in the plan have to be implemented if desertification is to be brought to an end".

In 1990-91 an external general assessment of the implementation of the UN Plan was undertaken. On the basis of its conclusions,UNEP report (ibid) presented new guiding policies and some 11 practical targets in the form of modified (UNCOD Plan) recommendations (Appendix 2). In the modified recommendations of 1991 and in the recommendations of UNCOD Plan ,the choice of priorities and suitable action to be taken was left to the individual Governments to decide upon. The important part, however, is that continuous reference has to be made to the UNCOD Plan for guidance. The reasons for this are recalled in the following paragraphs.

The validity of UNCOD/PACD was upheld in the 1984 General Assessment of Progress (UNEP 1984). it was again confirmed after the assessment of 1990-1991 (UNEP/1991). This last assessment, however, was considered by the Governing Council of UNEP in 1992. The Council reaffirmed "its convinction that the PACD is an appropriate instrument to assist governments in developing national programmes for arresting the process of desertification" and also requested the Executive Director "to take into account when revising the existing recommendations of the PACD, the approved findings and recommendations of the evaluation report and of this decision" (UNEP, 1991).

In response to the Governing Council's directive, guiding policies and practical steps were prepared. The guiding policies concerned preparation of PACD (ibid). The practical steps are general priorities worded in the form of 11 recommendations; essentially under preventive,corrective and rehabilitation measures. As required under the guiding policies each one of these recommendations is related to the Recommendation of the original PACD of 1977 on which it is based. In light of the above the following programmes are proposed for the Sultanate of Oman.

5.5 ELEMENTS OF THE STRATEGY : SELECTED PROGRAMMES

5.5.1 Introduction of Improved Land Use Systems in Areas Affected by or Prone to Desertification

This programme is proposed for preventive corrective and rehabilitation measures along the lines of the practical steps of the revised PACD recommendations (ibid). The programme addresses issues or specific actions relating to;

(i) Introducing integrated approach in land utilization.

(ii) Introducing improved land/water/crop

management systems in irrigated lands.

(iii) Stabilization of rainfed croplands.

(iv) Introducing improved range land/husbandry management systems.

(v) Undertaking major afforestation programmes.

(vi) Undertaking a campaign on stabilization of shifting sands. Specific project proposals to halt desertification in Al-Batinah, Al-Sharguiyah and Dhofar regions which are priority areas should be adopted and prioritized in space and time as part of the priority projects (1994-96) or during the remaining period of the long-term horizon. (For reference and additional information see recommendations 2,6,7 and 19 of the original PACD of 1977 and Recommendation 1 of the 1990/91 General Assessment (Appendix 2).

5.5.2 Sound Integrated Water Resources Management Programme

The practices of misuse, over use, over-exploitation and mismanagement of the water resources are important factors behind the desertification processes in Oman. Therefore changing such practices within the framework of a country-wide rational and integrated water resources management is a key factor for combating desertification.

The main objectives of this programme are :

- To protect the existing available water resources which have been seriously affected by development.
- To control water salinization resulting from different causes, with particular emphasis on the sea water intrusion problem in the coastal aquifers.
- To augment the depleted groundwater resources by artificial recharge and other non-convertional resources.
- To explore, assess, and develop new, groundwater resources where possible. (For reference and additional information see Recommendations : 5,8 and 26 of the original PACD of 1977).

5.5.3 Improved Soil Management programme

Soil degradation which is spreading in the Sultanate

Of Oman as a result of salinization, over-grazing and trampling... etc needs to be stopped and if possible degraded soils regained. In this programme projects for mountain regions, marginal lands or cultivated lands should be formulated and executed. (For reference and additional information see Recommendations 6,8,9,19 of the original PACD of 1977).

5.5.4 Appropriate and Improved Technologies Programme

This programme is complementary to the first programme. Its aim is the introduction of appropriate and improved technologies which are socially and environmentally feasible and compatible with new land use systems in : agriculture; range and pasture; forestry; livestock and wild life management. (For reference see Recommendations : 4,6,7,9,10,19 of the original PACD of 1977 and recommendations 2 and 5 of the 1990/91 External Assessment (Appendix 2.)

5.5.5 Public Participation Programme

Prevention of desertification and reclamation of desertified lands cannot succeed without direct involvement and support of the public. Recommendation 3 of UNCOD/PACD gives examples of some of the types of activities for consideration. People in Oman, whether in the north eastern part of the country or in the Dhofar mountains region have long experience and tradition with one form or another type of agriculture for thousands of years. The Aflaj watering system in the North and East, and the unique land use/animal husbandry balanced systems of the Jebalis are but two well known examples.

This programme should build on the positive aspects of peoples' experiences, spirit of cooperation and accumulated wisdom in managing their ecosystems. Involved in this programme will be the furtherance of public awareness and perfection of peoples' perception of the desertification problem and methods of its control. The programme which takes care of the above aspects should also ensure peoples increasing involvement in the discussions of the problems, in planning of and project preparation and in their execution. (For reference see Recommendations 3,12,20 of the PACD of 1977 and Recommendation 7 of the 1990/91 General Assessment (Appendix 2).

5.5.6 Socio-Economic Programme

This programme deals with two aspects:(i) the impact of the process of desertification on man, his welfare and institutions;, and (ii) a consideration of social and economic behaviour and systems as a primary cause of desertification.

In dealing with the first aspect, the programme will

comprise projects that are broadly grouped under the category of integrated comprehensive rural development. These generally aim at providing better conditions of life and at raising the income of farmers, herders and other under- privileged groups through various improved technologies and management procedures.

In dealing with the second aspect the stress will be on affecting changes in man with regard to his perception, attitudes and traditions that make him a victim of subsistence level economies and activities that result in overgrazing, the depriving of soils of natural vegetation through the inappropriate use of lands and deforestation that leads to extensive soil erosion. These underlying causes of desertification have been addressed in UNEP's modified recommendation No. 9(d) which calls for assessment of the social, economic and political causes of under-development and the resulting immediate causes of and processes of desertification...."

Projects dealing with either of the two aspects in this programme should address the removal of the inequalities in resource availability and development that exist within one region or between different governorates. In this respect this programme contributes towards realization of "emphasizing the regional dimension of development which is one of the main national targets". Furthermore the inequalities mentioned above have their most severe impact on the poorest people who eke out a living in marginally productive arid and semi-arid lands. Projects in this group depend on policies that extend credit facilities to the needy and which also provide subsidies for vitally needed inputs.

The nature of the objectives and types of activities pursued in projects dealing with either of these aspects of this programme should work with (co-operate) or take into consideration activities undertaken in other fields that are related to, or have a direct impact on human perception and attitudes. Of importance in this respect are education projects, particularly those directed at adults to make them fully aware of the ecological aspects of development and the more sensible use of arid lands. Also of importance is obtaining of support for the satisfaction of basic human needs for the under-privileged group through co-operation with projects that have these targets among their objectives.

The planners of projects in this programme should realize the importance and benefits to be gained from teaching farmers, herders and other rural inhabitants by example (actual demonstration) and through generous incentives.

In the Sultanate of Oman financial subsidies are

allocated and policies are adopted by the government to encourage farmers to introduce improved irrigation methods aiming at rationalization of water consumption in the agriculture sector. Modern irrigation methods i.e. sprinkle, pivot, drip and bubbler are introduced to some newly established farms and have achieved higher productivity. Shortage of capital, awareness and adequate technical knowledge delay the acquaintance of these irrigation methods by many of the Omani farmers and/or landlords.

This wise policy, apart from being supported in UNCOD/PACD, has also been given support in the Revised Recommendations by the 1990/91 Assessment (UNEP-1991 Page 59) of which recommendation 10 which calls for the introduction of "land use policies that would be directed to the improvement of land use, appropriate management of common lands, provision of incentives to small farmers and pastoralists, ensuring the involvement of women, and encouraging private investment in the development of drylands*. (For reference see Recommendations 4,12,19 of the original PACD of 1977 and Recommendations 2,3,8,9 and 10 of the 1990/91 General Assessment (Appendix 2).

