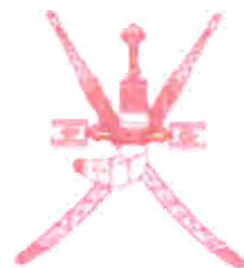




**NATIONAL ACTION PROGRAMME
(NAP)
TO COMBAT DESERTIFICATION
IN THE SULTANATE OF OMAN**

December 2005

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National Action Programme to Combat Desertification in the Sultanate of Oman

prepared by

Ministry of Regional Municipalities, Environment, and
Water Resources

in Collaboration with

United Nation Environment Program / Regional Office of
West Asia (UNEP/ROWA)

and

National Committee to Follow up the Implementation of
United Nation Convention to Combat Desertification
(UNCCD)

and revised by

Department of National Conservation Strategy
Directorate General of Environmental Affairs

December 2005

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ABBREVIATIONS

ALESCO	Arab League Educational, Cultural and scientific Organization.
AOAD	Arab Organization for Agricultural Development.
CAMRE	Council of Arab Ministries Responsible for the Environment.
DC/PAC	Desertification Control Programme Activity Center.
DSP&D	Division of Soil Pollution and Desertification.
ESCWA	Economic and Social Commission for Western Asia
FAO	Food and Agriculture Organization of the United Nations.
GCC	Gulf Co-operation Council.
GEMS	Global Environment Monitoring System.
Ha	Hectare
MRMEWR	Ministry of Regional Municipalities, Environment , and Water Resources
MAF	Ministry of Agriculture and Fisheries.
MRM&E	Ministry of Water Resources.
MWR	Ministry of Water Resources.
NaDeCC	National Desertification Control Commission.
NAP	National Action Programme to combat Desertification.
NCS	National Conservation Strategy.
NCPP	National Community Development Programme.
NGO	Non-Governmental Organization.
NPACD	National Plan of Action to Combat Desertification.
PACD	Plan of Action to Combat Desertification.
RO	Omani Riyal.
UN	United Nations
UNCCD	United Nation Convention to Combat Desertification
UNCED	United Nations Conference on Environment and Development.
UNCOD	United Nations Conference on Desertification.
UNDP	United Nations Development Programme.
UNEP	United Nations Environment Programme.
UNEP/ROWA	Regional office for West Asia.
UNSO	United Nations Sudano – Sahelian Office.
MMDI	MOH Moccdonalds International

EXECUTIVE SUMMARY

This document “The National Action Programme to Combat Desertification” (NAP) in the Sultanate of Oman is the result of a joint effort by the United Nations Environment Programme- Regional Office for West Asia (UNEP/ROWA) and the government of Oman (Ministry of Regional Municipalities, Environment and Water Resources). First, the Natural Resources Programme Officer visited the Sultanate in 2002 and 2003, when he discussed and reviewed the parts and sections of the National Plan of Action to Combat Desertification” (NPACD), which was prepared in 1993. In February 2004 the Natural Resources Programme Officer and Consultant prepared the first draft of The National Action Programme to Combat Desertification.

PART ONE : The Background Section consists of four chapters :

Chapter I: Inventory and Potential of Natural Resources, presents data and information on Location and Area, Administrative Governorates and Regions, Topography and Physiography, Climate, Geology, Land resources, Water resources, natural vegetation, Oils, Gas and Minerals. The overall picture is that of aridity with pronounced scarcity of water and non productive soil.

Chapter II: Presents the Socio-Economics Setting under three sub-headings: economics development, social setting and agricultural potentialities. The Sultanate with its moderately thin population about 2,331,391 has a GDP estimated at 7,809.1million RO (at current prices) in 2003. Nearly 41.7 % of this figure came from Oil and Gas revenue. The Sultanate agricultural potential is limited; of a total land area of 30.95 million ha there are about 72,820 ha were under cultivation in 2002.

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 of 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 NAP – Programmes and Projects

Comprise also four chapters . They are numbered chapter V through Chapter VIII. This Part which follows the Background Section deals with the substantive part of the NAP: its strategy, content and the institutional capabilities for implementation.

Chapter V: National Action Programme to Combat Desertification presents the programme 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 (2005-2020);
5. Elements of the strategy.
6. Remarks.

The proposed long-term strategy sets a horizon for 2005-2020 and suggests eleven programmes. Within this long-term horizon, , a short-term horizon is set for 2005-2010. During this period the NAP ,priority programmes and projects will be approved and implemented. Thirty three priority projects are proposed.

Considering the size of the proposed programmes and the priority in the NAP, their implementation and proper coordination requires creation of a competent institutional set up. This has been dealt with in Chapter VI. Chapter VII presents the priority projects in a brief from and mentions over projects from the sixth Five year plan which have a direct effect on desertification control. The presentation in Chapter V and VII recalls the proposals and information included in the draft "National Plan of Action to Combat Desertification" (NPACD) and the National Conservation Strategy (NCS) of Omani Environment and highlights those which have a direct influence on combating desertification or minimizing its risk.

It is worth noting that the programmes and projects in the NAP are reflecting the Sultanate of Oman commitment on implementation of UNCCD at the national level. This is important for the national committee on combating desertification to monitor and follow-up as well as for logical development and expansion of the work in desertification control in the Sultanate .

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 conclusion. It tells how similar or different this Plan is from those formulated for other dry land 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 environment and sustainable development .

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

The UNEP/ROWA missions in 2002 and 2003 discussed its findings on preparation of NAP and general recommendations with the government representatives (member of the national committee on combating desertification) in a roundup meetings attended also by the Under Secretary for Environmental Affair in the Ministry of Regional Municipalities, Environment and Water resources. Details were discussed, but the government representatives emphasized the need to refer to several projects in NAP including the activities and projects recommended by the workshop on combating desertification in Dhofar region ,which was

held in Sallalah 25-27 March,2002 . With this note there was general agreement on the main findings and the principal recommendations.

Preparation of this NAP is the start of a colossal task and a lot depends on active follow-up. The responsibility is follow-up section in Chapter VIII described four essential steps. The prime step of these four is the responsibility of the Ministry of Regional Municipalities, Environment and Water resources and the national committee on combating desertification 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 in its territory.

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 neighbors 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 H. M. 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:

- The high degree of state concern with the environment and its protection; and
- The advanced level of environmental awareness among the population.

It is, therefore, no wonder that Oman is one of the very few countries in the region which is about to complete possession of Strategy and National Action Programme to combat Desertification (NAP).

The coming up of this document of NAP is the result of cooperative efforts of UNEP/ROWA and the Ministry of Regional Municipalities, Environment and Water Resources. UNEP/ROWA is involved in a chain of joint activities with West Asia member countries to assist individual countries, on request, to prepare their National Action Programme (NAP).

In this case the job was done in two stages. First, the Natural Resources Programme Officer visited the Sultanate in 2002 and 2003, he discussed and reviewed the parts and sections of the National Plan of Action to Combat Desertification” (NPACD) ,which prepared in 1993. In February 2004 the Natural Resources Programme Officer and consultant prepared the first draft of The National Action Programme to Combat Desertification (NAP).

2. Contents of the National Action Programme

2.1 PART ONE: The Background Section

This part comprises four chapters. Chapter I – Inventory and Potential of Natural Resources of Oman is a rich chapter which deals with seven sub-titles including: Location and Area, Administrative Governorates and Regions, Topography and Physiography, Climate, Geology, Land resources, Water resources, natural vegetation, and Oils ,Gas and Minerals. Chapter II – deals with the socio-economic setting while Chapter III representing the status of Desertification. Chapter IV- review past and current efforts to Combat Desertification in Oman.

2.2 PART TWO: The NAP – Programmes and Projects

This Part also comprises four chapters (numbered V to VIII). Part two 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 NAP in six sub-Headings: (1) The magnitude of the desertification problem ; (2) National contribution towards the preparation of the NAP ; (3) National goals ; (4) A long-term strategy ; (5) Elements of the strategy ; (6) Remarks.

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

Chapter VII covers priority programmes and projects for the short-term, 2005-2010. Some 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

3. Similarities and Differences

UNEP/ROWA, is cooperating in a programme through which they offer assistance, on request, to West Asia countries for preparation of NAP. UNEP/ROWA completed about four and may go for a similar in future. The present NAP is similar in many respects to the NAP, prepared over the last five years, in its presentation, main divisions of the content and approach. It differs, however, in that it is perhaps the first time a NAP is set according to UNCCD : A Background Section and the programmes. Apart from other respects mentioned in the text, this NAP 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.

PART ONE

Background Section

CHAPTER I

INVENTORY AND POTENTIAL OF NATURAL RESOURCES OF OMAN

1.1 Location and Area

The Sultanate of Oman occupies the South-Eastern corner of the Arabian Peninsula and is located between Latitudes 16°40' and 26°20' North and Longitudes 51°50' and 59°40' East. It has a coastal line extending almost 3,165 km., from the Strait of Hormuz in the North to the borders of the Republic of Yemen, overlooking three seas; the Arabian Gulf, Gulf of Oman and the Arabian Sea , Figure (1.1).

The Sultanate of Oman borders Kingdom of Saudi Arabia and the United Arab Emirates in the West; the Republic of Yemen in the South; the Strait of Hormuz in the North and the Arabian Sea in the East.

The total area of the Sultanate of Oman is 309,500 Km²., and it is the third largest country in the Arabian Peninsula.

1.2 Administrative Governorates and Regions:

The Sultanate is divided into eight main Administrative regions. These are :

1.2.1. Muscat Governorate:

This is the central administrative area of the Sultanate and hence it is entrusted with the preparation and formulation of projects, programmes and plans aiming at realizing progress and prosperity for the whole population and in all regions of the country. It is characterized by high population density. Administratively, it comprises the Muscat Governorate and wilayat of Qurayyat. The Main Towns are :

1) Muscat

This is the capital of the country where Al-Alaam Palace is located and a few of the Government Offices. It is an old city and enjoys a strategic location. Muscat is full of historical monuments. The most famous are: Al-Jalali and Al-Mirani Forts.

2) Mutrah

A historical and busy trade center, and includes Mina Sultan Qaboos, the main commercial port in the Sultanate.

3) Bawshar

This is a new town where various Government Offices and other organizations are located. It has the largest sports complex and the Royal Hospital, the biggest hospital in the Sultanate.

4) As Seeb

As Seeb is an ancient town with a number of farms and is a summer resort. As Seeb International Airport is located here

1.2.2. Al Batinah Region :

Al Batinah region is divided into two main areas.

1. The coastal plain occupies the frontier with the United Arab Emirates for a distance of 270 kilometres South East of Muscat Governorate. It is situated between the coast and the Al Hajar Al Gharby mountain range.

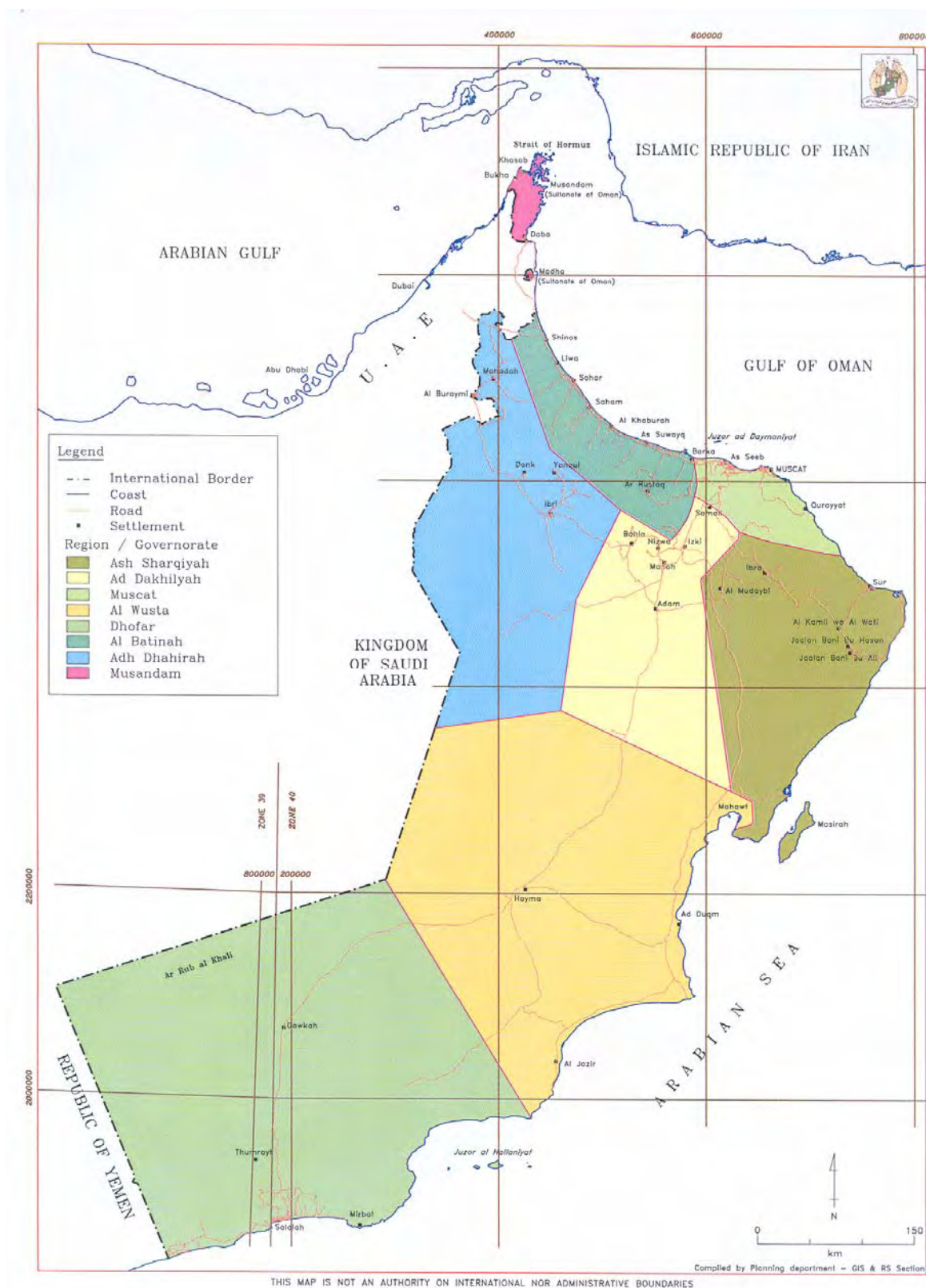


Figure 1.1 Map of Sultanate of Oman (Regions and Governorates).

2. The Al Hajar Al Gharby mountain range runs parallel to the coast from the United Arab Emirates in the North to the Wadi Al Maawil in the South. The highest peaks, up to 3075 meters, lie to the South East at Jabal Al Akhdar. The principal activities of the population in the area are agriculture and fisheries and is one of the most densely populated areas of the Sultanate.

The Main Towns are :

1) Sohar

Sohar is a well developed town with activities such as construction, industry, trade and agriculture. It is also famous for copper mining. Al-Shamma Fort represents one of its famous historical inheritance.

2) Ar Rustaq

Ar Rustaq is surrounded by Al Hajar Al Gharby mountain range from three directions and is at a distance of around 160 kms. from Muscat. It is famous for its historical buildings such as Al Hazm and Ar Rustaq Castles, besides Ain Al-Kasfa with its hot mineral springs and dates processing factory.

1.2.3. Musandam Governorate:

This area is located in the northern most part of the Sultanate and is separated from the rest of Oman by part of the United Arab Emirates. It has rough mountains reaching a height of 1800 meters above sea level and which jut into the Straits of Hormuz.

The Main Towns are :

1) Khasab

This is the regional center of the area and consists of three wilayats lying at the coast except Madha. It is famous for its forts, the most important of which are Khasab Fort and Castle.

2) Bukha

The most prominent features of this town are the port and the fishing Harbour. Its coasts are famous for their black turtles and coral reefs.

1.2.4. Adh Dhahirah Region :

This region is a semi-desert plain sloping from the Southern wings of Al Hajr Al Gharby in the direction of Ar Rub Al-Khali. It is bordered by the United Arab Emirates in the North and separated by Jebel Al-Koor in the South. Wadi dank and Wadi Al-Ayn are the two main Valleys with high density of population. The Main Towns are :

1) Ibri

A historical city embracing a number of Castles, Forts and Towers and is famous for its various falajs and farms. It lies approximately 350 kms. from Muscat.

2) Al Buraymi

Al Buraymi is located on the borders with the United Arab Emirates, with its two notable historical buildings, Al Buraymi Fort and Al-Khandaq Palace. It is also famous for its agricultural wealth including dates, lime and mangoes, etc.

1.2.5. Ad Dakhliyah Region :

This is a central plateau running from Jabal Al Akhdar in the north towards the desert in the South. It is bordered on the West by Adh Dhahirah and on the east by Ash Sharqiyah. There are four main Valleys; Andam, Halfein, Bahla and Samail. Samail and Al-Halfein together

form a natural gap in the Al-Hajar mountain range, providing a traditional route between Muscat and the Ad Dakhliyah Region. The Main Towns are :

1) Nizwa

Nizwa lies in the center of the Ad Dakhliyah Region, at a distance of 180 kms. from Muscat. It is famous for its historical features, the most important of which are the Nizwa Fort and the Daris Falaj, one of the largest Falaj in Oman. The Falaj provides irrigation facilities for cultivation of dates, lime, mango, sugarcane and others.

2) Bahla

Bahla is an old historical town at a distance of 210 kms. from Muscat and is famous for its walls, castles and the Jabrin Fort in addition to its reputation for handicraft industries such as pottery.

3) Samail

This lies around half way between Muscat and Nizwa i.e. 85 kms. from Muscat and 75 kms. from Nizwa. It is very famous for its date farms and handloom cottage industries.

1.2.6. Ash Sharqiyah Region

This can be divided into two areas.

1) The sandy plain penetrated by Wadis and located at the inner part of the Eastern Hajar mountain range. It is bordered by the Arabian Sea to the South East and by Wahiba sand to the South.

2) The Eastern Al Hajar mountain range is the continuation of the main mountains of Oman from Samail gap to Jebel Khamis in the East at a distance of 200 kms. and is extending up to the coast in the North. The highest elevation is 2100m. The main island is Masirah Islands.

The Main Towns are :

1) Sur

This is an ancient town famous for its ship building, and is well known in the Indian Ocean since centuries. The people of this town are sailors and some of them are engaged in handicraft industries (Boat Building) and agriculture. It has a number of Aflaj and Forts.

2) Ibra

Ibra is considered as the center of the area and is famous for agriculture and trade activities It is an ancient city with a number of forts and old mosques and lies around 180 km from Muscat.

1.2.7 Al Wusta Region

It is characterized by its abundant oil and fisheries resources, which constitute the major export commodities of the Sultanate. Fishing and animal husbandry are the main occupation of its population. The region is also characterized by its unique and special environment, in particular The Arabian Oryx sanctuary with a total area of 34 thousand sq. Km. and which was registered in the International heritage registry. The Main Towns are :

1) Hayma

A Commercial center which is located on the highway connecting Muscat with Salalah.

2) Wadi Say - Ad Duqm

It is coastal town. Most of its population depend on fisheries for living.

3) Haj - Muhut

It is the most populous town in the region, and famous for fisheries.

1.2.8. Dhofar Governorate :

This area occupies nearly one third of the Sultanate's total area and is one of the very few areas in the Arabian Peninsula with a wide range of topographic variations. It includes many historical monuments and cities such as Sumharam Port and the graves of Prophet Ayoub and Hood. Its people are engaged in agriculture activities and fishing. The Main Towns are :

1) Salalah

Salalah is located at the Arabian Sea coast, where a large number of farms especially with coconut trees are found. It has a central administrative office with Directorates and Departments of all the ministries in Muscat in addition to Salalah Civil Airport.

2) Taqah

Taqah is also located on the coast, East of Salalah, at a distance of 45 kms. and is an old historical city.

