No.

Japan International Cooperation Agency (JICA)
Ministry of Regional Municipalities, Environment and Water Resources (MRMEWR)
The Sultanate of Oman

THE MASTER PLAN STUDY ON RESTORATION, CONSERVATION AND MANAGEMENT OF MANGROVE IN THE SULTANATE OF OMAN

Final Report

Vol. 1 Main Report

July 2004

Pacific Consultants International
Appropriate Agriculture International Co., Ltd

G E
JR
04-035

Japan International Cooperation Agency (JICA)
Ministry of Regional Municipalities, Environment and Water Resources (MRMEWR)
The Sultanate of Oman

THE MASTER PLAN STUDY ON RESTORATION, CONSERVATION AND MANAGEMENT OF MANGROVE IN THE SULTANATE OF OMAN

Final Report

Vol. 1 Main Report

July 2004

Pacific Consultants International
Appropriate Agriculture International Co., Ltd

The exchange rate applied in this study is
R.O.1=JPY275.9 (As of January 2004)

PREFACE

In response to a request from the Government of the Sultanate of Oman, the Government of Japan decided to conduct the study to develop the master plan for restoration, conservation and management of mangrove in the Sultanate of Oman.

JICA selected and dispatched the study team headed by Mr. Tadashi Kume of Pacific Consultants International and consisting of Pacific Consultants International and Appropriate Agriculture International Co., Ltd. to Oman between June 2002 and July 2004.

It is with great pleasure that I acknowledge the close collaboration between the Ministry of Regional Municipalities, Environment and Water Resources and the JICA study team, which resulted in the formulation of the master plan.

I strongly wish that this master plan, formulated with under the strong initiative of the Ministry of Regional Municipalities, Environment and Water Resources, will contribute to the restoration, conservation and management of mangroves in the Sultanate of Oman.

Finally, I wish to express my sincere appreciation to all the officials concerned of the Government of Oman for their cooperation and support extended to the team.

July 2004

Etsuo Kitahara
Vice President
Japan International Cooperation Agency

Mr. Etsuo KITAHARA July 2004
Vice President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

Dear Sir,

We are pleased to formally submit herewith the Final Report of "The Master Plan Study on Restoration, Conservation and Management of Mangrove in the Sultanate of Oman."

This report compiles the results of the study, which was conducted from June 2002 through July 2004 by the study team organized by Pacific Consultants International and Appropriate Agriculture International Co., Ltd. under the contract with JICA.

The study team compiled this report, which proposed the future conservation and management scenario and master plan up to 2024, and short-term, medium-term, and long-tem action plans up to 2006, 2009, and 2014 respectively, through close consultations with officials of the Ministry of Regional Municipalities, Environment and Water Resources and other authorities concerned.

We would like to express our sincere gratitude and appreciation to the officials of your agency and the JICA advisory committee. We also would like to send our great appreciation to all those who extended their kind assistance and co-operation to the study team, in particular to the Ministry of Regional Municipalities, Environment and Water Resources and regional officials concerned.

We hope that the master plan will be able to contribute significantly to the development of the mangrove conservation and management system in Oman.

Very truly yours,

Tadashi KUME
Team Leader,
The Master Plan Study on Restoration, Conservation and Management of Mangrove in the Sultanate of Oman

Abbreviations

CAD	Computer-Aided Design
COD	Chemical Oxygen Demand
DG	Director General
DO	Dissolved Oxygen
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
GCC	Gulf Co-operation Council
GIS	Geographical Information System
GOJ	Government of Japan
GOO	Government of Oman
GPS	Geographical Positioning System
HTML	Hypertext Makeup Language
IUCN	International Union for the Conservation of Nature and Natural Resources (The World Conservation Union)
JICA	Japan International Cooperation Agency
MAF	Ministry of Agriculture and Fisheries
MCI	Ministry of Commerce and Industry
MD	Ministerial Decision
MPCZMS	Marine Pollution and Coastal Zone Management Section
MPEC	Mangrove Plantation Experimental Centre
MRMEWR	Ministry of Regional Municipalities, Environment and Water Resources
NR	Nature Reserve
QEIC	Qurm Environmental Information Centre
RA	Recreation Area
RD	Royal Decree
RDA	Recreational Development Area
ROPME	Regional Organisation for the Protection of the Marine Environment
RTK	Real Time Kinematics of Oman
SQU	Sultan Qaboos University
SR	Scenic Reserve
UAE	United Arab Emirates
UNESCO	United Nations Educational, Scientific and Cultural Organisation

English Spelling of Place-names in the Report

There were some difficulties in writing in English the Arabic names for the Region/Governorate, Wilayat, Locality and Study Sites. One place was spelled in different ways in official documents and maps in Oman. In order to avoid any misunderstanding, all the names in English have been standardised based on discussion between the JICA Study Team and the Omani Counterpart team. The "Socio-Economic Atlas, Ministry of Development, Information & Documentation Centre, November 1996" provided by the Ministry of National Economy has been used for the names of the Region/Governorate, Wilayat, Locality, while the "Map of the Sultanate of Oman" prepared by NSA (National Survey Authority) has been used for the Study Site names as follows:

Governorate/Region	Wilayat	Locality	Study Site	Zone
1. Governorate of Muscat	1. Mutrah	Murtafaat Al Qurm	5. Khawr Qurm	Muscat
	5. Muscat	Al Khayran	6. Bandar Khayran	
	6. Qurayyat		7. Qurayyat	
2. Al Batinah Region	3. Shinas	Tarif Al Makhamrah	1. Khawr Shinas	Batinah
	4. Liwa	Harmul	2. Khawr Harmul/Nabr	
	12. Al Barka	Al Sawadi As Sahil	3. Khawr Sawadi	
		Al Haradi	4. Khawr Haradi	
6. Ash Sharqiyah Region	1. Sur	Sur	8. At Tina 9. Batah	Sharqiyah
		Ras Al Had	10. Khawr Quq 11. Khawr Hajar - East Shore	
	11. Masirah		12. Wadi Muraysis	Wusta
7. Al Wusta Region	2. Muhut	Falam	13. Filim - Eastern Beach	
		Jazirat Muhut	14. Mahawt Island	
8. Governorate of Dhofar	1. Salalah		18. Khawr Dahariz	
			19. Khawr Balid	
			20. Khawr Kabir	
			21. Khawr Saghir	
	3. Taqah	Taqah	17. Qurm Taqah	
	4. Mirbat		15. Al Demer Beach	
			16. Khawr Rowri	Dhofar

Composition of the Reports

This report presents all results of the studies conducted during the studies in Japan and Oman. The Report consists of the following:

- Volume 1: Main Report
  - Part 1: Master Plan Study
  - Part 2: Appendix
- Volume 2: Technical Specifications of Afforestation, Conservation and Management

ABSTRACT

Introduction

The Sultanate of Oman has a coastline of approximately 3,000 km, which was thought extensively being covered by mangroves in the past. However, mangroves conceivably have been decreasing due to deforestation for firewood, grazing, and other factors related to human activities. At present, there are mangroves in Northern Batinah, Capital area (Muscat), Eastern Sharqiyah, Mahawt Island and Salalah. The current forest cover of mangroves in Oman is estimated at 1,100 ha.

Although mangroves were planted in Oman twice, this did not bring concrete results owing to the lack of technical knowledge and skills for mangrove afforestation. Hence, the Government of Oman (hereinafter referred to as "GOO") requested technical co-operation from the Government of Japan (hereinafter referred to as "GOJ"). In response to the request, the GOJ decided to conduct a Master Plan Study on Restoration, Conservation and Management of Mangrove in the Sultanate of Oman (hereinafter referred to as "the Study"). The objectives of the Study were set as follows:

(1) To formulate a master plan on restoration, conservation and management of mangroves, comprising site-specific plans in the priority sites as well as public awareness programmes, based on the natural and socio-economic characteristics of the mangroves sites. The master plan shall also cover a capacity building programme for the parties concerned covering restoration, conservation and management of mangrove.

(2) To transfer the relevant technology to the assigned counterpart personnel through on-the-job training in the course of the Study.

The JICA Study Team held meetings with the Omani side and an agreement was reached in July 2002 on the proposed study area and sites for the Study. In December 2002, the Omani side requested that Duqm site be deleted because of port development. Thus, the study area covers 15 sites consisting of 21 khawrs/ islands.

Zoning of Coastal Area in Oman

As a result of the survey on existing conditions covering geographical features, climate, wind/ wave and economic activity/ land use, it was decided that the study areas should be categorised into the following 5 zones.

- Batinah Zone
- Muscat Zone
- Sharqiyah Zone
- Wusta Zone (including Masirah Island)
- Dhofar Zone

Value of Mangrove

The main values of mangrove in Oman consist of non-consumptive use, indirect use and non-use. The function to maintain biodiversity is one of the most important values in Oman. From the worldwide biological point of view, Oman plays a very important role in providing a connection for wildlife between Africa and Asia. In the Study, this point was considered carefully.

Mangrove in Oman comprises one species and also is spread on a very small scale. Therefore, the value of mangrove ecosystem in Oman is limited mainly to that of the resources for tourism/ recreation, education, heritage, scientific research, and the maintenance of biodiversity. Nonetheless, its value as greenery is particularly significant for this "desert country".

Issues and Strategy

The current situation in Oman is that many natural habitats, including those of mangrove lagoons and other khawrs (*khayraan*), are subject to damage from rapid development; they are not being "left alone" and thus **active management measures** are essential. In particular, **protective management measures** are required to manage/ control those development activities, in order to minimise their impact. In addition, **creative management measures** (such as rearing and planting of mangrove seedlings) are also necessary in order (i) to mitigate existing damages and (ii) to create new mangrove habitats for their support to the conservation of biodiversity and their direct and indirect role in providing exploitable natural resources.

Therefore, in simple terms, the overall strategy for the "restoration, conservation and management of mangroves" has two separate approaches:

- **Protective Management Measures** that ensure the security of existing mangrove ecosystems from inappropriate development activities and management practices.
- **Creative Management Measures** that create new mangrove ecosystems at appropriate locations, and that enhance existing mangrove ecosystems, primarily by plantation of mangrove seedlings.

Furthermore, it is indispensable for institutions and personnel to be able to carry out effective **protection** and **creation** activities for mangrove habitats. Therefore, some **Supporting Measures** to rectify the lack of trained Omani personnel and to provide easy-to-use information storing/ sharing systems and other facilities, and so on are also required to deal with these issues.

Mangrove Conservation and Management

It is highly desirable to conserve and manage mangrove ecosystems and other coastal areas for the benefit of present and future Omani generations. The following legal instruments and measures are among those which may be required for successful conservation and management; some are already in place:

- Arrangement of laws and regulations related to the conservation activities
- Execution of patrol and enforcement
  - Daily patrol by police of each Wilayat
  - Inspection of facility conditions and waste disposal on the ground and water by implementing agency of conservation and management
- Establishment of signs and information boards (direction signs, guide signs and information boards for visitors, etc.)
- Implementation of restoration and rehabilitation work
- Implementation of public awareness programmes such as education and campaigns
- Plantation of new mangrove areas
- Maintenance of nursery and facilities
- Implementation of monitoring activities

Conservation of natural environment as well as restoration of plantation areas should be implemented at various levels of administration, organisations and peoples of Oman. Participation and co-ordination of all relevant agencies and peoples are most important for effective conservation activities. The establishment of the Qurm Environmental Information Centre (QEIC) will provide the opportunity to coordinate activities for all people and organisations.

QEIC will carry out the following activities.

- Establish an information and monitoring centre to collect and compile necessary information and data concerning conservation and management of the mangrove forests in Oman.
- Provide necessary facilities and materials for implementation of public awareness and education programmes on mangrove and coastal environment for school children as well as residents, visitors, and tourists.
- Co-operate with or assist those who study and investigate mangrove and the coastal environment of Oman.
- Train personnel engaged in the activities concerning mangrove ecosystem conservation.

Action Plan

After deliberate consideration, the Study proposes the 33 projects and programmes as follows:

Type of Projects and Programmes	No. of Projects and Programmes
1. Legal Set up Programme	3
2. Stakeholder Co-ordination Programme	1
3. Facility Development Control Programme	1
4. Facility Development Project	8
5. Restoration and Afforestation Project	4
6. Monitoring Programme	9
7. Public Awareness Programme	5
8. Implementation Programme of Further Study	2
Total	33

These projects and programmes are to be implemented to form the basic framework and core roles of the Master Plan. The implementation schedule of the projects and programmes are divided into the following three terms:

- Short term (2 years): Up to 2006
- Mid term (5 years): Up to 2009
- Long term (10 years): Up to 2014

Detailed implementation plan for each project/ programme is compiled as the Technical Specifications for each study site included in this study.

For the implementation of these projects/ programmes, quick response to set up institutional arrangement is the most important matter. It is especially urgent to implement the institutional arrangements for QEIC. The cost for these projects/ programmes is estimated at about R.O. 4.5 million.

Final Report
Vol. 1 Main Report

Table of Contents

List of Tables

List of Figures

PART 1: MASTER PLAN STUDY

Chapter 1: Introduction

1. Introduction

1.1 Foreword

In response to the request of the Government of the Sultanate of Oman (hereinafter referred to as "GOO"), the Government of Japan (hereinafter referred to as "GOJ") decided to conduct a Master Plan Study on Restoration, Conservation and Management of Mangrove in the Sultanate of Oman (hereinafter referred to as "the Study"), together with GOO in accordance with the relevant laws and regulations in force in Japan.

Accordingly, the Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of the technical co-operation programmes of the GOJ, undertook the Study in close co-operation with the authorities concerned with the GOO.

1.2 Background of the Study

The Sultanate of Oman has a coastline of 3,165km, which was thought extensively being covered by mangroves in the past. However, mangroves have been decreasing due to deforestation for firewood, grazing, and other factors related human activities. At present, there are mangroves in Northern Batinah, Capital area (Muscat), Eastern Sharqiyah, Mahawt Island, and Salalah. The current forest cover of mangroves in Oman is estimated at 1,100 ha.

The related sections in the Ministry of Regional Municipalities, Environment and Water Resources (MRMEWR), and the Sultan Qaboos University (SQU) have carried out fundamental research on mangrove. The mangrove ecosystem has some important functions such as protection against erosion, cultivation of fishery resources, preservation of biodiversity, and tourism resources. The socio-economic importance and vulnerability of the mangrove ecosystem are described in the Coastal Zone Management in Oman (1991), in which the management system for mangroves is planned. The mangrove ecosystem of Oman is one of the important elements of the coastal zone. Although mangroves were planted in Oman twice, this did not bring concrete results owing to the lack of technical knowledge and skills for mangrove afforestation.

The Government of Japan (GOJ) dispatched an expert for mangrove afforestation to the MRMEWR in April 2000, and the afforestation of *Avicennia marina* and technical transfer for the staff in MRMEWR has been implemented.

In this situation, the Government of Oman (GOO) requested technical co-operation from the GOJ. Japan International Cooperation Agency (JICA) dispatched a preparatory study team in February 2002 and made an agreement on the scope of work with the MRMEWR of the GOO on 5 February 2002.

1.3 Study Objectives

The objectives of the Study were set as follows:

(1) To formulate a master plan on restoration, conservation and management of mangroves, comprising site-specific plans in the priority sites as well as public awareness programmes, based on the natural and socio-economic characteristics of the mangroves sites. The master plan shall also cover a capacity building programme for the parties concerned with restoration, conservation and management of mangrove.

(2) To transfer the relevant technology to the assigned counterpart personnel through on-the-job training in the course of the Study.

1.4 Study Area and Study Site

At the Scope of Work stage of this Study, it was decided that the study area should cover 16 sites, consisting of 21 khawrs (khawr is an Arabic word for wadi estuary and lagoon, including both with and without mangrove) including their surrounding coastal areas along the Batinah Coast, Muscat, Qurayyat, Sharqiyah, Masirah - Mahawt - Duqm and Dhofar (Salalah Coast) in the Sultanate of Oman as shown in Appendix 1.1. The names of the 16 sites with mangrove (hereinafter referred to as "mangrove sites") and without mangrove (hereinafter referred to as "potential khawrs") are shown in Appendix 1.2.

At the beginning stage of the Study, the JICA Study Team met the Counterpart Team to discuss the study area and study sites. In this meeting, the following points were made.

- decision on specific study sites
  - Barka (2 Khawrs)
  - Suwaiq (2 Khawrs)
  - Salalah (4 Khawrs)
- confirmation of the potential of mangrove afforestation at the sites 'Potential Khawrs,' which were selected at the Scope of Work for this Study,
- confirmation of the intention for each area,
- inspection of the characteristics of each area.

From the end of June to the beginning of July in 2002, the JICA Study Team carried out the quick survey at 47 sites including 21 sites decided in the Scope of Work. The results of this quick survey are shown in Appendix 1.3. The main points of the survey are as follows:

- some 'Potential Khawrs' are not suitable for mangrove afforestation,
- some important sites are not included in the study sites (such as Qurm, which has a nursery and is a candidate site for the Mangrove Information Centre, and Harmul, which is one of most important sites of existing mangroves),
- related agencies in Wusta Region strongly requested to JICA Study Team to implement the mangrove afforestation in the Mahawt Island and Filim area as fishery is a main industry in this region,
- related agencies in Dhofar Governorate strongly requested to JICA Study Team to establish plans not only for the mangrove area in conjunction with a wider area, such as basin management plan and coastal management plan.

The JICA Study Team held the meetings with the Omani side and an agreement was reached in July 2002 on the proposed study area and sites for the Study. In December 2002, the Omani side requested that Duqm site be deleted because of port development. Thus, the study area covers 15 sites consisting of 21 khawrs/ islands as shown in Figure 1.4.1 and Table 1.4.1.

Table 1.4.1 List of Study Area/Site

Study Area		Mangrove Area (ha)
Study Site	Study Khawr/ Island	
1. Shinas	1. Khawr Shinas	53
2. Liwa	2. Khawr Harmul & Nabr	56
3. Sawadi	3. Khawr Sawadi	0
4. Barka	4. Khawr Haradi	0
5. Qurm	5. Khawr Qurm	74
6. Bandar Khayran	6. Bandar Khayran	83
7. Qurayyat	7. Qurayyat	80
8. Sur	8. At Tina	0
	9. Batah	58
9. Ras Al Had	10. Khawr Quq	0
	11. Khawr Hajar – East Shore	0
10. Masirah Island	12. Wadi Muraysis	0
11. Filim	13. Filim – Eastern Beach	10
12. Mahawt Island	14. Mahawt Island	162
13. Salalah (4 Khawrs)	15. Al Demer Beach	0
	16. Khawr Rowri	0
14. Salalah (Taqah)	17. Qurm Taqah	1.6
(13. Salalah (4 Khawrs))	18. Khawr Dahariz	0
	19. Khawr Balid	0
15. Salalah (Khawr Kabir & Khawr Saghir)	20. Khawr Kabir	4.2
	21. Khawr Saghir	1.7

Source: "Status of Mangrove Resources in the Sultanate of Oman (Moustafa M. Fouda, 1995)"

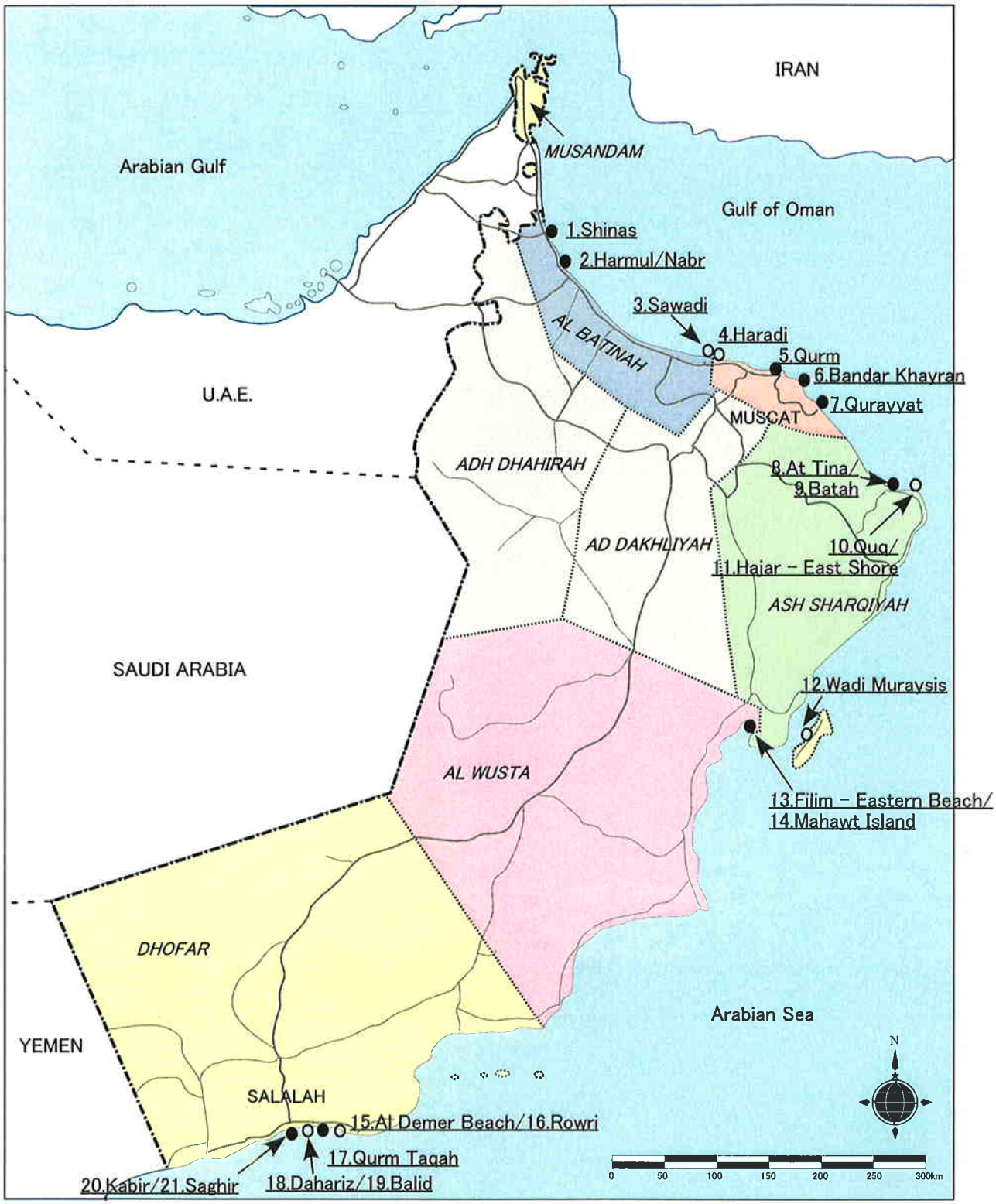

Figure 1.4.1 Study Area/Site

1.5 Study Organisation

The Study was carried out by the JICA Study Team, which closely collaborated with the Omani counterpart organised by the GOO. The Steering Committee was organised for the implementation of the Study. At large, the Omani counterpart played a core role for the Study, and the Steering Committee actively interacted with the Study Team, which helped increase their sense of ownership towards the Project.

Figure 1.5.1 shows the overall study organisation whereas names and assignments/titles of the Steering Committee, JICA Advisory Committee, JICA Study Team, and Omani Counterpart Team are listed in Table 1.5.1 ~ Table 1.5.4.