5.5.7 Supporting Actions Programme

This programme deals with training and research, in order to strengthen the scientific and technological capabilities required for the success of anti-desertification programmes. The corresponding section in the UNCOD/PACD is entitled "strengthening science and technology at the national level", and includes recommendation 18. Omanis with professional training relevant to desertification or the environment related topics were less than 10 in 1989 (The Council for Cooperation among Gulf States, 1990). The programme also deals with environmental education and national legislation appropriate for the needs of the anti- desertification campaign. An additional aspect under this programme is the establishment or strengthening the national institutional capabilities for implementing the NPACD. The programme also covers building nation-wide anti- desertification awareness and extension services. (For reference see Recommendation 15,18,20 of the PACD of 1977 and Recommendations 6,7,8 and 10 of the 1990/91 External Assessment (Appendix 2).

* For the full text of Recommendations 9 (d) cited earlier and 10 see Appendix 2.

5.5.8 Assessment of Desertification and Related Parameters Programme

This programme deals with the assessment of the status of desertification in the country which is given significant position in the UNCOD/Plan PACD in 1977. In fact the first section in that plan dealt with "Evaluation of Desertification and Improvement of Land Management", and the first Recommendation focussed on assessment and evaluation of desert and the degradation processes as they affect people, the physical elements of the environment and the plant and animal products. Although several areas in the east and in the south are affected with one form or another of desertification , no monitoring or assessment has ever been done; hence the urgent need for this programme. (For reference see Recommendations 1, 11, 12 and 16 of the PACD of 1977 and Recommendation 9 of the 1990/91 External Assessment (ibid).

5.5.9 Insurance Against the Risk and the Effects of Recurrent Drought Programme

The Executive Director of UNEP reporting to the UN conference on Environment and Development (UNEP, 1991) said that in industrialized countries elaborate drought insurance schemes have been put into practice to cushion rural communities from these natural disasters. But since UNCOD, efforts have been made to ensure affected populations particularly those in Africa by the institution of "drought early warning systems" and the establishment of grain reserves. Other efforts met with little success. He added that although drought risk insurance in drylands is more applicable and important to livestock and rangelands, little has happened in this direction during the 14 years since UNCOD. For many countries foreign aid remains the main insurance against famine during the drought years.

Chatty (1991) deals with this issue in another context, namely "Modern Interpretation of System of 'Reserve' for Emergencies". The author states that pastoral nomads, in the Middle East (and indeed in other parts of arid lands) have traditionally maintained a system of reserve to protect the family unit from disaster, disease and other emergencies. This system or organization had traditionally two expressions:(1) the large size of the livestock herd - (greater than actual subsistence needs demanded), and (2) the land itself. Careful management of these two resources was developed over centuries in order to ensure sustainable survival.

Over the last two decades, in Oman, "reserve" has come to be interpreted in a wider sense to include:

(1) Communal grazing; (2) fodder farming; (3) supplementary feed purchases; and (4) paid employment,

whereby the "salaries increasingly become a "reserve" or a guarantee that they can keep their herds alive in times of drought", (ibid).

This concept is too valuable to be left undeveloped. It is therefore suggested that a programme based on these principles or pillars be developed for the benefit of the pastoralist nomads.

5.5.10 Regional and International Action and Co-operation

This programme is important for handling issues and actions that cannot be taken up by one country. "The experience of the 1980's indicated clearly that the regional approach to international cooperation in solving major environmental and development problems is the most promising one, "(UNEP 1991). The achievement by UNSO in mobilization of resources needed for combating desertification should be considered for replication in the region of west Asia. This programme is also important for dealing with international cooperation in desertification control and organizing " this cooperation on a partnership basis among all countries of the world as this environmental/developmental problem is of global magnitude and should not be considered as just another aid programme of the richer countries to the poorer ones, "(ibid).

The areas identified for cooperation are:-

- Mobilization of financial resources and provision of financial assistance to the countries that cannot cope with the problem by themselves.
- Development of pricing and trade policy that would favour agricultural development and sustainable productivity of drylands;
- Provision of technical assistance to the countries in need;
- Development of appropriate anti-desertification technologies and technology transfer to the needy countries on favourable terms;
- Monitoring and coordination of the anti-desertification campaign at the global level;
- Information exchange;
- International legislation, as appropriate.

(For reference see Recommendations 23, 24,25, 26 of

the PACD of 1977 and Recommendation on the course of Action Regionally and Internationally (UNEP, 1991 - PP 61,62).

5.6 REMARKS

The ten programmes described in the previous paragraphs constitute the core and framework of the NPACD in the Sultanate of Oman for the next 25 years; hence they cover extensive areas of project activities. They are interdependent and complement each other. Similarly the priority projects which will be identified and formulated under them for implementation during the period 1994-1996 must share the same qualities of interdependence and complementarity. These projects will be detailed in Chapter VII.

The implementation of this NPACD composed of ten programmes for its long-term strategy and tens of priority projects for its short-term horizon requires setting up an efficient and capable institutional machinery. Rather than including this complex activity as a programme among the above mentioned programmes it will be elaborated in the next chapter.

In concluding this chapter it should be emphasized that all desertification control work, whether it is part of the long-term strategy or the priority action for the short-term, should form part of the national social and economic development plan.

CHAPTER VI

ESTABLISHMENT OF NATIONAL INSTITUTIONAL CAPABILITIES

6.1 BACKGROUND

6.1.1 "The Sultanate's Government embarked upon nature conservation several years ago and has become the leader in this field in the Middle East". This is indeed an important statement in the Sultanate of Oman National Report to the United Nations Conference on Environment and Development in 1992 (Ministry of Regional Municipalities and Environment, 1992). This may be a well-earned position in view of the Sultanate's institutional and functional accomplishments.

6.1.2 "It is generally said and accepted that the process of national development in Oman started from a base of virtually zero in 1970 "(ibid). In 1974 the office of the Adviser for Conservation of the Environment was established. Its functions were: (a) "to acquire knowledge about Oman's flora and fauna", and (b) "to ensure that wildlife and other natural resources would be protected and managed in harmony with other forms of development."

As it happened three very important studies - not to mention others - have been completed. These are:

(1) Flora and Fauna Survey of Jabal Al-Akhdar in northern Oman in April 1975.

(2) The scientific Results of the Flora and Fauna Survey, 1977 (Dhofar), Published in the Journal of Oman Studies special Report No.2.

(3) The Scientific Results of the Royal Geographical Society's Oman Wahiba Sands Project 1985-1987 Published in the Journal of Oman Studies Special Report No. 3.

6.1.3 In an attempt to address environmental problems in the Southern Region in preparation for development after peace has returned to that part of the country, a conference of local and foreign specialists was convened in 1983. To implement one of its recommendations, the Planning Committee for Development and Environment in the Southern Region was formally instituted by Royal Decree in 1984.

6.2 ENVIRONMENTAL INSTITUTIONS IN OMAN

The history and development of environmental Institutions in Oman is of special interest. Until

recently there were four principal government institutions for environmental matters.

6.2.1 **Council for Conservation of the Environment and Prevention of Pollution.**

Created in 1979 its initial purpose was to oversee the control of marine pollution. In 1984 its responsibilities were expanded to cover protection of the environment and prevention of pollution generally. The Council was chaired by his Majesty the Sultan; the Deputy Chairman was the Minister of Environment. But in December 1991 the Ministry of Regional Municipalities and Environment came into existence. The responsibilities, allocations and records of the Council for Conservation of Environment and Prevention of Pollution, and the Ministry of Environment have been transferred to the new Ministry.