3) Raysut

This lies in the West of Salalah with Mina Salalah the second largest port in the Sultanate occupying a prominent location. Most of the population is engaged in agriculture and fishing and Raysut is famous for its dried sardines.

1.3 Topography and Physiography

The Sultanate is composed of varying topographic areas consisting of plains, wadis and mountains. The most important area is the plain overlooking the Gulf of Oman and the Arabian Sea with an area of about 3% of the total. The mountain ranges occupy about 15% of the total, the most important of which are 'Al Hajr', extending in the form of an arch from Ras Musandam in the North to Ras Al-Had and Al Qara' in the South Western corner of Oman. The remaining area is mainly sand and desert which includes part of Ar Rub Al-Khali occupying about 82% of the total area.

Oman is divided into eleven physiographical regions (Fig. 1.2). These are:

1.3.1 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 (Hallniyat). These mountains are mostly steep and barren formations of igneous and sedimentary rocks.

The Hajar mountain range stretches northwest-southwest, along the Gulf of Oman, over about 700 km from 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 intercept moist air masses, hence receiving relatively higher precipitation than surrounding areas. A dense network 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.

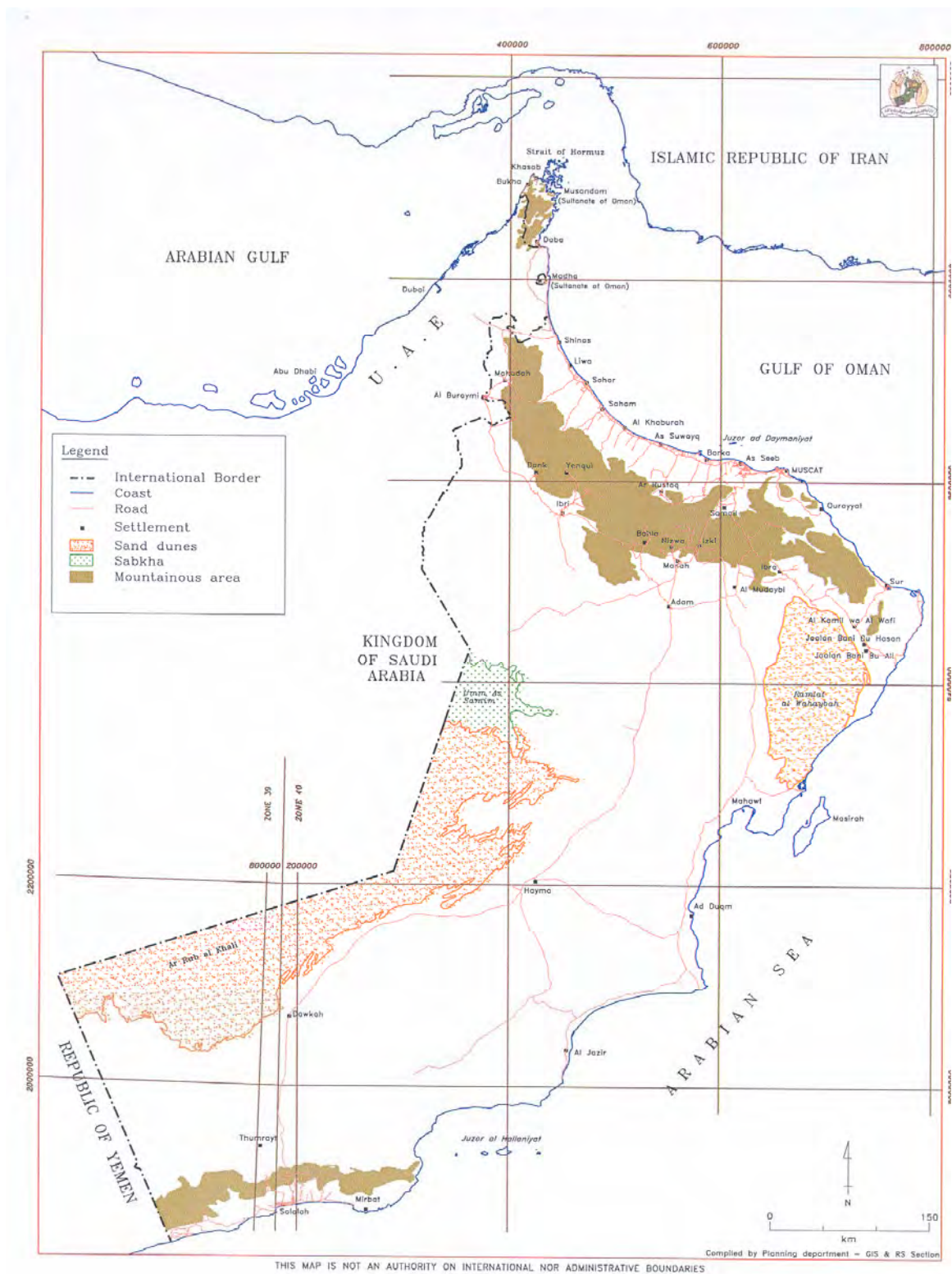


Figure 1.2. Physio-geographical Regions of the Sultanate of Oman

1.3.2 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 Rakhyout 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 rangelands. 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.

1.3.3 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.

1.3.4 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 bajdas formed by the accumulation of three generations of alluvial fans and terraces. The Sawqirah plain differs somewhat from the other accumulation 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 exist. 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 provide 33 % of total water used for irrigation where wells contribute for 59 % of this water (National Well Inventory Project, 1996, and National Aflaj Inventory Project, 1999). The wells are expanding very quickly in and around the oases.

1.3.5 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 grown in this area.

1.3.6 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 plain 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.

1.3.7 Sabkha-dunes-rock Outcrop Complex

This landscape occurs extensively in Al Hugf 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.

1.3.8 The Eastern Pediplain

It is a nearly level 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.

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

1.3.9 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.

1.3.10 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 too saline for conservation and cultivation.

1.3.11 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.

1.4 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 regions, the up-welling of cold coastal water and the cyclones.

The location of the twenty four main weather stations in Oman are presented in Fig. 1.3 .

1.4.1 Air Temperature

According to the available sources of information , the annual mean temperature ranges between 17.8°C and 28.9°C . 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°C and 21.6°C respectively. Salalah and Thumrait also have slightly lower mean temperatures than the national average which is 26.3°C because they are effected by the southwesterly monsoon winds reduce the temperature of the southern region during summer. In other areas mean annual temperatures range from 26.3°C to 28.9°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°C in Saiq to 46.1°C in Fahud. The coldest month all over the country is January, with monthly mean minimum temperatures ranging from 9.4°C in Saiq to 24. °C in Mina Raysut.

In the last 20 years , the mean maximum temperatures for the country range from 33 to 50°C, and the mean minimum temperature range from -4 to 16 °C . Temperatures below zero are only recorded in Saiq where they occur every year (recorded minimum temperature of -4°C). The annual mean maximum and mean minimum temperatures recorded in the eight meteorological stations are shown in Tables 1.1 (1980 –2002) . Fig. 1.4 shows Average maximum and minimum temperatures at several Meteorological stations (for the year of 2002).

1.4.2 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 350 mm (MRMEWR, 2000). 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 . The average annual rainfall is about 6470 Mm³ (Master Plan, 2000). The maximum annual rainfall in 1997 was recorded as (900.9 mm) in Saiq, Ad Dakhliyah, whereas the minimum annual rainfall in 1997 was recorded as (0mm) in Masahe, Dhofar.

Table 1.1: Annual Extreme Max and Min Temp (°C) – 1980 - 2003 by Meteorological Stations

Station	Muscat		Salalah		Sohar		Masirah		Sur		Thumrayt		Khasab		Saiq		Al-Buraimi	
	Temperature (°C)																	
	Max.	Min	Max.	Min	Max.	Min	Max.	Min	Max.	Min	Max.	Min	Max.	Min	Max.	Min	Max.	Min
1980	46	14	38	15	47	7	40	14	47	13	45	16	47	12	34	-2	48	6
1981	47	14	38	15	49	8	43	15	47	15	44	6	48	12	34	-1	48	6
1982	45	14	36	15	45	7	45	15	46	16	45	6	45	10	33	-3	49	5
1983	47	14	36	11	47	6	43	12	47	14	45	2	49	10	35	-4	49	6
1984	46	13	36	14	45	7	41	13	46	13	44	5	47	8	33	-2	48	6
1985	47	15	38	15	44	7	43	15	47	14	44	7	45	10	34	-1	47	-
1986	47	14	37	14	47	8	43	13	47	14	44	4	44	12	34	-1	48	8
1987	47	13	44	14	50	9	42	15	47	13	45	7	45	14	33	-1	50	7
1988	47	15	40	15	48	8	45	12	48	13	44	4	44	11	34	-1	49	6
1989	47	13	38	13	46	8	42	12	47	11	43	2	45	12	33	-3	49	4
1990	49	15	42	15	48	11	41	14	48	14	46	7	46	14	35	-2	51	6
1991	47	10	41	16	47	7	40	15	49	11	45	7	43	14	36	-1	49	4
1992	48	13	35	14	46	8	45	12	47	14	44	4	44	11	33	-2	46	3
1993	47	13	43	15	47	6	42	12	50	13	44	4	46	12	34	-4	-	-
1994	49	14	45	15	45	9	44	14	48	14	45	7	46	13	35	-2	-	-
1995	47	12	38	16	43	10	44	16	48	14	44	9	45	16	36	0.3	48	8
1996	48	11	42	16	48	10	41	14	46	14	42	7	46	13	34	-0.3	-	-
1997	47	13	39	15	46	7	39	14	50	15	45	8	45	9	35	-1	-	-
1998	47	13	42	14	48	8	43	13	48	15	46	5	46	8	34	-2	47	7
1999	48	13	39	16	49	10	42	15	48	15	46	9	46	15	36	1	48	8
2000	45	13	41	14	44	9	43	13	47	14	45	9	44	14	33	1	47	7
2001	46	13	38	15	45	8	42	15	48	13	45	6	45	12	35	-	46	7
2002	48	12	40	15	48	5	43	15	48	13	44	7	46	13	35	-1	47	6
2003	46	11	42	15	47	9	41	14	47	14	46	8	45	14	34	-1	46	6

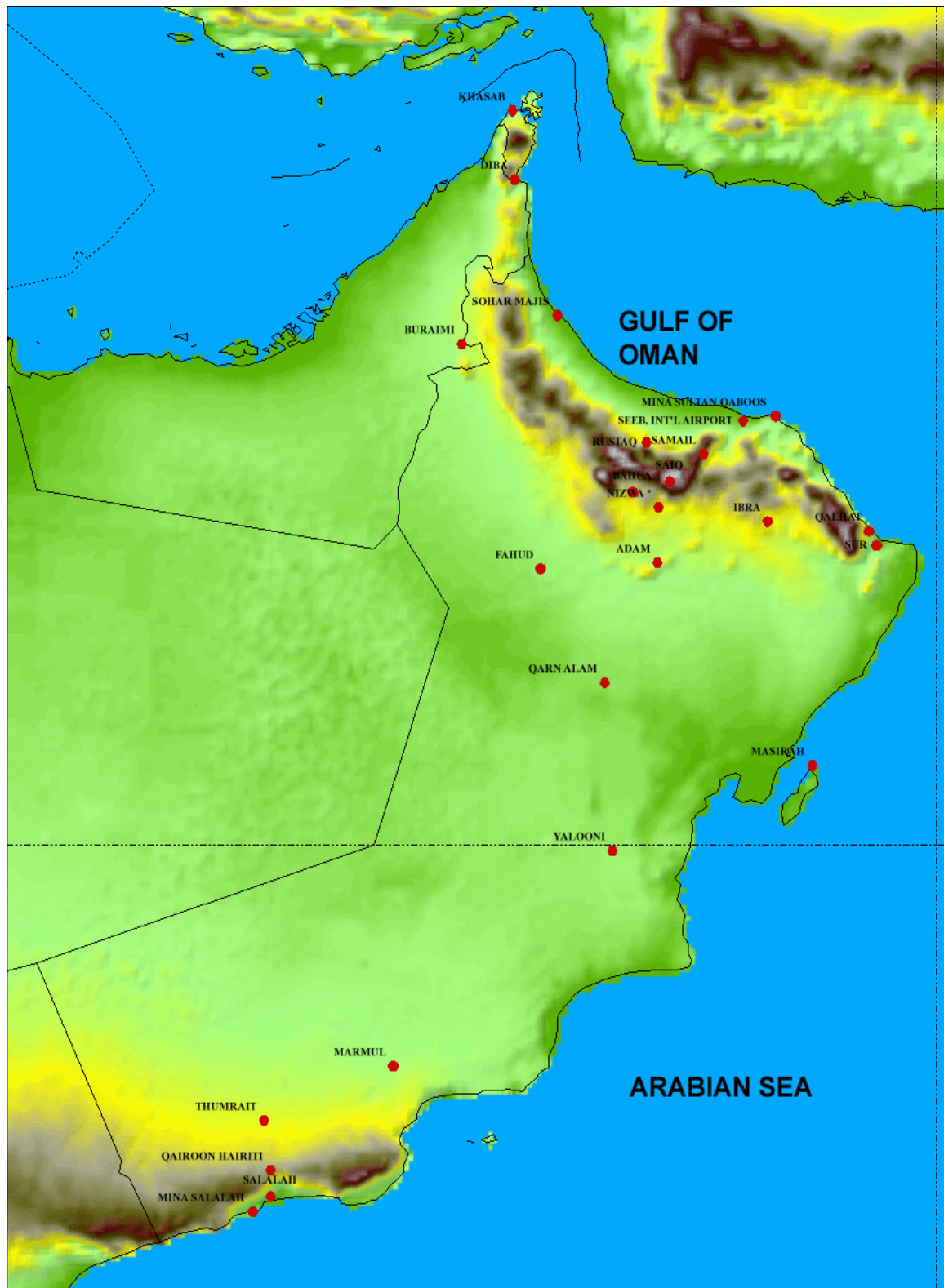


Figure (1.3) Network of Meteorological Stations of the Sultanate of Oman

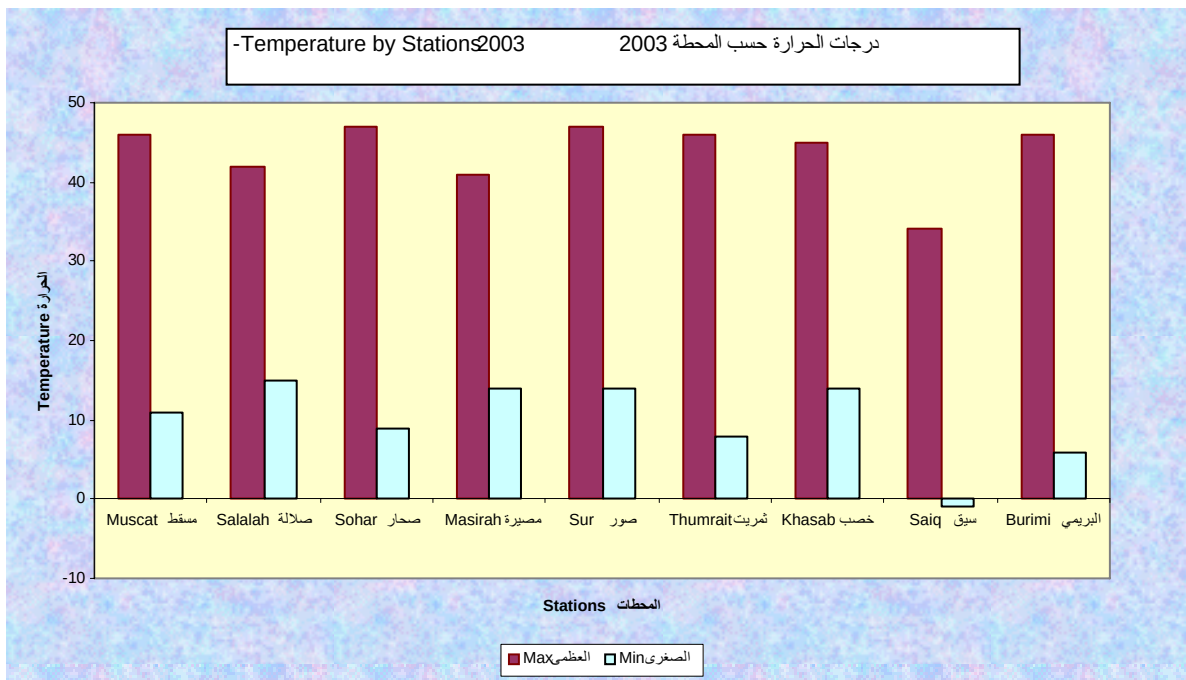


Figure (1.4): Average Maximum and minimum temperatures at several Meteorological stations

In the last 20 years, 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 Table 1.2 which shows annual rainfall at different meteorological stations from 1980 to 2002. Fig. 1.5 shows total rainfall by Meteorological stations (1995 – 2002) .

1.4.3 Relative humidity

Monthly mean relative humidity is highest in coastal area where it ranges from 50 to 90%. The interior areas are much drier and have mean relative humidity or 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 humidity 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 nineteen eighties, 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).

Table 1.3 shows the annual maximum relative humidity values which range from 93 to 100% and the annual minimum relative humidity values which range from 1 to 22% at different meteorological stations from 1994 to 2002 .

1.4.4 Winds

Since Oman is located in a region between 16°40'N to 26°20' N latitude, and between 51° 50' E to 59°40' E longitude, it is under the influence of the equatorial convergence zone. This is a belt of governing trade wind systems that encircles the earth near the equator . In summer, this system reaches southern Oman and brings monsoon conditions to the Dhofar mountains. In winter, the system moves to 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. in December to 0.98 m. sec. in June in Oman interior, 0.45 m. sec. in December to 1.09 m. sec. in June at Batinah, 1.6 m. sec. in December to 3.33 m. sec. in June at Sharqiya, 1.97 m. sec. in December to 3.14 m. sec. in June: at the Location of the main weather stations at Jabal Al Akhdar, and 1.05 m. sec. in October to 2.47 m. sec. in January in Al Janubiya regions (Omani's Digital atlas 2000).

1.4.5 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 where the relative air humidity is low.