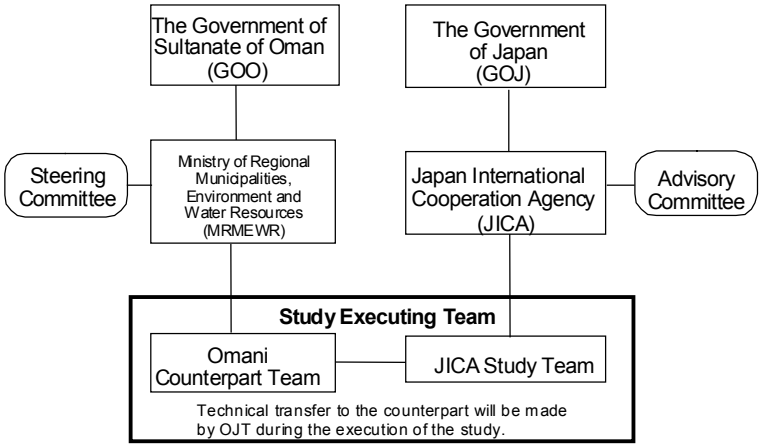

Figure 1.5.1 Overall Study Organisation

Table 1.5.1 Members of the Steering Committee

	Title	Name
1	Chair/ D.G. for Environmental Affairs, MRMEWR (Jun. 2002 ~ Mar. 2003)	Mr. Mohammed Bin Khamis Al-Araimi
2	Chair/ D.G. for Environmental Affairs, MRMEWR (Mar. 2003)	Mr. Mohammed Bin Abdullah Al-Muharrami
3	D.G. for Nature Conservation and Biodiversity, MRMEWR	Mr. Ali Bin Amer Al-Kiyumi
4	Deputy D. G. of Fisheries, Ministry of Agriculture & Fisheries	Mr. Ibrahim Al-Busaidi
5	Marine Science and Fisheries Centre, Ministry of Agriculture & Fisheries	Ms. Lamiya Bint Sinan Al Kiyumi
6	Department of Marine Science and Fisheries, College of Agricultural and Marine Science, Sultan Qaboos University (Jun. 2002 ~ Aug. 2003)	Dr. Peter Cookson
7	Department of Marine Science and Fisheries, College of Agricultural and Marine Science, Sultan Qaboos University (Aug. 2003 ~)	Dr. Hamd Al Oufi
8	Department of Marine Science and Fisheries, College of Agricultural and Marine Science, Sultan Qaboos University (Aug. 2003 ~)	Dr. Malik Al Wardi
9	Director of Afforestation & Parks, Muscat Municipality	Mr. Mohammed Bin Gharib Al Kishri
10	Ministry of Culture and National Heritage	
11	Adviser for Conservation of the Environment, Diwan of Royal Court	Dr. Andrew Spalton

Table 1.5.2 Members of the JICA Advisory Committee

	Assignment	Name
1	Team Leader/Mangrove Plantation Technique	Mr. Yoshihisa SETO
2	Coastal Environment	Mr. Nobuo ICHIHARA
3	Regional Society	Mr. Hisao USHIKI
4	Ecological Conservation	Prof. Ken YOSHIKAWA

Table 1.5.3 Members of the JICA Study Team

	Assignment	Name
1	Team Leader/Regional Development Plan	Mr. Tadashi KUME
2	Deputy Team Leader/Monitoring/Administration/Organisation	Mr. Osamu ISODA
3	Mangrove Afforestation-1	Mr. Chiharu MIYAMOTO
4	Mangrove Afforestation-2	Dr. Robert WHITCOMBE
5	Ecosystem	Dr. Nicholas CLARKE
6	Fishery	Mr. Motohiro OHASHI
7	Soil/Water Analysis	Mr. Yoshihisa ZAITSU
8	Social-Economy/Ethnology	Dr. Nahoko NAKAZAWA
9	Land Survey/GIS/Remote Sensing-2	Mr. Manabu KAWAGUCHI
10	GIS/Remote Sensing-1	Mr. Hiroyasu OHNUMA
11	Facility Design	Mr. Kenji ASAKAWA
12	Administration (Jun. 2002 ~ Feb. 2003)	Mr. Motohiro YASUHISA
13	Administration (Mar. 2003 ~)	Mr. Ryo HAMAGUCHI

Table 1.5.4 Members of the Omani Counterpart Team

	Title	Name
1	D.G. for Environmental Affairs, MRMEWR	Mr. Mohammed Bin Abdullah Al-Muharrami
2	Deputy D.G. for Environmental Affairs, MRMEWR	Mr. Ibrahim Bin Ahmed Al-Ajmi
3	Head of Marine Pollution & Coastal Zone Management Section, MRMEWR	Mr. Musallam Bin Mubarak Al-Jabri
4	Environmental Inspector, Marine Pollution & Coastal Zone Management Section, MRMEWR	Mr. Mohammed Khamis Saif Al-Mazaiyani
5	Environmental Specialist, Marine Pollution & Coastal Zone Management Section, MRMEWR	Ms. Thrraya Al-Sariri
6	Environmental Technician, Marine Pollution & Coastal Zone Management Section, MRMEWR	Mr. Bader Al-Balushi
7	Environmental Technician, Marine Pollution & Coastal Zone Management Section, MRMEWR	Mr. Adel Al-Omari
8	Marine Expert, Marine Pollution & Coastal Zone Management Section, MRMEWR	Dr. Barry P. Jupp
9	Environmental Adviser, Marine Pollution & Coastal Zone Management Section, MRMEWR	Dr. Vanda Mendoca
10	Remote sensing specialist, GIS Section, MRMEWR	Mr. Addulaziz Abdulla Sulaiman Al Balushi
11	Remote sensing specialist, GIS Section, MRMEWR	Mr. Saleh Sulaiman Mahammed Al Adhary

1.6 Schedule of the Study

The Study comprised the following study tasks. The basic work flow is shown in Figure in 1.6.1.

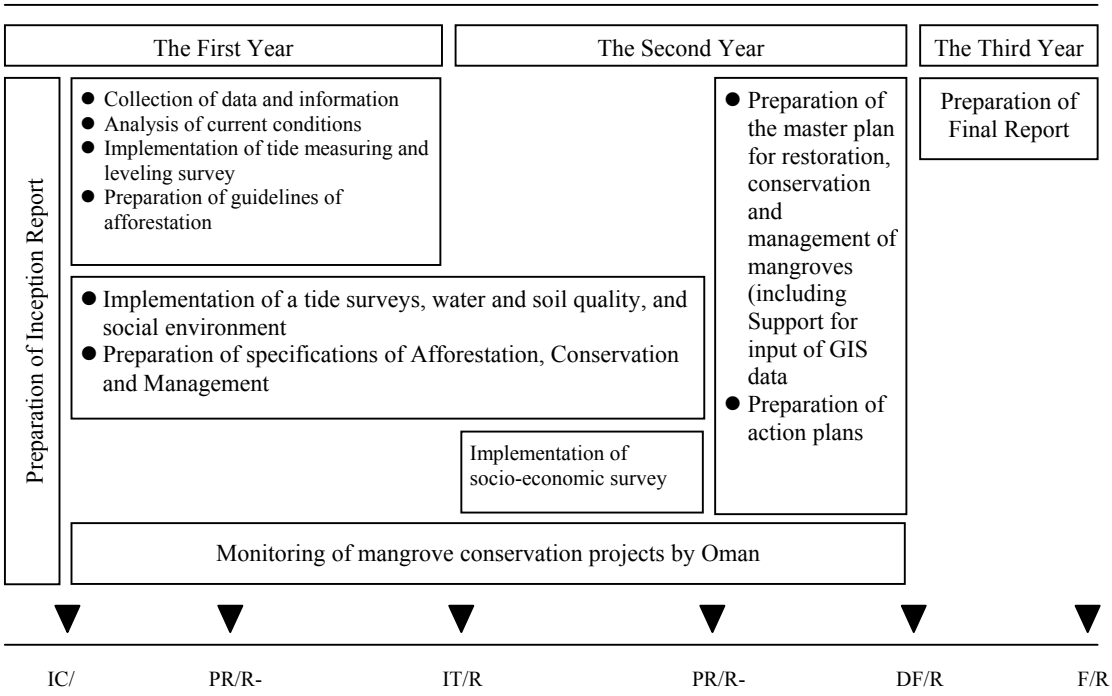

Figure 1.6.1 Work Schedule

1.7 Other Activities for the Study

1.7.1 Support for Input of GIS Data

a. Preparation of GIS

In order to organise the information collected during the current master plan study, a GIS was prepared mainly based on the survey data on topography, mangrove trees, soil property and water quality. This system can be utilised as baseline data for the future monitoring practice. This is therefore including various information such as survey results, panoramic views of remarkable points and the photographs of selected monitoring trees for all survey sites. Monitoring data should be added to this system for observing the changes of selected environmental elements. The system should thus be developed along with the availability of survey data during the monitoring period. For the effective sharing of the information, it is recommended to upload the system to Internet through IMS (Internet Map Server) as a future programme.

b. Structure of GIS

ArcView (Version 3.2) was selected as the most prevailing GIS software for the operation of the system. All the information collected during the study was stored in the following manner.

Main Directory	Sub-Directory		Files
C:¥mangrove	¥project		Project files for each mangrove site and the distribution of all sites prepared by ArcView
	¥image		Geo-referenced remote-sensing image for each site based on Ikonos or LandSat Image
	¥data	¥existingforest	Polygon data of existing mangrove forest prepared by the GIS section
		¥general	General information on administrative border, population, road network and major towns
		¥faunaflora	Description of present condition on fauna, flora and pollution for each mangrove site
		¥mapdata	Topographic survey data prepared under the subcontract of master plan study
		¥panoramadata	Photographs of panoramic view taken at the remarkable points in each site
		¥sitephoto	Photographs of each site on general condition, mangrove condition and soil condition
		¥soildata	Results of soil analysis such as texture, colour, hardness of sample soil and underground water condition
		¥soilprofile	Description of soil profile for typical soil pits in each site
		¥treedata	Results of tree survey such as height, diameter and remarks on each sample tree
		¥treephoto	Photographs of distant and near view of sample trees selected for future monitoring
		¥waterdata	Results of water analysis such as colour/visibility, pH, salinity, temperature, DO, COD and NO_3

1.7.2 The Results of the Sub-contract Survey

a. Tide Measuring and Levelling Survey

With respect to the tide measuring and levelling survey, subcontract was concluded and field identification has been conducted at 22 survey sites in the following manner.

With respect to tide measuring, tide level at the standard port adjacent to each survey site has been established using “Tide Table of Oman, 2002 edition”, based on the chart datum established by Oman National Hydrographic Office. In addition, measurement was made every hour continuously for 24 hours. The results of tide measuring are shown in the following table.

No.	Site Name	All heights in metres above CD*1			*MHHW above MSL*	Derived From
		MSL *2	MHHW *3	*MLLW* *4		
1	Shinas	2.10	2.67	0.83	0.57	Saham/Ras Dillah
2	Liwa	2.10	2.67	0.83	0.57	Saham/Ras Dillah
3	Sawadi	1.86	2.62	0.93	0.76	Sawadi
4	Barka – Khawr Haradi	1.86	2.62	0.93	0.76	Sawadi
5	Khawr Qurm	1.96	2.84	1.01	0.88	Marsa Al Murjan
6	Bandar Khayran	1.84	2.64	0.91	0.80	Bandar Jissah
7	Qurayyat	1.89	2.27	0.63	0.38	Daghmar
8/9	Sur – all 5 sites	1.77	2.57	0.83	0.80	Qalhat
10	Ras Al Had – Khawr Quq	1.67	2.27	0.93	0.60	Khawr Al Hajar
23	Ras Al Had – Khawr Hajar	1.67	2.27	0.93	0.60	Khawr Al Hajar
25	Masirah	1.79	2.36	0.75	0.57	Ras Hilf/Rounders Bay
29	Filim	1.79	2.56	0.80	0.77	Mahawt
31	Mahawt	1.79	2.56	0.80	0.77	Mahawt
32	Duqm	1.71	2.36	0.70	0.65	Sirab
35	Dhofar – Khawr Rowri	1.30	1.68	0.65	0.38	Port Salalah
37	Dhofar – Qurm Taqah	1.30	1.68	0.65	0.38	Port Salalah
43	Dhofar – Khawr Dahariz	1.30	1.68	0.65	0.38	Port Salalah
44	Dhofar – Khawr Balid	1.30	1.68	0.65	0.38	Port Salalah
45	Dhofar – Khawr Kabir	1.30	1.68	0.65	0.38	Port Salalah
46	Dhofar	1.30	1.68	0.65	0.38	Port Salalah

*1: CD; Chart Datum, *2: MSL; Mean Sea Level, *3: MHHW; Mean Higher High Water, *4: MLLW; Mean Lower Low Water

With regard to the levelling survey, it installed the following new control points for each survey site, on the basis of existing control points of Oman National Survey Bureau. Surveys method adopted "Real Time Kinematics (RTK)", using GPS, in order to efficiently comprehend the coastal landform. The results of the survey will also be used as GIS base maps after converting to a digital topographic map, using CAD software. The results of the levelling survey are shown in the following table.

No.	Site Name	Existing Survey Control Stations	New Survey Control Stations
1	Khawr Shinas	986-56, BKS-83054, BM-03	1680-09
2	Khawr Harmul and Nabr	NSA-4076, PGM-014	1680-07, 1680-08
3	Khawr Sawadi	NSA-1006, 85-1-034, JT-71, 85-1-035, 85-1-036	1680-03, 1680-04
4	Khawr Haradi	968-06, BM-01	1680-05, 1680-06
5	Khawr Qurm	NSA-1008, 1386-03	1680-33, 1680-34
6	Bandar Khayran	1652-05, BM-02	1680-01, 1680-02
7	Qurayyat	NSA-1012	1680-21, 1680-32
8 / 9	Sur-Site 1	NSA-1015, BM-921	1680-22
8 / 9	Sur-Site 2	NSA-1015, BM-921	1680-23,
8 / 9	Sur-Site 3	NSA-1015, BM-921	1680-24
8 / 9	Sur-Site 4	NSA-1015, BM-921	1680-25, 1680-28
8 / 9	Sur-Site 5	NSA-1015, BM-921	1680-26
10	Ras Al Had - Khawr Quq	NSA-1015, BM-1	1680-27, 1680-30
23	Ras Al Had - Khawr Hajar	NSA-1015, BM-1	1680-29
25	Masirah Island - Wadi Muraysis	NSA-1085	1680-10, 1680-11, 1680-12
29	Filim – Eastern Beach	MWR94149	1680-13
31	Mahawt	MWR94149	1680-14
32	Sabkha A'Duqm	NSA-1079, MOF89009, MOF89008	1680-31
35	Dhofar - Khawr Rowri	NSA-5007, NSA-5184	1680-20
37	Dhofar - Qurm Taqah	NSA-5007, NSA-5184	1680-19
43	Dhofar - Khawr Dahariz	NSA-5007, NSA-5184	NSA-5303
44	Dhofar - Khawr Balid	NSA-5007, NSA-5184	1680-17
45	Dhofar - Khawr Kabir	NSA-5007, NSA-5184	1680-16
46	Dhofar - Khawr Saghir	NSA-5007, NSA-5184	1680-15

b. Topographic Survey in Khawr Qurm

The subcontracted survey for detailed topographic survey in Khawr Qurm was concluded in August 2003. The results provide the basic data for the planning and designing of the proposed Qurm Environmental Information Centre.

c. Socio-economic Survey

The subcontracted socio-economic survey in Oman was concluded in June 2003. The socio-economic survey was conducted to find out the local needs and awareness of the local people to the existing mangrove ecosystem. In general many people realises the importance of the mangrove forest conservation, and also they are willing to join the conservation and restoration activities. The results of the survey are shown in Appendix 3.

d. Analysis of Microbes

The microbiological survey of soils in mangrove forest in the Sultanate of Oman was carried out. Soil samples were collected and divided into upper layer (aerobic layer) and lower layer (anaerobic layer) from 2 different places (Site A and Site B) in mangrove forest. These samples were measured for ignition loss, number of heterotrophic bacteria, number of anaerobic bacteria and number of sulphate reducing bacteria. Several isolates were obtained from incubation plates of heterotrophic bacteria, which analysed for biochemical characteristics.

The soil sample on Site A was silt and on Site B it was sand. Ignition loss of samples were upper layer on Site A 11%, lower layer 7.7%, upper layer on Site B 6.5%, and lower layer 5.6%. The number of heterotrophic bacteria of the upper layer sample on Site A was 6.8 x 106 Colony Forming Units (CFU)/g and that on Site B was 3.2 x 107 CFU/g. On the other hand, the number of sulphate reducing bacteria on Site A was 4.4 x 106 Most Probable Number (MPN)/g and that on Site B was 3.9 x 104 MPN/g. These data of microbial numbers agreed with the nature of sample soils.

Six isolates of heterotrophic bacteria from Site A and 4 isolates from Site B were obtained. These isolates were observed under a photomicroscope after Gram-stained and analysed biochemical characteristics. These results suggested that isolate A-A belongs to Vibrionaceae, isolate A-B belongs to Cytophagales and isolate A-E belongs to Bacillus sp. The detail result is shown in Appendix 4.

Chapter 2: Existing Conditions of Coastal Area in Oman

2. Existing Condition of Coastal Area in Oman

2.1 Natural Conditions

2.1.1 Geography

Oman includes some of the most varied landscapes in the Gulf region; 'sabkha' (salt-flats), 'khawrs' (lagoons), oases and stretches of sand and gravel plain, which are dominated by mountain regions. The Hajar Mountains are the largest range, running from Mussandam through northern Oman, rising to almost 3,000 m at Jabel Shams: the highest peak in the country. The countryside is crossed by 'wadis' (riverbeds), which are formed by the force of torrents of water during the rainy season. Off the coast, there are several islands, and the largest of which is Masirah Island in the southeast.

Wide areas of desert are a feature of Oman covering large parts of the country. The seemingly endless Rub Al Khali (Empty Quarter) continues into Saudi Arabia and the UAE. The other main desert area is the Wahiba Sands. In contrast to the desert, the Dhofar region in the south of the country is famous for its green, tropical appearance and monsoon season with relatively high rainfall.

2.1.2 Climate

a. General

Oman's climate varies considerably with the different regions, but the country as a whole has sunny weather and hot temperatures for most of the year. In summer, humidity is quite high.

The north is hot and humid during the summer, with June and July temperatures often reaching 48 °C during the day and averaging about 32 °C at night. Humidity rises to 90%. Between October and March, temperatures are far lower, averaging about 30 °C. The interior is usually hotter than the coastal area, although at altitude in the mountains, temperatures fall to around 5 °C at night. Rainfall is infrequent and irregular mainly in winter, November to March. Annual rainfall in the Muscat area is 100 mm.

In the south, the Dhofar region commonly has high humidity even in winter. Between June and September, the area receives light monsoon rains, creating very different environmental conditions from the rest of Oman. In summer, the area around Salalah has green fields because of its cooling mist. The landscape image is different from the deserts and bare rocky mountains found elsewhere in Oman.

b. Flood Condition

Figure 2.1.1 shows annual total rainfall and monthly total rainfall in years with more than 150 mm annual total rainfall in three coastal areas in the north of Oman and two coastal areas in the centre and south part of the country. There are some regional differences in the pattern of rainfall between the north and the south and centre. As shown in Figure 2.1.1 f-j, in the north rainfall occurs during the winter (November-April), while in the centre and south it is a result of seasonal summer storms (April-September). Moreover, Figure 2.1.1 a-e describes that northern areas have a comparatively stable annual total rainfall (0-3 times larger than the average), whereas central and southern areas records steeper ups and downs (0-5 times larger than the average) on the figure.

These five areas, however, have a similarity in the feature of total monthly rainfall. Most of years with more than 150mm annual total rainfall have at least one month whose monthly total rainfall exceeds the average annual total rainfall, as described in Figure 2.1.1 f-k. In addition, most of years with less than 150mm annual total rainfall do not have such a month (see Table 2.1.1). According to the monthly climatological summary at Seeb Airport (see Table 2.1.2) including daily and hourly rainfall data from October 2000 to September 2001, in such a month much of total rainfall (more than 100mm) concentrates on a very short period (this is the only data source which the study team could obtain for the finer investigation of rainfall patterns). It is said that, therefore, in nearly all wadis surface runoff occurs only for some hours or up to few days after a storm in the form of rapidly rising and falling flood flows. This is known as a flash flood which sweeps huge boulders away and kills many people.

These facts explain that most of flash floods can occur in one month in years with more than 150mm annual total rainfall. Accordingly, the cycle of flash flood is likely to be correspondent with that of years with more than 150mm annual total rainfall. This is not uniform to all cases in Oman. In Dhofar region for instance the average total rainfall for two days during the tropical storm (cyclone) that happened in Dhofar region (9~10 May 2002) was almost more than 300mm in Qara mountains and more than 150mm in Salalah plain. 150mm annual total rainfall can be considered as a rough criterion of the incidence of a flash flood. Figure 2.1.1 a-e. depicts that each area has differences in the cycle of flash floods. It ranges from 5 to 10 years depending on locations.