6.2.2 **Ministry of Environment**

This Ministry was created in 1984 and charged with the responsibility for environmental pollution control and water resources. It is noteworthy that the Ministry had a Division of Soil Pollution and Desertification within the general Directorate of Environmental Affairs (Fig 1). In 1989 the responsibility for water resources was taken from it and a separate Ministry for Water Resources was established. In December, 1991 the Ministry of Environment was amalgamated with that of Regional Municipalities which was renamed as the Ministry of Regional Municipalities and Environment (MRM & E).

6.2.3 **Office of Adviser for Conservation of the Environment.**

The creation and functions of this office were dealt with under 6.1.2.

6.2.4 **Planning Committee for Development and Environment in the Governorate of Dhofar.**

This important regional entity was established in May 1984 as a ministerial Committee responsible to the Development Council. Its functions include preparing studies and plans for the development of the Southern Region.

6.2.5 In addition to the foregoing institutions there are about 18 established governmental committees dealing with one aspect or another of the environment from the marine environment supervision to climatic change. None of these 18 committees has a direct responsibility for desertification matters.

6.2.6 Private Initiative Policies and Practices

In this category, there are at least four practicing bodies:

(1) The National Community Development Programme (NCDP) of the Ministry of Social Affairs which has about 15 years of experience in working directly with local communities with the aim of raising living standards through education income - generating and self- help schemes in 346 villages and 375 smaller population centres (The Sultanate of Oman National Report to the UNCED).

(2) Omani Womens' Association which is Government- supported NGO with 11 local branches in the Sultanate.

(3) Women and Child Care Task Force which aims for a broader improvement in the quality of life of the people of Oman by addressing a range of health and social issues.

(4) Muslim Religious leaders and institutions enjoy a respected position in the community and have the capacity to influence positively community-based efforts.

(5) Non-governmental organizations (NGOs) are poorly represented in Oman and just beginning to work on the health of woman and children.

6.3 INSTITUTIONS CURRENTLY RESPONSIBLE FOR DESERTIFICATION MATTERS IN OMAN.

6.3.1 General

By the nature of desertification whose causes, symptoms, consequences and effects on population, livestock, renewable and non-renewable resources, there are many government institutions which are de-facto involved in the causation and control of desertification. And there are others which claim responsibility/or are dealing with desertification. A brief account on them is given in the following paragraphs.

6.3.2 The Ministry of Regional Municipalities and Environment.

This ministry has prime responsibility for desertification control vested in its General

Directorate of Environmental Affairs whose organogram (Fig-1) includes a division for Soil Pollution and Desertification. The Ministry is represented in Dhofar by a General Directorate.

6.3.3 Ministry of Agriculture and Fisheries, the Ministry of water Resources, the Development Council, and the Planning Committee for Development and Environment, Southern Region are all involved in one way or another in desertification control. The role of each one in desertification control, however is not always spelled out in their establishment decree or order.

The general Directorate of Agricultural, Livestock and Fisheries Resources in Dhofar is an exception in this respect as its Rangeland and Forestry Department has been and continues to be extensively involved in fighting land and soil degradation in general and manages a direct attack on desertification.

6.4 PROPOSED NATIONAL MACHINERY FOR DESERTIFICATION CONTROL

6.4.1 Structure of the National Machinery

The control of desertification is the concern of several disciplines and professions, and therefore no single profession or discipline can claim overall responsibility for this complex field. The advance level of environmental awareness in the Sultanate makes the Omani in a far better situation for understanding how to deal with issues relating to the composition and placement of the national control organ in view of the sectoral organization of ministries.

Recommendation 21 of the UNCOD Plan calls for establishment of coordinated national machinery to combat desertification and drought. It further expressed the desire that the machinery be in the form of a national desertification commission at the highest level of government, composed of high ranking representatives of the appropriate ministries, agencies and institutes, together with community leaders and non-governmental organizations (NGOS). The recommendation gives advice on the task of co-ordinating and consolidating activities, as well as the need for administrative and scientific support for the national body. This recommendation was slightly modified and elaborated in the UNEP report presented to UNCED (UNEP 1991). As Recommendation 6 in chapter III it reads "To establish or to strengthen the national institutional capabilities for implementing the NPACD, including hierarchical networks down to the grassroots level".

In elaboration it called for:

(i) Establishing a national authority within the government with access to the highest executive and decision making level;

(ii) Establish commissions/boards in regions or provinces.

(iii) Establish land users' committees in affected rural communities.

(iv) Organize working cooperation among the local authorities, extension services and land users committees in planning and implementing anti- desertification measures.

(v) Support existing or newly established NGOs ... and strengthen their working cooperation with the national and local authorities concerned with the implementation of the NPACD, with a view to their active participation in the national anti- desertification campaign. (In implementing this recommendation reference should be made to Recommendations 3,18 and 21 of the NPACD of 1977).

What came in this recommendation seems to fit smoothly and without much toil the current situation in the Sultanate of Oman. The Sultanate's Report to UNCED described in its section "3.3 Institutions" the principal government units dealing with environmental matters as well as the established committees and the private initiative policies. It thus appears that formation of a commission and boards of Recommendation 6 could be done among the established committees while the land user's committees and NGO's could find their parallel or similar bodies in the group of private initiative Policies and Practices. Along these lines the following institutional structures are recommended.

6.4.2 National Desertification Control Commission (NaDeCC)

An extensive survey of the views of senior government officials revealed that the executing government bodies most concerned with desertification are the Ministries of (i) Regional Municipalities and Environment, (ii) Agriculture and Fisheries , and (iii) Water Resources. Almost all people met by the mission were agreed to have the NaDeCC placed within the Environment.

It is therefore recommended that a National Desertification Control Commission be established under the chairmanship of the Minister of Regional Municipalities and environment , and with the following membership:

(i) Permanent Secretary , Ministry of Agriculture and Fisheries as vice chairman.

(ii) Permanent Secretary, Ministry of Water Resources.

(iii) Representative of the Development Council.

(iv) Director General , Environmental Affairs, MRM & E.

(v) Director General, Agricultural Research.

(vi) Director General of Agriculture, livestock and Fisheries Resources (Governorate of Dhofar).

(vii) Director General, Environment, Governorate of Dhofar.

(viii) Director, Department of Desertification control, MRM&E. ix) Director Environmental Planning, MRM & E.

(x) Representative of Sultan Qaboos University.

(xi) Director, National Conservation Strategy, MRM&E.

(xii) Representative, Ministry of Education and Youth.

(xiii) Representative, Ministry of Social Affairs.

(xiv) Representative, of the National Community Development Programme.

(xv) Representative of Non-Governmental Organizations (NGOs)*

*NGOs involved in desertification control activities.

6.4.3 Directorate for Desertification Control Coordination

It is recommend that a directorate, under a competent professional director be established within the General Directorate of Environmental Affairs in the MRM&E. This Directorate should find urgent staffing by a suitable number of professionals and technicians. The Director would be designated secretary of the NaDeCC. The number of staff required would be determined in accordance with the amount of administrative and technical support required for the functioning of the commission and for whatever executive activities the unit becomes responsible for.

6.4.4 Regional Units

Recommendation 6 of the revised recommendations in UNEP Report to UNCED (op.cit.) called for the establishment of anti-desertification boards within provincial local governing or executive bodies in accordance with the existing administrative structure of the country. It is, therefore, recommended that the Directorate for Desertification Control should establish regional units in the Governorates, where appropriate. The ones recommended for immediate establishment are for Dhofar, Al-Batinah and Al-Sharqiyiah. The selection of membership in the regional units should be guided by the pattern in the NaDeCC.

6.4.5 Land User's Anti-Desertification Communities

Formation of land users anti-desert committees should be pursued in response to the call of recommendation 6 (opcit) for the establishment of "hierarchical networks down to the grassroots". The existence of the NCDP network, the Women and Child Care Task Force and some NGO's would provide a starter for the formation of such committees with the assistance of, and under the supervision of the regional anti-desertification units and the Ministry of Social Affairs.