Table 1.2: Annual Rainfall at different Meteorological stations from 1980 - 2003 (mm)

Station	Muscat	Salalah	Sohar	Masirah	Sur	Thumrayt	Khasab	Saiq	Al-Buraimi
	Rainfall M.M.								
1980	4	81	8	4	3	4	-	241	48
1981	110	53	33	20	101	8	36	235	43
1982	133	147	218	98	175	7	329	633	249
1983	80	360	122	279	255	145	245	433	142
1984	2	74	15	7	12	0.0	20	151	9
1985	1	55	TR	TR	11	3	27	128	-
1986	94	73	95	7	120	30	118	294	24
1987	194	66	143	83	110	53	144	324	97
1988	63	145	261	28	30	43	152	420	92
1989	70	120	143	16	67	227	251	246	110
1990	79	83	121	47	164	6	177	441	98
1991	45	72	77	8	5	TR	280	267	19
1992	101	97	103	185	145	132	321	497	12
1993	31	45	53	23	42	2	239	320	68
1994	44	62	76	17	129	14	22	429	86
1995	219	120	306	140	188	9	442	487	423
1996	43	311	131	95	93	33	351	358	-
1997	237	93	261	117	206	3	352	1000	-
1998	79	67	137	13	18	TR	419	336	113
1999	61	119	96	12	80	20	140	189	12
2000	7	41	20	6	3	0.00	110	414	21
2001	17	33	23	1	10	0.0	118	262	0.0
2002	32	136	53	6	6	24	51	138	72
2003	86	46.6	45.6	129.5	47.2	21.1	79.4	168.5	82.6

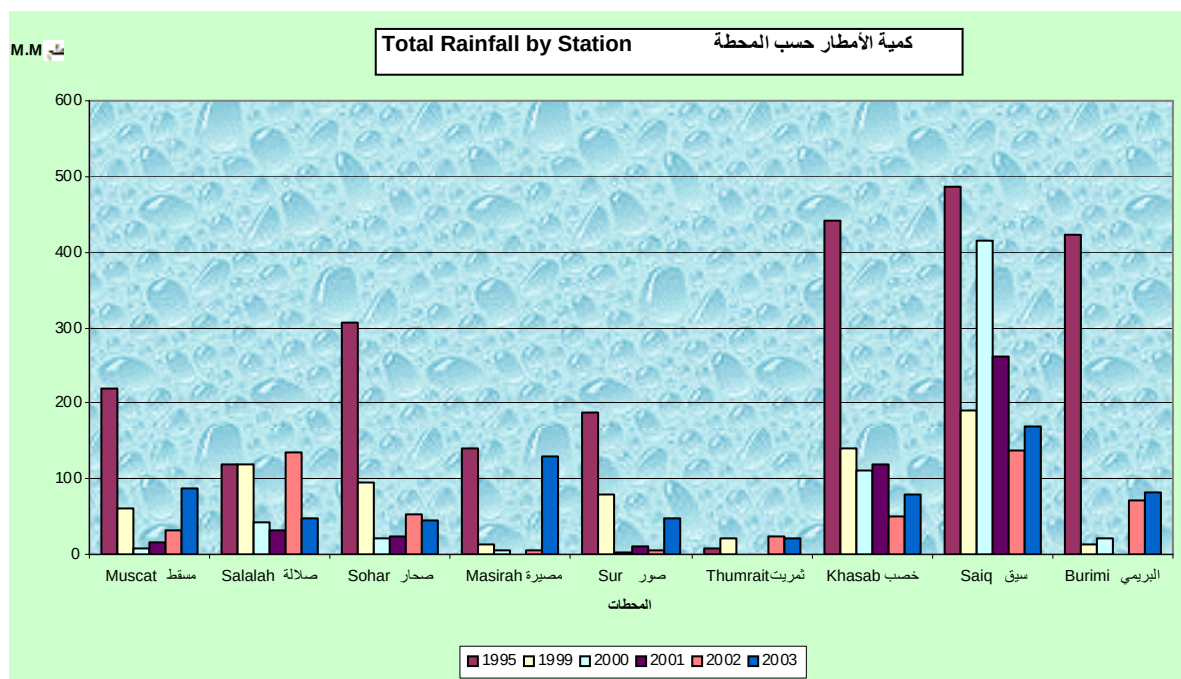


Fig (1.5): Total rainfall by meteorological station

Table 1.3 Maximum & Minimum Relative Humidity (%) by Station (1994 - 2003)

Station	Muscat	Salalah	Masirah	Sur	Sohar	Thumrayt	Khasab	Saiq	Al Buraimi
Period									
1994									
Max.	98	100	100	100	100	95	98	100	100
Min.	9	4	22	7	6	2	8	1	7
1995									
Max.	100	100	100	100	100	99	100	100	100
Min.	6	6	18	11	9	4	7	1	8
1996									
Max.	100	100	100	100	100	99	100	100	-
Min.	4	6	11	13	10	4	10	1	-
1997									
Max.	98	100	99	100	100	98	96	100	-
Min.	7	8	14	11	7	4	7	1	-
1998									
Max.	98	100	100	100	100	99	100	100	99
Min.	3	7	16	11	14	5	8	1	4
1999									
Max.	100	100	100	100	100	95	100	100	95
Min.	4	10	9	8	13	2	2	1	4
2000									
Max.	100	97	99	100	99	98	100	100	100
Min.	4	4	9	9	2	4	7	1	5
2001									
Max.	97	95	98	95	98	99	100	100	100
Min.	5	7	10	7	6	4	8	1	4
2002									
Max.	99	95	100	100	93	99	96	100	100
Min.	4	7	9	6	5	5	3	1	4
2003									
Max.	98	94	98	96	100	97	100	100	99
Min.	5	5	9	9	5	5	6	1	5

The annual open water evaporation rates are 1,400 mm in South Batinah, 2,360 mm in Al Ayn, 2,216 mm at Ibra (JICA, 1990) and about 3,000 mm in 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.

1.5 Geology

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. The autochthonous strata include extensive limestone successions of Hajar Supper Group and the Allochthonous Hawasina and Samail nappes. 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.

The Oman mountains form a part of the Alphine range and are located on the southern 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 the Geological map of Sultanate of Oman and map of Oman's geological heritage in Fig. 1.6 and Fig 1.7 respectively, produced by MRMEWR).

A basement of granites and gneisses, partly metamorphosed sediments and meta-volcanic. The basement was folded in the pre-Middle Permian orogeny. 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 Later Cretaceous. The Sumeini Group – local-thrust sedimentary sequences comprising mainly calcareous rocks that range in age from Middle Permian to Cretaceous. These sequences are stratigraphically overlain by Middle Cretaceous rocks.

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 that have a substrate of sheared basaltic pillow lavas.

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

1.6 Land Resources

1.6.1 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 1:5000,000 the soils of Oman were classified in 1977 to two types of soil, Yermosols (Now named as Calcisols, Cambisols, and /or Gypsisols) and Lithosols (Now named as Leptosols). Solonchaks and Regosols could, however, be found in certain areas. Haplic yermosols (Cambisols) are spread in northern coastal areas, lithosols (Leptosols) in the mountainous areas and calcic yermosols (Calcisols) in the inland areas. In southern Oman, there are mainly calcic yermosols (Calcisols) and some gypsic yermosols (Gypsisols) 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 (Calcisols, Gypsisols) , Arensols, Fluvisols, Regosols, Solonchaks, Solonetz and Lithosols (Leptosols).

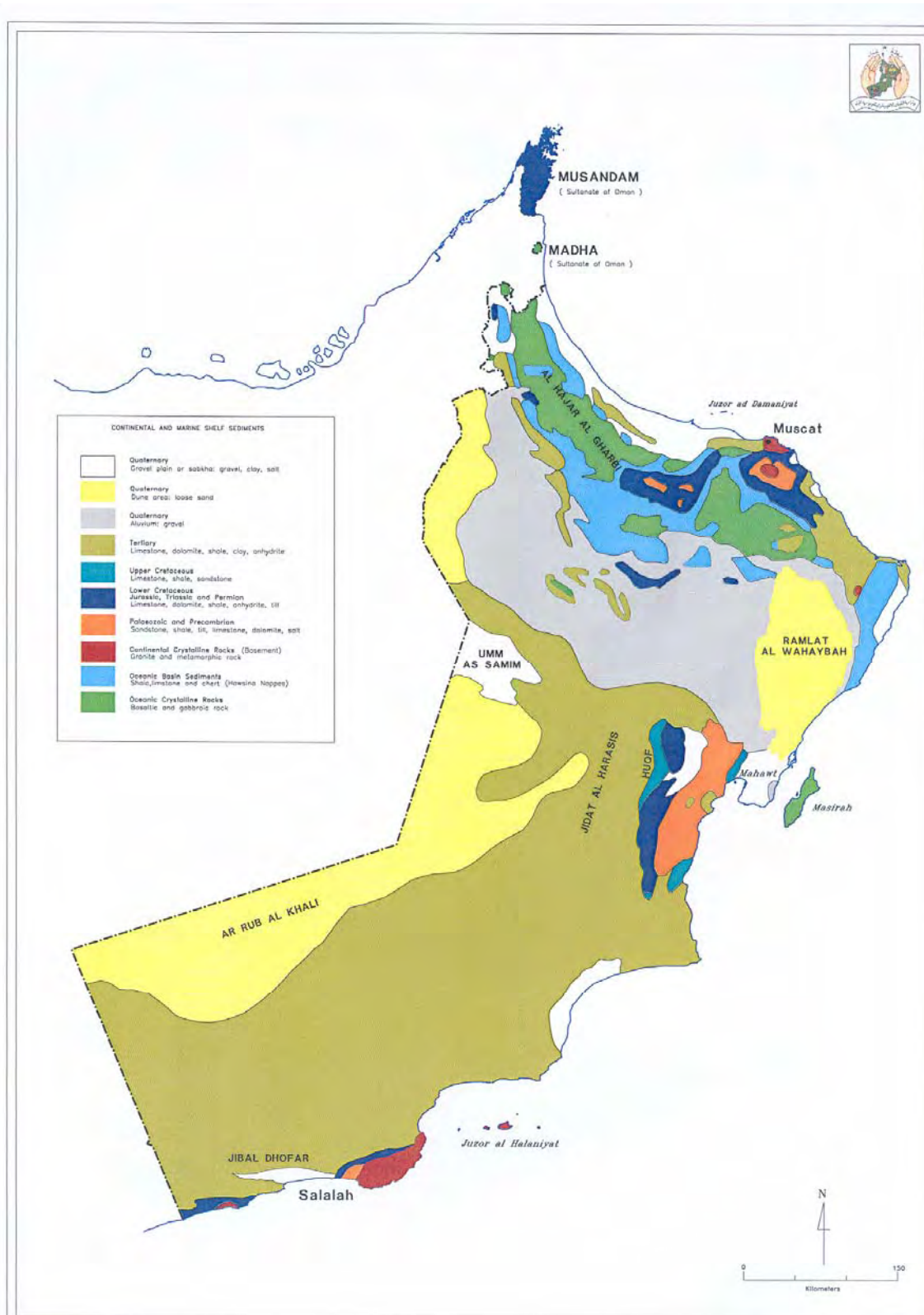


Figure 1.6. Geological Map of the Sultanate of Oman

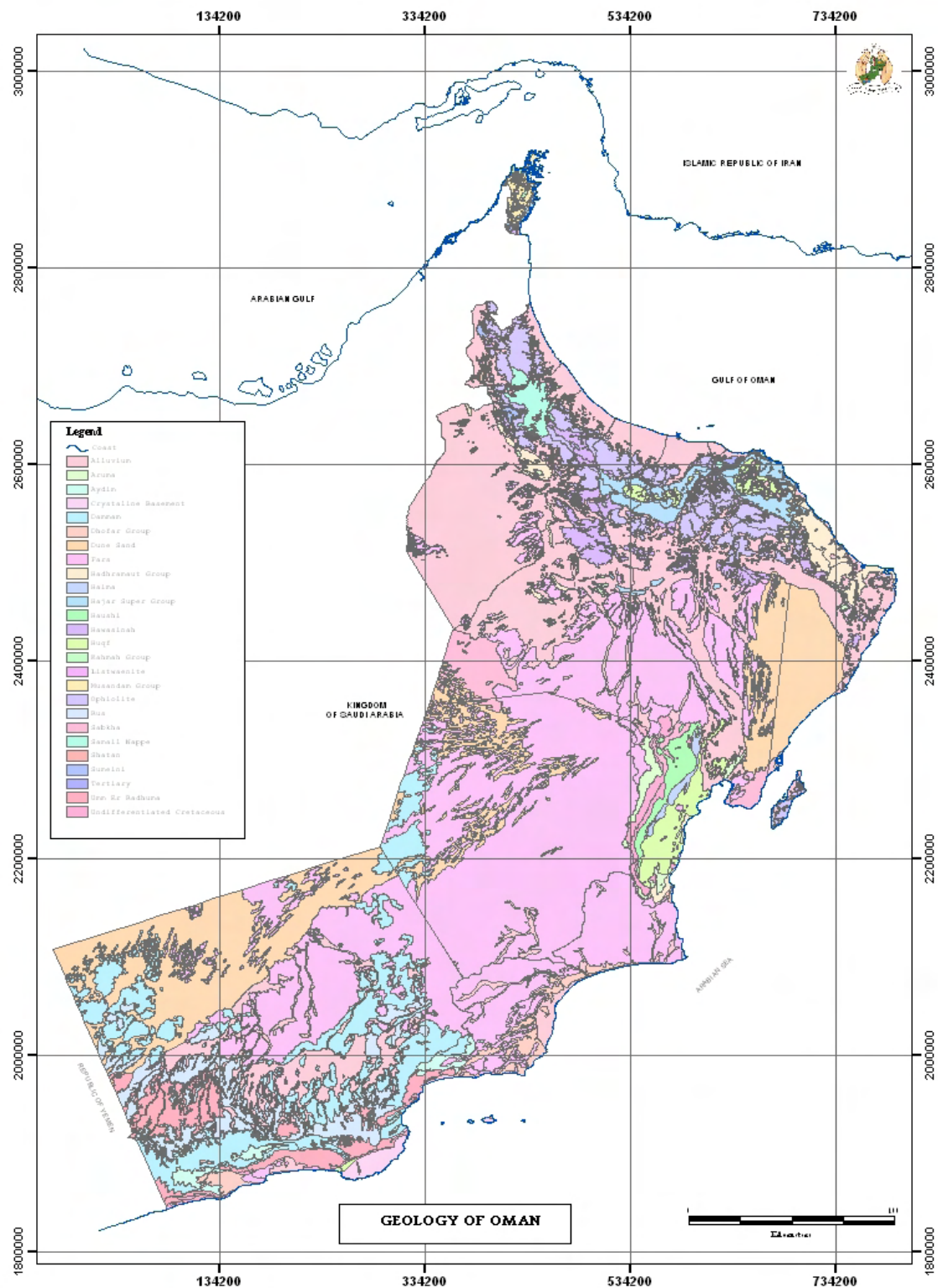


Figure 1.7. Oman's Geological Heritage

In the study of (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 the Soil Taxonomy 2000) AND USING THE SAM CONCEPT OF THE DIAGNOSTIC HORIZONS. Six diagnostic horizons were recognized in Oman during this soil survey, namely: Ochric epipedon, Calcic horizon, Cambic horizon, Gypsic horizon, Petrogypsic horizon and Salic horizon. Some more details about these horizons are given in Appendix (1).

Out of the twelve orders that are 'defined by Soil Taxonomy, only three exist in Oman. These are the Entisols, Inceptisols and Aridisols. Out of these Orders the following soil great groups are present in Oman: Torripsamments, Torrifluvents, Torriortents, Ustorthents (only in Dhofar), Calciorthids (Haplcalcids), Gypsiorthids (Haplgypsid), Cambisols (Haplcambids), and Ustochrepts (which is also only found in Dhofar). 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:

(i) 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.

(ii) 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.

(iii) 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.

(iv) The Sharqiya Region

The soils of the Sharqiya region are formed mainly by alluvial and Eolian processes. Yermosols represent here are 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).

(v) 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 Regions.

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

1.6.2 Agricultural Lands

The soil survey by MAF revealed that out of the total area of the country amounting to 30.95 million hectares only 2.223 million hectares are suitable for agricultural activities or about 8% of the country area (Table 1.4).

Table 1.4 Area by land suitability class for agriculture selected according to soil survey of 1990 . (source: MAF 1990 , modified 2004).

Area		
Land Class	In Hectares	In Percent
S ₁ *	791,651	2.56
S ₂ **	1,431,406	4.62
Total suitable land (S ₁ and S ₂)	2,223,057	7.18
Total unsuitable land (N)***	28,726,409	92.82
Total land	30,950,000	100.00

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

**Class S₂ (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 irrigation agriculture.

The figures of cultivated land areas which were reported in different sources of information were varied. The following data are taken from Digital Atlas 2000 and presented in table 1.5. The area of cultivated lands is estimated in 2002 as 72,820 ha .

Table 1.5 Estimates of Cultivated Areas (1000 ha) and of Agricultural Production (1000 Ton)

Year	1993	1994	1995	1996	1997	1998	1999
Estimates of Cultivated Area (1000 ha)	70.42	70.83	71.67	72.08	176	71.67	72.92
Estimates of Agricultural Production (1000 Ton)	1,085	1,102	1,121	1,182	1,232	1,197	1,287

The widely accepted figure for irrigated land area in Oman is about 72,820 hectares. This area was cultivated in 2002 to vegetable crops (6,650), field crops (6,250), fruit trees (42,040) and other crops (17,880). See Table 1.6. The most common cultivated crops in the country are the date palm and alfalfa .

Table 1.6 Estimates of cultivated areas (1000ha) and of production by crops (1000T)

Agricultural crops	2000		2001		2002	
	Area	Production	Area	Production	Area	Production
Vegetables	6.54	151.7	6.77	172.242	6.65	162
Fruits	41.81	345	42.26	313.385	42.04	329.2
Field Crops	6.17	23.8	6.33	25.785	6.25	24.8
Perennial folder crops	17.73	692.2	18.03	765.439	17.88	728.8
Total	72.25		73.39		72.82	

1.7 Water Resources

Oman, as mentioned earlier, is arid and characterized by potential evaporation rates more than 2,000 mm/ year (annual evaporation is estimated about 7,585 Mm³) (Master Plan, 2000). Evaporation values of more than 3,000 mm / year are recorded for parts of the interior. In most of the country the rainfall is unreliable(annual rain fall is estimated to be about 100 - 150 mm).

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 Daygah (70 km 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 (annual runoff is estimated about 123 Mm³). Perennial springs issue from the limestones in the northern mountains and the Dhofar Jabels . They remain occasionally as flow at the surface over substantial distance.

1.7.1 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 . Water resources are basically

equivalent to groundwater resources. Most of the surface flow from catchments areas in the mountains percolates underground at the foot of the mountains.

1.7.1.1 Hydrogeology

The hydrogeological 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. 1.8) and the hydrogeology of each has been outlined by MMDI (1991a) as follows:

a)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 remain, 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 system of the plains described below.

b) 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 and direct infiltration of rainfall on the plain. 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.

c) 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) 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.

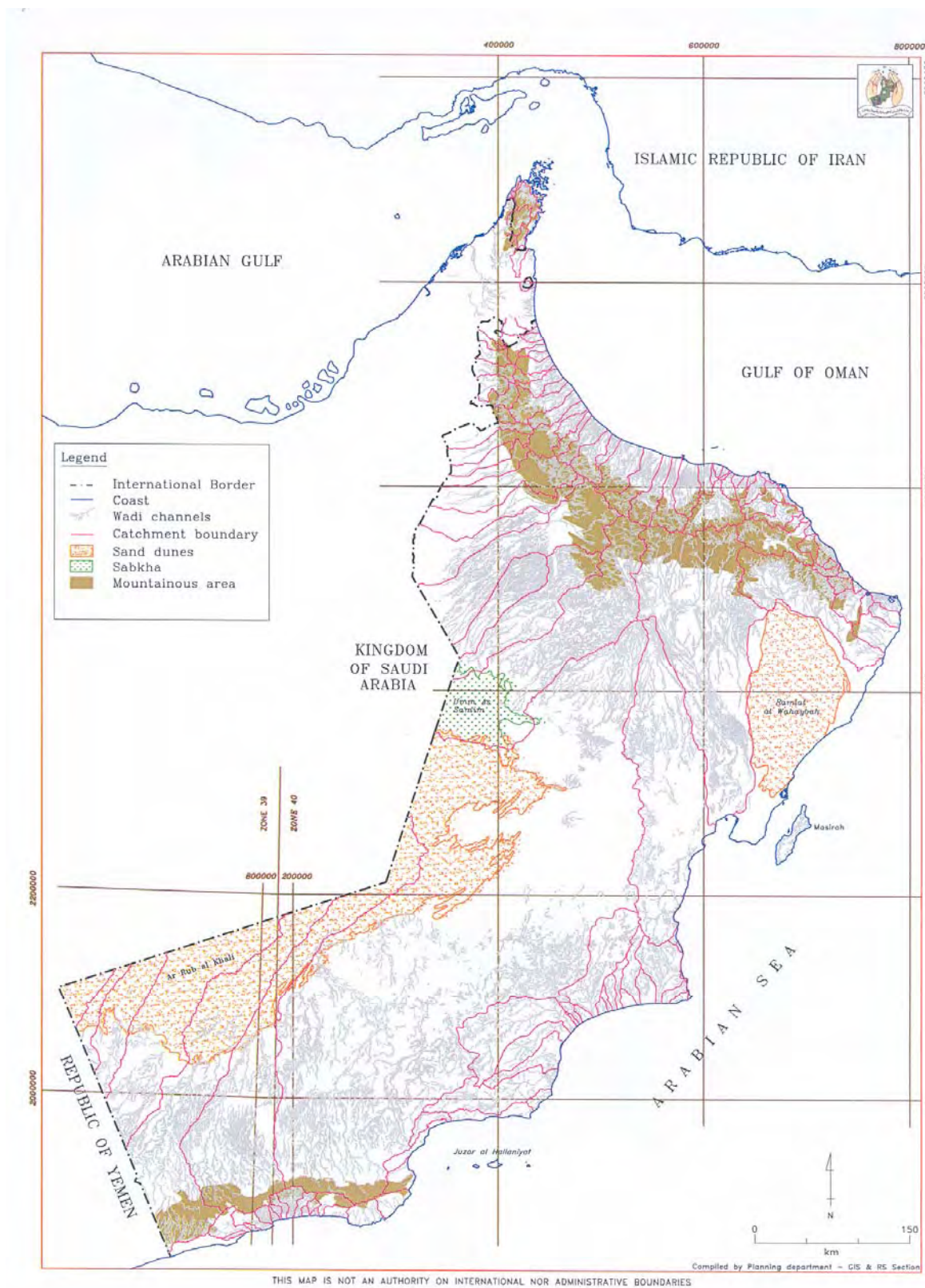


Figure 1.8. Physical Features and Hydro-geological Regions of Oman

d) Wadi Al Batha and 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.

e) The Central Region (Al-Wusta)

The Central Region is underlain mainly by Tertiary sediments of the Hadramout 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 land 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.

f) The Nejd

The Nejd is a gently sloping plain, falling from the Dhofar Jebels 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.

g) 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.

h) 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.