Figure 2.1.1 a. Batinah

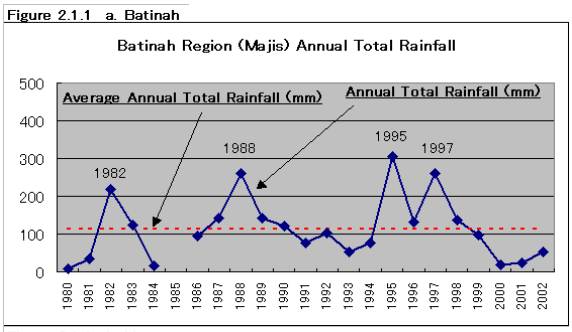

Figure 2.1.1 b. Muscat

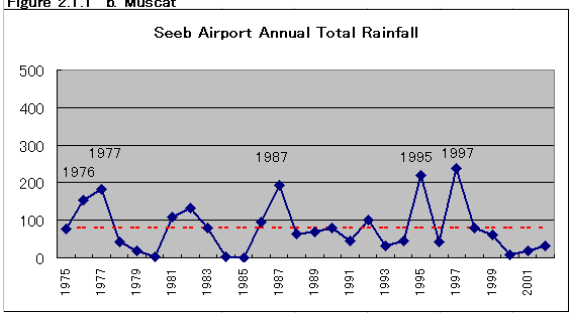

Figure 2.1.1 c. Shargiyah

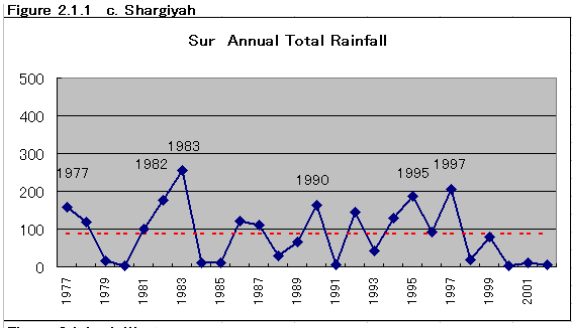

Figure 2.1.1 d. Wusta

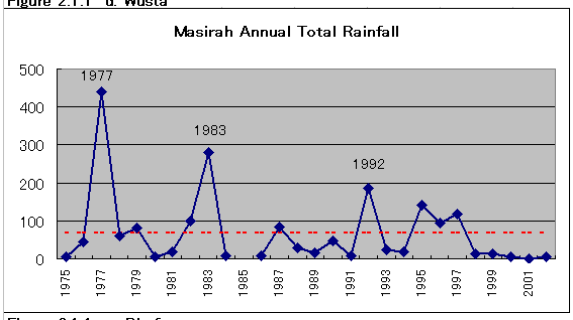

Figure 2.1.1 e. Dhofar

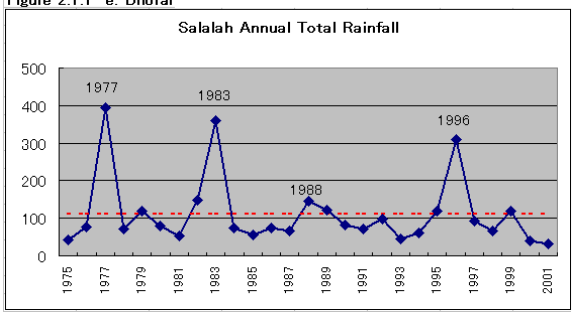

Figure 2.1.1 f. Batinah

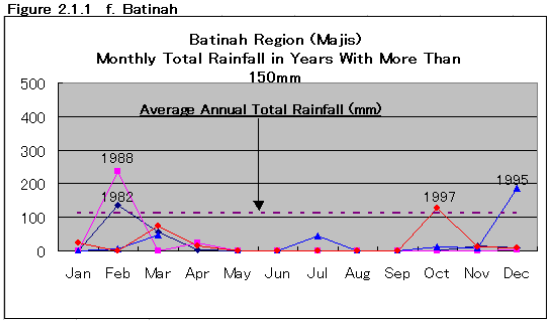

Figure 2.1.1 g. Muscat

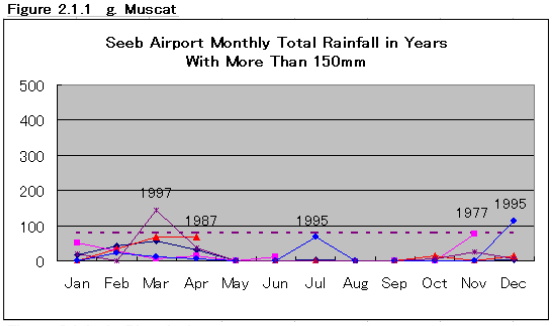

Figure 2.1.1 h. Shargiyah

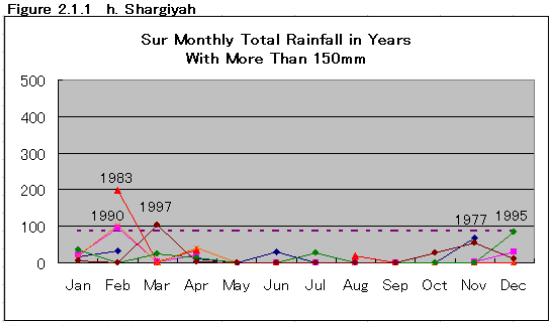

Figure 2.1.1 i. Wusta

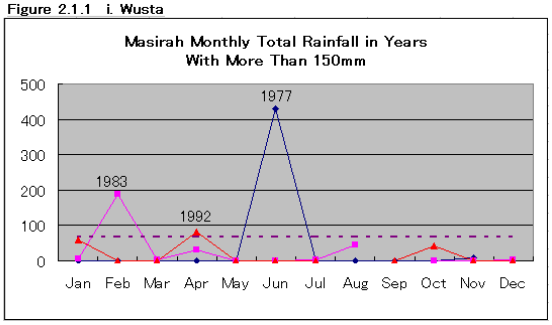

Figure 2.1.1 j. Dhofar

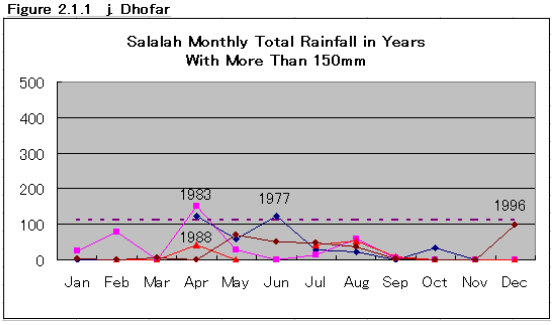

Figure 2.1.1 Annual Total Rainfall and Monthly Total Rainfall in Years with more than 150mm

Table 2.1.1 Annual Rainfall (mm)

Year	Batinah Region (Majis)	Muscat Municipality (Seeb Airport)	Sharqiyah Region (Sur)	Wusta Region (Masirah)	Governorate of Dhofar (Salalah)
1975	-	76.6	-	5	41.6
1976	-	152.3	-	45.1	76.4
1977	-	182.6	158.1	440.9	393.1
1978	-	41.9	119.5	59	71.9
1979	-	19.5	16.5	80.6	118.5
1980	7.9	3.7	3	4.1	80.5
1981	33.1	109.7	100.5	19.6	53.4
1982	217.6	132.5	175.4	98.4	147.4
1983	122.4	80.3	254.6	278.9	360.2
1984	14.7	2.4	11.5	7.4	73.7
1985		1.3	10.7		54.9
1986	95.2	94.4	119.9	6.6	72.8
1987	142.5	194.3	109.7	82.8	66.1
1988	260.5	62.5	30.1	28.3	144.7
1989	143	69.9	66.6	16.2	120.4
1990	120.6	78.8	163.5	47.4	83.2
1991	76.5	44.8	5	7.9	72.1
1992	102.9	100.5	145.1	185.2	97.4
1993	53.3	30.7	42.2	23.3	44.9
1994	76.3	44.3	129	17.2	61.9
1995	306.1	219	187.5	140.1	120
1996	131.1	43	93.3	95	310.6
1997	261	237.1	205.9	117.4	93.2
1998	137.3	78.6	17.9	13.4	66.6
1999	96.3	61.1	80.1	12.1	118.9
2000	19.6	6.9	3	6.1	41
2001	23.4	17.2	9.7	1.3	32.4
2002	53.2	32.1	5.8	5.6	-

Table 2.1.2 Monthly Total Rainfall with more than 150mm (Unit: mm)

Batinah Region (Majis)

	1982	1988	1995	1997
Jan	0.0	0.0	0.0	24.7
Feb	135.3	235.3	5.3	0.0
Mar	57.3	0.0	46.2	74.8
Apr	2.1	22.3		13.5
May	0.0	0.0	0.0	0.0
Jun	0.0	0.0	0.0	0.0
Jul	0.0	0.2	45.3	0.0
Aug	0.0	0.0	0.9	0.0
Sep	0.0	0.0	0.0	0.0
Oct	0.0	0.0	12.2	127.2
Nov	13.8	0.0	8.8	12.2
Dec	9.1	2.7	187.4	8.6
To.	217.6	260.5	306.1	261.0

Muscat Municipality (Seeb Airport)

	1976	1977	1987	1995	1997
Jan	16.0	50.5	0.0	0.3	19.5
Feb	42.5	27.0	32.7	22.3	0.0
Mar	57.0	4.6	67.9	11.5	145.4
Apr	30.3	14.0	67.3	4.3	35.4
May	0.0	0.9		0.0	0.0
Jun	0.0	9.9	0.0	0.0	0.0
Jul	2.4		0.0	68.3	0.0
Aug	0.0			0.0	0.0
Sep	0.0	0.0	0.0	0.0	0.0
Oct		0.0	13.0	0.0	7.0
Nov	0.0	75.7	0.0	0.0	24.4
Dec	4.1		13.4	112.3	5.4
To.	152.3	182.6	194.3	219.0	237.1

Sharqiyah Region (Sur)

	1977	1982	1983	1990	1995	1997
Jan	17.3	21.8		18.3	35.8	5.7
Feb	33.0	95.8	197.1	104.6	0.5	0.0
Mar		3.7	1.8	0.0	25.1	103.6
Apr	10.1	21.0	36.4	40.6	14.4	3.7
May	0.0			0.0	0.0	0.0
Jun	30.1	0.0	0.0		0.0	0.6
Jul	0.0	0.0			28.0	0.0
Aug	0.7	0.0	19.1	0.0	0.0	0.0
Sep	0.0	0.0	0.0		0.0	0.0
Oct	0.0		0.0	0.0	0.0	26.9
Nov	66.9	3.2	0.0		0.0	53.4
Dec		29.9	0.2	0.0	83.7	12.0
To.	158.1	175.4	254.6	163.5	187.5	205.9

Wusta Region (Masirah)

	1977	1983	1992
Jan	0.0	6.2	60.2
Feb	0.0	187.2	0.0
Mar	0.0	3.6	0.7
Apr	0.0	29.8	82.0
May	0.0	0.0	0.0
Jun	430.6	0.0	0.0
Jul	0.0	3.5	0.2
Aug	0.0	45.6	
Sep	1.2		0.0
Oct	0.0	0.0	41.8
Nov	9.1	0.0	0.0
Dec		3.0	0.0
To.	440.9	278.9	185.2

Governorate of Dhofar (Salalah)

	1977	1983	1988	1996
Jan	0.7	24.8		0.0
Feb	0.0	77.4	0.0	0.0
Mar		0.2	0.0	30.2
Apr	123.0	150.9	42.1	7.8
May	59.6	27.5	0.0	0.0
Jun	124.0	0.4		0.5
Jul	27.3	13.0	41.7	46.0
Aug	23.6	59.5	52.4	35.4
Sep	0.9	6.5	8.5	0.1
Oct	34.0	0.0	0.0	0.0
Nov	0.0	0.0	0.0	0.0
Dec	0.0	0.0	0.0	0.0
To.	393.1	360.2	144.7	310.6

2.1.3 Soil and Water

a. Batinah Zone

All khawrs are located on the mouth of wadis coming from Al Hajar al Gharbi mountains and lies on alluvial plain along Batinah coast. There are many khawrs where the surface waters have dried up in this zone. Some of the observed khawrs are completely dried up and some of them have stagnant water. These stagnant waters are generally muddy and cloudy, and have algae. Theses khawrs are washed away during flooding occasionally but the mouth of these khawrs are closed by the sedimentation of sands.

The soils in the khawrs where mangrove vegetations existed showed similar conditions. Mangrove vegetations mainly exist on the soils along water channel of the khawrs. Surface soils near the mouths of khawrs are basically sands. On the other hand, silty or clayey soils lie on the upper places of khawrs in surface. However, deeper soils in the subsurface are sandy everywhere. All khawrs where mangrove vegetations have existed are opened to sea. The waters near the beach in these khawrs generally have high visibilities (clear).

In the back areas of water channels of Khawr Shinas and Khawr Kalba, new mangrove vegetation has been developing. The soils on these areas are generally sandy through soil layers.

Halophytic plants are growing around the khawrs in many places. The soils of these areas are compact in surface and have salt accumulation. Soil textures are generally silty at surface with sandy soil below. General conditions in each khawrs are summarised in Table 2.1.3.

Khawr Shinas

Harmul & Nabr

Khawr Sawadi

Table 2.1.3 General Observation in Batinah Zone

Name of Site	Surface water		General observation
	Salinity (%)	pH	
Khawr Kalba*	-	-	Located at the border of UAE.
Khawr Shinas*	3.5 - 4.0	7.8 - 8.1	Two main channels; Sandy soil with aerobic condition at mouth of khawrs; silty and muddy surface soil with anaerobic condition at upper channel of south khawrs; extend sand channel on north khawr
Khawr Harmul & Nabr*	3.5 - 4.3	7.5 - 8.2	Meandering channels; strong sand sedimentation along beach, many mangrove areas under no surface water; sandy soil along beach; silty surface soil in middle and upper channel of khawr
Khawr Milh (Khaburah)			Silty surface soil with aerobic condition; many gravels from wadi
North Khaburah (Khaburah)			Sandy soil near beach; silty surface soil in lower terrace of khawr; no surface water in the area
Khawr Za'ab (Khaburah)	6.4		Silty and humic surface soil near channel of khawr; sandy soil near beach and surrounding areas of water channel; humic stagnant water on the surface
North Suwayq (Suwayq)	-	-	Sandy soil with aerobic condition, no surface water in the area
Khawr Qizmi (Suwayq)	6.2	-	Sandy soil near beach, silty and humic soil in surface near channel of khawr; humic stagnant water on the surface
Khawr Sawadi*	4.1 – 4.7	-	Wide tidal area; meandering khawrs; deep sandy soil with aerobic condition at most area except on some water channels; (new planted mangrove vegetation)
Khawr Hafri (Barka)			Sandy soil at whole area, no surface water in the area
Khawr Haradi (Barka)	4.8	-	Black and silty surface soil near surface stagnant water, sandy soil near beach and along the khawr, and silty soil at banked area, humic stagnant water on the surface
Wadi Buhayyis (Seeb)	0.2/upper 1.3/mouth	-	Relaxation area as rural park, artificial bank protection by rocks along khawrs

*: Existing mangrove forest
Soil Texture was classified based on visual and touching observation at field.

b. Muscat Zone

There are three sites including Khawr Qurm, Bandar Khayran and Qurayyat in this zone. The khawrs are located at the mouth of wadis and are basically surrounded by rock outcrop.

Khawr Qurm is located in Muscat. Sabkha occurs on the centre of khawr. Mangroves are located at the both shores along water channels. The soils of these areas are basically silty or muddy in surface. Khawr Qurayyat was closed to the sea by the sedimentation of the sandbar. Water in the khawr has not circulated unless there is water supply by heavy rain and/or seawater inflowing by spring tide. Therefore, waters in the khawr are getting muddy and cloudy. Soils on this area are sandy except areas near upper water channel. Mangroves are surviving on sand deposition. Bandar Khayran has a unique form of mangrove vegetation. Mangroves are scattered along the narrow shores with shallow soils in bay, but form relatively large areas in the

inner bay. Soils in this area are comparatively deep and sandy. General conditions in each khawrs are summarised in Table 2.1.4.

Khawr Qurm

Qurayyat

Bandar Khayran

Table 2.1.4 General Observation in Muscat Zone

Name of Site	Surface water		General observation
	Salinity (%)	pH	
Khawr Qurm*	2.5-3.9	7.5-8.2	Two different main khawrs; deep sandy soil at mouth of khawrs; silty and clayey surface soils with humous along middle and upper channels; open place with halophyte at centre of area
Bandar Khayran*	2.8-4.6	7.9-8.0	Scattered mangrove vegetated areas, silty soils at vegetated area; sandy and gravel soil at back areas of vegetations
Qurayyat*	4.5	8.1	Strong sedimentation affected by current; sandy soil at seaside and higher lands with aerobic condition; silty and organic surface soil around water channel with anaerobic condition

*: Existing mangrove forest
Soil Texture was classified based on visual and touching observation at field.

c. Sharqiyah Zone

There are four sites including At Tina and Batah in Sur Bay, and Khawr Hajar and Khawr Quq in Ras Al Had. These areas are surrounded by rock outcrops.

In Sur, the soils near mouth of khawr are sandy, but silty or muddy in inner places of khawr in general. In Batah area, there are some natural vegetations of mangrove. The soils under mangrove vegetation are silty in surface and sandy in sub-surface samples. Salinities of water in the khawr have higher values in the inner areas of the khawr becoming lower towards the mouth.

At Ras al Had, there are no places of mangrove vegetation. Wide and gentle beach cover the khawr. Soils in north and south shore in Khawr Hajar are shallow but relatively deep at eastern shore on rocky base. This area is covered by coarse sand. Khawr Quq located on the south-west shore near mouth of bay and their soils are deep and sandy. General conditions in each khawr are summarised in Table 2.1.5.

Batah (Sur)

Khawr Quq

Khawr Hajar

Table 2.1.5 General Observation in Sharqiyah Zone

Name of Site	Surface water		General observation
	Salinity (%)	pH	
Batah * (Sur)	7.4/mud 4.1/sand		Sandy at Sukeikra area; silty surface soil and salty soil at upper khawrs
At Tina (Sur)	4.6 at nursery 4.2/Q-E	8.5/nurs.	Basically sandy soil; silty soil near the area of transplanted vegetation
Khawr Quq (Ras al Had)	3.9	8.2	Sandy soil at whole khawr; isolated sub- khawr
Khawr Hajar (Ras Al Had)	3.6 /sea 3.6-3.8 /upper khawr	8.2 /sea 8.2-8.3 /upper khawr	Sandy soil at whole khawr; shallow soils near rocky surface areas on both north and south shores

*: Existing mangrove vegetation
Soil Texture was classified based on visual and touching observation at field.

d. Wusta Zone

Relatively large-scale intertidal areas extend along the coast. At Filim, very large tidal flats extend from east to west. Sabkha surrounds these coastal areas. Soils in these areas, however, show different feature. The soils at the eastern coast of Filim are relatively sandy but at the western coast they are clayey and silty with anaerobic conditions. Groundwater has high salinity due to the intrusion of salty water from upper wadi. Duqm also has large tidal areas with large salt marsh behinds. Soils in this area are sandy.

The tidelands in Wadi Muraysis and Umm Al-Rusay lie along the eastern coast of Masirah Island. The tideland in Wadi Muraysis is larger than at Umm Al-Rusay. Soils of these areas are sandy but deeper in Wadi Muraysis. Groundwater has high salinity due to the intrusion of salty water from upper wadi. The mangroves in Jazirat As Shaghaf grow on shallow sandy soils along a narrow shore. General conditions in each khawr are summarised in Table 2.1.6.

Filim

Wadi Muraysis

Duqm

Table 2.1.6 General Observation in Wusta Zone

Name of Site	Surface water		General observation
	Salinity (%)	pH	
Umm As Rusay (Masirah Island)	-	-	Sandy and shallow soils at whole sea shore in narrow beach,
Wadi Muraysis (Masirah Island)	-	-	Sandy and deep soils at whole sea shore, harder soil in north-west and softer soil in south-east area
Jazirat a' Shaghaf* (Jazirat Muraysis)	3.9	-	Shallow and sandy soil along narrow beach, high salt contents in upper Mangrove areas
Wadi Halfayn	2.5	8.1	Northern Khawr of Filim area, silty and shallow soil
Filim* (Eastern Beach)	3.8	8.2	Wide extended coastal beach; basically sandy soil, silty and relatively humous soil along channels of khawrs
Filim* (Western Beach)	3.8	8.2	Wide extended coastal beach; clayey and silty soil with anaerobic condition;
Duqm	4.9	8.7	Wide extended salt marsh area; sandy soil along beach, relatively harder soils in tidal pools

*: Existing mangrove vegetation
Soil Texture was classified based on visual and touching observation at field.

e. Dhofar Zone

Along the coastline in Dhofar region, many small khawrs are scattered near seashore. Thirteen khawrs located between Mirbat and Salalah were observed for the preliminary survey. The observed khawrs and their characteristics are listed in the Table below. According to the information in Salalah, the sandbars of the some khawrs were flushed away and opened to the sea by typhoon during the spring season in 2002. However, most khawrs were now closed by sedimentation of beach sand, except Khawr Jnawf-west and Khawr Shaah at the time of the survey.

Salinity of water in Khawrs Rowri, Taqah, Qurm Taqah, Sawli, Balid, Awqad, Kabir and Saghir showed lower values ranging from 0.3 to 2.6%. The inflows of ground water to khawrs would be expected from the mountains situated in the north of Salalah area. There are no mangroves in these khawrs except Khawrs of Qurm Taqah, Jnawf, Asis, Sha'a, Rzat, Saghir and Kabir. But several vegetations including halophytes and reeds are observed in many khawrs.

The surface waters where the mangrove and other vegetations have existed are relatively cloudy by the accumulation of organics and/or mud. And soils in these

khawrs are basically silty in the surface and sandy in sub-surface. The soils at the mouth of khawrs are deep sand. The areas under mangrove and other plantation have fine textured soils with humic substances on surface and sandy in sub-surface.

Much organic matters floated on the surface water of Khawr Kabir and Khawr Saghir, which would be carried in during cyclone floods. General conditions in each khawr are summarised in Table 2.1.7.

Khawr Rowri

Qurm Taqah

Khawr Balid

Table 2.1.7 General Observation in Dhofar Zone

Name of Site	Surface water		General observation
	Salinity (%)	pH	
Khawr Hino	4.0	8.0	Sandy soil along beach; constant surface water from sea
Khawr Rowri	1.0-1.6	7.9	Blackish and silty surface soil at upper khawr; sandy or silty surface soil at beach side
Khawr Taqah	0.3	7.7	Silty surface soil at upper khawr
Qurm Taqah *	2.0		Silty surface soils along khawr
Khawr Sawli	1.9	8.1	Silty and organic accumulated surface soil with anaerobic condition; humic surface water
Khawr Jnawf*	4.2	8.2	Silty soil near mouth of khawr
Khawr Jnawf-west*	3.9	8.1	Silty and organic accumulated surface soil with anaerobic condition; humic surface water
Khawr Shaah*	3.9	7.9	Silty and organic accumulated surface soil with anaerobic condition; humic surface water
Khawr Dahariz	3.4	8.1	Sandy soil at beach side, many *Prosopis juliflora* trees at upper khawr
Khawr Balid	2.1	7.8	Silty and organic surface with anaerobic condition in upper khawr
Khawr Awqad	2.6	-	Sandy soil near mouth of khawr
Khawr Kabir*	3.5	7.8	Sandy soil with aerobic condition at beach side; silty soil and organic matter in surface with anaerobic condition at upper khawr, relatively high COD (5 to 10 ppm)
Khawr Saghir*	1.3	7.4	Silty and organic matter in surface with anaerobic condition at upper khawr; smelly water and many floating organic matters by flooding; high COD

*: Existing mangrove vegetation
Soil Texture was classified based on visual and touching observation at field.

2.1.4 Ecosystem (General Flora and Fauna associated with Mangroves in Oman)

a. Plants

Plants associated with mangroves include species that grow in the lagoon or tidal channels, along the wet edges and in the surrounding saline soils. Plants that are subtidal include seagrasses and algae while the channels and lagoons include waterplants adapted to brackish water. Plants that emerge from shallow water at the edges of less saline khawrs are mostly reeds and sedges. A zone of salt tolerant plants (halophytes) often occurs in wet saline mud adjacent to the mangroves. Drier saline areas support sabkha vegetation with a variety of succulent species. In the Central Region, there is an endemic halophyte on coastal areas (*Suaeda moschata*) and a woody species is characteristic of the small islands (*Suaeda monoica* on Mahawt and Muraysis). Watercourses leading into the khawrs often have clumps of spikey rushes as well as typical wadi vegetation. Vegetation zones at Al Qurm, Muscat, and in the khawrs of Dhofar have been studied in detail (Kurschner 1986, TS-PCDEGD 1993). Plants are described in more detail in the appendices and site descriptions.

b. Birds

Oman's coastal zone supports huge numbers of wintering and migrating waterbirds and seabirds. Khawrs and mangrove areas form important feeding and resting sites for migrant birds as well as breeding sites for many resident birds. There are massive concentrations of waders over winter at Barr al Hikman and these were described by Green et al (1992) who recorded 26 species of waders, 5 species of gulls and 7 species of terns. Erikson (1994) gave mean annual winter counts recorded over five years. The most numerous species was the Dunlin (over 30,000 birds) while over 1% of the world population was recorded for 11 species. Roosts of hundreds of seabirds (gulls and terns) are common at khawrs as well as along the beaches.