6.4.6 Responsibilities of the National Machinery

6.4.6.1 The responsibilities of the national Desertification Control Commission might include the following:

(a) Analysis, evaluation and dissemination of existing information on desertification;

(b) Preparation of a national plan of action to combat desertification that would co-ordinate all national activities

formulated in accordance with the modified recommendations of the plan as stated in UNEP Executive Director, Report (1991).

(c) Arrangement of the financing for the implementation of the national plan of action through national institutions;

(d) Monitoring the progress of measures to combat desertification and recommending necessary changes to the national plan of action;

(e) Participation in international and regional programmes and maintaining liaison with regional and international organizations on the problems of desertification.

6.4.6.2 <u>Functions of the Directorate for Desertification Control Co-ordination</u>

(a) To service NaDeCc as its technical and administrative arm;

(b) To co-ordinate and consolidate activities related to desertification;

specifically the following:

(i) To execute alone or in co-operation with national, regional or international bodies, desertification control projects of a multi-disciplinary nature;

(ii) To maintain an up-to-date inventory of all programmes and projects as well as present and planned activities, in order to identify the gaps related to finance or technical omissions.

(iii) To prepare preliminary surveys and studies for the formulation of programmes and projects for the implementation of the national plan following the practical steps (preventive, corrective and rehabilitation measures and the supporting measures) described in UNEP's report (opcit).

(iv) To monitor the implementation of the national plan and to prepare an evaluation of its effectiveness;

(v) To record the results of the monitoring of human conditions in areas prone to desertification including demographic and social indicators with particular reference to recommendation 9 (opcit).

(vi) To liaise with regional and international organizations (UNEP Regional Office, Desertification Control Programme Activity Centre (DC/PAC), the Global Environmental Monitoring System (GEMS), ESCWA etc.) in order to receive and update knowledge on the international situation and to contribute to the regional and international monitoring/assessment operation.

(vii) To prepare and publish a quarterly newsletter giving news and information on programmes, desertification processes and progress made in the implementation of the national plan.

6.4.6.3 Functions of the Regional Units

The functions of these regional units are essentially the execution of projects and the provision of an extension and reporting service. The stress will be more on field action detailed in the section on practical steps in UNEP Report (opcit).

6.4.6.4 Implementation of the Above Recommended Set-up

If the Government of the Sultanate of OMAN accepts the above proposals, assistance from UNEP/ESCWA/FAO could be requested in order to formulate details and provide advice on implementation, staffing and financial requirements.

CHAPTER VII

PRIORITY PROGRAMMES AND PROJECTS FOR THE SHORT-TERM 1994-1996

7.1 GENERAL

Priority programmes and projects for the short- term that cover the period 1994-1996 form part of the programmes proposed for the long-term (1994-2020). An attempt will be made to follow the same titles and sequence of presentation as in chapter V. This has the benefit of enabling those responsible for action to see how this short-term relates to the long-term (presented in chapter V). It will also facilitate additions in the future so that in each area, progress can be measured and gaps identified.

The priority projects under each of the programmes identified in Chapter V will be presented in a brief form. Only in a few cases is an elaborate description given in an appendix or in the main report if the information could be reasonably accommodated. It is not intended at this stage to present project proposals in any great detail because it is not certain that these proposals would be accepted. It will thus save time, effort and funds to work out the details at a later date, and only for those proposals which are accepted by the government.

The following priority projects are proposed, and are to be implemented, when approved by the government with due care to save the unique genetic resources presently found in certain localities in the Sultanate of Oman.

7.2 INTRODUCTION OF IMPROVED LAND USE SYSTEMS IN AREAS AFFECTED BY OR PRONE TO DESERTIFICATION (5.5.1)*.

7.2.1 Range and Forestry Management - Southern Region

Project No. 1

Duration: 3 years

Execution: National and FAO

Objectives: (1) To stop degradation of natural resources of Dhofar through better management of grazing land, (2) To improve or promote the welfare of the pastoral population of the area.

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* The information given for projects regarding duration and cost is only a rough approximation. Figures in brackets refer to the serial number of the programme mentioned in chapter V.

The immediate objectives are to:

(1) Complete the creation of a Range and Forestry Department within the Ministry of Agricultural; this is a conclusion of the ongoing work begun by project OMA/87/013;

(2) Assist the Government in devising a land-use policy for the range and forest lands of the project area. (This is an essential political decision if improvement of the rangelands is to succeed, the project will provide advice on technical aspects);

(3) Train the pastoral community in sustainable methods of range and forest use: this will be done with community participation through implementation of management and planning in pilot units;

(4) Train national staff, at all levels, in sufficient numbers for the needs of the project and the continuation of work once the project ceases.

Cost - Approximately $ 1,200,000

More information on this project will be found in Appendix 3-1.

7.2.2 **Sand Dune Stabilization and Revegetation**.

Project No. 2

Duration: 3 years

Execution: National and FAO

Objectives: (1) Implement in, critically affected and threatened areas in Wahiba Sand, a sand dune fixation, stabilization and range management programme to protect Bani bu Hassan and Bani bu Ali areas, (2) Provide training materials in sand dune stabilization. (3) Promote communities participation in sand dune stabilization and range management programme, (4) Formulate a sand dune stabilization, revegetation and range management programme.

Cost : about $ 970,000

Note: More information on this project will be found in Appendix 3-2.

7.2.3 Establishment of a Forestry and Rangeland Department

Project No. 3

Execution: National and FAO

Duration: 3 years

Objectives: Long-term

To develop administration and management of Oman's woodland and rangeland resources.

Immediate

To create an efficient forestry and rangeland department with properly trained personnel and a sound forest and range policy and forest and range legislation.

Cost: about $ 860,000

More information on this project proposal is found in Appendix 3-3.

7.3 SOUND INTEGRATED WATER RESOURCES MANAGEMENT PROGRAMME (5.5.2)

7.3.1 Aquifer Recharge Using Treated Sewage Water and Urban Drainage Water -Southern Batinah Area.

Project: No. 4

Duration: 3 years

Execution: National

Objective

Control sea water intrusion into coastal aquifers.

Priority Area:

Southern Batinah has been chosen as priority area for using the treated waste water and drainage flood water of the capital city of Muscat.

Cost: About $3,500,000.

7.3.2 Aquifer Recharge Using Treated Sewage Water and Urban Drainage Flood Water of Salalah City.

Project No. 5

Duration: 2 years.

Execution: National (MAF+MWR) and External Technical Assistance).

Objective:

Control sea water intrusion into coastal aquifers in the Salalah plains using the treated waste water and drainage flood water of Salalah city.

Cost: $ 1,500,000

7.3.3. **Groundwater Exploration, Assessment and Development in the Nejd Area.**

Project No. 6

Duration: 18 months.

Execution: National (MWR+Consultant).

Objectives:

(1) Provide irrigation water for fodder and other agricultural crops.

(2) Assess the long-term potential sustainable yield of the main aquifer (Umm Raduma) in this area.

Cost: $ 2,500,000

7.3.4. **Groundwater Exploration and Assessment in the Wahiba Sand Dunes Area.**

Project No. 7

Duration: 18 months.

Execution: National, MWR+MRME+Consultant.

Objectives:

(1) Explore and assess the groundwater potential in the alluvial deposits, and determine its hydraulic continuity with the developed groundwater in Wadi Al-Batha.

(2) Determine its exploitability for rehabilitation of the natural vegetal cover as a means for sands dune stabilization.

Cost: $ 1,500,000

7.3.5. **Well Inventory and Survey.**

Project No. 8

Duration: 18 months

Execution: National (MWR).