1.7.1.2 Groundwater Resources.

MRMEWR has estimated the total replenishment of renewable resources for the year 2000 to be 1,300 M.m³/yr (Master Plan, 2000). The groundwater amounts were estimated by several groups. The JICA group reported in 1990 of 1,239.8 Mm³ / year available groundwater. This figure was estimated by MRMEWR to be 970 Mm³ / year (Master Plan, 2000). Here also about 50% of the available groundwater resources is in the Batinah and Muscat area. It has been also reported in AQUASTAT of Oman (Nov. 2002) that the renewable water resources

have been evaluated at 985 Mm³ / year .In 1996, the total dam capacity is 58 Mm³ and groundwater recharge is estimated at 955 Mm³ / year. According to water resources statistics of MWR in 1998 (Table 1.7), the renewable water resources have been evaluated at 1,645 Mm³ and the annual natural groundwater discharge at 378 Mm³ in the year of 1997. The different estimates of the present groundwater available was attributed to one or more of the following factors:

- The short period of hydrological records;
- The sparseness of hydrological data; and
- The lack of accurate data on the extent of cropped areas and agricultural water use.

Table 1.7 Summary of Water cycle component by region for the year 1998

Region	Rainfall Volume Mm³/Year	Runoff Losses Mm³/Year	Evaporation Mm³/year	Groundwater Recharge Mm³/Year	Groundwater outflow Mm³/Year
Musandam	302	7	258	36	18
Al Batinah	1,814	38	1,182	595	9
Adh Dhahira	1,386	10	1,199	178	24
Ad Dakhliya	1,188	5	1,070	114	28
Muscat	979	24	742	213	96
Ash Sharqiya	2,986	9	2,585	392	163
Al Wusta	160	0	144	16	13
Dhofar Governorate	666	30	534	101	27
Total	9,481	123	7,714	1,645	378

Source: MWR Water Resources Statistics, 1998

Therefore , the water data in this section will be according to the sources of available information which has not been updated since the two major studies (MMDI,1991a , JICA, 1990) .

Opportunities to increase groundwater resources, the so-called potential new resources for groundwater seem to be very limited as compared to the available resources at present. According to the Water Master Plan of Oman (MMDI,1991a) only about 82 Mm³ / year 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 scheme is in the order of 7Mm³ / year while through the planned schemes an additional of 12Mm³ / year could be recharged to the groundwater and totaling 19Mm³ / year .

1.7.2 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 number of desalination plants in 1997 are 20 and the total amounts of desalinated water are in the range of 51Mm³ / year , representing only 3.1% of the Sultanate's total water resources (1,645 Mm³ / year , MWR Water Resources Statistics, 1998). Desalination of seawater in coastal areas as well as of inland brackish water offer in limited 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.

Table 1.8. Potential new groundwater resources by source and region, status 1990 (Mm³ / year)

Potential New Sources, Mm³ / year				
Region	Total	Additional Recharge Dam	Recharge of TSE	Wadis Catchments
Batinah and Capital Area	55	20	20	15
Northern Dakhira and Dakhiliya	25	5	-	20
Northern Sharqiya	2	-	-	-
Salalah Plain	-	-	7	-
Nejd	-	-	-	-
Musandam	-	-	-	-
Central Region (Al-Wusta)	-	-	-	-
Total	82	25	20	35

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

1.7.3 Treated Sewage Effluent (TSE)

Treated sewage effluent (TSE) represents according to the studies of (Al-Shiniani, 1991) , a renewable source of water when properly managed. It was reported in this study that TSE amounts to about 70,000m³ / day or 25.6 Mm³ / year in that particular year , out of which about 30,000m³ / day (11 Mm³ / year) are use by the municipality of the capital area for irrigating ornamental plants. In MWR Water Resources Statistics(1998) , it was reported that the wastewater production in 1997 was only 27.0 Mm³.

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). The standards were established in 1989.

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 a forestation programmes, controlled cropping, industrial uses and aquifer recharge.

1.7.4 Water Demands.

According to water resources statistic of 1998 (MWR) ,the total nationwide water use in 1997 was 1,721 Mm³ and the average total water use categories in1997 was 2.095 m³/c/d. Table 1.9 shows a summary of the water use in 1997 (MWR).

Agriculture is the main water consumer in Oman, demanding about 93% of the total water consumption (MRMEWR, 2000). Domestic/Industrial water demands, in spite of the recent rapid increase along with Oman's economic development, represent only 12% of the country's demand. The total domestic, commercial and industrial water supply of the Sultanate is estimated at 169 Mm³/year in 2000 out of this supply 114 Mm³/yr is derived

from groundwater and represent only 4% of the country's demand. The remaining 55 Mm³/yr comes from the desalination of sea water (MRMEWR, 2000).

Table 1.9 Types of water use in 1997

Type of Use	Percentage
Agriculture	
Wells	54
Aflaj	32.4
Domestic/Industrial	
Household (wells)	3.8
Municipal	3.7
Desalination	3.0
Tanker Supply	1.0
Industrial/Commercial	0.5
Others	
Waste-water reuse	1.3
Livestock	0.3

Groundwater is used to irrigate about 72.8 thousand hectare cultivated to fruit trees including date palms (58%) , vegetable crops (9%), field crops (9%) and other crops (24%).

The cultivated area is watered by wells is about 52,000 hectares (Table 1.10 and 1.11), the remaining is irrigated by Aflaj and springs. The Falaj (plural Aflaj) comprises a channel leading from the water source to the irrigation system. Qanat Al falaj (the channel) is fed by the water table and exploit the groundwater resource.

Table 1.10 Water Use (Wells And Aflaj) by region

Region	Agricultural use NMW-wells Mm ³ /year	NWI Other*/ MEW** well field Mm ³ /year	Aflaj use estimate Mm ³ /year	Total use estimate Mm ³ /Year	Deficit Mm ³ /year
Musandam	17	1.2/1.7	2	22	4
Al Batinah	588	26.9/10.8	140	766	180
Adh Dhahirah	90	8.4/10.7	110	219	65
Ad Dakhliyah	52	8.7/10.56	80	151	65
Muscat	37	18.3/14	75	144	27
Ash Sharqiyah	73	18.3/4.5	140	236	7
Al Wusta	1	2/0.015	0	3	0
Dhofar, including Al Najd and Salalah	77	11.7/11	5	104	30
Total	935	95.5/63.28	552	1,645	378

* NWI/Other - domestic and commercial use of well water estimated by NWI

** MEW well field - water production from MEW operated municipal well fields

Table 1.11. National Well Inventory Property Area Details

TOTAL PROPERTY AREA DETAILS									
#	REGION NAME	CROPPED		UNCROPPED		UNDEVELOPED		TOTAL	
		m ²	ha	m ²	Ha	m ²	ha	m ²	ha
1	ALWUSTA	207,528.47	20.75	358,669.75	35.87	434,685.58	43.47	1,000,883.79	100.09
2	BATINAH	364,959,784.61	36,495.98	46,663,389.43	4,666.34	114,507,956.43	11,450.80	526,127,179.21	52,612.72
3	DAKLIYAH	27,368,334.00	2,736.83	4,456,510.84	445.65	46,744,078.22	4,674.41	78,568,923.07	7,856.89
4	DHAHIRAH	50,869,779.64	5,086.98	7,887,297.59	788.73	64,260,454.41	6,426.05	123,015,748.81	12,301.57
5	DHOFAR	31,031,565.00	3,103.16	4,668,330.00	466.83	10,892,636.00	1,089.26	46,592,531.00	4,659.25
6	MUSANDAM	7,458,296.76	745.83	635,725.64	63.57	1,323,791.24	132.38	9,417,813.64	941.78
7	MUSCAT	18,102,209.56	1,810.22	975,726.54	97.57	4,516,656.49	451.67	23,594,592.41	2,359.46
8	SHARQYAH	28,573,581.57	2,857.36	3,345,752.05	334.58	33,566,671.66	3,356.67	65,486,054.89	6,548.61
	TOTAL	528,571,079.61	52,857.11	68,991,401.84	6,899.14	276,246,930.03	27,624.71	873,803,726.82	87,380.37

NATIONAL WELL INVENTORY: WELLS SUPPLIED FOR THE ABOVE PROPERTIES

The Falaj system is managed by the local community to satisfy the domestic use and the irrigation of perennial crops, primarily dates. Annual crops are grown when the Falaj water is plentiful. Even though water wells are owned by citizens but there are regulations to limit the abstraction of groundwater. 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 motorized 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 increase the water use efficiency to reach 65 - 70% (Table 1.12).

Table 1.12. Water use efficiency of different irrigation methods in Oman

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

Farmers tend to over irrigate growing crops to control the build up of salt concentration in the soil within the root zone. The facilitated water abstraction through motorized pumping contributed to the problem. Salinity of both irrigation water and cultivated soils have increased to an extent of damaging crops of coastal farms. Abandonment of agricultural activities in coastal farms of Batinah Region represents a real threat.

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.

1.7.5 Water Balance

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

Surplus water in some regions due to rationalization of present uses;

Savings due to rationalization of present uses;

New groundwater sources explored; and

Extensive use of TSE or recharge to groundwater.

Calculations made by JICA (1990) indicated that there are few groundwater resources available for development (1.13). General trends of regional balance of groundwater were, according to JICA (1990), as follows:

Batinah Region indicated serious over drafting of groundwater amounting to 201.4 Mm³ / year over the available groundwater recharge (557. 1 Mm³ / year) or about 36% over drafting.

The over drafting is mainly seen in salinization areas;

Dhahira Region is reasonably balanced;

Dakhiliya Region show 14.4 mm³ / year over drafting or about 9% of the rechargeable groundwater.

Sharqiya Region is shown to have a positive balance amounting to 2401 Mm³ / year of about 10.4% of the rechargeable groundwater; and

Salalah Region (Al-Janubiya) is shown to also have a positive balance of 91.0 Mm³ / year. This is a considerable additional water resource, although salinization has unfortunately occurred in the central Salalah plains.

The regional assessments made by MRE are also presented in a map indicating the availability of groundwater to support additional agricultural development .

Table 1.13. Water resources, demands and balance by region, status 1989 (Mm³ / year)

	Ground Water Recharge	Demands of Ground Water			Ground Water Balance
Region		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

In the late nineteen ninety MWR published the balance status of water as presented in Table 1.14 to illustrate the water recharge ,demand ,and balance and to indicate the size of water problem .

Table 1. 14. Water resources, demands and balance status in Mm³ / year (1990 - 2020)

Year	Water	Recharge		Water Demands			Water Balance
	Gr.water	Des.water	Total	Agriculture	Domestic	Total	
1990	899	41	940	1152	73	1225	-- 285
1995	949	50	999	1152	156	1308	-- 309
2000	1004	100	1104	1250	185	1435	-- 331
2020	1004	100	11	1250	460	1710	-- 606

Assessment of water balance in Oman in 2000 revealed water deficits being 247 Mm³ / year (annual water recharge (1294 Mm³) and total nationwide water use (1,217 Mm³) (Master Plan, 2000).

The suggested savings in irrigation water seems realistic as the present water consumption in Oman for irrigation growing crops is more than twice as much as the water requirements estimated for Northern Oman. 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.(Previous studies see references).

1.7.6 Water Quality for Irrigation

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

There is no adequate recent information about the quality of irrigation water abstracted from the aquifers in different regions of the Sultanate. Previous 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 (Gibbs, 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. 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 ground water from sea side 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.

Some analysis of Aflaj water, groundwater and TSE are presented in Table 1.15. 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.

1.8 Natural Vegetation

The type of natural vegetation coincides with the pattern of water resources in the different physiographical regions of Oman, the variation in the latitudes, the geological formations and the soil characteristics. The variation in such differ according to Batanouny (1987) in their floristic composition and plant life forms.

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

The great sandy regions of the Wahiba Sands and Arub Al-Khali

The coastal Zone of the Gulf of Oman.

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.

Numbers of livestock estimated by Munton (1988) range between 18.8 thousand sheep and goats in January and 26.3 thousand in March and for camels, 3340 and 3193 respectively. Estimated No. of animal in recent years shown in Table 1.16. The livestock estimation for the Governorate of Dhofar only in the year of 2000 were 17,000 sheep and goats and 85,000 camels (see Table 1.17).

Table 1.15 Quality of some irrigation water and TSE, By source (1991)
(contents in Mg. / L)

Properties	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 Sols, Salts	680	2000	547	784	796	878
Chloride	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	28.02247	4.0	0.2
Sodium	130	430	220	15	246	258
Potassium	4	17	7	46	16	15
Calcium	39	150	58	29	46	47
Magnessium	51	95	20	202	34	32
Phosphate	-	-	0.3	-	2.7	2.7
Fe	30	52	-	0.05	-	0.03
Mn	1	21	0.05	0.02	0.03	0.02
Cd	-	-	0.02	0.05	0.02	0.05
Co	-	-	0.05	0.03	0.05	0.04
Cu	-	-	0.03	0.09	0.04	0.05
Ni	-	-	0.05	0.16	0.06	0.05
Pb	-	-	0.050.	0.85	0.05	0.90
Zn	-	-	95	118	1.34	15
Bod,	-	-	0	294	15	92
Cod	-	-	0	228	138	100
Total Alkalinity	-	-	138	1.0x10	119	1.1x10
Total Bacterial	-	-	1.3x10	1.46x10	3.1x10	0
count	-	-	0	4.4x10	1.26x10	0
Coliform Group	-	-	0	12.5x10	1.8x10	0
E.Coli	-	-	0	7	1.0x10	0
Faecal	-	-	0		3.7	
Streptococcei						
Clostridium						
perfringens						

(1) ME (1991)

Al Shuriani (1991)

Used for preparation of potable water

Drinking water

Table 1.16 Estimated No. of Animals By Type (in Thousands) (2000-2002)

Animals	2000	2001	2002
Cows	298.9	313.5	319.8
Camels	118.9	120.8	112.3
Sheep	343.9	354.2	364.8
Goats	978.5	998.4	1,023.2
Total	1,740.2	1,786.9	1,820.1

Source: Statistical Year Book, 2002.

Table 1.17 Estimated No. of Animals By Type (in Thousands) in the year 2000 for Dhofar .

Animals	Number	% over all the Sultanate
Cows	220	74
Camels	85	71
Sheep	163	17
Goats	7	2
Total	475	--

Source: Statistical Year Book, 2002.

Concern was expressed by Muntron (1988) because of the overuse of the prosopis woodland especially in Area J (Fig. 1.9). 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. Prosopis cineraria trees are reported by Brown (1988) to be resistant to harsh environmental conditions of the Al-Sha 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 forestation of the deteriorated areas with vegetatively propagated Prosopis cineraria trees (Unfortunately , no more general vegetation cover studies have been implemented recently, the next sections will depend mainly on the studies conducted in the late eighties and early nineties)

1.8.1 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

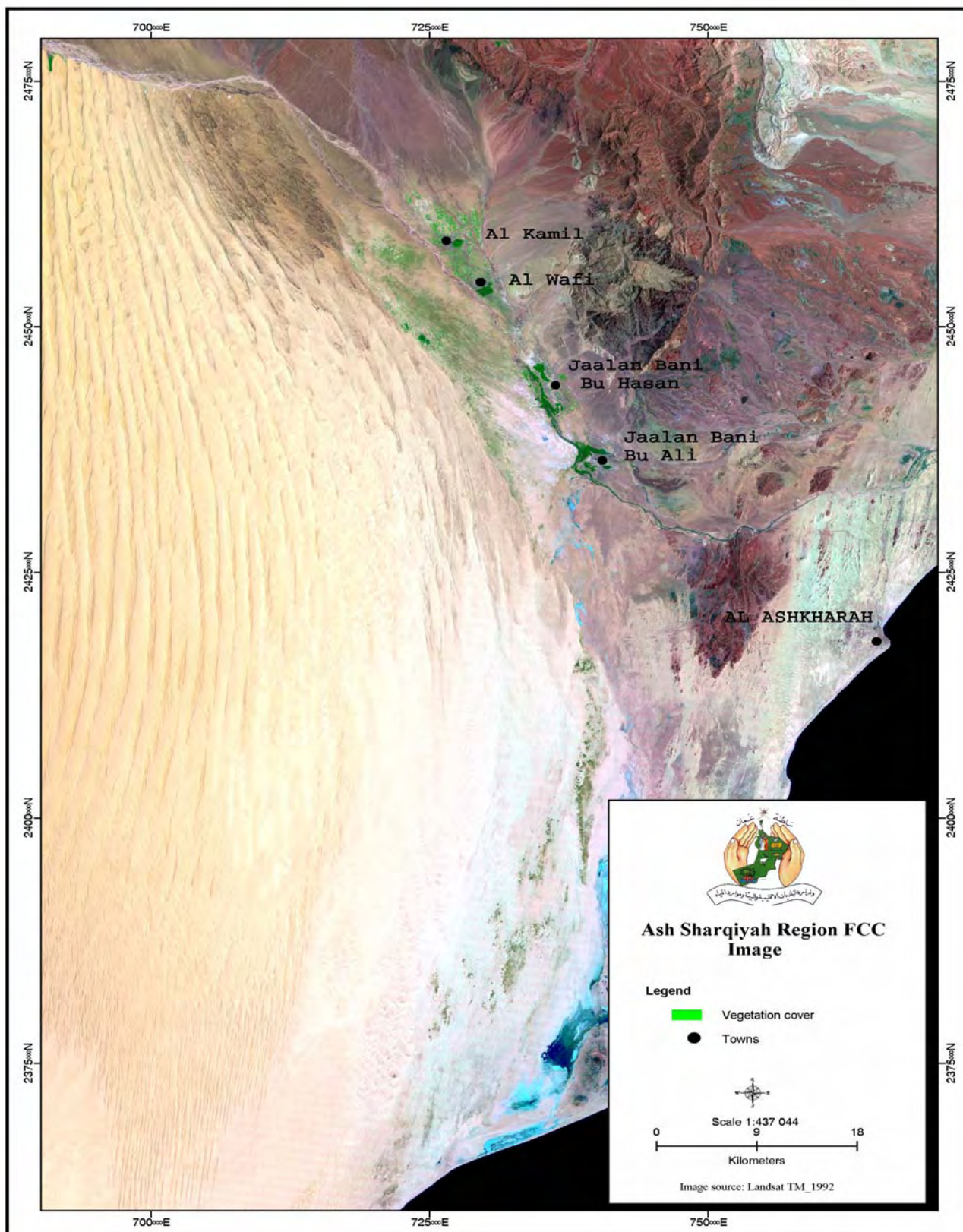


Figure 1.9 Vegetation Distribution in Al-Sharqiyah Sands

agricultural mismanagement occupy increasingly large areas. These saline areas harbour halophytic plant communities. According to Batanouny (1987), these are:

- Avicennia marina
- Arthrocnemum glaucum
- Halocnemum strobilaceum
- Halopeplis perfoliata
- Aeluropus Lagopoides
- Suaeda spp
- Salsola spp
- Seidlitzia rosmarinum
- Tamarix spp
- Other halophytic plant communities i.e halopyrum mucronatum, Sporobolus spicatus, S. arabicus, Nitraria retusa and Juncus arabicus.