In Dhofar, waterfowl (ducks) such as pintail, wigeon, gadwell, mallard, teal and garganey are common on the larger khawrs as well as moorhen and coot.

The endemic Arabian collared kingfisher is regularly seen at Khawrs Nabr, Shinas and Kalba in Oman and it is considered rare (small, localised population) and vulnerable (depleted population that is not protected), (Salm & Jensen, 1991). Another mangrove specialist is Syke's Warbler (a subspecies of the booted warbler) found mainly at Liwa and Shinas. The recently discovered Oriental White-Eye lives only in the mangroves of Mahawt Island. The Crab Plover is commonly seen at Ras al Had lagoons, Barr al Hikman, Masirah and Duqm but is rare elsewhere. A summary of numbers of species for each site is given in Table 2.1.8. Generally the khawrs of Dhofar support the greatest number of species. This is because of the high number of birds, especially ducks, which use these freshwater/brackish khawrs during the winter. Al Qurm also has a high score but this is partly due to the greater number of observations at this site.

Table 2.1.8 Numbers of Water Bird Species, Oman Bird Record Database

Site Abundance	1	2	3	5	7	8,9	10,11	12	13,14	15	17	18	19
Abundant species	5	9	5	26	7	3	11	2	17	8	19	15	28
Common species	27	9	22	27	27	31	13	20	21	14	31	12	14
Fairly common	10	11	13	8	22	13	1	24	3	15	18	40	38
Common species Subtotal	42	29	40	61	56	47	25	46	41	37	68	67	80
Uncommon Spp.	37	18	32	19	32	18	24	9	14	5	25	25	12
Rare species	20	12	10	48	30	33	20	24	42	19	42	37	43
Vagrant species	0	0	1	10	2	0	0	0	4	0	9	13	14
Total water bird Species	99	59	83	138	120	98	69	79	101	61	144	142	159
Total of all bird spp.	172	95	164	254	214	166	96	134	170	99	260	249	241

1-Shinas; 2-Liwa; 3-Sawadi+Ras; *4-Haradi; 5-Qurm; *6-B.Khayran; 7-Qurayyat; 8,9-Sur; 10,11-Hajar/Quq+Jaramah; 12-Masirah Sur; 13,14-Filim/Barr al Hikman; 15-Duqm; *16-Demr; 17-Rawri; 18-Taqah+Khawr; 19-Dahariz; *20-Balid; *21-Kabir; *22-Saghir. *=no data

c. Fish

Many fish species are associated with the mangroves and khawrs of Oman. The small pupfish, *Aphanius dispar,* is very common and breeds in khawrs as well as freshwater springs. The mudskipper, *Periophthalmus koelreuteri,* is only recorded from Mahawt Island although it was seen at Filim during this study. In Dhofar, the Flathead Sleeper, *Ophiocara porocephala,* can breed in low salinity conditions. Typical residents of mangroves include milkfish, mullet, glassfish, *Ambassis natalensis,* gobies, grunts, and tigerperch, (*Terapon jarbua*). While living in water of variable salinity they still enter the sea to breed. Other groups usually associated with mangroves, especially as juveniles, include snapper, shad, tenpounders, juvenile carangids and seabream. Several of these species form part of the commercial catch of the local fishery. At Al Qurm, 40 species of fish were recorded while at Mahawt 41 species were recorded (Fouda & Al Muharami 1995). Environmental monitoring at Liwa recorded 20 species of fish (Atkins 2002).

Potentially commercial species such as milkfish, *Chanos chanos*, white shrimp, *Penaeus indicus,* and mud crabs, *Scylla serrata*, found in mangrove areas can appear abundant, but the populations in such small ecosystems are fragile and cannot sustain a commercial fishery. The mangroves should be regarded as marine protection areas, which can serve to enhance biodiversity, as well as supplementing fisheries, by migration of adults into surrounding coastal waters. An exception is found at Ghubbat Hashish where Mahawt Island forms part of a large shallow bay system and provides a nursery ground for the commercial white shrimp fishery as discussed in Appendix 5.

d. Crustacea

So far 43 crustacean species have been recorded in mangrove areas of Oman, although many of these are also found in other intertidal habitats such as mudflats and rocky shores. Different species occupy different zones within the mangrove habitat with

swimming crabs found in water channels, burrowing crabs found in the mud around the trees and marsh crabs actively moving over the mud and trees.

Differences between regions of Oman include the large land crab, *Cardisoma carnifex,* which is a resident of the khawrs of Dhofar but is absent further north. Tidal inlets normally support the sand crabs, *Dotilla* and *Scopimera,* in the north but these species are absent in the south. One large marsh crab species (*Neosarmatium meinerti*) found on trees at Mahawt was not recorded at other sites.

e. Molluscs

A total of 58 species are recorded from the mangroves of Oman, however, many of these are not mangrove specific and are also found in other habitats.

Most mollusc species are found in the tidal channels. The gastropods included cowries, ceriths, dog whelks, dove shells, olives, moon shell and conch, while bivalves include venus clams and ark shells. Species attached to mangrove roots include oysters, vermitids and rock shells. Species on mud and in pools included the horn shells.

The large horn shell or mud snail, *Terebralia palustris,* is characteristic of mangroves in the northwest but was not found surviving elsewhere. Semi-fossilized shells were found on Mahawt and dead shells were found at Bandar Khayran so the population may be in decline. The pulmonate *Onchidium,* which has no shell, is found at Mahawt and at Al-Qurm.

2.2 Mangrove

2.2.1 Past Activities in Oman

Mangrove was planted in Oman at various times from 1983 to 1985, however they did not produce concrete results (Table 2.2.1). The reason they did not succeed is the lack of experience on technical knowledge and skill for mangrove afforestation.

The JICA Expert for mangrove afforestation was dispatched to MRMEWR in April 2000. The mangrove nurseries were constructed at Qurm, Sur and Salalah from 2000 to 2001 (Table 2.2.2). The transplanting of *Avicennia marina* made at nurseries is successful.

2.2.2 Future Plan

a. Transplanting of *Avicennia marina*

The Omani counterpart section intends to transplant *Avicennia marina* at some sites, such as Sawadi, Sur and Salalah regularly. Recently, the Omani staff found some sites suitable for mangrove planting. They will implement mangrove plantation in the near future.

b. Introduction of Other Species

Before any introduction of an animal or plant species into the wild takes place evidence of its previous existence in that habitat is needed. Lézine A-M. et al. (2002, Late Holocene Mangroves of Oman: Climatic Implications and Impact on Human Settlements, Journal of Archaeobotany and Palynology, 141, pp. 221-232) carried out pollen analyses on sediments from Suwayh south of Ras Al Had. The Suwayh depression belongs to a series of fossil lagoons along this coastline. The analysis provides evidence linking environmental changes to the extent of the summer monsoon rains and sea-level variation. Sediments from about 6000 years ago, contained pollen from *Avicennia marina* and *Rhizophora mucronata* mangroves. Pollen from freshwater plants (e.g. *Typha*) suggests input from wadis and the presence of oysters and marine plankton (foraminifera) demonstrate a sea connection.

The absence of pollen from *Prosopis cineraria*, a tree characteristic of the semi-desert conditions around Suwayh today, supports the idea of wetter conditions. After 5000 years ago, the sediments show a sequence of saline conditions suggesting successive periods of drought and rainfall with unstable conditions up to the present day. *Avicennia* only disappeared from Suwayh relatively recently. The presence of *Amiantis* shells indicates a brackish lagoon as found at Khawr al-Jaramah today where *Avicennia* occurs as a relict population. The change from a summer rain to a winter rain climate occurred after 5000 before present. Shells and fish remains from archaeological sites confirm the picture as species associated with mangroves (*Terebralia, Isognomon*) were replaced by shells of brackish lagoon species (*Amiantis*) at about 4000-5000 years ago. This research indicates that the disappearance of *Rhizophora* and the decline of *Avicennia* were caused by a change in climate, possibly accelerated by recent impacts from man.

Table 2.2.1 Planting/ Transplanting Activities in Oman

Year	Species	Plantation Method	Area	Scale	Implementing Agency	Results
1983	*Rhizophora stylosa or Rhizophora mucronata/ Lumnitzera racemosa/ Conocarpus erectus*	Direct sowing	Balid		Oman/ Japan	produced concrete results partially
1983	*Rhizophora stylosa*	Direct sowing	Qurm		Oman/ Japan	not produced concrete results
1983	*Rhizophora stylosa/ Bruguiera gymnorrhiza*	Direct sowing	Salalah		Oman/ Japan	not produced concrete results
1984 Sep.	*Avicennia marina*	Using seedling taken at Qurm	Barka	1,200 seedlings	Oman/ Japan	not produced concrete results
1985	*Rhizophora stylosa*	Direct sowing	Qurm		Oman/ Japan	not produced concrete results
1985	*Rhizophora stylosa/ Bruguiera gymnorrhiza*	Direct sowing	Salalah		Oman/ Japan	not produced concrete results
2001 Feb.- Mar.	*Avicennia marina*	Transplanting using pots seedlings made at Qurm mangrove nursery	Sawadi (1.15 ha)	11,500 seedlings	Oman/ JICA	Success
2001 Nov.	*Avicennia marina*	Transplanting using pots seedlings made at Qurm mangrove nursery	Sur (1.2 ha)	12,000 seedlings	Oman/ JICA	Success
2002	*Avicennia marina*	Transplanting using pots seedlings made at Sur mangrove nursery	Sur		Oman/ JICA	On-going
2003 Jan.	*Avicennia marina*	Transplanting using pots seedlings made at Salalah mangrove nursery	Salalah		Oman/ JICA	On-going
2003 Feb.	*Avicennia marina*	Transplanting using pots seedlings made at Qurm mangrove nursery	Sawadi		Oman/ JICA	On-going
2003 Feb.	*Avicennia marina*	Transplanting using pots seedlings made at Sur mangrove nursery	Sur	12,000 seedlings	Oman/ JICA	On-going
2003 Mar.	*Avicennia marina*	Transplanting using pots seedlings made at Salalah mangrove nursery	Salalah	7,200 seedlings	Oman/ JICA	On-going
2003 May	*Avicennia marina*	Transplanting using pots seedlings made at Qurm mangrove nursery	Musanaa	10,000 seedlings	Oman/ JICA	On-going
2004 Jan.	*Avicennia marina*	Transplanting using pots seedlings made at Qurm mangrove nursery	Sawadi	12,000 seedlings	Oman/ JICA	On-going
2004 Jan.	*Avicennia marina*	Transplanting using pots seedlings made at Salalah mangrove nursery	Salalah	4,800 seedlings	Oman/ JICA	On-going
2004 Jan.	*Avicennia marina*	Transplanting using pots seedlings made at Qurm mangrove nursery	Shinas	9,750 seedlings	Oman/ JICA	On-going
2004 Feb.	*Avicennia marina*	Transplanting using pots seedlings made at Qurm mangrove nursery	Musanaa	3,250 seedlings	Oman/ JICA	On-going
2004 Feb.	*Avicennia marina*	Transplanting using pots seedlings made at Sur mangrove nursery	Sur	12,000 seedlings	Oman/ JICA	On-going
2004 Feb.	*Avicennia marina*	Transplanting using pots seedlings made at Salalah mangrove nursery	Salalah	2,100 seedlings	Oman/ JICA	On-going

Table 2.2.2 Construction of Mangrove Nursery in Oman

Year	Species	Irrigation System	Area	Capacity	Implementing Agency	Remarks
2000	*Avicennia marina*	Pump-up	Qurm	12,000 pots	Oman	Renovated in 2001
2001	*Avicennia marina*	Tidal	Qurm	13,000 pots	Oman	
2001	*Avicennia marina*	Tidal	Sur	13,000 pots	Oman	
2001	*Avicennia marina*	Pump-up	Salalah	13,000 pots	Oman	

Today the nearest *Rhizophora* mangrove is found on the southwestern end of the Arabian Peninsula in Yemen and in the Sirik estuary of Iran (World Mangrove Atlas, 1997). The mangrove species, *Bruguiera gymnorrhiza,* is recorded as extinct in Yemen though still present in Somalia.

Because of the complicated causes of mangrove degradation in Oman, the wide-ranging introduction of *Rhizophora mucronata* to the present natural ecosystem in Oman has not been justified yet.

Oman already has problems with exotic species, such as *Prosopis juliflora*, which was introduced as roadside trees, and conflict with local species especially at Salalah. The Oman Government is concerned about extermination of this species. Therefore, the Oman Government is reluctant to introduce other exotic species. The JICA Study Team also cannot recommend introducing them.

2.3 Social Conditions

2.3.1 Socio- economic Condition in Oman

a. Population

Statistical data is limited and only the National Census was implemented in 1993 and the Statistical Year Book is available at the national level. The second National Census was conducted in December 2003. Population by Governorate/Region and Wilayat, where the survey sites are located, is shown in Table 2.3.1. Every area has a large increase of population (between 1993 to 2001), and an outstanding increase can be seen especially in wilayats of Barka, Mutrah, Muscat, Sur, and Salalah. The concentration of people in wilayats of Salalah and Mahawt is obvious. This can be said to put some impacts of population increase on the survey sites. The share of the total Oman population in this region and the wilayats has not changed so much. Also, the share of Omanis in total region and wilayat populations has not changed so much. With unchanged distribution of population in the country, population as a whole has been increasing.

The largest part of the population is located in Al Batinah Region, which constitutes about 28% of the total population in Oman, followed by Muscat Governorate, with almost the same share of the total population. Although Al Wusta Region is very large in terms of area, it has the lowest population percentage, which amounts to less than 1% of the total population, as shown in the following Table. Omanis constitute 74% of the

total population of the Sultanate. With each region/governorate the percentages of Non-Omani show a vast degree of variation. Generally, with the exception of Muscat and Dhofar Governorates, the percentage of Non-Omanis is lower than the general average for the Sultanate in all other governorates and regions.

The results of statistics in 2001 confirmed that the Omani society is a young one. The percentage of Omani population who are less than 15 years old has almost reached 42% of the total Omani population. This means that education and awareness among the young generation is a key factor for development programmes.

b. Regional Development

The Sixth Five-Year Development Plan (2001-2005) states that the most prominent regional consideration is the necessity of benefiting from the diverse resources and ecological variation and utilising it for the best interest of the development process. The Plan aims at producing comparable levels of development in the different regions of the Sultanate through adopting specific policies and mechanisms package. The most important is the use of regional balance of development as one of the basic criteria for distributing the investments of the Plan Investment Programme. The package above includes provision of basic services of education, health, and clean water for remote and least developed regions. Promotion of access to remote areas through paving of roads, encouragement of industries and services may help upgrade the least developed areas and provide suitable employment opportunities for the citizens of those regions. Such services include tourism services of various types, tourism products such as handicrafts and fishing.

It is expected that, the share of the regional investment in the Sixth Five-Year Development Plan investment programme – as shown in Table 2.3.2, will be about O.R. 2,724.9 million, representing about 40.7% of the total investments. The relative shares varied for each region. It reaches the highest of 48.5% for Al Batinah Region. As density of population is considered an effective factor in defining the volume of investments per region/area, the indicator for per capita investments allocated to region/area, is considered a more precise equity index for investments distribution between different regions. The top of the regions arranged according to the per capita investment is Al Wusta region (O.R. 2,905), which is the least developed, followed by Al Batinah where the per capita is expected to reach about O.R. 1,982 and Ash Sharqiyah (about O.R. 1,720).

c. Economic Activities

Data of regional products and labour force by industry, by region/wilayat are not available. The National Census in1993 and some other references provide the following information.

(a) Al Batinah

A percentage of 76% of the Omani labour force in the Region works in the public sector, while 24% works in the private sector, of this 32% works in agriculture, 17% in fishing and 16% in commerce based on the National Census 1993.

Table 2.3.1 Population by Governorate/Region and Wilayat of Survey Site in 1993 and 2001

Governorate/ Region/Wilayat	Total (persons)		Share of Omani in Total Region/Wilayat (%)		Share of Wilayat in Region (%)		Share of Region in Oman Total (%)	
	1993	2001	1993	2001	1993	2001	1993	2001
Al Batinah	564,677	686,284	83.6	83.5	100.0	100.0	28.0	27.7
Shinas	44,313	53,851	84.8	84.7	7.8	7.8		
Liwa	22,667	27,544	85.8	85.7	4.0	4.0		
Barka	64,526	78,468	75.3	75.1	11.4	11.4		
Muscat	549,273	685,676	53.8	48.7	100.0	100.0	27.2	27.7
Mutrah	173,908	215,092	35.2	36.3	31.7	31.4		
Muscat	40,856	51,580	75.7	75.3	7.4	7.5		
Qurayyat	34,405	43,047	88.5	88.9	6.3	6.3		
Ash Sharqiyah	258,665	315,584	84.9	84.9	100.0	100.0	12.8	12.7
Sur	53,381	65,368	80.3	80.3	20.6	20.7		
Masirah	8,299	10,139	74.3	74.3	3.2	3.2		
Al Wusta	16,623	21,019	79.5	80.0	100.0	100.0	0.8	0.8
Muhut	7,369	9,622	92.6	92.9	44.3	45.8		
Dhofar	189,094	232,563	66.4	66.7	100.0	100.0	9.4	9.4
Salalah	131,813	162,021	86.0	86.1	69.7	69.7		
Taqah	15,677	19,321	84.9	85.0	8.3	8.3		
Mirbat	11,280	13,905	61.4	61.7	6.0	6.0		
Musandam	28,727	35,945	78.2	78.3			1.4	1.4
Adh Dhahirah	181,224	221,687	74.6	74.7			9.0	8.9
Ad Dakhliyah	229,791	279,829	86.8	86.7			11.4	11.3
Sultanate of Oman	2,018,074	2,477,687	73.5	73.7			100.0	100.0

Source: Socio-economic Atlas, November 1996 (based on the 1993 national Census), Ministry of Development Statistical Year Book, August 2001, Ministry of National Economy

Table 2.3.2 Regional Distribution of the Investment Programme in the Sixth Five-Year Development Plan

Governorate/Region	Planned Investment (Mn. R.O.)	Region's Share in Total Investment (%)	Region's Share in Regionally Allocated Investment (%)	Per Capita Investment (R.O.)
Muscat	277.9	4.2	10.2	420.4
Al Batinah	1,322.1	19.8	48.5	1,982.2
Ash Sharqiyah	528.2	7.9	19.4	1,720.4
Al Wusta	58.1	0.9	2.1	2,905.0
Dhofar	251.1	3.8	9.2	1,116.2
Musandam	30.4	0.5	1.1	894.1
Adh Dhaira	76.2	1.1	2.8	354.4
Ad Dakhliyah	180.9	2.7	6.7	665.1
Total Approved Investments for the Regions	2,724.9	40.7	100.0	1,134.4
National Projects	3,962.8	59.3		
Total Investment	6,687.7	100.0		

Source: The General Framework of the Sixth Five-Year Development Plan 2001-2005, Ministry of National Economy, February 2002

Fishing and agricultural activities were popular but rapidly changed to sectors of commerce and industry following the policy of economic diversification. Traditionally farmers and fishermen, the occupations of the Batinah citizens, are now supplemented by jobs in commerce and industry. The population is well dispersed along the coast and villages sprawl one after the other along its spacious beaches. Date plantations and small fruit and vegetable farms stretch almost continuously along the coast. Although there is a long stretch of fertile land under cultivation, the region has faced the problem of salinity over the past few years. The heavy consumption of water has reduced the underground reserves, causing saline intrusion along the coast.

(b) Governorate of Muscat

The Census results showed that 68% of the Omani labour force in the Governorate of Muscat works in the public sector, while 32% is engaged in the private sector. Most of those employed by the private sector work in commerce, amounting to 22%, followed by 16% in the mining sector and 14% in banks.

In Qurayyat, fishing and agriculture used to be main occupations of the residents and whilst they still are, they are now supplemented by trade and government jobs.

(c) Ash Sharqiyah Region

Sixty-eight percent of the Omani labour force in the Region works for the public sector. Workers in the private sector make up 32% and are distributed among various activities: 37% of them work in agriculture; 21% in fishing; and 16% in commerce.

The population is concentrated in Ibra and Sur. There are small fishing villages scattered along the coastline. The people of Sur are sailors and fishermen and some of them are engaged in boat building and agriculture. Sur is still an active shipbuilding centre, with dhows constructed directly on the beach.

(d) Al Wusta Region

Nineteen percent of Omanis in the Region of Al Wusta work in the public sector and 81% in the private sector in various economic activities. Fifty-eight percent of those in the private sector work in fishing, and 14% in agriculture and grazing, the rest work in other activities according to the National Census.

The major economic activity is still fishery and animal husbandry. This region is peopled largely by semi-nomadic Bedouins while those who live on the coast are fishermen and own livestock. The Mahawt Island is an important part of the prawn fishery industry.

(e) Governorate of Dhofar

Eighty-three percent of the Omani labour force in the Governorate of Dhofar works in the public sector and the remaining 17% in the private sector. The private sector workers are distributed among all the activities; 22% are in agriculture, 22% in mining, 15% and 14% work in commerce and fishing activities, respectively.

Most of the area is under pastoral land use based on cattle, camels and goats. Grazing pressure is high. Apart from long-established coastal settlements, dependent mainly on fishing, the area was exclusively pastoral prior to oil development. To some extent these forms of land use still persist, but the advent of oil development has brought transport, water and other forms of income and occupation, so that fewer people now move with and depend on their livestock. However, camels are still important and goats and sheep increasingly so, both in coastal and pastoral settlements; money is being spent on fodder now. Nowadays there is marketing for camels as per government subsidies for 2 years started from June 2003. The government plan is to receive 95% of the camels from Wilayats Dalkut, Rakhut, Salalah, Mirbat, Saddah and Taqah during this period of time.

2.3.2 Fishery Status in Oman

The Sultanate of Oman occupies the southeastern corner of the Arabian Peninsula and has a coastline extending 3,165 km. It overlooks three seas, the Arabian Gulf, the Gulf of Oman and the Arabian Sea. The Exclusive Economic Zone (EEZ) declared in 1981 covers an area of 350,000 km^2.

The combination of the marine topography with the summer monsoons leads to the phenomenon of coastal upwelling in the southern region. As a result, the surface waters are replenished by the cold and nutrient-rich deep waters, which result in enhanced fishery stocks mainly in the Dhofar and subsequently Wusta and Sharqiyah coastal region.

During 2001, the total fish landings remained steady at about 130,000 metric tons (mt). Sardines with a total catch recorded at 56,335 mt, comprised 85% of the small pelagic landings, and 43% of total Omani landings. The large pelagic, represented largely by yellow fin tuna followed by longtail tuna and kingfish were harvested by both traditional and industrial fisheries, and yielded a total catch of 25,528 mt, or 20% of total fish landed. The demersal fisheries on emperor, seabream, grouper and so on contributed 20% of the total catch recorded to be 25,941 mt (Table 2.3.3). The relative share of the traditional and industrial sectors was approximately 96% and 4%, respectively. The industrial landings which are allocated a capable limit of 80,000 tons' catch per year by the authority have gradually decreased since 1998 (Table 2.3.4). Omani fishermen also catch substantial amounts of lobster, shrimp and abalone that are all highly quoted on the international market.