Objectives:

(1) Collect physical and hydrogeological data on groundwater levels, quality, extraction and water use for all groundwater wells in the different regions.

(2) Provide this information as an input to the proposed water data bank.

Phase I:

Batinah plain, Wadi Al-Batha, Salalah plain, and the coastal areas of Al Sharqiya region.

Phase II

Other areas which are less affected by aquifer over-exploitation and desertification.

Cost: $ 300,000.

7.3.6 **Assessment and Strengthening the Existing Hydrological and Hydro-Meteorological Monitoring Networks and Programmes.**

Project No. 9

Duration: 12 months;

Execution: National (MWR+MAF).

Objectives:

(1) To strengthen the existing water data-base particularly for the time-dependent information , and to keep it up-to-date.

(2) To provide the required information for the proposed technical studies, and for the planning and management process.

Priority Areas:

Start Phase I with the most important groundwater basins and surface water catchments in the Batinah, Sharqiya and the Southern regions, then proceed to Phase II in the other regions.

Note:
The Fourth five-year plan has seven projects, each of them is called "Development of the meteorological and hydrographic network" in Table a-49, Development expenditure, Ministry of Water Resources. The projects are located in different sites. As no information, other than name and cost is given in the five-year plan, it is suggested that this proposal be studied with those in the Current Plan.

Cost: $ 1,500,000

7.4 IMPROVED SOIL MANAGEMENT PROGRAMME (5.5.3)

7.4.1 Soil and Water Conservation

Project No. 10

Duration: 3 years

Execution: National and FAO

Objectives

Within the long-term development objectives of efficient use and conservation of the renewable national resources, improved incomes and human resources development in the agricultural sector the immediate objectives of the project are:

- prepare a study on the water and soil conservation in two selected areas;
- identify techniques for the water and soil conservation;
- prepare and execute a water and soil conservation programme in two pilot projects; and
- train the Omani professionals in water and soil conservation.

Cost: About $ 1,100,000

Note: More information on this project proposal will be found in Appendix 3-4.

7.5 APPROPRIATE AND IMPROVED TECHNOLOGIES PROGRAMME (5.5.4)

7.5.1 Artificial Recharge of Exploited Aquifers by Flood Water Using Low-Cost, Simple Retention Dikes and Spreading Areas Along Selected Stream Channels and Alluvial Fans in Al-Batinah plains.

Project No. 11

Duration: 2 years

Execution: National (MAF) with External Technical Assistance.

OBJECTIVES:

(1) To augment the presently exploited groundwater resources by using surplus, unused flood water.

(2) To help control sea water intrusion and improve the groundwater quality.

Cost: US$ 4,500,000

7.5.2 Artificial Recharge of Exploited Aquifers by Flood Water Using Low-cost, Simple Retention Dikes and Spreading Areas Along Selected Stream Channels and Alluvial Fans in Salalah Plains.

Project No.: 12

Duration: 2 years

Execution: National (MAF) with External Technical Assistance.

Objectives: Same as for project No. 11

Cost: US$ 1,500,000

7.6 PUBLIC PARTICIPATION PROGRAMME (5.5.5)

7.6.1 Public awareness and participation

Project No. 13

Duration: continuous - Phase I - 3 years

Execution: National with external technical assistance.

Objectives:

(1) To promote popular participation in programmes of desertification control.

(2) To increase public awareness and bring about a change in their perception of the desertification problem, causes and methods of control.

Cost: $ 250,000

Note: The above objectives are best served by preparation of documentary material for extensive use in communications mediae. (Radio and television).

7.7 SOCIO-ECONOMIC PROGRAMME (5.5.6)

7.7.1 Assistance to Farmers to Increase Productivity and Conserve Scarce Water Resource

Project No. 14

Duration: 3 years

Execution: National with external technical assistance.

Objectives:

(1) To introduce improved irrigation methods for rationalization of water consumption in agriculture production.

(2) To achieve higher productivity.

Cost: A revolving fund and $ 200,000 for administrative charges.

7.7.2 Livestock and Meat Marketing

Project No. 15

Duration: One year

Execution: National + external technical assistance.

Objectives:

(i) Enhancement of livestock off-take through the identification of livestock and meat marketing constraints and formulation of programmes and projects to address constraints identified;

(ii) Increased understanding of the local meat market situation and possibilities for increased local meat supply in relation to import.

Cost: US$ 120,000

NOTE: More information on the project will be found in Appendix 3 - 5.

7.7.3 Small Scale Milk Processing Units in the Jebel Area (A project proposal by FAO)*

Project No. 16

Duration: 2 years

Execution: FAO

Objectives:

FAO proposed this as a pilot for eventual development of larger dairy industry in the Southern Region.

Cost: $ 520,000

7.7.4 Environmental Education for the Young and the Youth

Project No. 17

Duration: Continuous; phase I : 3 years

Execution: National.

Objectives:

(1) To positively influence the perception and attitudes of the young in favour of the environment in general and desertification control in particular.

(2) To augment, for local and regional use, the preparation of material on desertification processes, Al Batinah and Al- sharqyiah. The selection of and how this relates to the food security and stability of the society.

Cost: About $ 700,000

7.8 SUPPORTING ACTIONS PROGRAMME (5.5.7)

7.8.1 Establishment of a Computerized Water Data Bank, and Data Management System.

Project No. 18

Duration: 1 year

Execution: National (MWR + MAF)

Objectives:

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* Proposed as no. 9 in FAO Report (1991), Programming/Project Identification Mission, Sultanate of Oman.

(1) Integration of water data which is being collected by various Ministries and agencies.

(2) Provide a base for a knowledgeable, and resourceful water resources management.

Cost: US$ 250,000

Note : In the Agricultural Research HQ. a proposal was put forward for setting up a data bank and network in a central place (Development Council) for all information and data in agriculture, water resources, Dhofar Governorate and its Planning Committee for Development and Environment. This proposal may be taken up with the above proposed water data bank before deciding on writing up a project document.

7.8.2 **Establishment of Institutional Set Up For Desertification Control**.

Project No. 19

Duration: 6 months

Execution: National with external technical assistance.

Objectives:

(1) To set up the secretarial and technical arm of the NaDeCC.

(2) To establish the hierarchical networks for implementing the NPACD.

Cost: US$ 250,000

7.8.3 **Regional Research Training and Communication Programme On Desertification Control in the ESCWA Region:**

Phase I

Project No. 20

Duration: Phase I : 3 years

Execution: National and regional institutions with the help of the international organizations and bodies concerned (UNEP, UNESCO, FAO, ESCWA, ACSAD, etc)

Objectives:

Cover in the short-term, exchange of information, facilitation of application of new technologies, formulation of research projects to cover gaps in knowledge and training programmes. For details on both short and long-term objectives see complete text in Appendix 3-6.

Cost:

Total cost of the project was estimated at $ 9.1 million. The contribution by all national governments was estimated at US$ 3.1 million.

Note: This, in fact is a regional programme developed jointly by UNEP,ESCWA .. etc in a meeting in Aleppo in 1984.

Since then the document was circulated by UNEP/ROWA in some ESCWA region countries. The document is reproduced in Appendix 3-6. The cost estimates are only orders of magnitude and should be up-dated.

7.8.4 Short-Term Advisory Service in Environment and Sustainable Development.

Project No. 21

Duration: A total of 18 m/m during the short-term programme

Execution: National (MRM & E) with external technical assistance.

Objectives:

(1) To provide urgently needed technical specialized advise in the review, evaluation and inter-relationships of pressing problems in environment and sustainable development.

(2) In particular, to provide required assistance while formulating NPACD projects or other projects in the National Development Plan to ensure that implementation of such projects will proceed with due care to save the unique genetic resources found in certain localities in Oman.

Cost: $ 300,000

Note: this project is based on a proposal in appendix 3-7.