1.8.2 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 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, aspect, soil type and the amount of precipitation from rain or mist. Each of the six vegetation bands form a distinct zone , namely:

Coastal plain

Foothills

Escarpment, woods and grassland

Dry plateau

North draining wadis and cliffs

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 conglomerates 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 Cissuss 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 500m) consist mainly of deciduous bush land and thicket composed of Acaia Senegal, commiphora spp., Mayttenus dhofariensus, Croton confertus and Blepharispermum hirtum. On the open slopes there are few trees of delonix elata, Anogeissus dhofarica, sterculia African, Lennea spp. And Euphorbia smithies. The valleys contain a dense riparian woodland dominated by fig trees including Focus 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 500 m semi-evergreen woodland dominates i.e. olea europaea, Euclea schimper, 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, Branchiaria spp., Arthraxon spp and Cenchrus spp, These grasses can reach a height of 1.5 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 bulbosa, Habenaria myodes, H. malacophylla, eulophia quineensis 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 macleishini 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 Zuqophyllum qatarense and the leguminous tree Prosopis cineraria dominate in some localities.

On the very edge of Arub Al Khali the extreme north of the area, the common vegetation species are: Calligonum Crinitum, Tribulus arabicus, Dipterygium glaucum, Cyperus conglomerates, Heliotropium kotschyii and Zygophyllum qatarense. Local and scientific names of the most common plants in Dhofar mountains are give in Appendix III.

The forage yields of natural pasture areas of the Dhofar mountain environment was estimated in 18 sites in – and outside enclosure 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 dry matter outside the enclosures (average 2.14 ton / ha), while inside the enclosure the biomass yield was higher and ranged between 1.4 - 9.4 ton / ha. 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).

1.9 Oil , Gas and Minerals.

1.9.1 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 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 are refined in the country.

1.9.2 National 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 developments of the Rusayal 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.

1.9.3 Minerals

Copper, chromate 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 chromate. 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 1962-2002. The Gross Domestic Product (GDP) has risen from 41.3 MRO in 1967 to 7809.1 MRO in 2002 at current prices (Table 2.1 and 2.2), and from 946.9 MRO in 1978 to 6176.7 MRO in 2002 at constant prices (Table 2.3, 2.4). The country has, until oil production started in 1967, subsided on agriculture and fisheries 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. Six 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. The last one (sixth plan, 2001-2005) concentrated on economical diversities, enhancing the roll of private sector, and increasing development process in the southern part Of the Sultanate . Construction works were reduced drastically from 242.2 MRO in 1985 to 106.0 MRO in 1989 , whereas in 2002 it was 174.1 MRO .

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), whereas in 2002 reaches to 184.8 MRO and the percentage of GDP was 30% .

The annual growth rate of the agricultural sector was outstanding by 9.6% (average of 8 years). Variable growth rates of 20.8% and 16.1% recorded for 1980 and 1985 respectively indicate the ambitious development in this sector (JICA, 1990). Provision growth rate of agriculture and fishery in 2002 was 0.5% .

Other activities witnessed also considerable growth over the last 32 years, especially after 1970 when oil revenues increased drastically (Tables 2.1 and 2.2 ,2.3 and 2.4).

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 two decades (1980 –2002) are presented in table 2.5 and 2.6 respectively. Oman's imports increased by 223.9% from 598.1 MRO in 1980 to 1,937.3 MRO in 2002 due to the increase of imported foodstuffs, chemicals, machinery and other industrial articles (Table 2.5). Machinery and transport equipment topped the country's imports during the 2002, accounting for 43.3 % of the total imports of the country.

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		1970	1975	1980	1985	1989	
	MRO	%					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	1,280.60	1,683.90	1,478.60	45.80
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	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	103.7	721.7	2,054.20	3,412.70	3,201.20	99.10
Plus Import Duties	-		-	-	8.6	41.1	29.4	0.9
Total GDP at market prices	41.3		103.70	721.70	2,062.80	3,453.80	3,230.60	100.00
Estimated GDP, RO. Capital					2,062.00	2,756.30	2,026.70	

Table 2.2. Gross Domestic Product (GDP) by kind of activity at current prices in (MRO) 2000 – 2002.

Economic Activity		2000			2001			2002	
	GDP	%	Annual Growth %	GDP	%	Annual Growth %	GDP	%	Annual Growth %
Petroleum	3,717.7	48.7	57.1	3,264.4	42.6	-12.2	3,257.4	41.7	-0.2
Agriculture and fishing	149.4	2.0	-6.1	157.3	2.1	5.3	162.9	2.1	3.6
Industry	655.4	8.6	33.6	898.4	11.7	37.1	862.8	11.0	-4.0
Services	3,274.7	42.9	4.3	3,499.3	45.6	6.9	3,692.5	47.3	5.5
Total	7,639.2	100		7,670.4	100		7,809.1	100	

Source: Statistical Year Book (2002)

Table 2.3. 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
Service	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)

Table 2.4. Gross Domestic Product (GDP) by kind of activity at 1988 constant prices in (MRO) .

Economic Activity	2000			2001			2002		
	GDP	%	Annual Growth %	GDP	%	Annual Growth %	GDP	%	Annual Growth %
Petroleum	1,978.9	35.0	5.6	1,971.4	32.5	-4.0	1,886.0	30.5	-4.3
Agriculture and fishing	177.9	3.1	-5.3	183.9	3.0	3.4	184.8	3.0	0.5
Industry	582.5	10.3	23.0	739.2	11.6	21.1	739.2	12.0	4.8
Services	3,043.7	53.9	4.5	3,509.6	55.0	5.1	3,509.6	56.8	5.1
Total	5,649.5	100		6,073.6	100		6,176.7	100	

Source: Statistical Year Book (2002)

Table 2.5. Progress of Oman's Imports during the period of 1980 - 2002 (MRO)

Commodity Classification	1980	1989	2002
Foodstuffs and Livestock	72.9	148.5	266.7
Beverages and Tobacco	14.8	17.5	167.6
Raw Materials, Inedible (except Fuels)	9.9	10.0	56.1
Mineral Fuel and Lubricants	64.6	16.6	31.6
Vegetable and Animal Oils and Fats	3.2	3.7	12.8
Chemicals	20.8	53.5	140.4
Manufactured Goods	96.3	157.5	267.9
Machinery and Transport Equipment	235.7	313.3	838.1
Miscellaneous Manufactured Articles	45.1	117.1	118.4
Non Classified Commodities and Transactions	34.8	29.5	71.7
Total	598.1	867.2	1,971.3

Source: Statistical Year Book (2002)

Manufactured goods came second accounting for 13.6 % in 2002 . Foodstuffs came in third place accounting for 13.5 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 came 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 center rather than as a production site (re-export).

The non-oil exports of Oman (Table 2.6) increased from 4.62 MRO in 1980 to 261.6 MRO in 2002, indicating a growth rate of 213 % annually. Foodstuffs and livestock represented the biggest part totaling 84.7 MRO in 2002 or 32.4% of the total non-oil exports. Manufactured goods followed with 21.8 % of Oman's non-oil exports in 1989. Exports of Miscellaneous Manufactured Articles occupied third place with 13.9% (36.5 MRO).

Table 2.6. Omani Domestic Exports during the period 1980 - 2002 (MRO)

Commodity Classification	1980	1989	2002
Foodstuffs and Livestock	4.60	29.5	84.7
Beverages and Tobacco	0.02	3.5	4.1
Raw Materials, Inedible (except Fuels)	0.00	1.8	12.1
Mineral Fuel and Lubricants	0.00	0.4	8.1
Vegetable and Animal Oils and Fats	0.00	0.1	7.1
Chemicals	0.00	2.5	30.9
Manufactured Goods	0.00	24.8	57.0
Machinery and Transport Equipment	0.00	68.9	19.7
Miscellaneous Manufactured Articles	0.00	8.5	36.5
Non Classified Commodities and Transactions	0.00	27.9	0.9
SUBTOTAL	4.62	167.9	261.6
Oil Exports	1,244.6	1,344.4	3,307.2
Re-export	45.3		726.7
TOTAL	1,294.52	1,512.3	4,295.0

Source: Statistical Year Book (2002)

Oman exports depend heavily on crude oil. Revenues from oil exports increase from 1,294.52 MRO in 1980 to 4,295.0 MRO in 2002. Despite this fact, the share of oil in total exports has decreased from 96.1% in 1980 to 77.0% in 2002 .

Oman's trade balance (Table 2.7) 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. In the year of 2002 it has increased about four folds and reaching 3,307.2 MRO . Surplus in trade balance reached 628.4 , 644.2 , 3,307.2 MRO in 1985 , 1989 ,2002 respectively.

2.1.3 Balance of Payments

The balance of payments (Table 2.7) 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 continue onwards at low levels at these times. The balance of payments became again of a surplus of 70 MRO in 2002 .

The average annual growth rate of revenue was 0.6% during the years of (1980 - 1989); 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). On the other hand, the

Table 2.7. Balance of Payments Estimates during the period 1975 - 2002 (MRO)

Activities	1975	1980	1985	1989	2002
Exports					
Crude Oil	488.10	1,244.60	1,597.00	1,344.40	3,307.20
Non-Oil Exports	1.10	4.60	22.90	66.60	261.60
Re-exports	Not Determined	45.30	97.40	101.20	726.7
Total Exports	489.20	1,294.50	1,717.30	1,512.20	4,295.50
Total Imports	264.30	598.20	1,088.90	868.00	1,937.60
Total Trade	753.50	1,892.70	2,806.20	2,380.20	6,233.10
Trade Balance	224.90	696.30	628.40	644.20	2,357.90
Total Revenues		1,187.90	1,776.20	1,481.80	3,007.30
Total Expenditures		949.80	1,928.30	1,644.10	2,937.30
Balance	-	238.10	-152.10	-162.30	70.00

Source: Statistical Year Book, 2002

average annual growth rate of revenue was 7.9 % during the years of 1989 - 2002; while that of expenditures was 6.1% over 0.75 times the revenue

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). However , from Statistical Year Book (2002) ,the total Oman's population in the year of 2002 was stated as 1.87 million . Table 2.8 shows estimated total ,Omani ,and Expatriate population in sultanate of Oman .

The concentration of population living in the capital is high. The Batinah Region holds over 50% of the Omani population. Urban populations 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 2.8). The total number of population was reached about 2.5 million inhabitants by the year 2002 , the expatriates consist of about 26% of the total. No information was available about distribution of population by age and sex.

2.2.2 Education

Education actually only started in the 1970s. Until 1969/1970 school years 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 2.9 reflects the development in the education sector so far. The number of schools has increase steadily from 3 in 1970 to reach 578,000 in 2002. The numbers of students and teachers increased within three decades from 91000 and 30 in 1970 to 578,000 and 30,000 in 2002 respectively. The development of Omani education culminated with the opening of the Sultan Qaboos University, which started activity in the 1986/1987 academic years with 1000 students. About 8000 students were enrolled for studies at the university in 2002 while 13,000 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 1,630 in 1970 to 7,380 in 2002 (Table 2.10). The number of expatriate labour force increased also rapidly from 210 in 1970 to 498,500 in 2002 in both government and private sectors. Omanization of labor force was successful in decreasing the numbers of foreign laborers to 17,500 in 2002 compared to 29,480 in 1990 despite the high economic growth in the Sultanate during this period. But this was true only in government sector . On the other hand , Expatriates have increased rapidly in private sector (see Table 2.10) .

Table 2.8. Total, Omani, and Expatriate Population in the Sultanate of Oman(1980 - 2003)

Year	Omani	Expatriate	Total
1980	914	146	1,060
1981	949	181	1,130
1982	984	206	1,190
1983	1,019	266	1,285
1984	1,060	297	1,357
1985	1,102	314	1,416
1986	1,143	295	1,438
1987	1,185	239	1,424
1988	1,226	275	1,501
1989	1,274	285	1,559
1990	1,321	304	1,625
1991	1,369	388	1,757
1992	1,417	465	1,882
1993	1,465	535	2,000
1994	1,512	538	2,050
1995	1,557	574	2,131
1996	1,602	612	2,214
1997	1,642	613	2,255
1998	1,685	602	2,287
1999	1,729	596	2,325
2000	1,725	624	2,349
2001	1,826	652	2,478
2002	1,870	668	2,538
2003	1,779,318	552,073	2,331,391

Source: Statistical Year Book, 2002 and 2003.

Table 2.9. Development of Education in the Sultanate of Oman (1970-2002)

Description	School Academic Year						
	1970	1975	1980	1985	1990	1995	2002
Students (000)	0.91	49.7	96.2	197.3	333.0	489	578
Schools	3	183	382	588	801	953	1,019
Classrooms	ND	1387	3214	6297	11000	15000	19000
School Teachers, Technical & Admin. Staff	30	2138	5007	9776	17,570	22,000	30,000
Sultan Qaboos University Students	-	-	-	1000	3000	3000	8000
Gov. Expenditure on Education (MRO)	ND.	ND.	ND	102.3	124.3	163.8	255.4

Source: Statistical Year Book (2002).

ND: Not Determined

Construction, wholesale and retail trade and the combined construction and trade employed the highest numbers of expatriates

The Number of Omani Employed in agriculture is not known. The dependence on foreign labour in the agriculture sector is dominant and may represent a problem in the continuity of acquired agricultural techniques.

Table 2.10. Employment in Government Institutions and in Private Enterprise (1970-2002) in (1000).

	1970	1980	1990	2002
1-Government Institutions				
Omanis	1.63	23.45	47.79	73.8
Expatriate	0.21	15.36	29.48	17.5
Sub-Total	1.75	38.84	77.27	91.2
% of Omanis	93.1	60.40	61.8	81.0
2- Private Enterprise				
Omanis	---	---	---	52.8
Expatriate	---	130.6	258.4	481.0
Sub-Total	---	---	---	533.8
% of Omanis	---	---	---	10.0
Total				625

--- No Available Data

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, Electricity and Water (MHEW). MHEW is by law the executor of the Royal Decree prescribing land utilization including the agricultural purposes. During the period between 1970 and 1988 the government distributed 27,436 ha to farmers or companies qualified who intended to use it for agriculture.

The total area under cultivation has increased from 70,420 ha in 1993 to 72,920 ha in 1999. This increase by 2,500 ha in the these years represented a rate of less than 1% annually (Table 1.5). The principal crops are fruit trees including mainly dates accounting for 58% of the total cropped area in 2002 (Table 1.6) .

2.3.2 Agricultural Production and Self Sufficiency

Although some of the Oman's production of fruits and vegetable i.e. limes, dates, watermelons and tomatoes were exported in the past, the self sufficiency in agricultural food products is unexpected with the exception of dates. The local production of the major crops in last years shown in Table 1.6 .provided only very small percentage of self sufficiency. It is projected to keep it at that level until the year 2005. The government is planning to achieve surplus in fruit and a larger surplus in date production by 2005.

Animal products in Oman show, however, a large increase since late nineteen nineties . Table 2.11 shows the Estimated Local Production of some Animal Product (2000-2002).

Table 2.11 Estimated Local Production of some Animal Product (2000 - 2002)

Type of product	2000	2001	2002
Red Meat (Tons)	8,922	9,200	9,428
Dairy (Tons)	40,000	42,000	43,000
Poultry(Tons)	8,359	14,740	11,950
Eggs (No. in Millions)	123	160	156

Fish caught during the period 1985-2002 varied between 95,000 and 144,000 tones / year (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.

Table 2.12. Quantity of fish caught in the Sultanate of Oman during the period 1985 - 2002

Year ► Item ▼	1985	1990	1995	2002
Fish Landed (000 Ton) :-	95	119	140	144
Commercial Fishing	13	19	31	27
Traditional Fishing	82	100	109	117
Fishing Licenses:-				
Renewed	--	1,977	2,792	2,128
New	1,833	1,563	1,361	1,247
Export of Fish:-				
Quantity (000 Ton)	19	34	59	46
Value (000) R.O	8,764	17,280	23,612	29,494

Source: Statistical Year Book (2002).

CHAPTER III

THE STATUS OF DESERTIFICATION IN OMAN*

3.1 General

The definition of desertification which was adopted by the United Nations Conference on Environment and Development (UNCED) 1992 and by UNCCD 1994 is :

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

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 been recognized internationally as a world-wide problem since 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 of 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 Cause 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:

- The climate in the Sultanate of Oman is 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.
- 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 has led to severe salinization of the cultivated lands in Batinah Plain. Now available 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 to salinization of water as a direct consequence to sea water intrusion in the coastal plains i.e. Batinah. This worsens the situation. 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.
- Sand drifting represent serious problems especially over areas adjacent to Wahiba Sands and in the plains and wadis of Dakhliya, Wusta and Janubiya Regions.
- 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. 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.
- 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 three decades has encouraged pastoralists 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. The current desertification in Dhofar Mountains is 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

1- Exact data concerning the population of Oman, their distribution according to sex, age, trend of growth, labor force and their distribution according to area of activity are available only in limited amount as mentioned before. Therefore, the evaluation of socio-economic factors affecting desertification processes in Oman is limited and difficult. However, the following are the socio-economic factors that contribute to the desertification process in Oman :

- 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 crops i.e. vegetables and forage crops (alfalfa). It is quite evident 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 causes by traditional subsistence farming. The improvement will need however skilled labor, active extension service, financial supporting system and organized marketing of products.
- 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:
 - Misconception of prestige;
 - Hard working conditions'
 - Long day work; and
 - Lower money reward as compared to governmental and other jobs.
- The number of foreign agricultural labor has therefore increased in recent years, 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.
- The zero value of water has encouraged farmers to the extent of overusing this scarce resource. This overuse has contributed to increasing salinization

2- 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 old Dhofari animals to decrease their numbers has, on the contrary, stimulated the livestock holders to increase the number of animals for higher prices and/ or profits. Al-Khuthairi (1992) found that the number of animals 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 remain unchanged high during the same period (Table 3.1). In 2000, the number of cows ,sheep and goats decreased while the number of camels increased as compared to the numbers in 1989 .

Table 3.1. Changes in Livestock Numbers in Dhofar Region during the period 1979 - 2000.

Animal	1979		1983		1989		2000	
	Number	%	Number	%	Number	%	Number	%
Cows and Sheeps	77,932	100.00	163,687	210.0	323,333	44.9 197.5	227,000	76
Camel	54,365	100.0	97,982	180.2 100.0	76,336	140.0 77.9	85,000	71
Goats	106,246	100.0	450,191	423.7 100.0	450,191	423.7 100.0	163,000	17

Source: calculated from data by Al-Kuthairi (1992), Updated 2004 .