Oman is self-sufficient in fishery resources and has surplus for export to GCC and European countries. The share of domestic consumption and export was 60% and 40% in 2001. Although resources such as lobster, abalone, cuttlefish and kingfish are being subjected to rather fishing pressure, Oman is still not fully utilising other available resources, which appear to have potential for future development.

Table 2.3.3 Traditional and Industrial Fisheries: Total Landing by Region and Sector during 2001

(mt)

	Traditional						Industrial		Total
	Dhofar	Wusta	Sharqish	Muscat	Batinah	Musandum	Longline	Trawlers	
Large pelagics									
Yellow fin tuna	423	232	3,895	1,122	525	62	1,686	0	7,945
Longtail tuna	162	263	2,138	490	1,682	1,275	0	0	6,010
Kawakawa	74	5	767	491	402	223	0	0	1,962
Striped bonitto	31	0	88	133	36	0	0	0	288
Frigate tuna	3	0	212	339	77	7	0	0	638
Skipjack	0	0	0	0	0	0	0	0	0
Other tuna	7	131	25	19	5	1	0	0	188
Kingfish	88	691	1,231	205	381	189	0	0	2,785
Queenfish	17	102	90	71	132	116	0	0	528
Baracuda	12	101	142	521	864	129	0	12	1,781
Cobia	7	3	16	10	16	2	0	0	54
Sailfish	1	0	85	11	34	0	88	0	219
Large jacks	358	69	204	114	228	260	0	69	1,302
Other	610	629	541	4	11	5	25	3	1,828
Subtotal	1,793	2,226	9,434	3,530	4,393	2,269	1,799	84	25,528
Small pelagics									
Sardine	5,786	746	13,013	17,036	19,069	685	0	0	56,335
Indian oil sardine	1,373	328	58	751	113	2	0	0	2,625
Indian mackerel	15	201	850	1,014	658	486	0	0	3,224
Anchovy	2	0	0	360	46	562	0	0	970
Small jacks	2	190	244	389	184	208	0	0	1,217
Mullets	33	128	295	40	1	46	0	0	543
Neddlefish	0	0	11	89	11	19	0	0	130
Other	1	0	251	1,047	221	15	0	28	1,563
Subtotal	7,212	1,593	14,722	20,726	20,303	2,023	0	28	66,607
Demersal									
Emperor	2,437	2,252	1,117	179	205	313	0	23	6,526
Seabream	1,754	577	647	96	61	59	0	781	3,975
Grouper	1,002	1,283	1,015	96	117	276	0	10	3,799
Crocker	216	1,088	537	13	1	1	0	18	1,874
Sweetlips	60	229	127	55	37	32	0	2	542
Snapper	73	1	11	16	70	208	0	2	381
Jobfish	178	155	202	285	279	0	0	106	1,205
Rabbitfish	120	8	210	4	3	18	0	0	363
Catfish	38	546	1,597	36	11	10	0	0	2,238
Ribbonfish	7	95	684	385	232	22	0	1,192	2,617
Other	295	550	144	382	267	408	0	375	2,421
Subtotal	6,180	6,784	6,291	1,547	1,283	1,347	0	2,509	25,941
Sharks & Rays									
Sharks	391	476	1,727	356	339	211	90	43	3,633
Rays	4	0	30	23	133	1	0	6	197
Subtotal	395	476	1,757	379	472	212	90	49	3,830
Crustaceans									
Lobster	291	72	15	0	0	0	0	0	378
Shrimp	0	627	0	0	0	0	0	0	627
Cuttlefish	516	2,215	2,453	150	251	17	0	71	5,673
Abalone	51	0	0	0	0	0	0	0	51
Undentified fishs	0	528	686	60	0	0	0	0	1,274
Subtotal	858	3,442	3,154	210	251	17	0	71	8,003
Grand total	16,438	14,521	35,358	26,392	26,702	5,868	1,889	2,741	129,909

Maximum Sustainable Yield (MSY) in the Oman Bay and The Arabian Gulf

	MSY	Yield in 2001
Large pelagics	78,000	25,500
Small pelagics	250,000	66,600
Demersal	58,000	25,900
Sharks & Rays	14,000	3,800
Crustaceans	19,000	8,000
Total	419,000	129,800

Source: "The challenge of optimizing the development of Omanis fisheries sector (1989)"

Present and planned aquaculture project by private sector in Oman

Project	Area	Number	Remarks
Finfish cage culture	Musadandam	1	Plan
Finfish cage culture	Muscat	1	Present
Finfish cage culture	Bandar Khairan	1	Present
Finfish cage culture	Qalhat (Al-Sharqiuah region)	1	Plan
Earthern pond for shrimp	Shinas (Al-Batinah region)	3	Plan
Earthern pond for shrimp	Liwa (Al-Batinah region)	1	Plan
Earthern pond for shrimp	Musaniah (Al-Batinah region)	2	Plan
Earthern pond for shrimp	Quriyat	1	Plan
Earthern pond for shrimp	Masirah island	1	Plan
Mullet culture	Masirah island	1	Plan
Earthern pond for shrimp	Bintot (Al-Wusta region)	1	Plan
Abalone culture in plastic tank	Mirbat	1	Plan

While aquaculture is still in its infancy in Oman, interest in mariculture as an alternative source of high quality protein has increased. Ministry of Agriculture and Fisheries established the aquaculture laboratory at Marine Science & Fisheries Centres in 1992 in order to promote aquaculture growth. The aquaculture laboratory has conducted the following projects in co-operation with private company or JICA.

- Preliminary site survey for aquaculture possibilities
- Experimental shrimp & shellfish culture *(Pnaeus indicus, P. monodon, P. japonicus, Pinctada magaritifera, P. radiat, Mytilus pictus)*
- Finfish cage culture *(Sparus aurata, Acanthopagrus cuvieri)*
- Abalone pilot seed production *(Haliot mariae)*

The private sector already started finfish cage culture in Muscat and Bandar Khayran after the successful research project by the aquaculture laboratory. The projects to start aquaculture business were consulted in recent years as follows.

The fishery resources have a good development potential to diversify possibly from the Sultanate' s dependence on oil resources alone.

Table 2.3.4 Traditional and Industrial Fisheries: Total Landing (mt) from 1985 to 2001

Year	Traditional						Industrial		Total
	Dhofar	Wusta	Shargish	Muscat	Batinah	Musandum			
1985	18,707	14,593	16,620	10,706	19,331	1,568	13,368		94,893
1986	18,500	21,515	9,206	11,596	20,444	1,515	13,561		96,337
1987	11,592	49,379	22,521	12,274	26,515	1,852	10,956		135,089
1988	24,088	31,188	45,664	14,373	30,861	1,994	17,911		166,079
1989	22,855	13,528	20,804	11,899	32,106	4,055	12,290		117,537
1990	21,512	10,244	15,718	17,585	31,999	2,740	18,843		118,641
1991	20,659	10,067	11,023	16,529	41,916	3,342	14,229		117,765
1992	19,913	7,600	19,677	16,610	29,949	3,297	15,267		112,313
1993	15,491	4,830	26,570	17,610	24,013	3,920	24,035		116,469
1994	12,659	5,562	26,755	19,127	28,840	4,592	21,037		118,572
1995	12,320	5,845	28,085	25,937	31,982	4,397	31,295		139,861
1996	10,526	7,257	21,858	20,009	26,017	2,847	33,101		121,615
1997	11,857	8,675	18,242	18,751	23,392	3,528	34,549		118,994
1998	14,447	12,262	20,657	16,636	20,034	4,521	17,608		106,165
1999	11,393	15,906	24,663	19,817	20,681	4,204	12,145		108,809
2000	18,738	11,524	22,964	25,664	23,749	5,380	12,402		120,421
2001	16,437	14,522	35,357	26,388	26,702	5,868	4,629		129,903
Rate per total in 2001 (%)	12.7	11.2	27.2	20.3	20.6	4.5	3.6		100

2.4 Institutional Setting

2.4.1 Environmental Legislation

a. General Environmental Protection

The following Royal Decrees (RD), Ministerial Decisions (MD), and regulations are relevant to coastal issues.

- RD 6/2003. Law on Nature Reserves and Wildlife Conservation (replaces RD 26/79 Law on National Parks and Protected Areas). See 2.4.1 b. for further details.
- RD114/2001. The Law on Conservation of the Environment and Prevention of Pollution (replaces RD 10/1982).
- RD 53/81. Law of Sea Fishing and the Protection of Marine Biological Wealth.
- RD 26/79. Law on National Parks and Protected Areas (now replaced by RD 6/2003).
- MD187/2001. This regulates issuance of Environmental Approvals and the Final Environmental Permits.
- MD 200/2001. This regulates permits for crushers, quarries and mining sand from wadis and beaches.
- MD 207/93. Bans hunting, trapping or shooting animals or birds in the Sultanate.

- MD 128/93. Bans cutting green trees.
- MD 20/90. Establishes a System for Coastal Setbacks for new construction along the coastline. Natural coastline setback 300m, sandy beach around khawrs 150m, sandy beaches 50m.
- MD 40/81. Building Code for Oman. Defines buildings, permanent buildings, temporary buildings, requirement for building permits, setback, and inspections and violations.

RD 114/2001 enables the Minister of Regional Municipalities, Environment and Water Resources to set regulations to protect the environment and control pollution. Any development that may impact on the environment must obtain a permit from the Ministry. Before issuing a permit, the MRMEWR may require that an environmental impact assessment study be conducted.

An environmental impact assessment must be applied as early as possible in a project's planning stage and before irrevocable decisions are made. Making information available to the public is an important part of an open and balanced EIA process.

- Guidelines for obtaining environmental permits have been set out for the following types of projects:
  - Industrial; Mining; Agricultural; Food; Tourism; and Light industries.
  - Service projects include roads, and designs for roads crossing wadis and tributaries, which must be submitted to the Ministry for approval.
  - Marine and coastal projects must take care to protect vulnerable areas such as mangroves, khawrs and coral reefs.
- Provisions of these Laws relevant to mangroves include the following:

It is not allowed to: Cut down or damage trees in public forests without obtaining a permit; Remove stones, soil, sand, or uproot trees, shrubs or grass from watercourses, beaches, wadis, ponds without a permit. No waste can be dumped into the marine environment without a permit. It is an offence to damage nature conservations areas or wildlife, particularly species listed in appendix 1 and 2 of RD 114/2001 (this includes sea turtles, flamingo, pelican, gull and tern species, and all wild mammal species).

Oman is also a signatory to the Convention on Biological Diversity, ratified by Royal Decree (119/94). In 2001, the Ministry of Regional Municipalities, Environment and Water Resources published the National Biodiversity Strategy and Action Plan with input from relevant government and private institutions. Among the objectives of the convention are the conservation of biodiversity and the sustainable use of biological resources.

b. Protected Areas

Further to earlier laws on wildlife protection such as MD 207/93, which banned the hunting, trapping or shooting of animals or birds in the Sultanate (in effect superseded by RD 114/2001) and MD 128/93, which banned cutting green trees, the following law enables specific habitats and species to be protected.

- Royal Decree 6/2003. The Law on Nature Reserves and Wildlife Conservation (which replaced Royal Decree 26/79, the Law on National Parks and Protected Areas).

This law allows for Nature Reserves to be established by Royal Decree according to proposals from a committee with representatives of certain Ministries. Making any alteration to the reserve's boundaries, classification or buffer zone is not permitted, except by Royal Decree. An important new article in this law is the provision for the Minister of Regional Municipalities, Environment and Water Resources, after approval by cabinet, to establish a Temporary Protected Area or an Area of Special Significance. This should allow the more rapid legal protection of a sensitive area until full Nature Reserve status can be established by Royal Decree. Under the original RD 26/79 several protected areas have been declared:

- Royal Decree 04/94 proclaimed the Arabian Oryx Sanctuary. The boundary at present recognised by the MRMEWR covers 24,785 km^2 of the central plateau, which is home to the reintroduced Arabian Oryx and other mammals, as well as having important geological and archaeological sites. The sanctuary was listed as a UNESCO World Heritage Site in 1994.
- Royal Decree 23/96 proclaimed Dimaniyat Islands Nature Reserve. The reserve covers 203 km^2 distributed over 9 islands, 16-18 km from the coast. The conservation objectives are to protect turtle nesting beaches, coral reefs, birds and plants and to promote ecotourism. A permit is required to visit the islands.
- Royal Decree 25/96 proclaimed Ra's al Had Turtle Reserve. The reserve covers 120 km^2 of beaches, coastal lands, seabed and Khawrs al Hajar (including Quq) and Khawr Jaramah. Conservation of turtles and their nesting beaches is given first priority under the management plan, but it also deals with the needs of the fishermen. Various options for tourism, which benefit the local people, without causing damage to the biological resources, are also addressed. A permit is required to visit the nesting beaches.

- Royal Decree 48/97 proclaimed Jebel Samhan Nature Reserve. The reserve covers 4,500 km^2 of barren mountain peaks and deep canyons. It includes the escarpment overlooking the foothills and coastal plain, as well as an escarpment towards the east, which reaches the shore. One of the aims is to conserve the coastal environment and use it sustainably.
- Royal Decree 49/97 proclaimed The Khawrs Reserve of Dhofar Coast. The areas of the khawrs vary from a few hectares to a hundred hectares. The main conservation objective is the sustainable use of the resources. Several khawrs have been fenced to protect against overgrazing, while controlled harvesting will be allowed. The eradication of invasive exotic plant species is also planned. Excavation and restoration of the main archeological sites is planned. Khawrs mentioned specifically include: Mughsayl, Dahariz, Balid, Awqad, Qurm as Saghir and Qurm al Kabir, Sawli, Taqah and Rowri. Khawr Rowri is the largest of the proclaimed khawrs. It has been proposed that the area be fenced and, as soon as there is a recovery in vegetation, that some indigenous wild animals could be introduced. Limited visitor facilities are also proposed with an information centre at the archaeological site.
- Royal Decree 50/97 proclaimed As Saleel National Park. It covers 220 km^2 of alluvial plain and protects a variety of wildlife.

It has been proposed by MRMEWR that the coastal area of Barr al Hikman and the shallow water surrounding Mahawt Island be established as a Nature Reserve by Royal Decree. As of early 2004, decisions were made that the proposed boundaries and zones should be reviewed and clarified and that there should be consultations with the local people regarding the proposal. It is expected that management plans for this area would include the protection of fishery resources and wildlife, particularly turtles and birds.

Several study sites chosen for the JICA mangrove study fall within the boundaries of declared protected areas and any master plan will need to take account of existing management plans for these areas. These study sites include: Al Qurm – originally designated as a Protected Area in 1975 (and now managed as such with the agreement of Muscat Municipality), Khawr Quq, Khawr Hajar, Film shoreline, Mahawt Island, Khawr Rowri, Khawr Dahariz, Khawr Balid, Qurm Kabir and Qurm Saghir.

The GIS Remote Sensing Office of the Ministry possesses the following satellite image data and the Study Team was granted permission to make data linkage between the satellite image data and the data of this survey. The list of protected Area is shown in Table 2.4.1.

Table 2.4.1 List of Protected Areas

No.	Name of Protected Area	Category	Satellite Image	Scene No.	Image Date
1	The Arabian Oryx Sanctuary	Reserve	LandSat TM	158/046	28/01/1985
				158/047	02/11/1993
2	As Saleed Natural Park	National Park	LandSat TM	157/044	14/04/1992
				157/045	14/04/1992
3	Ra's al Had Turtle Reserve	Reserve	LandSat TM	157/044	14/04/1992
				157/045	14/04/1992
4	Jebel Samhan Nature Reserve	Reserve	LandSat TM	159/048	04/08/2001
5	Dimaniyat Islands Nature Reserve	Reserve	LandSat TM	158/044	08/07/2000
6	Barr Al Hikman Reserve	Reserve	LandSat TM	157/046	10/03/1985
7	Khawr Taqah Reserve	Reserve	LandSat TM	159/048	04/08/2001
8	Khawr Sawli Reserve	Reserve	LandSat TM	159/048	04/08/2001
9	Khawr Rowri Reserve	Reserve	LandSat TM	159/048	04/08/2001
10	Khawr Mughsayl Reserve	Reserve	LandSat TM	159/048	04/08/2001
11	Khawr Dahareez Reserve	Reserve	Ikonos	----	--/12/2000
12	Khawr Balid Reserve	Reserve	Ikonos	----	--/12/2000
13	Khawr Awqad Reserve	Reserve	Ikonos	----	--/12/2000
14	Khawr Saghir Reserve	Reserve	Ikonos	----	--/12/2000
15	Khawr Kabir Reserve	Reserve	Ikonos	----	--/12/2000

In order to carry out mangrove prevention management in the future, the topographic map of each site, which was prepared by subcontract, will be imported as a GIS base map. In order to have a general understanding of the neighbouring environment of each site, the management of green area and water areas using "IKONOS Satellite Image" will be conducted. This will be linked to the above-mentioned "Meteorological Data" and "Social and Economic Statistics Data" as attribute information.

2.4.2 Organisations

a. Central Government Organisations

Several central government institutions have a role or an interest in the management of mangrove ecosystems, while the activities of others can support mangrove conservation and research or may have an impact on the mangrove ecosystems and surrounding areas. These institutions may have conducted studies or hold data that have contributed to the mangrove ecosystem activities of the MRMEWR and JICA Study Team; these activities may continue and be helpful for future monitoring and management. Some of the relevant institutions are described below.

(a) MRMEWR

The organisation chart of the Ministry of Rural Municipalities, Environment and Water Resources (MRMEWR) is shown in Figure 2.4.1. There are three Undersecretaries in MRMEWR, Undersecretary of Regional Municipalities, Undersecretary of Regional Environment, and Undersecretary of Water Resources. There are three Directorate Generals under the Undersecretary for Environment, Directorate General of

Environment, Dhofar, Directorate General of Nature Conservation, and Directorate General of Environmental Affairs.

Two Directorate Generals, Nature Conservation and Environmental Affairs, are concerned with mangrove conservation/ management. The main unit is the Marine Pollution & Coastal Zone Management Section (MPCZMS) in Environmental Inspection & Control Department under the Directorate General of Environmental Affairs. MPCZMS has the tasks of marine pollution control and coastal management including mangrove conservation and management. As of Jan. 2003, there are 10 staff (Head/ Specialists/ Technicians). At least 4 staff, including section head, are engaged in mangrove conservation and management. These staff have rich experiences and skills for mangrove nursery construction/ management/ transplantation under the guidance of a JICA expert, and through training overseas including at Okinawa, Japan.

The Directorate General of Environment, Dhofar is responsible agency for mangrove conservation/ management in Dhofar Region. This office has some experienced staff for conservation and management of mangrove because there are mangrove nurseries at Khawr Kabir in Salalah. In order to obtain more experiences and skills, each member of the staff will have mangrove training at Okinawa, Japan, in the near future.

The Directorate General of Regional Municipalities & Environment in the Regions under the Undersecretary for Regional Municipalities has 8 regional offices. The regional office for Northern Sharqiyah in Sur carries out many activities for mangrove conservation/ management. The staff members manage the mangrove nursery in Sur, and implement plantation activity. The other regional offices (and Wilayat level office under them), especially offices in Sohar (Northern Batinah), Rustaq (Batinah South), Hayma (Al Wusta), should be involved in mangrove conservation/ management in the near future.

(b) Ministry of Agriculture and Fisheries

This Ministry is responsible for licensing and overseeing the activities of fishermen and of the management of fish stocks and other marine resources. The Marine Science and Fisheries Centre is responsible for carrying out research on marine resources.

(c) Sultan Qaboos University

This institution is independent from the Ministry of Education. Two faculties have an interest in mangrove ecosystems as “living laboratories” for teaching their students and for carrying out research: The Faculty of Science, especially its Department of Biological Sciences, and the Faculty of Agriculture, especially the Department of Marine Science and Fisheries and the Department of Soil Science. There is also a Centre for Environmental Studies and Research (CESAR), which has a role in facilitating co-operation between the University and other institutions and has a particular interest in environmental education.

(d) Diwan of Royal Court, Office of the Adviser for Conservation of the Environment

This office was responsible for arranging the creation, by Royal Decree, of the Qurum Nature Reserve in 1975, published a book on the shells of this reserve and has given support to the activities of MRMEWR and the JICA Study Team in mangrove conservation.

(e) National Survey Authority (NSA)

This organisation of the Ministry of Defence holds a comprehensive set of maps, aerial photographs and satellite imagery of the Sultanate, including coastal areas with mangroves. For example the study team obtained from NSA copies of topographic maps, at 1/5,000 and/or 1/100,000 scale, covering each site; but the material obtained was just copies of printed maps and the scales available were limited for some sites.

(f) Ministry of National Economy and Planning

The Public GIS Centre of this Ministry provided the JICA Study Team with "Social and Economic Statistics (1993 edition)", which was incorporated in a CD (2000 edition). The December 2003 population census was carried out under the auspices of this Ministry and the National Supreme Committee for Census.

(g) National Meteorological Agency

This organisation, under the Ministry of Transport and Communications, records meteorological data at various locations throughout the country and makes it available in printed and digital forms. For instance the JICA Study Team obtained "Wind Direction Data (2000 ~ 2001)" and has also requested "Rain Precipitation and Temperature Data".