7.9 ASSESSMENT OF DESERTIFICATION AND RELATED PARAMETERS PROGRAMME (5.5.8)

7.9.1 Vegetation Survey and Assessment of the Current Status of Desertification.

Project: No. 22

Duration: 3 years

Execution: national with FAO

Objectives:

(1) To identify the vegetation association or grouping composition and trend;

(2) To prepare vegetation cartography at the scale of 1/250000;

(3) To identify the potentialities of the vegetation.

(4) Undertake assessment of the current status, of desertification including.

- (a) The status of rural populations;
- (b) The state of lands and physical causes of their degradation.
- (c) The trends in local climate changes.
- (d) Social,and economic causes of under development and the resulting immediate causes and processes of desertification.

(5) Provide the government with detailed and up-to-date information related to desertification.

Cost: $2,000,000

7.10 INSURANCE AGAINST THE RISK AND THE EFFECTS OF RECURRENT DROUGHT PROGRAMME (5.5.9)

7.10.1 Insurance Against Recurrent Drought in Al-Sharqiya and the Southern Regions.

Project No. 23

Duration: 3 years

Execution: National with external technical assistance.

Objectives:

(1) To develop a combination of protective measures operating on (i) communal grazing (ii) fodder farming (iii) supplementary feed purchases and (iv) Opportunities for paid employment, to provide adequate protection and/or reserve in case of drought disaster.

(2) To develop and promote the use of modernized "Hema" system through various types of differed grazing and fodder banks.

Cost: About $ 1,500,000

7.11 REGIONAL AND INTERNATIONAL ACTION AND COOPERATION (5.5.10).

7.11.1 Preparation of National Priorities for Action and Financing.

Project No 24

Duration: 6 months

Execution: National with assistance from, UNEP, FAO and ESCWA.

Objectives:

(1) To organize a national workshop on the NPACD.

(2) To consolidate national priorities for action and formulate project files for potential donors.

Cost: $ 0.25 million.

7.12 RELEVANT PROJECTS IN THE FOURTH FIVE-YEAR DEVELOPMENT PLAN:

A survey of the text and lists of projects in the Fourth Five-Year Development Plan (1991-95) showed that there are tens of projects which would have been proposed with same or a slightly modified form, in the NPACD had they not been found included in the Development plan.

These projects are mentioned in the Development Plan by title only; no objective or any detailed description of the project activities are given. Nonetheless,a look into Table (a-17) page (294) for the MAF (Agriculture sector) would reveal some projects as relevant to the cause of land degradation and some perhaps to the issue of desertification control.

These projects are:

Serial No.	Sector Project	Location
(3)	Grazing control project	Salalah
(7)	Support for intensive livestock production	Salalah
(11)	Development of nurseries in Dhofar	Salalah
(13)	Integrated agricultural development project in Nejd	Salalah

A similar set of projects for other localities is also included in the same Plan.

In table (a-18) also for the MAF (Irrigation and Water Resources Sector) there are about 20 of the 53 total projects which deal with aspects of the water resources issue quite close to those in the NPACD. Following are a few for illustration purposes:

No.	Name
1.	Support for the modern irrigation system in Muscat Governorate.
2.	Aflaj repair and maintenance in Muscat Governorate.
5.	Support for the modern irrigation systems in Dhofar.
6.	Support and repair of the existing irrigation wells.

No.	Name
20.	Aflaj feeding wells in A'Sharqiya.
24.	Construction of recharging dam in Wadi-Hatta.
30.	Construction of recharging dam in Wadi A'hin.
45.	Preliminary and feasibility studies on proposed recharging dams.
47.	Aflaj repair and maintenance.
49.	Studying of the legal form of the utilization of water for agriculture.
50.	Monitoring and evaluation of the hydrological performance of recharging dams.
51.	Erosion control and protection of agricultural land against floods.
52.	Studying of the effectiveness of recharging water.

In Table (a-33), Ministry of Environment the following projects fall into a category of companions for those in the NPACD:

No. 5 Special study for the implementation of the National conservation strategy.

And under Ongoing projects lists;

No. 5 Central laboratory for Environmental Services.

No. 6 Study on coastal erosion.

No. 8 Environmental awareness.

In Table (a-49) for the Ministry of Water Resources seven projects,Nos 8 through 14 for Salalah are closely related to those suggested in the NPACD. It is noted that the same set of projects are suggested in the Development Plan for other locations.

If the draft NAPCD is accepted by the Government of Oman the total number of projects in its service would jump from 24 listed in this chapter to over 50 when those projects in the Development Plan are taken into consideration.

7.13 GOVERNMENT APPROVAL

When the government of Oman signifies its acceptance of the plan and decides on all or some of the projects proposed in this chapter, assistance from UNEP/ESCWA/FAO could be requested in order to formulate details and provide advice on implementation, staffing and financial requirements.

CHAPTER VIII

CONCLUDING REMARKS AND FOLLOW-UP

8.1 GENERAL

8.1.1 In this closing chapter of the document, it is intended to distill from all that was said the highly significant articles of information as well as sound but simple analysis derived from facts and supported by the wisdom of those who managed to harness sustainability in drylands environment with remarkable skills and practices. The chapter will also include, for ease of reference, important conclusions presented in their relevant positions in the preceding chapters.

8.1.2 The complete NPACD has been prepared in two parts and by two different missions. **PART ONE - THE BACKGROUND SECTION** comprising chapters 1 to IV and **PART TWO - The Plan -Programmes and Projects** comprising, also four chapters: V to VIII.

The Background Section document was finalized by March 1992 and delivered to the Government of Oman shortly after that date. It has been revised and included as Part I of this document.

8.1.3 For more relevance supplementary information on the status of desertification in Oman and on past and current efforts to combat desertification in Oman was entered in appropriate places in chapters V through chapter VIII.

8.1.4 This is the first time a NPACD appears in two parts - a Background Section and a substantive section comprising the Plan - Programmes and Projects. This arrangement would be closely examined to determine if it would be more responding to the needs of the countries in the ESCWA region or perhaps for other developing countries.

8.2 CONTENT OF THE PLAN

The draft Plan presented in chapters V,VI and VII gives the main outlines of two programmes - one for the long-term (1994-2020) and the other for the short-term (1994-1996). It also gives a fairly detailed description of institutional matters so that implementation of the NPACD proceeds without difficulties or ambiguity.

8.2.1 The project proposals are only presented in a very preliminary form. They would be elaborated only after the Government signifies its agreement with the proposals. This line of action will be taken up again later in this chapter under follow-up action.

8.2.2 The present plan looks similar in its main aspects with plans prepared for other countries. The reason being they are all prepared for dryland developing countries, mostly with an agricultural economic base but with sizeable constraints which hamper the effective use of available resources. The present Plan, however, differs from the lot in that two main and important natural resources are categorized as scarce and constitute limiting factors in the path of development; these are water and soil. Another difference is that Oman is not, like most dryland developing countries, a poor country which will find difficulty in purchasing saviour requirements when the country is hit with drought on top of desertification.

8.2.3 Another departure from previous procedure is that recommended actions and proposed programmes and projects are not related to the Recommendations of the UNCOD/PACD alone, but they are also referred to the revised Recommendations of the 1991 External Assessment of Implementation of the UNCOD/PACD.

8.2.4 The important difference, however lies in the uniqueness of Oman's environment. This is particularly observed in Dhofar Region and is best described in Seal's words in his study of "The Ecology of the Mountain Region of Dhofar" (The J. of Oman Studies Special Report No. 2) which reads:

" The brief survey of the Ecology of the mountain region of southern Dhofar enables us to begin to understand the nature of the five ecosystems represented. From information presented here and in other papers in this Special Report it is clear that the natural vegetation and animal populations present bear many distinctive characteristics that confirm the biological uniqueness of the area. In particular, the grassland and woodland ecosystems of the mountains are so unusual for the Arabian peninsula that the question of their origin is a puzzle to scientist and layman alike."