3- Touristic activities represent additional threat to both the coastal plain and the foothills of the Dhofar Mountains in the Southern Region. 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 activities before the 1970s to be visited by 11,300 , 19,000, and 113,859 in 1988 , 1989 and 2002 respectively, mainly from GCC countries (Table 3.2). The trend of increase is alarming (particularly values of 2002). The rate of increase was much higher for visitors discovered the beauty of the region. Rates of increases vary wildly. The leftovers after enjoyments have serious effects on camels (broken glass, tins , etc.) and on goats (plastic bags). Migration of pastoralists and agricultural labor to the tourism sector may also affect these activities in future.

Table 3.2. Number of Tourists to Dhofar Mountains (1988 - 2002).

Country	1988	1989		1990	2002	
	Numbers	Numbers	% Increase over 1988	Numbers (*)	Numbers	% Increase over 1988
United Arab Emirates	8,356	9,726	16.3	6,596	40,190	380.9
Kuwait	415	1,086	161.2	498	2,687	547.4
Saudi Arabia	340	635	86.8	189	6,235	1823.8
Qatar	199	750	276.9	431	1,563	685.4
Bahrain	122	254	108.2	434	788	545.9
Local tourists	1,332	4,210	216.0	4,780	57,918	4248.2
Others	578	2,482	329.4	1,568	5,266	811.1
Total	11,300	19,000	68.1	14,500	113,859	907.6

(*)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) , updated 2004 .

CHAPTER IV

REVIEW OF PAST AND CURRENT EFFORTS TO COMBAT DESERTIFICATION IN OMAN

4.1 Background

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 sand's 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 to 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.

4.2 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 and conserve water resources, improve capabilities of land for agricultural purposes, realities 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.

4.3 Development and Conservation of Water Resources

With exception to Oman, where is of interests importance to the inhabitants of arid regions, the Omani Government pays 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:

1- The establishment of MRMEWR acting as central authority for water resources development, conservation and management. The structure of MRMEWR allows for good interaction with other concerned bodies.

2- 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) and 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.

3- 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.

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

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

6- The Sultan Qaboos University has contributed to the research on siltation and storage efficiency of Recharge Dams (Saleh, 1992).

7- 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).

8- A Master Plan for Agricultural Development was prepared and improvement of irrigation methods is highly emphasized.

9- 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 detectable nature of the groundwater in the Wahiba sands.

Further work is, however, still needed to compile data on recharge ability 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.

4.4 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:

1- 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.

2- 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, of agricultural farms. Options are given when considered along with the water master plan (MMDI, 1991, AND) to combat some desertification factors in the different regions of the Sultanate.

3- 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 Southern Regions provide a very important tool to improve land productivity through generating of :

- Research finding for appropriate agricultural procedures including tillage, cultivation, irrigation , Pest control, harvesting, marketing and processing.
- Extension services to farmers
- Training of their young staff, agricultural engineers, extension personnel and farmers.
- Providing pest control services.

4- 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.

5- 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.

6- 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).

7- 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.

4.5 Rehabilitation of Rangeland in Southern Region

The development of the Southern Regional of Oman (Governorate of 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 people living in Dhofar. A great deal of effort was made among which the following are worth mentioning:

1- The MAF had conducted through GRMI 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 was that improving management grazing through controlling animal movement and increasing the biomass productivity.

2- Forest resources of the Southern Region 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:

- 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.
- Establishment of Range and Forestry Department within the Ministry of Agriculture and Fisheries as soon as possible.
- Recruitment and training of forestry staff so that the new department would have specialists trained at postgraduate 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.

- In order to formulate sound planned management programmes, the forest resources must be surveyed, inventoried, and mapped.
- 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:
 - o Development and standardization of nursery techniques.
 - o Development of tree establishment techniques appropriate to the conditions in Governorate of Dhofar.
 - o 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.
 - o Testing of systems for the management of natural forests for browse production and watershed management, and
 - o 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.
- Conduct research on water collection from the fog prevailing during monsoon times and develop methods for exploitation.

3- Considering the impacts of socio-economic factors i.e. land tenure, land use pattern, social habits in the postural 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 migrating pattern as well as the land property regulations on which the whole system is based.

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

5- A strategy for rehabilitation of Dhofar forest and for rangeland management has been suggested by Jebbali (Mountain Duelers) in his M.Sc. thesis (Al-Kuthairi, 1992).

PART TWO

NATIONAL ACTION 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 land mass known as the Arabian Peninsula which is classified according to the World Atlas of Desertification (UNEP, 1992) as mostly hyper-arid 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. Most of the lands in Oman are either desert or exposed to desertification processes .

5.1.2 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 (UNCOD) which was held in Nairobi, Kenya with a delegation from the Ministry of Agriculture and Fisheries (MAF) and the Diwan of Royal Court.

Of particular interest to this study is Sale’s (1980) special note of the careful balance between animal 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 animal 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. 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 Qabil, 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 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 and Fisheries, Ministry of Housing, Electricity and Water, Regional Municipalities, Environment and Water Resources, and The Governorate of Dhofar have drawn the attention to the growing problem of desertification following expansion in agriculture and Construction. Of 65 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.

In last two decades there were several reports published , therefore 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 , International and National forum and Workshops on desertification and environmental aspects in the Southern Region were held . These were:

1- International Workshop on Environmental Aspects of Development in the Southern Region which was held under the auspices of the Diwan of Royal court in September 1983.

Two Major recommendations of the workshop were :

- The urgent need for a comprehensive land use plan.
- The fundamental need for an inter ministerial 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 (Planning Committee for Development in the Governorate of Dhofar, Oman, 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.

2- The National forum and workshop on desertification in Dhofar Governorate 25 – 27 March 2002 .

The following major recommendations of the forum and workshop were :

- Implement all themes of the national strategy on sustainable management of rangeland and livestock in Dhofar Governorate.
- Implement all projects that included in the national Conservation strategy of environment and on the draft of national action plan to combat desertification in Dhofar Governorate.
- The civil society should participate in the planning and implementation of all the range management and combating desertification projects .
- Rehabilitate the degraded rangeland in Dhofar governorate.
- Establish a national remote sensing and GIS unit for desertification monitoring.
- Establish an ecotourism projects in Dhofar Governorate.
- Follow up and evaluate the development plans for Dhofar Governorate.
- Enforcement of all legislations that call for efficient use of water resources in Salalah plane.
- Encourage use of treated waste water for irrigation of afforestation or reforestation areas.
- Develop a national plan for environmental awareness.
- Establish committee to follow up the implementation of these recommendations

In response to these recommendations a committee to follow up the implementation was established by Ministerial Decisions in 2002. The committee has undertaken several activities on rehabilitation of degraded lands. These activities were used in the sustainable management of natural resources and helping to reduce the number of animals to 1970' level .

5.1.3 Examples of the Extent of Desertification

In September 1992, three experts from UNER/ASCWA/FAO visited the Sultanate of Oman for three weeks and prepared a quantitative assessment for the regions :

1- Al – Batinah:

From Al-Khabora village to wadi Al-Hawasna and wadi Al-Salahi, horticultural farms in the coastal strip along three kilometres showed signs of deterioration. Date palm 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 plains 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 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-Sabkha and Wadi Algazi area the water was too saline to be used for drinking or irrigation particularly after the establishment of the cooper factory as reported by the area inhabitants. The withering effects of Salinization on horticultural trees was marked and extensive in Masanah, Al Badia and many other locations. Increasing salinity in groundwater has been noted since 1975 as reported in the Background section "Part One" of this study, (Pg.36) and the levels of salinity in groundwater

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.

2- Al-Sharqiyah Wilayet of Al-Kamil and Al-Wafi

The road from Muscat to Al Kamil runs for the most part in a south east direction. About 186 km 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 are 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 now seen on the east side of the road for some 15 km; 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 km from Muscat and close to Jebel Qalhat.

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 of the situation. They considered sea water intrusion as 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 Bani bu 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 form Abu Ali in the north direction and has affected 80% of the wells in which the level exceeds 3000 $\mu\text{S}/\text{cm}$.

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 MRMEWR. Some irrigation wells have dried out. Wells with water salinity above 3000 $\mu\text{S}/\text{cm}$ have increased from 40% to 80% of the existing 5000 wells (approximately). The salinity increased in these wells to about 7000 $\mu\text{S}/\text{cm}$. 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 Bu-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 Quraiyat 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 $\mu\text{S}/\text{cm}$ in Quraiyat and Sur plains respectively.

Groundwater salinity levels up to 10,000 $\mu\text{S}/\text{cm}$ also reported in the coastal area of Wadi Al 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 Al 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 Mashyakh to Jaalan Bany Bu-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.

3-Dhofar Governorate

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

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.

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.

Escarpement, woods and grassland.

It is 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.

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.

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.

Desert and Pre-desert

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

5.1.4 General Comments :

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%. A part from overstocking leading to overgrazing, the area was subjected to deforestation which led to soil erosion. In addition, there was a deterioration 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.

In addition to the above mentioned, it was noticed during the last ten years (1993 – 2004) that the increased number of tourists visiting the area and urban expansion are both causing land degradation in Dhofar.

5.2 National Participation Towards The Preparation Of The NAP

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 it.

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

The following record gives details of the work by Omani Institution 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

Preparation of two surveys for land resources. The first generated the soil map in 1977 and the second generated the ‘‘Agricultural Resources Map’’ in 1988.

Al-Hatrushi, Salim M. (1989) Rangeland degradation.

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

Field study on socio-economic factors in pastoral living areas by MAF & FAO- (Johnson, 1992).

A study of rehabilitation of Dhofar forest and rangeland management in Al – Kuthairi-1992.

Al-Shriani, 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.

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

Al-Shanfari, 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.

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:

- The journal of agricultural and marine sciences, Sultan Qaboos university (1996 –2003).
- The journal of sciences, Sultan Qaboos university (1996 –2003).
- The Journal of Oman Studies, special Report No. 2 (see list of references).
- The Journal of Oman Studies, special Report No.3 (see list of references).
- The Sultanate of Oman National Report to the United Nations Conference on Environment and Development.
- State of the Environment in the Sultanate of Oman (1990).

- Annual Report (1991) Ministry of Municipalities and Environment. Directorate General for Environmental Affairs.
- National Conservation Strategy – Vol III in draft – (1992).
- Sectoral and Regional Planning Studies.
- Selected papers presented to International Workshop on Environmental Aspects of Development in the Southern Region which was held under the auspices of the Diwan of Royal court in September 1983.
- Selected papers among 120 papers presented to the International Symposium on Agriculture and Fisheries Development in Oman. (October 1989).
- Selected papers presented to the National Forum and Workshop on desertification in Dhofar Governorate 25 – 27 March 2002 .
 - o Al Hatrushi ,S.M . Degradation of Rangeland in the mountains of Dhofar ,University of Qaboos .(in Arabic)
 - o Al Najjar ,K.A. An Experiment dealing with water collection from Low clouds during the Fall in the mountains of Dhofar .(in Arabic) .
 - o Shamas, M.E. Desertification and its environmental impact in Dhofar Governorate (in Arabic)
 - o Department of Agri., Animal Wealth and fisheries , the mountains of Dhofar. Local Laws to Organize the range management in Governorate of Dhofar in Arabic).
 - o Al-Kuthairi, A.M. and others . Forestry and Range activities in the mountains of Dhofar.
 - o Omani National Livestock Development Co.(S.A.O.G) .Desertification and Sustainable Development in the mountains of Dhofar .
 - o Al Rawahi , S.A and Others . Sustainable Management of Soil , Water , and Rangeland for combating Desertification in the Governorate of Dhofar.

5.2.4 National Participation in the Formulation of the NAP.

1- 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 and The Salalah forum and workshop on desertification in March 2002 . 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 the 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.

2 - 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 ESCWA. An expert was sent in 1991 to the Sultanate to prepare the background section of the first draft of National Plan .

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

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 which shared responsibility with one or more aspect of the environment. These meetings were very informative and provided unique opportunities for the mission to collect important first hand information.

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

5- The third source of information was the individual meeting or personal communication.

6- This document “ The National Action Programme to combat desertification” (NAP) in the Sultanate of Oman is the result of a joint effort by the United Nations Environment Programme- Regional Office for West Asia (UNEP/ROWA) and the government of Oman (Ministry of Regional Municipalities, Environment and Water Resources). First, the Natural Resources Programme Officer visited the Sultanate in 2002 and 2003, he met with the senior decision making staff and the member of the national committee ,he discussed and reviewed the parts and sections of the National Plan of Action to Combat Desertification” (NPACD) ,which prepared in 1993. In February 2004 the Natural Resources Programme Officer and consultant collected missing information and data, ,reviewed the draft of (NPACD) and prepared the first draft of The National Action Programme to Combat Desertification.

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 three decades was focussed on the successive five-year development plans.

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

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

- To develop new sources of income to supplement and eventually to replace oil revenues;

- To increase the proportion of capital investment expended on income-generation projects, particularly in the sectors of manufacturing, mining, agriculture and fisheries;
- To affect 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;
- 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;
- To pay more attention to the development of water resources which are of vital importance to economic progress;
- To develop the local human resources in order that they may be able to play a more active role in the national economy;
- To continue the development of basic infrastructure;
- 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;
- 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;
- 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 **Five-Year Plan** which specifies protection of the environment and the 5th **Five-Year Plan** 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 target:

- Achieving an appropriate growth rate for GDP with emphasis on diversifying sources of income.
- Maintaining the financial balance of the state.
- Developing human resources and limiting dependence on expatriate labour.
- Emphasizing the regional dimension of development.
- Supporting the role of the private sector in economic activity.
- Emphasizing 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:

- Monitoring and controlling all possible forms of environmental pollution.
- Provision of environmental advice and applying environmental measures and specifications.
- 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:-

- Reduce the current shortage in water resources and stabilize the main underground aquifers throughout the Sultanate by the year 2000.
- 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.
- Widen the scope for protection of water resources and reuse of treated drainage water for watering gardens and forestation.
- 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. 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 .

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. According to the Secretary General, desertification control in the Southern Region will be accorded top priority.

5.3.4 Targets in the Fifth Five Year Plan (1995-2000) and in the Sixth Five Year Plan (2001-2005)

The 5th Five-Year Plan (1995 –2005)and also,the 6th Five-Year Plan (2001 –2005) have 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 For both was based on the following targets:

- To ensure stability of the real average per capita income at its current level and its improvement to a target of achieving an average annual growth in the GDP at constant prices at a minimum rate of not less than 3%.
- Adopt sustainable fiscal policies through rationalizing the government spending, increasing the government revenues, particularly the non-oil revenue, and build up of government financial reserves.
- Maintenance of the current low levels of inflation.
- First priority in the Plan shall be given to raising the rate of enrolment ratio in higher education institutions and the upgrading and spreading basic education.
- Supporting the programmes that aim at promoting the activities of the youth sector as it is considered to be the ground stone for the building of the society.
- Special attention shall be given to culture and heritage and they shall be considered as two fundamental dimensions that are integrated with the economic and social development
- Upgrading the scientific standard in the judicial field and enhancing international cooperation in the field of exchanging judicial expertise.
- Provision of suitable employment opportunities to the Omani citizens through implementation of a set of economically feasible and labour intensive production projects.
- Acceleration of the diversification activities growth rates as well as raising their share in GDP.
- Development of non-oil goods and services exports through increasing their share, quality standard, and structure.
- Development of the natural gas based industries.
- Upgrading tourism as it is one of the basic supports of comprehensive development.
- Adoption of transparent population policies consistent with the directions aiming at sustainability of development.
- Special attention shall be given to the privatization programme, enhancement of its processes so as to reduce the national economy’s dependence on public spending, encourage private sector investment, provide competitive environment and improve the efficiency of the national economy.
- To increase the private sector share in (GDP) through participation in the industrial programme related to natural gas based projects in addition to strengthening its activities in its traditional fields of investment and raising its productivity.
- Increase private savings, encouragement of local and foreign investment through creation of a suitable investment climate, and expansion of the sector’s activities.
- Realization of comparable levels of development in the different regions of the Sultanate

5.4 A Long-term Strategy for Desertification Control (2005 –2020).

5.4.1 Guidance from the long-term national goals

The National goal's during the last three decades have been extracted and reviewed under section 5.3 . All through the targets in six 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 February 1975. Since a principal directive in the United Nation Conference on Desertification (UNCOD) Plan of Action – Recommendation 22, calls for integration of anti-desertification programmes into development plans are recognizing the UNCCD adopted 1994, specially article 10 that provide gridline for preparation of National Action Programmes (NAP) and the validity and the relevance of decisions adopted at the UN Conference on Environment and Development, particularly agenda 21 and its chapter 12 which provide a basis for combat desertification. It becomes imperative that the long-term strategy for desertification control should anchor its roots into the long-term development strategy 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 part of Oman and expensively 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 form the basis of the global anti-desertification strategy, according to the UCCD adopted 1994, specially article 10 that provide guidelines for preparation of National Action Programmes (NAP) and the validity and the relevance of decisions adopted at the UN Conference on Environment and Development , particularly agenda 21 and its chapter 12 requires that ''NAP for all the countries effected by desertification should be fully incorporated into national programmes for development, including appropriate financial and institutional provision''.

The current Five-year Development Plan (2001-2005) has about one more year. As the suggested NAP for the Sultanate of Oman would have a long-term horizon and a short-term one, it appears that one year would not be appropriate for the short-term horizon. It is therefore suggested that the short-term horizon be for 2005-2010. The long-term horizon would be set for 2020. This last date is chosen to coincide with the date set in 2020 vision for Oman economy to complete execution of a set of practical steps proposed for implementation to combat desertification at the national.

5.4.3 Aims of Strategy for Desertification Control (Guiding Policies / General)

The purpose of the National Action Programmes (NAP) to combat desertification is to identify the factors contributing to desertification and practical measures necessary to combat desertification and mitigate the effect of drought in the affected countries. It is therefore recommended that it should be prepared on the basis of the general policy guidelines as directed by article 10 of the UNCCD:

- The principal aim, as spelled out in UNCCD; “is to ensure participation of populations and local communities, to facilitate action at national and local levels ,improve cooperation and coordination at sub-regional ,regional and international levels and to cooperate among all levels of government communities, nongovernmental organizations and land holders to establish a better understanding of the nature and value of land and scarce of water resources in effected areas and to work towards their sustainable use”.
- “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 (the Sultanate of Oman is included) 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 UNCCD, especially article 10 that provide guideline for preparation of National Action Programmes (NAP) and the validity and the relevance of decisions adopted at the UN Conference on Environment and Development , particularly agenda 21 and its chapter 12, 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 :

1. Raising the percentage of self sufficiency in food production and improving the status of food security.
2. Anti-desertification programmes and projects should be in conformity with national goals and contributing towards their success, improving the quality of life of the inhabitants of lands affected by desertification and protecting the environment.
3. 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 inter-alia, sound integrated water resources management and land reclamation projects.
4. Ensure public participation in design and implementation of the programmes side by side with developing and improving public perception of the desertification problem.
5. Achieve development of indigenous national and regional scientific research and technology capabilities (through the implementation of programmes designed to bring about this result).
6. Establishing national institutional and technical facilities for assessment and monitoring of desertification.
7. Contribute to strengthening of regional programmes and international cooperation in the campaign against desertification.

5.4.4 Basic Assumptions

The Sultanate of Oman, long known, for its concern with environmental protection and development will continue to pursue the direction.

Combating 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.

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.

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.

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 sub-regional and regional projects.

5.4.5 Elements of Strategy: A Long-term Programme (2005-2020)

The international community has long recognized that desertification is major economic, social and environmental concern to many countries in all region of the world. In 1977, the United Nations Conference on Desertification (UNCOD) was formulated and adopted a Plan of Action to Combat Desertification (PACD).

In 1991/1992, UNEP adopted new guiding policies and practical targets for implementing of the UN plan, the choice of priorities and suitable actions to be taken was left to the individual Governments to decide upon.