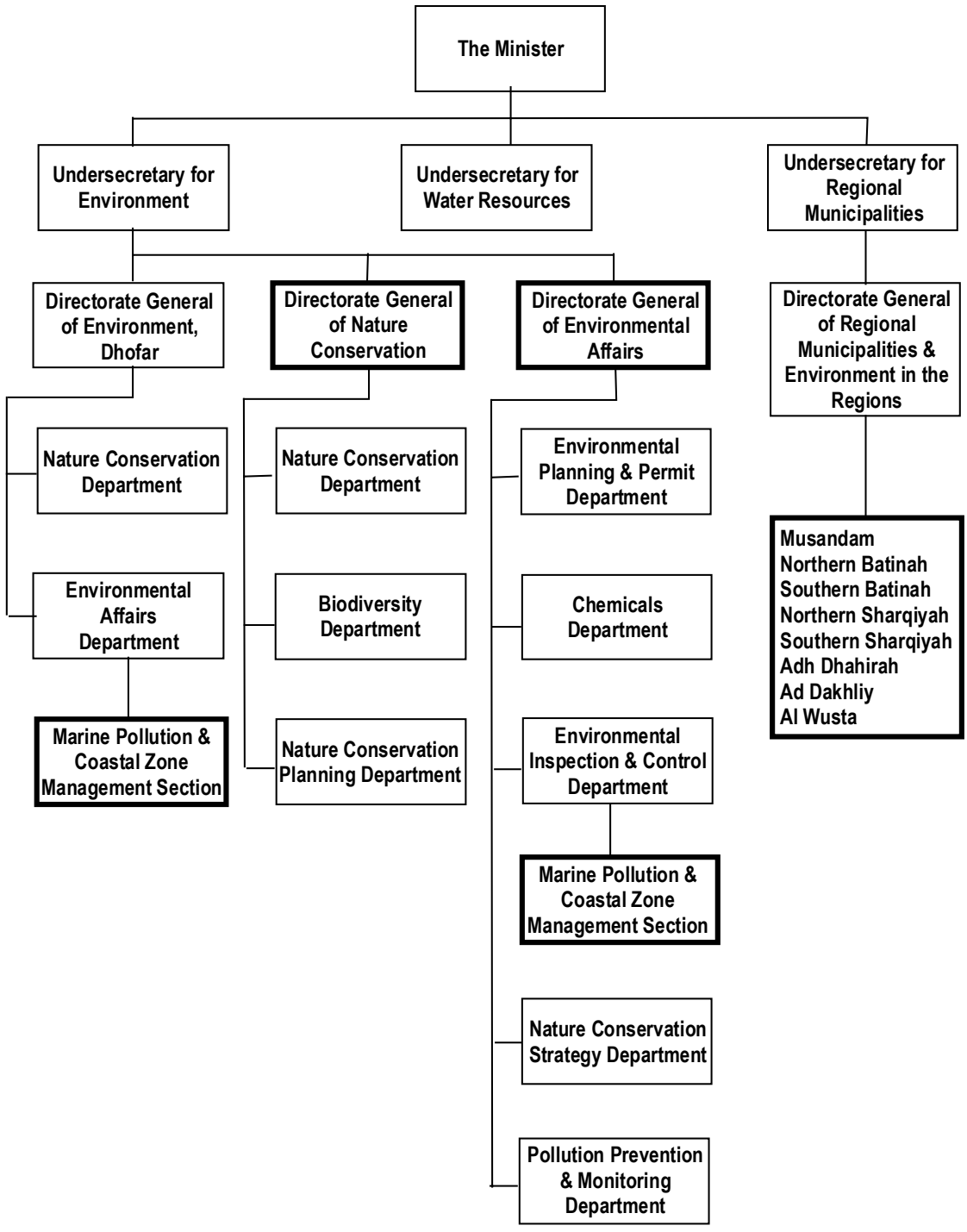

Figure 2.4.1 Organisation Chart of MRMEWR

b. Local Government

There are 3 Governorates and 5 Regions in Oman. Under these Governorates and Regions, there are 59 Wilayats for local municipalities (Table 2.4.2). The administrative unit under Wilayat is locality. The Governorates are managed by Governors who are appointed by the Sultan, and the Wilayats by Walis. These Governorates and Wilayats have environmental sections. However, there are no staff for conservation and management for mangrove in these sections, because the Wilayat office is a practical organisation, not a planning organisation.

(a) International Organisations and NGOs

Oman is a member of the Regional Organisation for Protecting Marine Environment (ROPME), which was established by 8 countries, Gulf Co-operation Council (GCC) countries (Kuwait, Saudi Arabia, Bahrain, UAE, Qatar, and Oman), Iran, and Iraq. The objectives of ROPME are technical support and policy co-ordination for marine environmental problems. In Jan. 2003, Oman was declared the lead country for research into mangrove management in ROPME. The other members accepted this declaration. As of Jan. 2003, there are no donors and NGOs in operation for mangrove management in Oman.

Table 2.4.2 Local Government System

1. Governorate of Muscat

No.	Name	Study Site
1	Wilayat Mutrah	
1-a	Murtafaat Al Qurm	5. Khawr Qurm
2	Wilayat Bawshar	
3	Wilayat As Seeb	
4	Wilayat Al Amrat	
5	Wilayat Muscat	
5-a	Al Khayran	6. Bandar Khayran
6	Wilayat Qurayyat	
6-a		7. Qurayyat

2. Al Batinah Region

No.	Name	
1	Wilayat Sohar	
2	Wilayat Ar Rustaq	
3	Wilayat Shinas	
3-a	Tarif Al Makhamrah	1. Khawr Shinas
4	Wilayat Liwa	
4-a	Harmul	2. Khawr Harmul/Nabr
5	Wilayat Saham	
6	Wilayat Al Khaburah	
7	Wilayat As Suwayq	
8	Wilayat Nakhal	
9	Wilayat Wadi Al Maawil	
10	Wilayat Al Awabi	
11	Wilayat Al Musanaah	
12	Wilayat Al Barka	
12-a	Al Sawadi As Sahil	3. Khawr Sawadi
12-b	Al Haradi	4. Khawr Haradi

3. Governorate of Musandam

No.	Name	
1	Wilayat Khasab	
2	Wilayat Bukha	
3	Wilayat Daba Al Bayah	
4	Wilayat Madha	

4. Adh Dhahirah Region

No.	Name	
1	Wilayat Al Buraymi	
2	Wilayat Ibri	
3	Wilayat Mahdah	
4	Wilayat Yanqul	
5	Wilayat Dank	

5. Ad Dakhliyah Region

No.	Name	
1	Wilayat Nizwa	
2	Wilayat Samail	
3	Wilayat Bahla	
4	Wilayat Adam	
5	Wilayat Al Hamra	
6	Wilayat Manah	
7	Wilayat Izki	
8	Wilayat Bid Bid	

6. Ash Sharqiyah Region

No.	Name	Study Site
1	Wilayat Sur	
1-a	Sur	8. At Tina, 9. Batah
1-b	Ras Al Had	10. Khawr Quq, 11. Khawr Hajar-East Shore
2	Wilayat Ibra	
3	Wilayat Bidiyah	
4	Wilayat Al Qabil	
5	Wilayat Al Mudaybi	
6	Wilayat Dima Wa At Tayyin	
7	Wilayat Al Kamil Wa Al Wafi	
8	Wilayat Jaalan Bani Bu Ali	
9	Wilayat Jaalan Bani Bu Hasan	
10	Wilayat Wadi Bani Khalid	
11	Wilayat Masirah	
11-a		12. Wadi Muraysis

7. Al Wusta Region

No.	Name	
1	Wilayat Hayma	
2	Wilayat Muhut	
2-a	Falam	13. Filim-Easten Beach
2-b	Jazirat Muhut	14. Mahawt Island
3	Wilayat Ad Duqum	
4	Wilayat Al Jazer	

8. Governorate of Dhofar

No.	Name	
1	Wilayat Salalah	
1-a		18. Khawr Dahariz
1-b		19. Khawr Balid
1-c		20. Khawr Kabir
1-d		21. Khawr Saghir
2	Wilayat Thumrayt	
3	Wilayat Taqah	
3-a	Taqah	17. Qurm Taqa
4	Wilayat Mirbat	
4-a		15. Al Demer Beach
4-b		16. Khawr Rowri
5	Wilayat Sadh	
6	Wilayat Rakhyut	
7	Wilayat Dalkut	
8	Wilayat Muqshin	
9	Wilayat Shalim Wa Juzur Al Hallniyat	

2.5 Zoning of Coastal Area

As a result of the survey on existing conditions covering geographical features, climate, wind/ wave and economic activity/ land use, it was decided that the study areas should be categorised into the following 5 zones Figure 2.5.1 shows the cross section of zones.

- Batinah Zone
- Muscat Zone
- Sharqiyah Zone
- Wusta Zone (including Masirah Island)
- Dhofar Zone

The characteristics of each zone are shown in Table 2.5.1.

Table 2.5.1 Characteristics of Each Zone

Zone	Geographical Feature	Climate	Wind/ Wave	Economic activity/ Land use
Batinah Zone	Hinterland is wide plain, and relatively flat. Near the coast, it is relatively shallow, and the seabed is relatively gradual.	Hot and humid during the summer. Rainfall is infrequent and irregular.	Northeast wind in summer, southwest wind in winter. 40% wave frequency in summer, 30% in winter.	Agriculture, fishery. Farmland, populated residential area.
Muscat Zone	Hinterland is hilly, and relatively steep. Near the coast, it is relatively deep, and the seabed is relatively steep.	Hot and humid during the summer. Rainfall is infrequent and irregular.	Northeast wind in summer, southwest wind in winter. 40% wave frequency in summer, 30% in winter	Agriculture, fishery. Farmland, populated residential area.
Sharqiyah Zone	Hinterland is hilly, and very steep. Near the coast, it is deep, and the seabed is steep.	Hot and humid during the summer. Rainfall is infrequent and irregular.	South wind in summer, north wind in winter. 20% wave frequency in summer, 40% in winter.	Fishery. Mountain area, fishing villages
Wusta Zone	Hinterland is desert, and very flat. Near the coast, it is very shallow, and the seabed is almost flat.	Hot and humid during the summer. Rainfall is infrequent and irregular.	Very strong south/ southwest wind in summer, east wind in winter. 30% wave frequency in summer, 40% in winter.	Fishery. Desert area, fishing villages
Dhofar Zone	Hinterland is narrow plain, which is closed by mountain, and plain is relatively flat. Near the coast, it is relatively shallow, and the seabed is relatively gradual.	High humidity commonly Light monsoon rains in summer	North wind in summer, southeast wind in winter. 30% wave frequency in summer, 40% in winter.	Agriculture, fishery. Farmland, populated residential area.

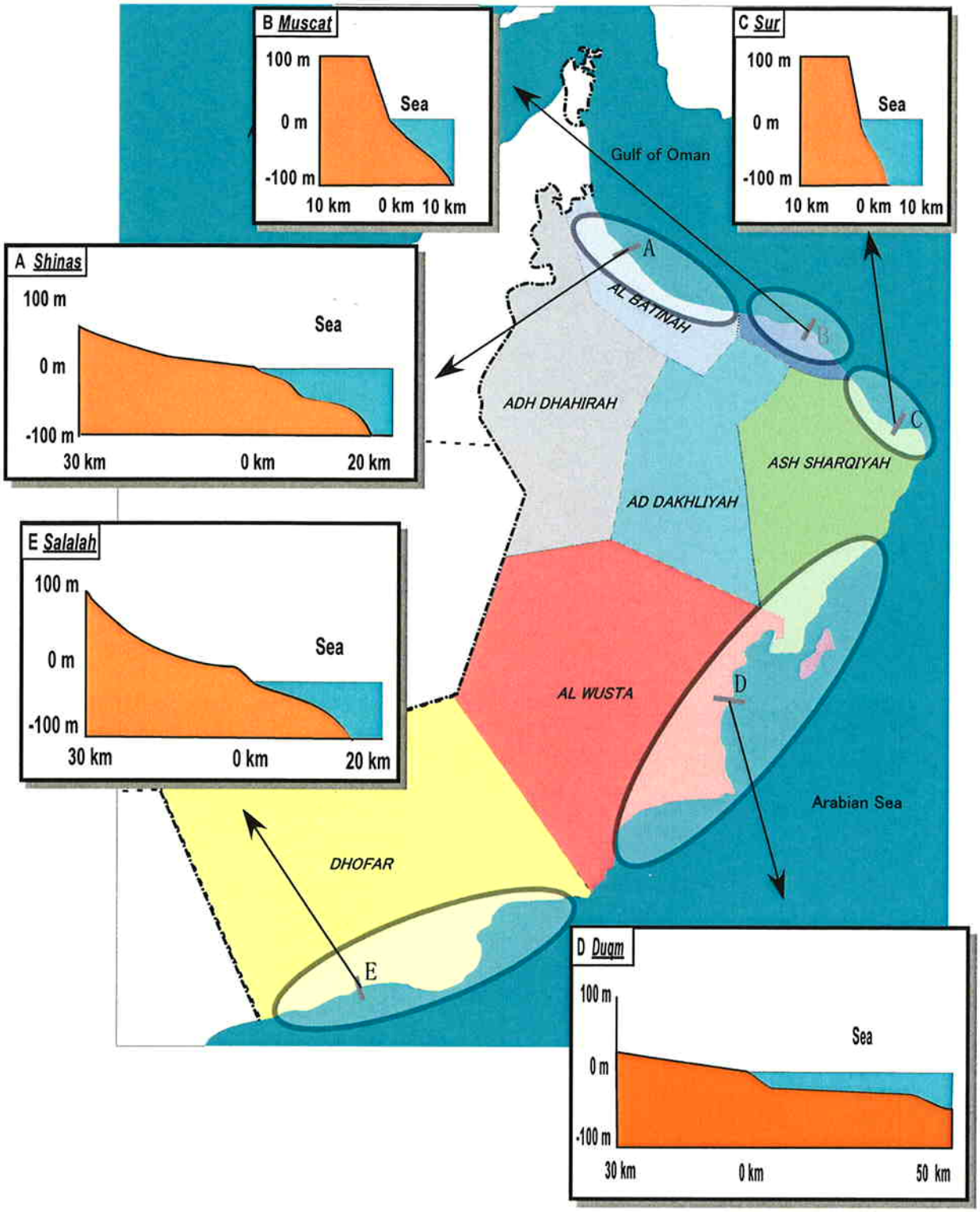

Figure 2.5.1 Classifications of the Study Area and Cross Section

Chapter 3: Value of Mangrove

3. Value of Mangrove

3.1 Value of Mangrove in General

The value of mangrove forests can be categorised as shown in the following figure. The value is divided into two categories of "use value" and "non-use value". The use value comprises direct value, indirect value and option value. The non-use value is usually the existence value. These values depend upon the people, in other words the social conditions and/or sites specific conditions.

In general, mangrove has some values as shown in the following figure. In case of Oman, the main value of mangrove is non-consumptive use value, indirect use value, and non-use value. Especially, the function of maintaining biodiversity is one of the most important values in Oman. From worldwide biological point of view, Oman plays very important role to connect wildlife between Africa and Asia. In this study, this point was considered carefully.

To implement the programmes and projects to be identified in the Master Plan, an understanding and agreement on the plan among Omani people and Government is indispensable. A valuation of mangrove ecosystems was carried out, as part of this study, to find out the most suitable use or conservation activities in this study.

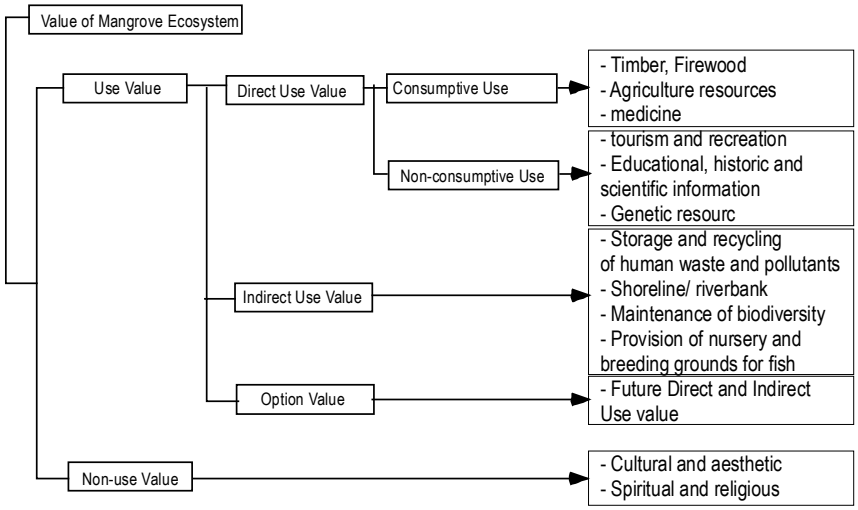

Figure 3.1.1 Value of Mangrove Forest

3.2 Social Conditions Related to the Mangrove

According to the socio-economic survey at 10 sites, some situations common to all sites and some unique characteristics of individual site can be found as summarised as below. Also, the background conditions that might create such characteristics are observed and presumed by the local people.

Table 3.2.1 Common Situations to be seen in All Sites

Item		Situations	Background that Create the Situation
Usage and Values	- Past	1-A. Fodder for camels and goats 2-A. Fuelwood for cooking 3-A. Construction wood for houses and ships 4-A. Fishing	- There were many mangrove trees. - A large number of fish were living.
	- Present	1-A. Recreation (fishing, picnicking) 2-B. Hatchery of fish 3-B. Providing beautiful natural view	- Prohibition of use of mangroves by law for their protection. - Green is attractive to the people.
Resources		- The number of fishes, crabs and shrimps decreased. - The number of wild birds decreased. - The size of mangrove area has increased. - Condition of mangrove trees is not good.	- The khawrs become smaller. - Habitats of wildlife have been damaged. - The mangrove area is protected. - Trees are not well cared for such as lopping.
Impacts on the Living		- The number of livestock animals decreased. - Fishermen go to sea all year round.	- Mangrove cannot be used for fodder. - The khawr cannot be used because of protection.
Awareness		- Many people know that mangrove grow naturally. - Many people know the Nature Reserve designation.	- Empirical knowledge with some relationship with mangroves. - Governmental instruction and regulation are observed by the people.
Local Needs		- Tourism development - People want to protect and extend the mangrove area.	- Villagers expect benefits from development. - They consider that natural green beauty is attractive to the local people and visitors.
Potentials		The people are willing to join the activities by providing labour and advice.	Protection by the local people is important.

Note: A is for Direct Use, B is for Indirect Use/Value in column of "Usage and Values"

In the past, the mangrove ecosystems and khawr systems were utilised for multi-purposes and some of them were managed and controlled well by the local people to avoid over-utilisation. The changes of geographical condition due to less rain and flood, sedimentation, etc. and of the lifestyle, and legal control have limited the usage accordingly. Especially, since the use was stopped by regulations, people's activities and feelings seem to have moved away from the mangrove areas and khawrs. While the people have recognized the changes in the area, some long for the past and feel a little bit uncomfortable about the present unutilised conditions. This is because most of the interviewees know the past conditions well. Most of the people hope for the expansion of mangroves in the area and are willing to be involved in the activities to be planned.

Table 3.2.2 Unique Characteristics in Individual Site

Items		Characteristics	Site	Background to Create the Characteristics
Usage and Values	Past	- Materials for making Omani cement	Bandar Khayran	--
		- Collecting honey	Bandar Khayran/ Qurayyat	- There are no income sources other than fishery. - Livestock animals are free to feed themselves and owners do not care. - Some mangrove areas are protected and surrounded by fence.
	Present	- Collecting honey	Bandar Khayran/ Qurayyat	
		- Fishing using net	Bandar Khayran/ Mahawt Island	
		- Browsing for goats	Bandar Khayran/ Qurayyat/ At Tina/ Mahawt Island/ Qurm Taqah	
		- Browsing for camels	Qurm Taqah	
		- No access by the people	Khawr Kabir/ Qurm Taqah	
Resources		- The number of turtles has decreased and coral reefs have been damaged.	Wadi Muraysis/ Batah	- Lack of environmental education and guidelines for coastal management to the local people.
		- Grasses grown around the khawr decreased.	Khawr Balid	- Over-utilisation for fodder.
Size and Quality		- Water quality has deteriorated.	Khawr Qurm/ Qurayyat	- Wastewater and garbage are disposed of into the sea and khawr water level becomes lower.
		- Mangrove area has decreased.	Qurayyat	- Overgrazing by goats and camels. - Management of trees is not enough.
		- Sedimentation is serious.	Qurayyat/ At Tina/ Khawr Balid	- Harbour construction, dam construction, less rain are causes.
Awareness		- Nobody knows the existence of plant nursery.	Khawr Qurm/ Khawr Kabir/ At Tina	- There are few opportunities to access the area and no information on the nursery.
		- Local people try to stop illegal cutting.	Khawr Qurm	- Local people have observed the regulation.
		- When the mouth is open, the number of fish increases.	Qurayyat	- People have empirical knowledge.
		- Planting activities by school students.	Batah	- The activities are well promoted.
		- Sheiks and the local people managed/controlled the area.	Qurayyat/ Wadi Muraysis/ At Tina	- The people knew the capacity of the mangrove and wanted sustainable use.
Local Needs		- Permanent open mouth of the khawr	Qurayyat	- The people need more fish and mangroves previously.
		- A bridge or a jetty from Filim to the Island	Mahawt Island	- Low tide limits the people's life.
		- The unemployed should be involved in the activities.	Batah	- There are many unemployed young and need job opportunities.
Potentials		- Information Centre is welcomed.	Khawr Qurm	- It will be tourism spot.
		- School participation is available.	Khawr Shinas/ Bandar Khayran/ Batah	- School activities in the field are frequent.
		- Monitoring of the area by the local people is required.	Wadi Muraysis	- Inspectors visiting from other areas are not familiar with the area.
		- Monitoring of the areas by women is recommended.	Mahawt Island	- Women have used the mangrove area more than men and know the significance of the mangrove ecosystem.

Among the above characteristics, positive ones can be made good use of to promote the activities of protection and management of the mangrove ecosystems, and for negative ones the ways of mitigation should be considered. The following table tries to find the measures to be taken, based on the results of the social survey. These information can be utilised for selecting transplanting sites and taking the conservation measures.

Table 3.2.3 Measures to Utilise the Advantages and Disadvantages

	Characteristics	Countermeasures
Advantage	• The frequency of recreational use of the mangrove and the khawr ecosystem has increased. • Activities of seedling planting have been done organised by MRMEWR. • There are school activities in the field as environmental education. • Women are very much involved in caring for mangrove area in some places. • People appreciate the natural beauty of a green landscape. • The local people know the Nature Reserve area and observe the regulation.	• Information on mangrove ecosystems and the importance of protection should be provided to the visitors by setting up signboards and distributing brochures, etc. • Planting activities should be continued involving more local people, especially school students. • School field activities should be utilised for this purpose, providing information on mangrove ecosystem to students as well as school staff and families. • Women should be involved in the activities. • In order to attract more people to visit the area, the way of protection should be considered (not just fencing the area but creating a nice atmosphere).
Disadvantage	• The number of fish, turtles and birds has decreased. • Conditions of mangrove trees are not good in spite of the area expansion. • The existence of plant nursery is not known well among the local people. • Still browsing by goats and camels is a problem in some places. • The protected area is fenced and keeps the people away, which makes the people feel uncomfortable and uninterested in the mangrove ecosystem. • In spite of many tourism development plans in various places, the involvement of the local people as beneficiaries is not promoted yet. • Awareness level of the local people for the mangrove ecosystem varies from place to place. • With population increase, urbanisation and motorisation, coastal area including mangroves gets impacts.	• Regulations and guidelines for protection of their habitats should be considered. • Regular management by the local people should be considered such as trimming, cleaning and monitoring. • Information on the MRMEWR activities should be disseminated widely. • Guidelines for feeding livestock animals can be considered. • Signboards and billboards explaining the mangrove ecosystem and importance of the protection (especially, the benefit to the people) should be set up and small facilities inviting the visitors should be considered. • The local people should receive benefits through employment and other ways. • Environmental education and enlightenment regarding mangrove should be flexible depending on the characteristics of the target groups. • Regulation and education for public awareness are necessary.

3.3 Value of Mangrove in Oman

3.3.1 Valuation Criteria

The valuation criteria set by the study are summarised in Table 3.3.1.