As it happens the Mountain Region in Dhofar, the wonder of this uniqueness, is also the primary site of desertification action in the Sultanate of Oman.

8.2.5 Another area, known as the Wahiba Sands has been extensively studied in the late 1980s. In the study on the Flora, Cope,(1988) commented that the flora of

the sands is not rich, but remarkably diverse. Looking beyond the sands into Arabia as a whole to see "Where the existing (diverse) flora may have had its origins, he recalled a highly significant fact, revealed in a previous study by Clayton and Cope concerning the phytogeography of the Arabian Peninsula: It sits on a phytogeographic crossroads, drawing its component flora from a wide range of distributional elements, the more interesting of which are the Afro-Oriental (Ethiopian Domain) in the mountains of Yemen and S.W. Saudi Arabia (Asir) and the Deccan-Malaysian in the mountains of Dhofar".

8.2.6 It is the importance of the above two scientific views and concern about them which motivated the inclusion of project No. 7.8.4 on advisory services in environment and sustainable Development No. 21.

8.2.7 An additional significant difference relates to: (i) the outstanding concern and involvement of the state in Oman with the environment and its protection, and (ii) the advanced stage of public awareness about environmental matters. In a way this may make environmental work easier in Oman, but it could be more demanding and expensive.

8.3 PROBLEMS AND PRIORITIES

8.3.1 The nationals as well as the government are aware of the nature of the causes of desertification and of land degradation in its broad sense. These are in brief:

(i) In Dhofar mountain overstocking leading, in the absence of effective measures, to over-grazing and serious degradation. This was further aggravated by extensive off-road vehicle tracks.

(ii) In Al Shargiyah and Batinah Regions it is irrational use of irrigation and over pumping which led to the salinization of water and soil.

8.3.2 Scanning the volume of meeting discussions and written reports it seems there is a general consensus that efforts should be directed towards:

(i) Rangeland management projects in Dhofar;

(ii) Fighting salinity in Batina; and

(iii) Fodder production in Nejd.

8.3.3 Some work has been done in connection with each of the above priority areas. This has been mentioned in the text of the report and programmes and projects in the plan have been proposed with this in mind. The work on deferred grazing (Alshanfari, et.al 1992) and destocking efforts, were steps in the right direction. Several efforts - administrative, legistrative and social in the use and management of irrigation water could on the whole be considered steps in the right direction. A sort of loose package of projects have been suggested in the priority programme (1994-96) in chapter VII.

8.3.4 Regarding fodder production in the Nejd, the experience and work in Marwul Farm is a rich record and provides guidance for future development. A decision to move the large fodder farm from Salalah plain to Nejd is a positive step and will open the way for a massive development movement in Nejd.

8.4 FOLLOW-UP

8.4.1 The follow-up action required is primarily the responsibility of the Government of Oman. However, a start is necessary on the part of the United Nations. This will begin with the delivery of this report to the Government, and of the expression of the keen interest of both UNEP and ESCWA and indeed, of other member organizations and bodies of the United Nations that are willing to assist the Sultanate of Oman in its endeavour to control desertification.

8.4.2 The Government of Oman particularly the concerned section in the Ministry of Regional Municipalities and Environment are expected to take subsequent steps to secure whatever assistance is required from the United Nations. In this respect, four steps seem to be essential.

(1) The proposed Division of Soil Pollution and Desertification (DSP&D) in the General Directorate for Environmental Affairs appears to be the most suited to assume responsibility for the follow-up. It should start to look after desertification matters, as was suggested in chapter VI and VII.

(2) The DSP&D should pursue the matter to secure the approval of the Government for the draft plan..

(3) The DSP&D should pursue the establishment of the institutional machinery.

(4) The DSP&D staff recruited for the desertification control machinery can embark immediately on the identification of project proposals and selected areas where UNEP/ESCWA/FAO assistance is required, in order to address them accordingly.

8.4.3 Having reached this stage, the matter is once again in the hands of the United Nations. No doubt quick responses can be expected from these organizations, and in the last analysis it will be the quality of the product of their missions that determines the success or failure of all these efforts to contain desertification.

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APPENDIX 1

LIST OF PERSONS MET BY THE UNEP/ESCWA/FAO MISSION IN THE SULTANATE OF OMAN, 7 -26 SEPTEMBER 1992.

[I] Introductory meeting in the Ministry of Regional Municipalities and Environment (MRME). 7/9/1992

1. Mr. Nageeb Bin Ali Ahmed Al Rawas, Director of Environmental Planning and Permits (Chairman of the meeting).

2. Mr. Ali Bin Saeed Bin Salim Ali El Baloushi, Demonstrator, Geography Department, Faculty of Arts - University of Sultan Qaboos.

3. Mr. Salim Bin Abdulla El Gofeili , Acting Head of Ocean Pollution.

4. Mr. Aziz Bin Ali Al Rashdi, Head Division of Air and Noise pollution.

5. Mr. Abdel Mahdi Bin Ali Bin Mohammed Al Agami, Head of Regional Organizations for Protection of Marine Environment.

6. Mr. Ibrahim Bin, Saleh Bin, Ali Al Migaini, Chemist - Laboratories Directorate,(MRME).

7. Mr. Tahir Bin Abdel Rahman Bin Omer BaOmer, Lecturer, Department of Biology University of Sultan Qaboos.

8. Mr. Lutfi Abdel Gadir Dosougi, Expert, Nature Protectorates.

9. Saeed Bin Ahmed Al Mogaddam, Head Follow-Up and Execution of National Conservation Strategy.

10. Mr. Hamdan Bin Nasir El Husni, Acting Head, Division of Environmental Impact Assessment.

11. Mr. Hilal Bin Mohamed Al Nabahani, Acting Head, Administration of Coastal Regions.

12. Mr. Ali Bin A'mir Al Kaiyumi, Director, National Conservation Strategy Directorate.

[2]. **Meeting in the UNDP** - 7/9/1992

13. Mr. Saleem Kassum, UNDP Resident Coordinator.

14. Mr. Aeneas C. Chuma, Assistant Resident Representative.

[3]. **Visit to the Laboratories of the MRME** - 8/9/1992

Mr. Ibrahim Bin Saleh Bin Ali Al Migaini, Chemist (see No.6).

[4]. **Meeting with the National Conservation Strategy Section** - 8/9/1992

- Mr. Ali Bin A'mer Al Kaiymi, (mentioned as No. 12 above).

15. Mr. Ali El Tom, Consultant on National Conservation Strategy, MRME.

- Mr. Saeed Al Mogaddam, (See No. 9).

[5]. **Meeting on Organization of the Mission Programme** - 8/9/1992

16. Mousa Bin Gaafar AL Mousawi, Acting Director of International Organizations Affairs - MRME .

- Mr. Hilal M. Al Nabahani, (See No. 11)

17. Mr. Paul Munton, Expert - Nature Protectorates.

[6]. **Meeting in the Ministry of Housing** - 12/9/1992

18. Mr.Ali Mohamed El Mazrooi, Deputy Director General of Town Planning and Survey and Director of Technical Affairs.

[7]. **Meeting in the Ministry of Water Resources (MWR)** - 12/9/1992

19. Mr. Barghash Bin Ghalib Al Said, Director General.

20. Mr. Steve S. Lixton, Water Management.

21. Mr. Wayne C. Curry, Surface Water Department.

22. Mr. Harley Young, Water Resources Assessment.

23. Mr. Bryan L. Eccleston, Director of Ground Water Assessment

24. Mr. Geoff Wright, Asst. Deputy Director General, Directorate General of Regional Affairs.

25. Mr. Mohamed Al Kalbani, Water Management.

26. Mr. Philip Johson, Deputy Director General, Water Resources Assessment.

[8]. **Meeting in the Ministry of Agricultural and Fisheries (MAF)** - 13/9/1992

27. Mr. Ahnaf Bin Omar Al Zubeiri, Advisor to the Minister on Agricultural Affairs.

28. Mr. Assudalah Ahmed Taki, Director, Soil and Water Research Department.

29. Mr. Yaslam Tahir Hanash Alyafi, Directorate General of Planning.

[9]. **Meeting in the Development Council, General Secretariat** - 13/9/1992

30. Mr. A. Mahdi Abdel Bagi, Director General,Production, Planning Section.

31. Mr. Abdel Rahman Ibrahim Alabry.

32. Mr. Salim Bin Hamed Al Tangi.

33. Mr. Issa Ibrahim.

34. Mr. Mahdi Al-Abduwani.

[10]. **University of Qaboos** - 14/9/1992

35. The Dean, Faculty of Agriculture.

- Dr. Tahir Ali BaOmar, Department of Biology. (mentioned above).