Unfortunately, despite this and other efforts, the problem of land degradation had intensified and with local example of success, the United Nation Conference on Environment and Development which was held in Rio de Janeiro in 1992 supported new, integrated approach to the problem emphasizing action to promote sustainable development at the community level.

The United Nations Convention to Combat Desertification (UNCCD) was adopted in Paris on 17 June 1994. Guiding policies concerned preparation of the National action Programme (NAP) included in articles 5, 9 and 10 of the convention and articles 3 and 4 of the regional implementation annex for Asia. The practical steps are general priorities worded in the form of commitments of effected country parties on the implantation of the convention at the national level, essentially identifying the factors contributing to desertification and practical measures necessary to combat desertification and mitigate the effect of drought.

In light of the above, especially articles 5, 9 and 10 of the convention and articles 3 and 4 of the regional implementation annex for Asia the following programmes are proposed for the Sultanate of Oman.

5.5 Elements of the Strategy: Selected Programmes

5.5.1 Implementing of preventive measures for land not yet degraded or only slightly affected by or prone to desertification programme

This programme is proposed for implementing of preventive measures along the lines of the practical steps of the article 10 of the convention. The programme addresses, issues or specific actions relating to;

- Introducing integrated approach in land utilization.
- Introducing sustainable management systems of soil / water /crop in irrigated and rainfed lands.
- Develop a system whereby farmer and pastorlists carry out collaborative range land / husbandry management.
- Regulate and protect forest and rangeland.
- Restrict of misuse of water resources and agriculture land .
- Ensure that regulations , legislations and rules of protecting land and natural resources are developed and applied .

5.5.2 Introduction of improved land use systems in areas affected by or prone to desertification programme

This programme is proposed for preventive corrective and rehabilitation measures along the lines of the practical steps of the article 10 of the convention . The programme addresses, issues or specific actions relating to;

- Undertaking integrated approach in land utilization.
- implementing improved land / water /crop management systems in irrigated lands.
- Stabilization of rainfed croplands.
- implementing improved rangeland / husbandry management systems.
- Undertaking major afforestation programmes.
- Undertaking a campaign on stabilization of shifting sands.

Specific project proposals to halt desertification in Al – Batinah, Al-Sharqiyah and Dhofar regions which are priority areas should be adopted and prioritised in space and time as part of the priority projects .

5.5.3 Sound Integrated Water Resources Management Programme

The practices of misuse, over use, over-exploitation and mismanagement of the water resources are important factor behind the desertification processes in Oman. Therefore changing such practices within the framework of a country-wide rational and integrated water resource 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-conventional resources.
- To explore, assess, and develop new groundwater resources where possible.

5.5.4 Improved Management of Soil Programme

Soil degradation which is spreading in the Sultanate of Oman as result of salinization, over-grazing and trampling...etc needs to be stopped, and if possible, degraded soils reclaimed. In this programme projects for mountain regions, marginal lands or cultivated lands should be formulated and executed. .

5.5.5 Appropriate and Improved Technologies Programme

The aim of this programme is the introduction of appropriate and improved technologies which are socially and environmentally feasible and compatible with new land use system in : agriculture; range and pasture; forestry; livestock and wild life management.

5.5.6 Public Participation Programme

According to article 10 paragraph 2 (f) of the convention "Provide for effective participation at the local, national and regional levels of non-governmental organizations and local populations, both women and men, particularly resource users, including farmers and pastorlists and their representative organizations, in policy planning, decision-making, and implementation and review of national action programmes" , 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 people's increasing involvement in the discussions of the problems, in planning of and project preparation and in their execution.

5.5.7 Socio-Economic Programme

This programme deals with two aspects:

- the impact of the process of desertification on man, his welfare and institutions.
- 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 article 10 paragraph 4 of the convention which calls for measures in some or all of the following priority fields as they relate to combating desertification and mitigating the effects of drought areas and to their populations: promotion of alternative livelihoods and improvements of national economic environments with a view to strengthening programmes aimed at the eradication of poverty and at ensuring food security; “

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 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 (cooperate 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 is being supported in article 10 paragraph 4 of the convention .

5.5.8 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 sections are articles 10 ,17 , 18, and 19 of the

convention. The programme also deals with environmental education and national legislation appropriate for the needs to combat desertification campaign. An additional aspect under this programme is the establishment or strengthening the nation institutional capabilities for implementing the NAP. The programme also covers building nation-wide combat desertification awareness and extension services.

5.5.9 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 Article 16 of the convention. 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.

5.5.10 Insurance Against the Risk and the Effects of Recurrent Drought Programme.

Over the last three decades, in Oman, ‘‘reserve’’ has come to be interpreted in a wider sense to include:

- Communal grazing ;
- fodder farming;
- supplementary feed purchases; and
- paid employment, whereby the ‘‘salaries increasingly become a ‘‘reserve’’ or a guarantee that they can keep their herds alive in times of drought’’ .

This concept is too valuable to be left undeveloped. It is therefore suggested that activities should be included within the programme to be developed for the benefit of the land users.

This programme addresses issues relating (article 10 Paragraph 3 of the convention):

- Establishment and/or strengthening, as appropriate, of early warning systems, including local and national facilities .
- Strengthening of drought preparedness and management, including drought contingency plans at the local and national levels, which take into consideration seasonal to interannual climate predictions;
- Establishment and/or strengthening, as appropriate, of food security systems, including storage and marketing facilities, particularly in rural areas;
- Establishment of alternative livelihood projects that could provide incomes in drought prone areas; and
- Development of sustainable irrigation programmes for both crops and livestock.

5.5.11 Sub-regional , 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 convention (articles 9 ,10 ,11, and 12) and annex II (regional implementation for Asia) indicated clearly that the sub regional , regional approach, and international cooperation in solving major environmental and development problems is the most promising one.

The achievement made by Sub-regional Action Programme for West Asia (SRAP/WA) in mobilization of resources for combating desertification in some member countries of the region should be supported in order to cover all effected countries in West Asia .

This programme is also important for dealing with international cooperation in combating desertification .

The areas identified for cooperation are :-

- Mobilization of financial resources and provision of financial assistance to the Sub-Regional Action Programme for West Asia (SRAP/WA) and the Regional Action Programme (RAP) for Asia in order to support countries that cannot cope with problem by themselves.
- Development of pricing and trade policy that would favour sustainable agricultural development;
- 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 Sub-Regional and Regional and global levels;
- Information exchange;
- International legislations, as appropriate.

5.6 Remarks

1- The eleventh programmes described in the previous paragraphs constitute the core and framework of the NAP in the Sultanate of Oman for the next 20 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 2005-2010 must share the same qualities of interdependence and complementarily. These projects will be detailed in Chapter VII.

2- The implementation of this NAP composed of eleventh 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 programme it will be elaborated in the next chapter.

3- 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

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 .

2. It is generally said and accepted that the process of national development in Oman started from a base of virtually zero in 1970 . 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”. This has resulted in a accomplishment of the following studies:

Flora and fauna Survey of Jabal Al- Akhdar in northern Oman in April 1975 .

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

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. 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 , forum and workshop of local and foreign specialists were convened in 1983 and 2002. To implement their recommendations, the Committees for Development and Environment for the Southern Region were formally instituted by Royal Decrees in 1984 and 2002 .

6.2 Institutions Currently Responsible For Desertification Matters in Oman:

6.2.1 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 :

6.2.2 Ministry of Regional Municipalities, Environment , and Water Resources:

The Ministry of Regional Municipalities, Environment , and Water Resources (MRMEWR) was designated as the key agency responsible for the development of a National Strategy and a National Action Programme to combat desertification and to determine the measures required to meet the obligations of the Convention, and to enhance co-ordination of national efforts aimed to rehabilitate the degraded land and the sustainable use of natural resources.

6.2.3 Other Institutes

Ministry of Agriculture and Fisheries (MAF) , Ministry of National Economy (MNE), Ministry of Communication and Transportation (MCT) , Ministry of Information (MI) and Sultan Qaboos University (SQU) 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 decrees or order .

The Governorate of Dhofar (G.D) has been and continues to be extensively involved in combating land and soil degradation in general and manages a direct combating on desertification.

6.2.4 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 aims to raise the living standards .
2. Omani women's Association .
3. Women and Child Care Task Force which aims for a boarder 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
5. Enjoy a respected position in the community and have the capacity to influence positively community-based efforts.
6. Non-governmental organizations (NGOs) .

6.3 Institutional Framework for NAP Implementation

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.

These have been addressed in article 10 paragraph 4 (e) of the convention which calls for Promoting policies and strengthening institutional frameworks which develop cooperation and coordination, in a spirit of partnership, between the donor community, governments at all levels, local populations and community groups, and facilitating access by local populations to appropriate information and technology.

In order to ensure an efficient, long-term implementation of the UNCCD, and to comply with its requirements, Oman will put in place an adequate institutional framework building on existing institutional structures. The framework will establish linkages between the local and the national levels and will facilitate a bottom-up approach.

6.3.1. At the local level, Local Focal Points (LFPs) will be assigned (from within the existing administrative structure). LFPs will act as catalysts and will be responsible for the organization of local discussion platforms bringing together the different

stakeholders (municipalities, cooperatives, the Non-Governmental Organization (NGOs and other CBOs) to discuss relevant environmental issues and develop remedial and local development plans. These will be used for local level decision making and would be communicated to the National Coordination Body (NCB) through yearly reports. This will ensure that environmental considerations are taken into account at the local level and that a bottom-up communication channel is established. LFPs will also coordinate their efforts to deal with more regional aspects.

6.3.2. At the national level, a National Coordination Body (NCB), will be assigned and will be made up of representatives of the different linkage. Ministries and relevant government institutions and research centers. The NCB is in charge of steering the UNCCD implementation process. In particular, it is responsible of the following tasks:

1. Identify regional needs and requirements based on LFP reports.
2. Prioritize actions needed at the local and national level in the short, medium and long terms.
3. Communicate relevant information to the various line Ministries and propose joint activities and coordination mechanisms to act on cross-sectional issues.
4. Communicate relevant information to the Ministry of Regional Municipalities, Environment and Water Resources, which is hosting the process and which will then be responsible for communicating issues which need to be acted upon to the council of Ministers.
5. Involve the various LFPs in the planning of interventions at the local level in order to ensure a real bottom-up approach.
6. Plan and implement a comprehensive awareness raising strategy.
7. Closely coordinate with MRMEWR, which is the focal point for the committee of the facilitation programme to combat desertification in the region.

The Minister of Regional Municipalities ,Environment and Water Resources is a member of the Council of Arab Ministers of Environment, which follows up on the implementation of international conventions at the regional level monitoring desertification processes and implementation of the UNCCD including the implementation of the NAP and the impact of the various measures.

In order to ensure full representation of all stakeholders, and an adequate technical backstopping on the various lines of action (water management, sustainable agriculture, socio-economics, etc.), the NCB would be supported by Technical Advisory Groups (TAG). These would be made up of researchers, development actors and NGO's. The NCB would act on the recommendations from the local level and from the technical advisory groups to define priorities and action plans. These would be communicated to decision making levels at the relevant Ministries and the Council of Ministers. The proposed institutional framework will ensure an efficient long-term implementation of the UNCCD and enhance horizontal and vertical linkages between the national and local levels and the different governmental and research institutions.

CHAPTER VII

PRIORITY PROGRAMMES AND PROJECTS FOR THE SHORT-TERM 2005-2010

7.1 General

Priority programmes and projects for the short-term that cover the period (2005-2010) form part of the programmes proposed for the long-term (2005-2020). 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, 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.

7.2 PRIORITY PROGRAMMES AND PROJECTS

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.

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.

7.2.1 Implementing of preventive measures for land not yet degraded or only slightly affected by or prone to desertification programme (5.5.1)

The following are the proposed projects :

(1) Project No. 1

Project title : Encourage land use planning at the local level within the framework of regional and national plans.

There is bound to be conflict over land use. The demands for arable land, grazing, forestry, wildlife, tourism and urban development are greater than the land resources available.

Two conditions must be met if planning is to be useful:

- The need for changes in land use, or action to prevent some unwanted change must be accepted by the people involved;
- There must be the political will and ability to put the plan into effect.

The Omani government today is well aware of the need for an integrated planning of land resources and of the need to initiate actions at many levels.

Land-use planning can be applied at three broad levels: national, district and local. These are not necessarily sequential but correspond to the levels of government at which decisions about land use are taken.

Prime agricultural land was lost to urban and industrial developments, Forests were cleared for agricultural purposes, roads were constructed and quarries and touristic centers were operated without adequate consideration of social and environmental impacts leading to severe land degradation in large areas of Sultanate of Oman, particularly in Dhofar .

Objectives:

- Promote popular awareness of land-use problems and opportunities;
- Address local constraints, whether these are related to natural resources or socio-economic problems;
- Feed better information upwards for higher levels of planning
- to select and put into practice those land uses that will best meet the needs of the people while safeguarding resources.
- the need for improved management or the need for a quite different pattern of land use dictated by changing circumstances.

Specific activities

- Choose one pilot area for implementation
- Define the planning area
- Establish goals and terms of reference
- Initiate a platform for negotiation between all stakeholders:
 - to identify the problems and the opportunities for change
 - Evaluate land suitability
 - Appraise the alternatives: environmental, economic and social analysis
 - Choose the best option
 - Prepare the land-use plan
 - Implement the plan
 - Monitor and revise the plan

Duration : 3 years

Execution: National and with the help of the Regional, and /or international UN organizations and bodies concerned.

Cost : Approximately \$ 1,200,000

Project area : Priority Area is Dhofar Governorate

(2) Project No. 2

Project title : Determining profitability and competitiveness of agricultural crops and varieties

Objectives:

Conducting feasibility studies for potential crops/varieties that could be suitable to the areas (climatic, physical) to determine their profitability competitiveness, in the domestic and regional markets .

Duration : Two - three years

Execution: National and with the help of the Regional, and /or international UN organizations and bodies concerned.

Cost : Approximately \$ 300,000

Project area : Selected Irrigated Lands

(3) Project No. 3

Project title : Promoting ecotourism through local community management in selected in Dhofar .

Objectives:

- The aim is to develop sustainable cultural and ecotourism models that preserve the region's environment and cultural heritage within an economically viable framework. This is through community-based ecotourism in which local communities themselves who plan and implement the activities.

Duration : 4-5 years

Execution: National and with the help of the Sub-Regional ,Regional, and /or international UN organizations and bodies concerned.

Cost : Approximately \$1, 300,000

Project area : Priority Areas is Dhofar Governorate and southern region

(4) Project No. 4

Project title : Promotion of irrigation water use efficiency

Objectives:

- To conserve water resources and promote sustainable agriculture through the efficient use of available water resources
- Create and strengthen institutional frameworks for water resource management
- Explore possible strategies for the introduction of water pricing
- Study crop water demand and promote suitable irrigation systems and practices

Duration : 5 years

Execution: National and with the help of the Regional, and /or international UN organizations and bodies concerned.

Cost : Approximately \$1, 000,000

Project area : Priority Areas is agricultural plains

(5) Project No. 5

Project title : Establishment of forest management plans in pilot areas.

Objectives:

- Encourage the protection of forests through local participation and the
- development of local management plans.
- Identify a forest area
- Identify stakeholders and current uses of the forest by different user groups
- Establish a negotiation platform involving public authorities, experts, local
- authorities and user groups
- Develop a local management plan taking into consideration:
 - the needs of the different groups and the provision of alternatives
 - where necessary
 - Reforestation and maintenance of the forest area
 - Conservation and/or sustainable use of local species
 - Protection arrangements by local authority and local user groups
 - Socio-economic feasibility
 - Analyze the experience, lessons learned and inform decision and policymaking.

Duration : 4 years

Execution: National and with the help of the Regional, and /or international UN organizations and bodies concerned.

Cost : Approximately \$1, 200,000

Project area : Priority Areas is Dhofar Governorate and southern region and Sharqiyah

(6) Project No. 6

Project title : Monitoring the Effects of Drought on Vegetation Cover and Land Use through Eco-physiological Measurements on Some plant Species

Objectives:

- The proposed project represents an eco-physiological approach to give adequate responses of the vegetation adaptation mechanisms to drought in relation to climate experienced.

Duration : 3 years

Execution: National and with the help of the Sub-Regional ,Regional, and /or international UN organizations and bodies concerned.

Cost : Approximately \$ 300,000

Project area : Priority Areas is the region of range land

(7) Project No. 7

Project title : Promotion of sustainable agricultural practices.

Objectives:

- To promote sustainable agricultural production through research and extension on suitable type and rate of agro-chemical application .

Duration : 3 years

Execution: National and with the help of the Regional, and /or international UN organizations and bodies concerned.

Cost : Approximately \$ 300,000

Project area : protected plains where agriculture is practiced.

(8) Project No. 8

Project title : Sustainable improvement of rangeland management in Southern Region

Objectives:

- Develop a model case for sustainable rangeland management in the region; with the participation of local authorities and rangeland users.

Duration : 5 years

Execution: National and with the help of the Regional, and /or international UN organizations and bodies concerned.

Cost : Approximately \$ 1,250,000

Project area : Priority Area is the region of range land

(9) Project No. 9

Project title : Soil conservation measures in saline and degraded soils of Batinah region .

Objectives:

- To study the causes of land degradation due to resalinization and to plan and implement proper conservation measures.

Project activities

- Soil study and soil map at 1/20000 scale

- Identify soil salinity and land degradation origin
- Plan and implement proper conservation measures

Duration : 3 years

Execution: National and with the help of the Regional, and /or international UN organizations and bodies concerned.

Cost : Approximately \$ 500,000

Project area : selected Area the region of Batinah

(10) Project No. 10

Project title : Elaborate a comprehensive legislative framework for the management of natural resources (Land ,water , Vegetation Cover)

Objectives:

- Revise relevant existing laws and legislation
- Identify gaps in existing legislation
- Compare the existing legislation with the obligations under the environmental conventions (UNCCD, UNFCCC, UNCBD)
- Identify the necessary steps to ensure the domestication of the Conventions
- Prepare a comprehensive legislative framework
- Revise laws accordingly

Duration : one year

Execution: National and with the help of the Regional and /or international UN organizations and bodies concerned.

Cost : Approximately \$ 100,000

Project Location : Ministry of Regional Municipalities ,Environment and Water Resources

7.2.2 Introduction of Improved Land Use Systems in Areas Affected By or Prone to Desertification (5.5.2)

The following are the proposed projects :

(1) Project No. 11

Project title : Range and Forestry Management – Southern Region

Objectives:

- To stop degradation of natural resources of Dhofar through better management of grazing land.
- To improve or promote the welfare of the pastoral population of the area.

Duration : 3 years

Execution: National and with the help of the Regional and /or international UN organizations and bodies concerned.

Cost : Approximately \$ 1,200,000

Project area : Selected areas in Dhofar Governorate

(2) Project No.12

Project title : Sand Dune Stabilization and Revegetation

Objectives:

- 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.
- Provide training materials in sand dune stabilization.
- Promote communities participation in sand dune stabilization and range management programme,
- Formulate a sand dune stabilization, renegotiation and range management programme.

Duration : 3 years

Execution: National and with the help of the Regional and /or international UN organizations and bodies concerned.

Cost : Approximately \$ 970,000

Project area : Selected areas in Wahiba Sand

7.2.3 Sound Integrated Water Resources Management Programme (5.5.3)

The following are the proposed projects :

(1) Project No.13

Project title : Aquifer Recharge Using Treated Sewage Water and Urban Drainage Water – Southern Batinah Area.

Objectives:

- To control sea water intrusion into coastal aquifers.

Duration : 3 years

Execution: National and with the help of the Regional and /or international UN organizations and bodies concerned.

Cost : Approximately \$3,500,000

Project 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.

(2) Project No.14

Project title : Aquifer Recharge Using Treated Sewage Water and Urban Drainage Flood Water of Salalah City.

Objectives:

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

Duration : 2 years

Execution: National and with the help of the Regional and /or international UN organizations and bodies concerned.