Table 3.3.1 Criteria of the Values of Mangrove

Value of Mangrove Ecosystem				Criteria			
				A; High potential	B; Medium potential	C; Low potential	N; No potential
1. Use Value	1.1 Direct Use Value	1.1.1 Consumptive Use	Timber, Firewood, Agriculture resources, Medicine	Almost all families are using	Half of families are using	A certain number of families are using	Almost all families are not using
		1.1.2 Non-consumptive Use	Tourism and Recreation Educational, Historic and Scientific Information Genetic Resource	National level (attraction for national tourists)	Regional level (attraction for regional tourists)	Local level (attraction for local people)	No possibility
	1.2 Indirect Use Value		Storage and Recycling of Human Waste and Pollutants	Occurs in almost all places	Occurs in many places	Occurs in some places	Does not occur
			Shoreline/ Riverbank Protection	At storm control level	Against normal wind and waves	Against tidal erosion	No possibility
			Maintenance of Biodiversity	National level (mangrove area)	Regional level (mangrove area)	Local level (mangrove area)	No significant value
			Provision of Nursery and Breeding Grounds for Fish	For regional economy	For supplement of income	For recreation	No possibility
	1.3 Option value		Future Direct and Indirect Use Value	For regional economy	For supplement of any income	For recreation	No possibility
2. Non-use value			Cultural and Aesthetics (landscape) Spiritual and Religious	National level (valuable/ rare for nation)	Regional level (valuable/ rare for region)	Local level (valuable/ rare for local area)	No potential

* There are many points of view on the evaluation of biodiversity. One of views is that there is a positive correlation between biodiversity and the size of mangrove area. In this study, the size of mangrove area is used as the evaluation criteria of biodiversity.

3.3.2 Value Recognised by Zone/Study Site and Management Direction

Based upon the socio-economic survey, the value of mangroves by zone is shown in Table 3.3.2, by study site in Table 3.3.3.

Table 3.3.2 Valuation of Mangrove Ecosystem by Zone

Value of Mangrove Ecosystem				Zone				
				Batinah	Muscat	Sharqiyah	Wusta	Dhofar
1. Use Value	1.1 Direct Use Value	1.1.1 Consumptive Use	1.1.1.1 Timber, Firewood	N	N	N	N	N
			1.1.1.2 Agriculture resources	N	C	C	N	N
			1.1.1.3 Medicine	N	N	N	N	N
		1.1.2 Non-consumptive Use	1.1.2.1 Tourism and Recreation	B	A	A	C	A
			1.1.2.2 Educational, Historic and Scientific Information	B	A	B	B	A
			1.1.2.3 Genetic Resource	C	C	C	C	C
	1.2 Indirect Use Value		1.2.1 Storage and Recycling of Human Waste and Pollutants	N	N	N	N	N
			1.2.2 Shoreline/ Riverbank	C	C	C	C	C
			1.2.3 Maintenance of Biodiversity	A	A	A	A	A
			1.2.4 Provision of Nursery and Breeding Grounds for Fish	N	C	C	B	N
	1.3 Option value		1.3 Future Direct and Indirect Use Value	N	N	N	N	N
2. Non-use value			2.1 Cultural and Aesthetics (landscape)	C	A	B	A	C
			2.2 Spiritual and Religious	C	C	C	C	C

Legend: A; High potential, B; Medium potential, C; Low potential, N; No potential

Table 3.3.3 Valuation of Mangrove Ecosystem by Study Site

Zone	Batinah				Muscat			Sharqiyah				Wusta			Dhofar						
Value of Mangrove Ecosystem	Khawr Shinas	Khawr Harmul/ Nabr	Khawr Sawadi	Khawr Haradi	Khawr Qurm	Bandar khayran	Qurayyat	At Tina	Batah	Khawr Quq	Khawr Hajar – East Shore	Wadi Muraysis	Filim – Eastern Beach	Mahawt Island	Al Demer beach	Khawr Rowri	Qurm Taqah	Khawr Dahariz	Khawr Balid	Khawr Kabir	Khawr Saghir
1.1.1.1	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
1.1.1.2	N	N	N	N	N	C	C	C	C	N	N	N	N	N	N	N	N	N	N	N	N
1.1.1.3	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
1.1.2.1	B	B	A	N	A	A	B	A	A	A	A	C	C	A	C	A	C	C	A	B	A
1.1.2.2	A	B	A	C	A	B	A	A	A	C	C	C	C	A	C	A	B	B	A	A	A
1.1.2.3	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
1.2.1	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
1.2.2	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
1.2.3	A	A	B	C	A	A	A	B	A	B	B	B	B	A	C	A	B	B	B	A	A
1.2.4	N	N	N	N	N	B	C	N	N	N	N	N	N	A	N	N	N	N	N	N	N
1.3	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
2.1	A	B	C	A	A	B	A	B	B	B	B	A	B	A	C	A	C	C	A	C	C
2.2	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C

Mangrove in Oman comprises one species and also is spread on a very small scale. Therefore, the value of mangrove ecosystem in Oman is limited mainly to that of the resources for tourism/ recreation, education, heritage, scientific research, and the maintenance of biodiversity. Nonetheless, its value as greenery is particularly significant for this "desert country". From the results of the valuation of the mangrove ecosystem, the basic policy on mangrove management was set.

In the Batinah Zone, mangroves play a role as a recreation site for residents, a source of educational information for residents/children, and as a biodiversity resource especially birds. The public parks adjacent to mangrove are used by residents at Khawr Shinas, and Harmul/Nabr, therefore the afforestation and management of mangrove is required. Khawr Sawadi is located near Sawadi Hotel, therefore the management and utilisation of mangroves as a tourism resource of mangrove are required. Coastal management, including pollution control, is required at Khawr Haradi.

In the Muscat Zone, mangroves play a role as a recreational site for tourism, not only national tourists but also international tourists, as a source of educational information for residents/children in Muscat City, a resource for biodiversity especially as a bird sanctuary, and as an element of the city aesthetics. Khawr Qurm, which is located at the heart of Muscat City, can be managed as a centre for educational information and place for the maintenance of biodiversity, possibly as a Ramsar Site. In Qurayyat, mangroves were managed by local people according to guidance from local Sheikhs. Based upon this historical fact, it is helpful if the mouth of khawr is kept open, therefore a training dike could be constructed. Mangroves in Bandar Khayran have the potential to support a fish nursery, therefore experimental afforestation for fishery could be considered.

The role of mangroves in Sharqiyah Zone is mainly for recreation for residents/ tourists, educational information for residents/ children, and a resource for biodiversity especially as bird sanctuaries. The mangroves at Batah are amongst the largest ones in Oman, so the protection and increase of mangroves are required. There are no mangroves at At Tina in Sur, and Khawr Quq and Khawr Hajar – East Shore at Ras Al Had. These sites have potential for mangrove growth, and maybe had mangroves in the past, afforestation is required for revival with special attention to protecting turtle habitat.

There are large-scale tidal flats in Wusta Zone. Mahawt Island has the largest mangrove area in Oman, and is the only site that appears to play a significant role in supporting fisheries. The mangrove at Mahawt Island might have the potential on the function of nursery of juveniles. It is better to have further study to clear up the relationship between the mangrove at Mahawt Island and the nursery of juveniles at Ghubbat Hashish which is located opposite side of Mahawt Island. This mangrove area should be kept as a symbol of mangrove in Oman. Careful management is required. Residents and government staff at Wadi Muraysis on Masirah Island and Filim have a strong willingness to plant mangroves. This is very important as an example of public participation.

The khawrs in Dhofar Zone are almost small scale and are often closed at their mouths. Therefore, the basic policy for coastal zone management in relation to mangroves is from the viewpoint of recreation and education for residents of Salalah City, and for the maintenance of biodiversity along with low level use as browse/ fodder for camels in sustainable basis with due consideration on conservation. For Al Demer Beach, further study of the sand dunes is required as a part of watershed management in Dhofar. The ecosystem at Khawr Rowri and Dahariz is intact, therefore any artificial activities are restricted. The adequate management for keeping existing ecosystem is required including the control of *Prosopis julifora*. Qurm Taqah, Khawrs Kabir and Saghir have existing mangroves, therefore management/ protection of the existing mangrove is required along with some planting. Khawr Balid, a site of archaeological importance, is located near the heart of Salalah City, recreational and educational function is expected. A centre for mangrove planting and garden can be considered.

The study sites are characterized mainly by the existence of mangrove and potential/ needs of mangrove plantation. Table 3.3.4 shows the characteristics of each khawr. The 21 study sites are divided in to 4 Types (Figure 3.3.1). Table 3.3.4 also shows the results of type classification.

Table 3.3.4 Type of the Khawr Site

No.	Site Name	Mangrove exist?	Potential and needs for mangrove plantation?	Remarks	TYPE
1	Khawr Shinas	Yes	Yes	Potential area in the north khawr	TYPE 1
2	Khawr Harmul & Nabr	Yes	No	No space for new plantation, Sand deposition on mangrove vegetation	TYPE 2
3	Khawr Sawadi	No	Yes	Wide potential areas	TYPE 3
4	Khawr Haradi	No	No	Mouth of the Khawr is closed, No water in khawr	TYPE 4
5	Khawr Qurm	Yes	Yes	Plantation for QIC project	TYPE 1
6	Bandar Khayran	Yes	Yes	Potential area in front of fishery port	TYPE 1
7	Qurayyat	Yes	Yes	Sand deposition on mangrove vegetation, Plantation for training dike project	TYPE 1
8	At Tina	No	Yes	New plantation was already implemented by MRMEW	TYPE 3
9	Batah	Yes	Yes	Natural regeneration, Wide tidal area in front of vegetation	TYPE 1
10	Khawr Quq	No	Yes	Medium size tidal area	TYPE 3
11	Khawr Hajar - East shore	No	Yes	Wide tidal area	TYPE 3
12	Wadi Muraysis	No	Yes	Long coast and tidal zone	TYPE 3
13	Filim – Eastern Beach	Yes	Yes	Wide tidal area, poor natural regeneration	TYPE 1
14	Mahawt Island	Yes	No	Coastal area mostly covered by natural vegetation	TYPE 2
15	Al Demer	No	No	Sand protection area	TYPE 4
16	Khawr Rowri	No	No	World heritage, potential area only on the sand bar	TYPE 4
17	Qurm Taqah	Yes	○	Very small area	TYPE 1
18	Khawr Dahariz	No	No	Mouth of the Khawr is closed, Small potential area near khawr mouth, but in danger of flash flood	TYPE 4
19	Khawr Balid	No	Yes	World heritage, plantation for a new project	TYPE 3
20	Khawr Kabir	Yes	No	Already planted by MRMEW in a potential area	TYPE 2
21	Khawr Saghir	Yes	No	Already planted by MRMEW in a potential area	TYPE 2

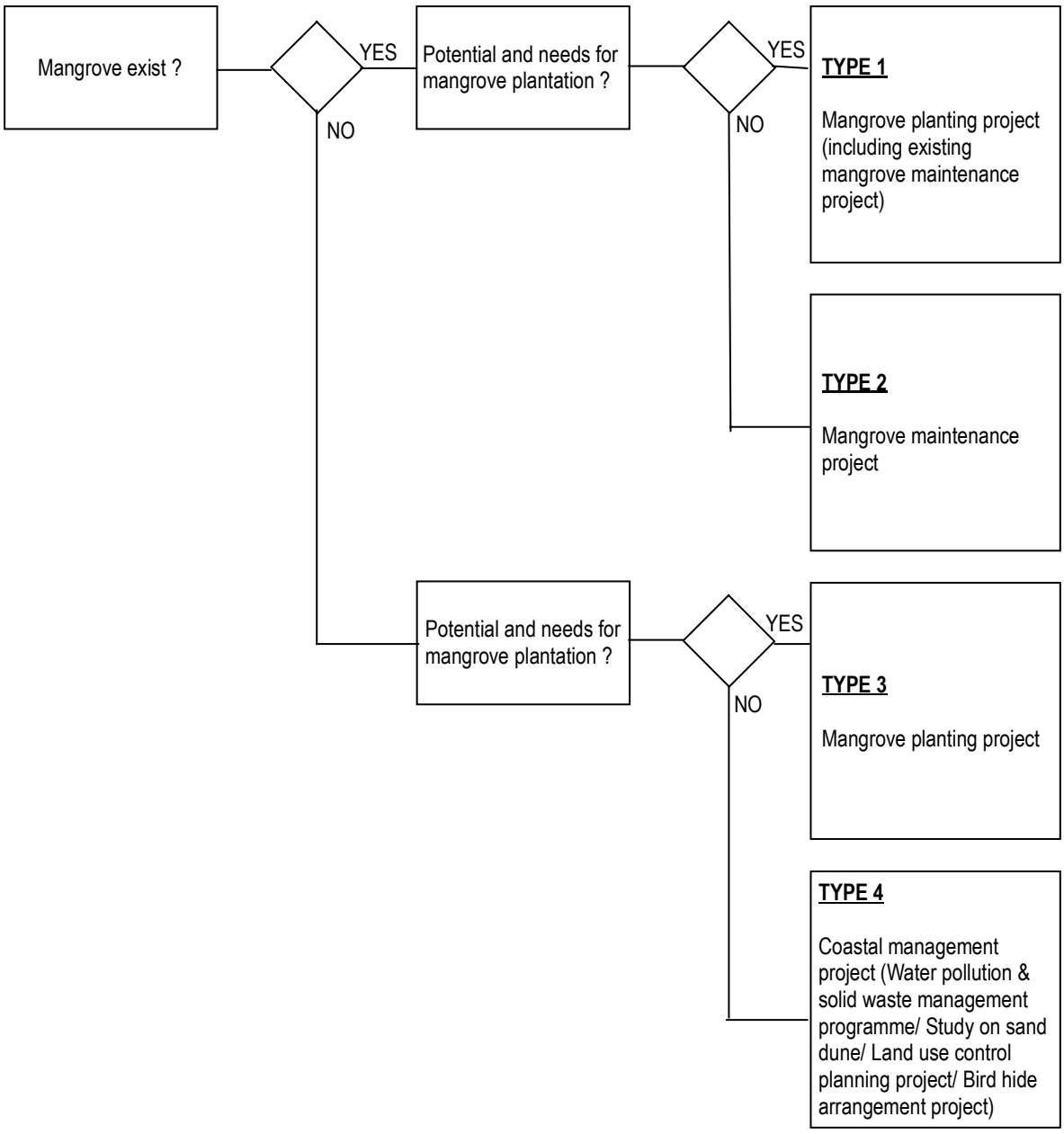

Figure 3.3.1 Types of the Khawr Site

Chapter 4: Issues and Strategy

4. Issues and Strategy

4.1 Introduction - Protective and Creative Management of Mangroves

Mangroves, *Avicennia marina*, have grown on the coast of Oman for many thousands of years. Historically, they have provided browse for livestock, fuel-wood, timber for building and stems for various crafts, including baskets used for fishing activities. These uses are generally declining due to increased wealth and the availability of gas for cooking. Though it is evident that their distribution, abundance and condition have been affected by sedimentation, climate and sea level change and the activities of man and his livestock, this species has survived at many locations to the present day without any supporting interventions (such as planting) from the human population.

The only form of "traditional" conservation/resource management that has been identified by the JICA study, took place at Qurayyat in the 20th Century (possibly earlier) up until about 40 years ago. Several leaders of the local communities in Qurayyat, especially those in the districts near to the Khawr, would monitor the condition of the mangrove. According to their advice, and perhaps three times per year, the Wali would authorise a public announcement allowing the local people to exploit the mangroves. As a result, local people would harvest living and dead mangrove stems (as a fuel for cooking, as fodder for livestock, for use in local crafts and possibly in construction), for a given period of time (e.g. 2 to 5 days).

As described in section 4.2, modern development, has brought other pressures, especially from urban, industrial, and recreational activities, port and harbour construction and the risk of oil pollution and eutrophication of enclosed waters - while some of the original pressures have continued, to a greater or lesser extent. Thus, in recent times, the mangroves have, at various locations, been subject to the negative effects of rapid development. For example, in northern Oman, the construction of coastal infrastructure and recreational facilities (see sections 4.2.1 and 4.2.2) does appear to have had some affect on mangrove ecosystems. Then in Dhofar, mangroves have been damaged by more intense browsing by camels, as well as the lopping of branches by the camel-owners, as a result of increased camel numbers and of traditional pastoral areas being lost both in the mountain and in the Salalah plain to the expansion of Salalah.

Nevertheless, if mangroves and their surrounding environs are "left alone" (i.e. are not subject to poorly planned or executed development activities and are protected from livestock), the general evidence suggests that little or no active management is required to ensure their continued survival.

However, the current situation in Oman is that many natural habitats, including those of mangrove lagoons and other khawrs (*khayraan*), are subject to damage from rapid development; they are not being "left alone" and thus **active management measures**

are essential. In particular, **protective management measures** are required to manage/ control those development activities, in order to minimise their impact. In addition, **creative management measures** (such as the rearing and planting of mangrove seedlings) are also necessary in order (i) to mitigate existing damages and (ii) to create new mangrove habitats for their support to the conservation of biodiversity and for their direct and indirect role in providing exploitable natural resources.

Therefore, in simple terms, the overall strategy for the "restoration, conservation and management of mangroves" has two separate approaches:

- **Protective Management Measures** that ensure the security of existing mangrove ecosystems from inappropriate development activities and management practices;
- **Creative Management Measures** that create new mangrove ecosystems at appropriate locations, and that enhance existing mangrove ecosystems, primarily by planting of mangrove seedlings.

Furthermore, it is dispensable for institutions and personnel to be able to carry out effective **protection** and **creation** activities for mangrove habitats. Therefore, some **Supporting Measures** to rectify the lack of trained Omani personnel and to provide easy-to-use information storing/ sharing systems and other facilities, and so on are also required to deal with these issues.

This chapter therefore sets out some of the main **Issues** facing mangrove ecosystems in Oman today, for which either **Protective Management Measures** and/or **Creative Management Measures** will be needed, along with various **Supporting Measures**. **Strategies** are proposed that will **guide actions** to address those issues.

4.2 Protective Management Measures for Mangroves

4.2.1 Protection Against Coastal Development

a. Port and Harbour Construction - Coastal Erosion and Sedimentation Issues

The introduction of a solid structure, such as a harbour wall or breakwater, to an open, sandy coastline such as that of the Batinah, can affect the natural movement and deposition of sand along its beaches. The change to coastal processes caused by such a structure can lead to accretion or erosion of sand along nearby beaches. Where the beach includes the mouth of a mangrove lagoon, the changes to the pattern of deposition and erosion of sediments may have a big impact on the mangrove ecosystem. An example can be seen at Khawr Harmul at Liwa, one of the few mangrove sites along the Batinah coast. Following the construction of the port at Sohar 2.5 km to the southeast, severe beach erosion has occurred at Sah Harmul village and deposition of sediment has taken place at the mouth of Khawr Harmul, such that the mouth had moved 200-300m by May 2002 (Figure 4.2.1). Though these changes may in part be due to natural processes and the mangrove trees did not appear to have been affected by July 2003, the

changes to the morphology and hydrology of the khawr may threaten long-term survival of the mangroves.

Khawr Harmul Shoreline Evolution (top; Feb 1998 : Before Construction of Sohar Port)

Coastal Development (bottom; May 2002 – after construction of Sohar Port)

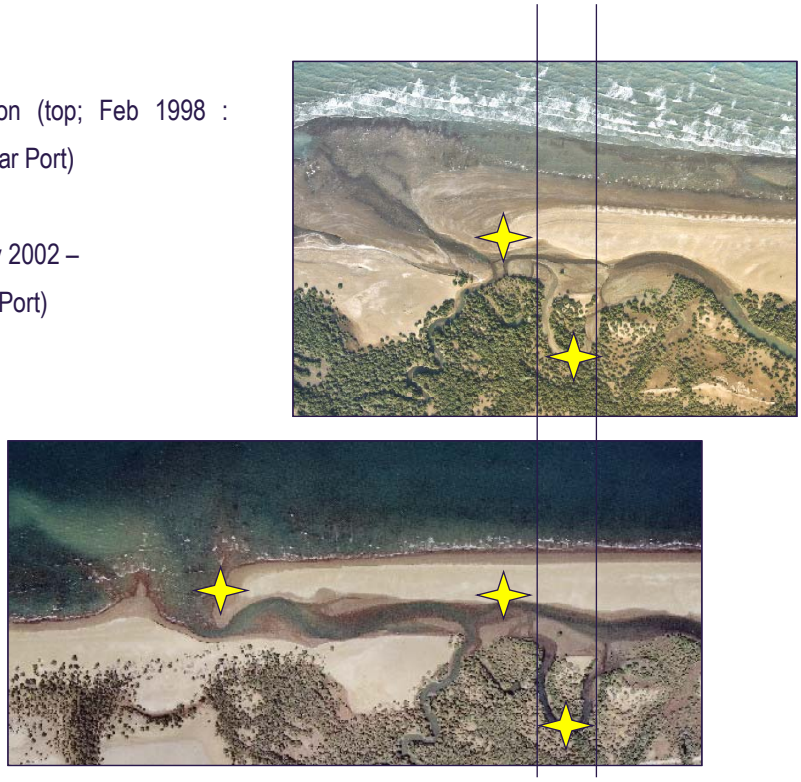

Figure 4.2.1 Location of where the mouth of Khawr Harmul has moved following construction of Sohar Port

Another example of a mangrove site probably affected by a similar coastal development is provided at Khawr Qurayyat (Khawr Al Hajar). Here the mangrove khawr mouth had been closed for several years and only recently (May 2003) was it opened by a flood from the wadi (and it was still just open in January 2004), but appeared likely to close in the next few months without another major flood. The lack of connection to the sea had led to a decline in the condition of some of the mangroves, a fall in populations of marine species and stagnation of the water. A similar process of increased sedimentation, to that observed at Khawr Harmul, may be responsible for the problems at Khawr Qurayyat (Al Hajar), due to the construction of the new port at Khawr As Seerah, 1.8 km to the southeast.

b. Road Issues

New roads have various **direct and indirect impacts** on the environment. The direct impacts include the loss of natural habitats and the damage to Oman's dramatic landscape; these, and the air and noise pollution produced by traffic, are of particular significance in potential tourism sites. Then there is the indirect impact that arises from increased human access to coastal habitats. Fishing, garbage, disturbance of

wildlife, illegal hunting and cutting of trees can all increase, with negative consequences for the environment.

One mangrove ecosystem, Khawr Qurm near to Muscat, has already been damaged by the construction of the coastal road and bridge linking Qurm Street and Shati Al Qurm. Though there have been clear socio-economic benefits (in that this stretch of coast has become very popular as a recreational area for Omanis and international visitors), one of the best examples in the Muscat area of coastal dune vegetation has been lost and the wading birds, which were once abundant on the shore, are now disturbed by the large numbers of visitors to the beach.

Two mangrove ecosystems are currently threatened by roads (Figure 4.2.2). Bandar Khayran is on the route of the new coastal road linking Muscat to Qurayyat. The environmental impact assessment (Atkins, 2003) for Muscat Municipality recommends taking the route inland behind the mountains at Bandar Khayran to avoid the coast altogether. This would leave the quiet bay, mangroves and natural landscape largely intact, with access still possible via a graded road and by boat. Nevertheless, whichever route is selected, the access to the area will be improved and as the numbers of tourists to Oman increase, impacts from increasing numbers of visitors to the area will still be felt.

a. Bandar Khayran – the existing graded road may be replaced by a larger coastal road,

b. Filim to Mahawt Island - a new road/causeway has been proposed.