36. Prof. C. Kent Brooks, Head Department of Earth Sciences.

37. Dr. Haydar Abdel Rahman, Land and Water Department.

38. Dr. Peter Cookson, Land and Water Department.

39. Dr. Tahir Alawi, Land and Water Department.

40. Dr. Salim Al Rawahi, Land and Water Department.

[11]. **Wilayat ALWAFI (MWR)** - 15/9/1992

41. Mr. Awad Thoweini Alburaimi, Director.

42. Mr. Mohamed Isam Eldin Saleh, Hydrogeology expert.

43. Saeed Al Saadi, Hydrogeology expert.

44. Ibrahim Abdalla Babiker, Hydrogeology, Civil Engineer.

[12]. **Quibit** - 16/9/1992

45. Sheikh Mossalem Bin Saeed Gaddad, Wali Magshan.

46. Mr. Ahmed Muhsin Ghalib, Director in the Office of the Governor of Dhofar.

[13]. **Desert Agricultural Project; Petroleum Development Oman** - 16/9/1992

47. Mr. M. Matin, Farm Superintendent.

48. Mr. M. Santon, Soil and Water Specialist.

49. Farm Agronomist.

Southern Region

[14]. **Directorate General of Agriculture, Animal Wealth & Fisheries** - 19/9/1992

50. Mr. Salih M. Al Shanfari, Director General.

51. Mr. Mohamed Bin Mahfuz Al Sheikh, Deputy Director General.

52. Mr. Abdel Haleem Hamid Mohamed, Expert, Agricultural economics.

53. Mr. Masoud Bin Salem A. Al-Kuthairi, Director Rangeland & Forestry.

[15]. **Department of Animal Wealth** - 20/9/1992

54. Mr. Haffeed Ahmed Abdalla Atheeb, Director.

[16]. **Livestock Research Station** - 20/9/1992

55. Mr. Abdul Hameed Ahmed Al Ghassani.

56. Mr. Ahmed A. Qadir Al Faqer Al Ojaili.

[17]. **Department of Range & Forestry** - 20/9/1992

57. Mr. Ahmed Hassan Kashool,

58. Mr. Ahmed Mohamed Al Kuthairi,

59. Mr. Faraj Ali Hardan,

60. Mr. El Hag B. Ahmed, FAO Team Leader.

61. Mr. Salah Eldin Ageeli, UN. Volunteer.

[18]. **Directorate General for Environment- Salalah Southern Region** - 19/9/1992

62. Mr. Salem F. Abdoun, Director General.

63. Mr. Fayez M. Bataineh, Senior Inspector, Water and Waste Pollution.

64. Mr.Omar A. Shanfari, Asst. Director, Administration and Finance.

65. Mr. Ahmed A. Mahroos, Environmental Coordinator.

[19]. **Planning Committee for Development and Environment in the Government of Dhofar** - 19/9/1992

66. - H.E. Mohamed Bin Farag Al Ghassani, Secretary General.

67. - Mr. Azzan Bin Ahmed Al Shanfari, Technical Coordinator.

68. - Mr. Nicholas Clarke, Ecologist.

69. - Ahmed Abu Baker Salim Al Ghassani, Head of Planning and Technical Services Section.

[20]. **Rumais Agricultural Research Station** - 21/9/1992

70. Mr. Tarig AlDzaggali, Director General.

[21]. **Diwan of Royal Court** - 22/9/1992

71. Mr. Ralph H. Dailly, W.O; O.B. E., Advisor for Conservation of the Environment.

[22]. **Ministry of Regional Municipalities and Environment, Department of Awareness and Guidance Activities for School Students** - 22/9/1992

72. A staff member provided a list of activities for school students and of organizations engaged in environmental protection.

[23]. **Round-up meeting of UNEP/ESCWA/FAO Mission with Government Representatives.** - 23/9/1992

- Mr. Saleem Kassum, UNDP, Resident Coordinator.

- Mr. Gaafar Karrar, UNEP/ESCWA Consultant & Mission Leader.

- Mr. Nour Eddin Gaddes, FAO/RNEA-Mission Member.

- Mr. Omar M. Joudeh, UN/ESCWA-Mission Member.

- Mr. Saeed Al Mogaddam, MRME.

- Mr. Hilal Al Nabhani, MRME.

- Mr. Assadalla Taki, MAF.

- Mr. Abdel Rahman Bin Ibrahim El Abry, The General Secretriat, for Development Council.

- Mr. Azzan Bin Hamed El Shanfari, Technical Coordinator, The Planning Committee for Development and Environmental in Dhofar.

- Mr. Tahir Bin Abdel Rahman BaOmar, Lecturer-University of Sultan Qaboos.

- Mr. Abdel Mahdi Bin Ali Bin Mohamed Alagami, Ministry of Municipalities and Environment

- Ali Bin Amer Al Kaiyumi, Director, Directorate NCS.

[24]. **The Office of the Under Secretary for Environmental Affairs.**

73. H.E. Sheikh Sultan Bin Rashid Al Malik Al-Shihy, Under Secretary for Environmental Affairs.

74. Mr. Ahmed Bin Ali Bin Saleh Al Sheryani, Director General of Environmental Affairs.

Persons Met For Obtaining Technical Information

[25]. **Administration of Water Resources Salalah**

75. Salim Omer Ahmed El Shanfari, Director General,Water Resources Salalah.

76. Salim Ahmed Salim, Geologist

77. Salih Salim, Engineer.

[26]. **The Ministry of Agricultural and Fisheries. The General Directorate for Agriculture and Animal Wealth, Salalah.**

78. Mr. Salim Bin Sallam Salim Al Ma'Wali, Head of Dams follow-up section.

79. Dr. Mohamed Sameer Fareed,

[27] **Ministry of Agriculture and Fisheries, Directorate of irrigation**

80. Imad abdel Majid Abdull Bagi, Director of Irrigation Department.

81. Ali Mohamed Habib Al Riami, Director of AFHAJ and wells maintenance.

82. Dr. Hassan Wahbi, Irrigation Expert.

83. Dr. Naime Abdel Rahman, Advisor on Dams.

84. Issa Abdulla Suleiman, Irrigation Department.

85. Dr. Ali Afifi, Advisor on Dam Construction.

86. Hilal Malik Mohamed Al Batashi, S.Tech. Dam D.P.T Monitoring.

- Omani Experts who accompanied the UNEP/ESCWA FAO Mission.

  Mr. Hillal M. Al Nabahani - General Directorate of Environmental Affairs.

  Mr. Ali , Al - Balouchi Sultan Qaboos University - Geography Department.

With the addition, during Al Sharqiyah and the Dhofar Governorate visits, of the following:

Engineer Mohamed Isam El Din Saleh - Hydrogeologist Ministry of Water Resources.

Mr. Masood Bin Salem A Alkuthairi - Director, Range Department and,

Mr. ElHag B. Ahmed - Team Leader, Rangeland management FAO Project OMA/87/013.