Cost : Approximately **\$1,500,000**

Project area : Salalah plains has been chosen as priority area for using the treated waste water and drainage flood water of Salalah city .

(3) Project No. 15

Project title : Groundwater exploration, assessment and development in the Nejd area.

Objectives:

- To provide irrigation water for fodder and other agricultural crops.
- To assess the long-term potential sustainable yield of the main aquifer (Umm Raduma) in this area.

Duration : 18 months

Execution: National and with the help of the Regional and /or international UN organizations and bodies concerned.

Cost : Approximately \$ 2,500,000

Project area :selected areas in Nejd

(4) Project No.16

Project title : Groundwater Exploration and Assessment in the Wahiba Sand Dunes Area.

Objectives:

- To explore and assess the groundwater potential in the alluvial deposits, and determine its hydraulic continuity with the developed groundwater in Wadi Al-Batha.

- To determine its exploitability for rehabilitation of the natural vegetal cover as a means for sands dune stabilization.

Duration : 18 months

Execution: National and with the help of the Regional and /or international UN organizations and bodies concerned.

Cost : Approximately \$ 1,500,000

Project area : selected areas in Wadi Al-Batha.

(5) Project No. 17

Project title : Well Inventory and Survey

Objectives:

- To collect physical and hydro geological data on groundwater levels, quality, extraction and water use for all groundwater wells in the different regions.
- To provide this information as an input to the proposed water data bank.

Duration : 18 months

Execution: National and with the help of the Regional and /or international UN organizations and bodies concerned.

Cost : Approximately \$ 300,000

Project area .: Priority Areas:

- 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.

(6) Project No. 18

Project title : Assessment and strengthening the existing hydrological , hydrogeological and hydro-metrological monitoring networks and programmes.

Objectives:

- To strengthen the existing water data base particularly for the time dependent information, and to keep it up-to-date.
- To provide the required information for the proposed technical studies, and for the planning and management process.

Duration : 12 months

Execution: National and with the help of the Regional and /or international UN organizations and bodies concerned.

Cost : Approximately \$ 1,500,000

Project area :. 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.

7.2.4 Improved Management of Soils Programme (5.5.4)

(1) Project No.19

Project title : Soil and Water Conservation

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;
- train the Omani professionals in water and soil conservation.

Duration : 3 years

Execution: National and with the help of the Regional and /or international UN organizations and bodies concerned.

Cost : Approximately \$ 1,100,000

Project area :. Priority Areas will be selected in two different physiographical regions namely : plain and mountain areas

(2) Project No. 20

Project title: Soil Protection from Flooding in the Oasis, mountains Range

Objectives:

- To stop land degradation in the mountains areas.
- Preserve the soil from erosion and replace the eroded one.
- To protect irrigated land from wadi flood.
- Increase farmer income and reduce the movement of the rural inhabitants to cities.

Duration: 5 years

Executions: National and with help of the Regional or international UN organization and bodies concerned.

Cost: Approximately \$ 6,000,000

Project Area: All wadies area at different regions.

7.2.5 Appropriate and Improved Technologies Programme (5.5.5)

(1) Project No. 21

Project title : 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.

Objectives:

- To augment the presently exploited groundwater resources by using surplus, unused flood water.
- To help control sea water intrusion and improve the groundwater quality.

Duration : 2 years

Execution: National and with the help of the Regional and /or international UN organizations and bodies concerned.

Cost : Approximately \$ 4,500,000

Project area :. Al-Batinah plains

(2) Project No. 22

Project title : 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.

Objectives:

- To augment the presently exploited groundwater resources by using surplus, unused flood water.
- To help control sea water intrusion and improve the groundwater quality.

Duration : 2 years

Execution: National and with the help of the Sub-Regional ,Regional, and /or international UN organizations and bodies concerned.

Cost : Approximately \$ 1,500,000

Project area :. Salalah plains.

7.2.6 Public Participation Programme (5.5.6.)

(1) Project No. 23

Project title : Public awareness and participation

Objectives:

- To promote popular participation in programmes of desertification control.
- To increase public awareness and bring about a change in their perception of the desertification problem, causes and methods of control.

Duration : continuous – Phase I – 3 years

Execution: National and with the help of Regional and /or international UN organizations and bodies concerned.

Cost : Approximately \$ 250,000

Project area : nation wise

Note: The above objectives are best served by preparation of documentary material for extensive use in communications media e.g Radio and television.

7.2.7 Socio-economic Programme (5.5.7)

(1) Project No. 24

Project title : Assistance to farmers to increase productivity and conserve scarce water resource.

Objectives:

- To introduce improved irrigation methods for rationalization of water consumption in agriculture production.
- To achieve higher productivity.

Duration : 3 years

Execution: National and with the help of the Regional and /or international UN organizations and bodies concerned.

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

Project area : selected two different irrigated areas in two different regions .

(2) Project No. 25

Project title : Livestock and Meat Marketing

Objectives:

- Enhancement of livestock off-take through the identification of livestock and meat marketing constraints and formulation of programmes and projects to address constraints identified;
- Increased understanding of the local meat market situation and possibilities for increased local meat supply in relation to import.

Duration : one years

Execution: National and with the help of the Regional and /or international UN organizations and bodies concerned.

Cost : About \$ 120,000

Project area : Nation wise

(3) Project No. 26

Project title : Small scale milk processing units in the Jebel Area

Objectives:

- To help for eventual development of larger dairy industry in the Southern Region.

Duration : 2 years

Execution: National and Regional and /or international UN Agency(ies)

Cost : About \$ 520,000

Project area : selected Town in Southern Region.

(4) Project No. 27

Project title : Environmental Education for the young and the youth

Objectives:

- To positively influence the perception and attitudes of the young in favor of the environment in general and desertification control in particular.

Duration : Continuous; phase I : 3 years

Execution: National and with the help of the Regional and /or international UN organizations and bodies concerned.

Cost : About \$ 700,000

Project area : Nation wise

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

7.2.8 Supporting Actions Programme (5.5.8)

(1) Project No. 28

Project title : Establishment of a Computerized Water Data Bank, and Data Management System.

Objectives:

- Integration of water data which is being collected by various Ministries and agencies.
- To provide a base for a knowledgeable, and resourceful water resources management.

Duration : one years

Execution: National and with the help of the Regional, and /or international UN organizations and bodies concerned.

Cost : About \$ 250,000

Project Location : Minister of Regional Municipalities ,Environment and Water Resources

(2) Project No. 29

Project title : Establishment of Institutional set up for Desertification control.

Objectives:

- To set up the secretarial and technical arm of the NAP
- To establish the hierarchical networks for implementing the NAP

Duration : 6 months

Execution: National and with the help of the Regional and /or international UN organizations and bodies concerned.

Cost : About \$ 250,000

Project Location : Minister of Regional Municipalities ,Environment and Water Resources .

(3) Project No. 30

Project title : Regional Research Training and Communication Programme on Desertification Control in the ESCWA Region: Phase I

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.

Duration : 1-3 years

Execution: National and with the help of the Regional and /or international UN organizations and bodies concerned .

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

Project Location : Minister of Regional Municipalities ,Environment and Water Resources .

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 cost estimates are only orders of magnitude and should be up-dated.

(4) Project No. 31

Project title : Short-Term Advisory Service in Environment and Sustainable Development.

Objectives:

- To provide urgently heeded technical specialized advise in the review, evaluation and inter-relationships of pressing problems in environment and sustainable development.
- In particular, to provide required assistance while formulating NAP 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.

Duration : A total of 18 m/m during the short-term programme.

Execution: National and with the help of the Regional and /or international UN organizations and bodies concerned.

Cost : \$ 300,000

Project Location : Minister of Regional Municipalities ,Environment and Water Resources .

7.2.9 Assessment Of Desertification and Related Parameters Programme (5.5.9)

(1) Project No. 32

Project title : Vegetation survey and assessment of the current status of desertification.

Objectives:

- To identify the vegetation association or grouping composition and trend;
- To prepare vegetation cartography at the scale of 1/250000;
- To identify the potentialities of the vegetation.
- To undertake assessment of the current status of desertification including:
 - o The status of rural populations;
 - o The state of lands and physical causes of their degradation.
 - o The trends in local climate changes.
 - o Social, and economic causes of under development and the resulting immediate causes and processes of desertification.
- To provide the government with detailed and up-to-date information related to desertification.

Duration : 3 years

Execution: National and with the help of the Regional and /or international UN organizations and bodies concerned.

Cost : \$ 2,000,000

Project Location : Minister of Regional Municipalities ,Environment and Water Resources .

7.2.10 Insurance Against The Risk And The Effects Of Recurred Drought Programme (5.5.10)

(1) Project No. 33

Project title : Insurance against recurrent drought and famine In AL-Sharqiya and the Southern Regions.

Objectives:

- To develop a combination of protective measures operating on communal grazing , fodder farming , supplementary feed purchases , and opportunities for paid employment, to provide adequate protection and /or reserve in case of drought disaster.
- To develop and promote the use of modernized “Hema” system through various types of differed grazing and fodder banks.

Duration : 3 years

Execution: National and with the help of the Regional and /or international UN organizations and bodies concerned.

Cost : : About \$ 1,500,000

Project Area : AL-Sharqiya and the Southern Regions.

7.2.11 Regional and International Action and Cooperation (5.5.11)

(1) Project No. 34

Project title : Preparation of national priorities for action and financing.

Objectives:

- To organize a national workshop on the NAP.
- To consolidate national priorities for action and formulate project files for potential donors.

Duration : 6 months

Execution: National and with the help of the Regional and /or international UN organizations and bodies concerned.

Cost : : About \$ 0.25 million

Project Location : Minister of Regional Municipalities ,Environment and Water Resources .

7.3 Projects Presented in The Previous and Current Five Years Development Plans .

A survey of the projects in the previous and current Five-year Development Plans showed that there are tens of projects which would have been proposed with same or a slightly modified form in the NAP if they had not been already applied during the implementation of the Development plans.

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 these projects as relevant to the cause of land degradation and some perhaps to the issue of desertification control.

The titles of these projects are:

1. Grazing control project in Salalah
2. Support for intensive livestock production in Salalah .
3. Development of nurseries In Dhofar
4. Integrated agricultural Development project in Nejd
5. Support for the modern irrigation system in Muscat Governorate.
6. Aflaj repair and maintenance in Muscat Governorate.
7. Support for the modern irrigation systems in Dhofar.
8. Support and repair of the existing irrigation wells.
9. Aflaj feeding wells in A'Sharqiya.
10. Construction of recharging dam in Wadi-Hatta.
11. Construction of recharging dam in Wadi A'hin.

12. Preliminary and feasibility studies on proposed recharging dams.
13. Studying of the legal form of utilization of water for agriculture.
14. Monitoring and evaluation of the hydrological performance of recharging dams.
15. Erosion control and protection of agricultural land against floods.
16. Studying of the effectiveness of recharging water.
17. Special study for the implementation of the National Conservation Strategy.
18. Establishment of central laboratory for environment services.
19. Study on coastal erosion.
20. Environment awareness.
21. Rehabilitation and Upgrading of Meteorological Stations in Northern Oman.
22. Supply and Installation of Telemetry System in Northern Oman
23. Upgrade Monitoring Network in Salalah Area.
24. Assessment and Upgrade of National Monitoring Network in Oman
25. Utilization of Brackish Water
26. Construction of Recharge Dam at Mudha.
27. Construction of Recharge Dam at Wadi Mistal.
28. Construction of Recharge Dam at Wadi Bani Kharus.
29. Construction of Recharge Dam at Khab.
30. Construction of Recharge Dam at Wadi Imti.
31. Construction of Recharge Dam at Jabal Al Akhdar.
32. Study of Management of Water Needs.

If the First draft of NAP is accepted by the Government of Oman , the total number of projects in its service would jump from 33 listed in this chapter to over 53 when those projects titles in the Development Plans are taken into consideration.

7.4 Government Approval

When the government of Oman adopt the NAP and decides on all projects proposed in this chapter , assistance from Regional and /or International UN organizations and bodies concerned 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

(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 dry lands 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.

(2) The complete NAP 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 NAP and projects comprising, also four chapters: V to VIII.

3) The Background Section discussed on 2002 and 2003 with the Ministry of Regional Municipalities, Environment and Water Resources and the National Committee has been revised and included as Part I of this document .

4) For more relevance supplementary information on the status of desertification in Oman and on past and current efforts to combat desertification in Oman, these could be referred to chapter V through chapter VIII .

8.2 CONTENT OF THE NAP

(1) The draft NAP presented in chapters V, VI and VII gives the main outlines of two programmes – one for the long-term (2005-2020) and the other for the short-term (2005-2010). It also gives a fairly detailed description of institutional matters so that implementation of the NAP proceeds without difficulties or ambiguity.

(2) 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.

(3) The present NAP looks similar in its main aspects with NAP prepared for other countries. The reason being they are all prepared for dry land developing countries, mostly with an agricultural economic base but with sizeable constraints which hamper the effective use of available resources. The present NAP, 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 dry land developing countries, a poor country which will find difficulty in purchasing savior requirements when the country is hit with drought on top of desertification.

(4) Another departure from previous procedure is that recommended actions and proposed programmes and projects are related to the articles and annex II of the UNCCD

(5) Advisory services in environment and sustainable development are included in project No. 21.

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:

- 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.
- In Al Sharqiyah and Batinah Regions it is the 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:

- Rangeland management projects in Dhofar;
- Fighting salinity in Batina; and
- 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 document and programmes and projects in the NAP have been proposed with this in mind. The work on deferred grazing (Al-Shanfari, et. Al 1992) and destocking efforts were steps in the right direction. Several efforts – administrative, legislative and social in the use and management of irrigation water could on the whole be also considered steps in the right direction. A sort of loose package of projects have been suggested in the priority programme (2005-2010) in chapter VII.

8.4 FOLLOW-UP

8.4.1 The follow-up action required is primarily the responsibility of the Government of Oman.

8.4.2 The Government of Oman particularly the concerned sections in the Ministry of Regional Municipalities, Environment and Water Resources are expected to take subsequent steps to secure whatever assistance is required to implement the activities and programmes. In this respect, three steps seem to be essential.

1. **At the local level**, establishment of Local Focal Points (LFPs) will be assigned (from within the existing administrative structure). LFPs will act as catalysts and will be responsible for the organization of local discussion platforms bringing together the different stakeholders (municipalities, cooperatives, NGOs and other CBOs) to discuss relevant environmental issues and develop remedial and local development plans. These will be used for local level decision making and would be communicated to the National Coordination Body (NCB) through yearly reports. This will ensure that environmental considerations are taken into account at the local level and that a bottom-up communication channel is established. LFPs will also coordinate their efforts to deal with more regional aspects.

2. **At the national level**, a National Coordination Body (NCB), should be assigned and will be made up of representatives of the different line Ministries and relevant government institutions, such as Sultan Qaboos University, and research centers. The NCB is in charge of steering the UNCCD implementation process. In particular, it is responsible of the follow up.

3-In order to ensure full representation of all stakeholders, and an adequate technical backstopping on the various lines of action (water management, sustainable agriculture, socio-economics, etc.), the NCB would be supported by Technical Advisory Groups (TAG). These would be made up of researchers, development actors and NGO's. The NCB would act on the recommendations from the local level and from the technical advisory groups to define priorities and action plans. These would be communicated to decision making levels at the relevant Ministries and the Council of Ministers. The proposed institutional framework will ensure an efficient long-term implementation and follow up of the UNCCD and enhance horizontal and vertical linkages between the national and local levels and the different governmental and research institutions.

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 document 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 endeavor to control desertification.

8.4.2 The Government of Oman particularly the concerned sections in the Ministry of Regional Municipalities, Environment and Water Resources 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.

The Ministry of Regional Municipalities, Environment and Water Resources (MRMEWR) 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. The MRMEWR should pursue the matter to secure the approval of the Government for the draft NAP. The MRMEWR should pursue the establishment of the institutional machinery.

The MRMEWR staff recruited for the desertification control machinery can embark immediately on the identification of project proposals and selected areas where UN organizations and bodies 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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APPENDICES

APPENDIX I

Diagnostic Horizons Recognized in Oman during Soil Survey

1. Ochric epipedon : It is a light colored 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 grayer colors, or has lost part of its carbonates through leaching. In Oman the cambic horizon is 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 , Sub groups and Great Groups in Oman according to the latest soil survey

Out of the 12 orders that are defined by Soil Taxonomy, only 3 exist in Oman. These are 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 strogly sloping or in very gravelly sandy alluvial deposits.

- Toriorthents are Orthents that have a torric moisture regime as defined by Soil Taxonomy.
- 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 formatin. The proportional extent of 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 an Ustic moisture regime as defined by Soil Taxonomy.

Ustochrepts are Inceptisols that have a high saturation in exchangeable bases and have a warm temperature regime. They occur I the monsoon-affected humid areas of the Dhofar Regions. They usually occur o 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- Calciorthids (Haplocalcids or Petrocalcids) 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 o 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 (Haplogypsids or Petrogypsids) 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 (Haplocambids) 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 (Haplosalids or Aquisalids) are very salty soils 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	قرض
Acacia etbaica	صعب
Acacia tortilis	سمر (طلع)
Acacia senegal	هشاب (ثمر)
Anogeissus dhofarica	سغات
Adenium obesum	اسفيد
Adansonia digitata	انكيجي
Acridocarpus orientalis	اثبوت
Azima tetracantha	ظيشي
Allophylus rubifolius	زركين
Boswellia sacra	مغيروت
Blepharis dhofarensis	عليوب
Boscia arabica	سبر
Blepharispermum hirtum	خفوت
Carissa edulis	فلق
Calatropis procera	عطب
Cordia perrottettii	شبحيط
Commiphora foliacea	عقبا
Commiphora gileadensis	شفوف
Commiphora hebensinica	عقر
Commiphora wightii	عقريت
Capparis cartilaginea	لوصف
Croton confertus	حور
Caesalpinia erianthera	قبطير
Cissus quadrangularis	عطراء
Cordia pupurea	سحل
Cordia Spp	عينيت
Dracaena serrulata	عيروب
Delonix viscosa	ارير
Dodonea viscosa	شيراز
Dyerophytum indicum	ملحج
Euphorbia cactus	طشوق
Euphorbia chimperi	زغر
Euphorbia smithii	أمبطوت
Euphorbia schimperi	هيشنوت
Ficus carica	كيليت
Ficus salicifolia	ايلوس
Ficus sycamorus	أثيب
Ficus vasta	غيضيت
Ficus carica	طيق

Scientific Name	Local Name
Flueggea virosa	أنف
Ficus lutea	ظريفيت
Hildebrandtia africana	اطبين
Hybanthus durus	اطبين
Hypoeste forskalei	اروت
Jatropha dhofarica	زبرات
Jasminum grandiflorum	مطبب
Lanea triphylla	اينور
Lawsonia inermis	حينا
Maerua crassifolia	سبر شحريت
Maytenum dhofarensis	شربيت
Nannorrhops ritchieana	عرفيت
Olea europaea	ميطان
Ormocarpum dhofarense	خير
Pavetta longiflora	عاصبيص
Ricinus communis	عشعشة
Rhus somalensis	زريفيت
Ruttya fruticosa	مغيف
Salvadora persica	ايهريك
Sansevieria ehrenbergii	شوبتا
Sterculia africana	اكثورة
Solanum incanum	حلقوت
Tamarindus indica	صبار
Woodfordia uniflora	طوب
Ziziphus leucodermis	حيضيت
Ziziphus spina-christi	ضيد - (علب)

Source: Al-Khuthairi (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 Tonnes	Dry Weight / ha	% 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. Quairoon 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	200 – 250	1.6 + 0.3	3.4 + 0.3	113
Range Average		0.7 + 0.1 – 3.8 + 0.6 2.139	1.4 + 0.3 – 9.4 + 0.8 3.872	11-395 81