Figure 4.2.2

The mangrove ecosystem at Mahawt is the other location where a potentially damaging road has been proposed - connecting Mahawt Island to the Mainland. The road, especially if constructed on a causeway, would change the seawater current system of the bay with potential impacts on the rich shrimp and fish nursery grounds. Equally, if not more significant, the road would change the fundamental interest of the island – it would no longer be an island! The road would give easy and free access to all and large numbers of visitors could easily pollute and damage the delicate island ecosystem, which contains the best developed and most diverse mangrove ecosystem in Oman.

c. Strategy for Protection from Coastal Development

The best approach to preventing unnecessary damage to mangrove ecosystems from the development of roads, breakwaters and other facilities along the coast is strict adherence to the Sultanate's Environmental Impact Assessment legislation and procedures. Before projects are approved, **comprehensive feasibility and EIA studies** should be undertaken, to ensure that the only projects to proceed are those that are sound from the technical, social, economic, financial and environmental aspects. Where a project is fully justified in order to promote the sustainable development of the country, but environmental impacts are inevitable, every effort should be made to adopt effective mitigation measures.

Coastal zone setbacks as approved in Ministerial Decision 20/1990 of the Supreme Council for Town Planning should also be followed.

4.2.2 Protection Against the Impacts of Tourism and Recreation

a. Tourism and Recreation Issues

Mangrove ecosystems can suffer directly and indirectly from poorly located tourism and recreation facilities. Examples of direct damage to mangroves by "reclamation/ landfill" (earth and rock being bull-dozed onto mangrove habitat) can be seen at Khawr Shinas (Figure 4.2.3) and Khawr Harmul near Liwa, where picnic sites have been constructed too close to the edge of the mangrove trees – and at Khawr Shinas some mangrove trees had been removed to make way for a small foot-bridge. This mangrove-edge habitat, which is normally rich in invertebrate life, has been lost and the solid fill material may affect the flow of water in the channel.

Similarly, at Khawr Balid in Dhofar, the development of the historical elements of the Frankincense Trail World Heritage Site for visitors, which is highly commendable, has been accompanied by the wholesale removal of natural vegetation along a significant part of the banks of the Khawr. Natural dune vegetation, which should protect the coast from erosive waves in the monsoon, has also been removed. Such "management" has been carried out as a "cleaning" landscaping exercise, but is ecologically damaging and is not essential for visitors to enjoy the natural aspects of such sites.

Figure 4.2.3 Khawr Shinas – environmentally damaging and unsafe construction of a bridge, illustrating need for better design of footpaths and other facilities

b. Tourism and Recreation Strategy

The MRMEWR in principle welcomes the interest of local people, tourists and scientists in mangroves and mangrove ecosystems, and wishes to encourage visitors to explore, enjoy and learn about this interesting and unusual environment in such a way that does not cause them any damage. **Management Plans and Technical Specifications**, that support the maintenance of mangrove and other khawr ecosystems in a natural state and do not permit up-rooting, covering with rocks/fill material or similar damage to native vegetation, **should be adopted and adhered to**.

Only in exceptional circumstances and if there is very good reason as set out in the management plan (e.g. the installation of a boardwalk and bird observation hide) should infrastructure require the destruction of mangroves or other natural vegetation/habitats close to the site (<150 m). A setback of at least 150m should be observed for such developments to prevent encroachment onto the mangrove areas.

4.2.3 Protection from Solid Waste and Water Pollution

a. Solid Waste and Water Pollution Issues

Prior to Oman's renaissance, much of the **solid waste** produced from traditional activities and households neighbouring khawrs was small in quantity, re-used in some way or was biodegradable. Modern Omani society produces much more solid waste, including many durable materials such as plastics, metals, concrete and other building materials. Despite the best efforts of the MRMEWR to collect and dispose of this waste in a safe way, some of this material (especially near urban areas) reaches the khawrs and can be found entangled in mangrove trees, in the water, on the mud and on the banks; most of this waste is believed to be non-hazardous. Some of the waste has been thrown directly into the mangrove areas, other waste has been disposed of in the wadis upstream and been washed into the khawr during a flood. The waste can pose a threat to wildlife, to livestock feeding in and near the mangroves and is very unsightly – this is highly undesirable for those mangrove sites where recreation and tourism are being encouraged.

There is a risk of raised nutrient levels in enclosed lagoons that are bordered by housing, agriculture or other developments as at Sur and Hajar (Ras Al Had). Leakage, into the lagoon system, from sewage tanks of houses and hotels may lead to small changes in nitrate and phosphate levels and increased growth of algae, which can cover mud surfaces and young mangroves. When these algal mats eventually die they decompose, using up oxygen in the water and so killing many of the animal species. The presence of mats of blue-green algae in such lagoons indicates that nutrient levels are already high. There are signs of significant algal growth in the Khawr at Sur, smothering young mangrove seedlings, which may not survive unless the algal mats are removed (Figure 4.2.4).

Sur. Water pollution. Blue-green alga *Lyngbya majascula* and high coliform bacteria counts.

Figure 4.2.4 Blue-green alga *Lyngbya majascula* smothering young mangroves at Sur; a sign of eutrophication

b. Solid Waste Management and Water Pollution Strategy

To help keep mangrove ecosystems in healthy condition and free of pollution from solid and liquid waste, the overall strategy is to raise knowledge, understanding and awareness among citizens and government officials of the value and sensitivities of mangrove ecosystems, and the threats to them, so that improvements can be made to the planning and management of development activities in these areas. The water quality monitoring at Batah in Sur is already started by local government. It is necessary to continue this programme. The strategy can be implemented through taking some of the following, and other, steps (and strengthened where initiatives or programmes are already in place):

- Agreement of responsibilities for monitoring and clean-up of khawrs (MRMEWR to play a lead role, but other organisations can be expected to support).

- Regular inspections by MRMEWR staff, e.g. to evaluate solid waste problems, arrange clean-up and deter illegal dumping.
- Education campaigns to encourage industries, retailers and citizens to reduce the amount of solid waste they produce and to dispose of it correctly.
- Cleaning campaigns, e.g. in Municipalities Month, focusing on mangrove sites.
- Scientific monitoring (e.g. water quality) to understand better the problem.
- Prevention of house construction and similar urban developments close to mangrove and other lagoons/khawrs.
- Where houses and similar urban developments are already close to mangrove and other lagoons/khawrs, domestic wastewater should not be discharged directly or indirectly into the surface water or groundwater.
- In mangrove and other coastal areas, those responsible for urban planning, issuing building permits and enforcing building regulations (especially in relation to septic and holding tanks) should be encouraged to pay close attention to the sensitivities of mangrove ecosystems to water pollution to ensure that plans, designs and implementation do not contribute to pollution/eutrophication of the ecosystem.

4.2.4 Sustainable Utilisation of Mangroves and Mangrove Ecosystems (including Fisheries) and Biodiversity Protection

a. Sustainable Utilisation and Biodiversity Conservation Issues

Mangrove ecosystems are still particularly vulnerable to damage from the various "use" and "non-use" activities of humans and their livestock, especially when located near towns and villages. Khawr Qurayyat is an example showing, on the landward fringe, encroachment from date palm plantations, tracks and football pitches – the latter to the south-west of the mangroves and the khawr, on an area that is now sabkha. On the south-east side, the mangroves adjacent to the main settlement, near to the coast have been subject to heavy browsing by goats. Recreational fishing, in the khawr, also takes place.

However, on a small-scale, mangroves are of direct benefit to livestock owners as the leaves and fruit provide good fodder for goats and camels; but the trees are easily "overgrazed" as can be seen in Dhofar (Figure 4.2.5), where browsing animals also prevent seedling regeneration. In a similar way, small-scale "fishing" is possible in the mangrove areas, with exploitable species including milkfish, mullet and invertebrates, especially crabs and molluscs (e.g. oysters and *Terebralia palustris,* the mud snail, a large gastropod). However, over-exploitation is a threat to some species such as the Mangrove crab (*Scylla serrata*), which has become quite rare in many khawrs.

Figure 4.2.5 Camels at Khawr Taqah; a clear browse line is visible

Finally, it has been found that young mangrove stems are used, on a small scale, in local crafts, especially at Qurayyat. They are used in the making of the "*mahlaq*", a basket used by fishermen for taking live bait on fishing trips (Richardson, N. and Dorr M., 2004, The Craft Heritage of Oman, Motivate Publishing, Dubai. ISBN 1-86063-157-6); they can also be used in the making of the traditional Omani drum or "*ṭubl*", where they form the internal rim (Shawqi, Yusuf, 1994, Dictionary of Traditional Music in Oman, Florien, Noetzel Verlag, Wilhelmshaven, Germany. ISBN 3-7959-0674-1). For both uses their flexibility is considered to be important and in the "*mahlaq*" their tolerance of salt water.

Since these uses can be sustainable and contribute to local livelihoods and demonstrate the value of mangroves, they should be encouraged – but in a non-conflicting way, i.e. one sustainable use should not conflict with another, including the use of the mangrove ecosystems as a wildlife resource for tourism, education and scientific research.

This leads to the "biodiversity value" of mangrove ecosystems in general and of some sites in particular; key elements of the flora and fauna associated with mangroves in Oman have been summarised in section 2.1.4 and further details of each site are given in Part 2 (Appendix 1. Study Area and Field Survey) and Vol. 2 (Technical Specifications of Sites). Several sites have been declared Nature Reserves (Khawr Qurm in Muscat and several Khawrs in Dhofar) and another site (Mahawt, as part of Barr Al Hikmann) has been proposed for declaration. Other sites would also benefit from legal protection, especially Shinas and Bandar Khayran; these, and Mahawt (Figure 4.2.6), are all outstanding examples of mangrove ecosystems in their regions and are vulnerable to the impacts from nearby developments, existing and proposed. Shinas and Mahawt provide important habitat for threatened species of birds. The small island of Muraysis, on the west coast of Masirah, is also an important conservation site (Figure 4.2.6); this is primarily for the large numbers of sea-birds that nest there, but it also has a small population of mangroves. It is biodiverse sites such

as these that have eco-tourism potential; eco-tourism and other sustainable use opportunities need to be recognised in legal protection measures and management plans.

Figure 4.2.6 Jazirat Muraysis (top) has mangroves and a large population of breeding birds, while Mahawt Island (bottom) has extensive mangroves and is rich in invertebrates. Both have potential for eco-tourism.

However, it must be emphasised that though the legal declaration of a mangrove site as a Nature Reserve and the approval of a management plan may **in theory** offer a site and its biodiversity some protection from inappropriate use and development, it is only the first step in ensuring sustainable management. As long as pressures from man and his livestock remain, **active management measures**, both **protective and creative**, will still be required.

Finally, there is one issue that all the various aspects of mangrove utilisation and conservation have in common and that is co-ordination – or rather **lack of**

co-ordination. Many settlements and much of Oman's population, including Muscat and Salalah, are concentrated within the coastal zone. Many Ministries and other government agencies, including the various parts of the MRMEWR, have projects and responsibilities here and the citizens have their own interests and activities to pursue, such as fishing, livestock rearing and recreation. Some of these projects and activities, unless carefully planned and managed, have been and will be in conflict with each other and may threaten the health of the mangrove ecosystems. There is a clear need for improving the communication and co-ordination between these "stakeholders" to ensure a sustainable future for Oman's mangroves.

b. Strategy for Sustainable Utilisation and Conservation of Biodiversity

The strategy for "Sustainable Utilisation and Conservation of Biodiversity of Mangrove Ecosystems" has three main components:

(1) Legal Protection/Declaration of Nature Reserves.

(2) The Preparation of Management Plans/Technical Specifications.

(3) Communication between and Co-ordination of Stakeholders

For those mangrove sites without existing **legal protection**, they should be declared as **Nature Reserves** under the responsibility of the MRMEWR, though responsibility for management could be assigned by the MRMEWR to another responsible government body or a non-government organisation that is active in environmental conservation.

Management Plans for each site should be prepared, discussed and agreed with other stakeholders (see next paragraph) and approved by the MRMEWR. The Technical Specifications for each site, prepared by this JICA Study (see Supporting Report), should provide the basis for the Management Plans. The Management Plans will establish "systems" for permitting sustainable utilisation of mangroves and of the other resources that they support. The utilisation may take the form of permitting specified harvesting activities to be carried out in certain sections of the mangrove habitat for an agreed period of time. These activities would have to be determined on a site by site basis and at some sites (or parts of a site), where biodiversity conservation is a priority, that no consumptive-uses (or even non-consumptive uses) will be permitted. The Management Plans will need to specify responsibilities for operating the "systems" and for monitoring their application and impact/effectiveness.

The MRMEWR will seek to improve the **Communication and Co-ordination** between the various stakeholders with interests in mangrove ecosystems or activities that may affect them in order to achieve integrated and sustainable development. At a national level MRMEWR will seek to inform and co-ordinate with the planning and project departments within each Ministry that is involved in developments in the coastal zone, and at a regional level MRMEWR will seek to exchange information and co-ordinate with local stakeholders. It is expected that the proposed Qurm Environmental Information Centre (QEIC) will play a key role in establishing and carrying out these **Communication and Co-ordination** functions (see section 4.5.2 for further details).

4.3 Planting Issues and Strategy

4.3.1 Conservation of Existing Mangroves

a. Issues

For Oman's existing mangroves and mangrove ecosystems to be maintained in a healthy condition, the most cost-effective approach should be the application of protective management measures as presented in Section 4.2. However, if an existing mangrove ecosystem has been damaged in some way, such that areas of mangrove trees have been damaged or lost completely, then consideration should be given to planting mangrove seedlings to replace those damaged or lost. At such locations there may also be scope for planting "new areas" with mangroves (i.e. parts of a lagoon at which mangroves are not known to have been present for many years), as compensation for the trees and ecosystems that have been damaged and lost.

b. Strategy

Priority will be given to the protection of the existing mangroves and mangrove ecosystems. The planting of mangrove seedlings should normally be undertaken only in those "locations" where they will replace mangrove trees that have been damaged or lost and it is believed that this will help to accelerate significantly the natural regeneration of the population. Where the "location" is a lagoon or other coastal habitat that has "areas" with and without mangroves, consideration should also be given to planting mangrove seedlings in "new areas" where it can be shown that this should enhance the lagoon ecosystem without damaging other features of value in terms of biodiversity and wildlife conservation.

4.3.2 New Plantations

a. Issues - Location

There are various locations on the coast of Oman where mangroves do not grow at present, but where it may be possible for seedlings to be planted and for them to survive and even thrive, reproducing naturally to establish a self-sustaining population without need for further planting.

Some of these locations may correspond quite closely to sites where evidence has shown that mangroves used to grow hundreds or thousands of years ago (e.g. 6,000 years B.P. at Suwayh south of Ras al Had), but have died out due to natural causes (climate and sea level changes) and/or the impacts of man and his livestock.

At other locations considered for planting by the JICA Study Team, e.g. at Hammar Muraysis, on the main island of Masirah, opposite to Jazirat Muraysis, mangroves may "never" have grown, at least not in the last 10,000 years or so. However, with man's

intervention (planting and protection) they may be able to survive at these locations and there may be good reasons to attempt to establish plantations.

With limited financial and human resources available, a strategy is required to give guidance on the priority to be given to planting activities and the criteria MRMEWR should apply for selecting such locations.

b. Strategy - Location

Though priority will be given to protecting and restoring **existing mangrove ecosystems** at locations where the success rate of any planting should be high (since the natural conditions are known already to be suitable for the growth of mangroves), the MRMEWR will also make efforts to promote and assist the establishment of **new plantations** at locations where the following conditions apply:

- **Local interest and support** for plantation of mangroves (including both the local community and authorities, e.g. Municipality, Wali, Agriculture and Fisheries).
- The plantation will be of **landscape/amenity** value for local citizens and visitors.
- The location is such that the mangroves should make a positive contribution to the **biodiversity and natural resources** of the proposed site or region.
- That the **physical conditions** (soil, water, shelter etc) are suitable.
- That a neighbouring **supply of mangrove seeds** will be used.
- The site is **accessible** enough for planting to proceed at low cost.

In evaluating locations and proposals, MRMEWR shall pay particular attention to local interest and support, even to the extent that sub-optimal planting sites may be considered - provided MRMEWR mangrove experts believe there is a reasonable chance (e.g. >50%) of success.

c. Issue - Use of Indigenous Species

There is only one species of mangrove, *Avicennia marina*, that can be considered native to present-day Oman, though there is good evidence that another species, *Rhizophora mucronata*, occurred here in the past (6,000 years B.P. at Ras Al Had); *Rhizophora* does still occur on the coasts of Yemen and Iran. Research has indicated that the disappearance of *Rhizophora* from Oman was caused by a change in climate, possibly accelerated by the activities of man. Though the introduction to Omani ecosystems of *Rhizophora* might not pose a threat to the native flora and fauna of Oman, in the way that the introduction of the mesquite tree, *Prosopis juliflora* (a native of the Americas), has posed a threat, the introduction of *Rhizophora* is hard to justify. Environmental conditions have changed and the protection and management of existing strands of *Avicennia marina*, and of other native ecosystems, should be a much higher conservation priority.

d. Strategy - Use of Indigenous Species

In all mangrove planting schemes, only the species native to Oman, *Avicennia marina*, should be used.

e. Issue - Seed Provenance

It is the understanding of the Study Team that the mangrove trees in the Batinah and Muscat zones of Oman usually flower only once per year (typically April-June at Khawr Qurm and Bandar Khayran), while the mangroves in the Dhofar zone may flower twice per year (in June-July and again from November to January). This difference would appear to be an adaptation to the climatic regime prevailing in Dhofar being very different to that found in central and northern Oman. However, some trees in Sharqiyah and Al Wusta are reported also to flower twice per year, so the situation is not entirely clear. The Dhofar mangrove trees may also have other, less obvious, adaptations to the differences in environmental conditions between Dhofar and the rest of Oman. Such adaptations may have a genetic basis, i.e. the populations in Dhofar may have evolved into a slightly different "race" or "ecotype", such that they might also flower twice a year if transplanted to northern Oman - but this has not yet been established.

There may also be small, genetic differences between the mangrove populations found in the other zones, and even within the different lagoons/*khayraan* within a single zone, given that *Avicennia marina* is insect pollinated and that the populations are quite isolated from each other (some are separated by over 50 km from the next population). In theory, any genetic differences might correspond to environmental adaptations by the mangroves, e.g. to slightly different salinity regimes in Khawr Qurm in Muscat (which is subject to regular surface and sub-surface freshwater flows) when compared to Filim and Mahawt, where the influence of freshwater flows would appear to be low and very occasional. On the other hand, *Avicennia marina* is one of the few species of higher plant that are adapted to a very extreme and variable environment (saline water and daily tides). Therefore, any variability (between populations), in their genetic adaptation to different local environments within Oman, may be almost insignificant in comparison to the species' overall adaptation to its extreme and variable coastal environment.

Only detailed research into genetic and phenotypic variation, including DNA analysis, is likely to resolve this issue of the extent of genetic variation of the various Omani mangrove populations. In the meantime, it would be advisable for MRMEWR to adopt the "precautionary principle" in its planting programmes. In case mangroves from one locality/population are not so well-adapted to another locality in Oman, seed of the most "local" origin should be used when planting seedlings at any site. If local seeds are not used, there is a small risk that the new seedlings and adult trees may not thrive, and may "contaminate" mangroves of local origin that are better adapted to that local environment.

f. Strategy - Seed Provenance

The guiding strategy for seed collection and use in planting programmes is for "local" seed to be selected.

- For sites where mangroves already exist, the seeds for planting should be collected from that site.
- For sites where there is no mangroves, the seeds for planting should be collected from the nearest existing mangrove site.

g. Mangrove Nurseries - Issues and Strategy

Since the strategy is to use local seed wherever possible, it should not be necessary to have large, permanent nurseries in each of the five zones. These are costly to construct and operate and seedlings may have to be transported considerable distances to planting sites. Temporary nurseries should therefore be established at those sites where planting will take place, with seed being transported from the nearest source. In case the sites are located in remote places, direct sowing of seeds in an alternative method to be considered.

4.4 Management Activities at Mangrove Sites

4.4.1 Monitoring

a. Monitoring Issues

Recognising the value of mangroves as described in Chapter 3, it is necessary to ensure that management activities, both protective measures and creative measures (planting), are proving successful. Therefore a monitoring programme is required that, ideally, can achieve the following:

- Detect immediate threats or damage to mangroves and mangrove ecosystems, so that rapid action can be taken to counter the threat and any potential or actual impacts.
- Detect early warning signs of longer term threats or changes to the mangrove ecosystem.
- Assess, on an ongoing basis, the success or otherwise of planting activities.
- Assess progress in the implementation and effectiveness of other management activities.

In addition, it is highly desirable that, whatever monitoring methods and personnel are used, they are cost and time-effective and do not constitute an unnecessary drain on the limited technical and financial resources of the MRMEWR.

Identifying personnel who will be willing and capable of undertaking the various monitoring tasks is a key issue. As a matter of principle, it is believed that local people and non-government groups should be encouraged to participate in such activities as much as possible (and preferably on a voluntary basis), so that local interest in the conservation and "ownership" of mangrove ecosystem resources is promoted.

b. Monitoring Strategy

To **detect immediate and visible threats** to the khawrs with (and without) mangroves a programme of frequent visual inspections should be developed. Depending on location of the Khawr/Mangroves in relation to MRMEWR offices, staff accommodation and that of other potential observers, these could be daily or weekly inspections, i.e. will have to be developed on a site specific basis. Rangers of the Directorate-General of Nature Conservation should play a role in monitoring, where this can be incorporated into their existing activities. At sites distant from local MRMEWR offices, not covered by rangers and if funds are available, the appointment of local guards (who live very near to the mangrove ecosystems) for a few hours a week could be considered. They would look for signs of illegal activity (cutting without a permit), damage, pollution and record any significant natural events (floods, very high tides, periods connected to and separated from the sea etc.).

The **detection of longer term threats or damage** to mangroves and mangrove ecosystems and their causes will be difficult, because the changes may be taking place slowly (over a number of years) and it can be difficult to distinguish whether changes are due to natural variation or man-made impacts. Negative impacts on a mangrove system may also take many years to show themselves and repeated site visits may be needed to detect them. For this reason it is important to have a good baseline and to collect data over several years, so that trends in the flora and fauna can be followed.

The desired monitoring should therefore consist of regular visits to selected mangrove ecosystems once or twice a year (summer and winter) to record the condition of selected mangrove trees and the numbers of the different plant and animal species, in order to provide a picture of their "normal" condition/status at each site. The easiest organisms to use for monitoring are members of the macro fauna, namely birds, crabs and molluscs. The flora can also be monitored to check the condition of the vegetation whether grazed, cut or disturbed in some way. The water quality and any indication of pollution should also be reported.

The use of indicator species is one way to determine the health of an ecosystem. However, this means that the relationship between the species or group of species with a set of environmental conditions has been demonstrated. This requires long-term detailed ecological studies. In the JICA study, an attempt has been made to identify characteristic species and to propose species for monitoring, but the reality is that very few organisms are restricted to mangroves.

To undertake the kind of monitoring described above typically requires a keen interest in scientific fieldwork and the ability to identify plants and animals, to take and interpret water quality measurements etc. At present there are very few Omanis who have the interest and skills in undertaking such work, either in mangrove ecosystems or the other terrestrial and aquatic ecosystems occurring in Oman. One role of the QEIC (Chapter 6) will be to develop such skills. In the meantime, the main strategy for such long term scientific monitoring will be for MRMEWR to encourage other local and international scientific institutions to play a key role in undertaking the work; this should include SQU, NGOs and foreign Universities.

The programme to monitor the success of planting activities should be designed so that (i) any site specific problems can be identified and remedied as soon as possible to increase the survival rate of seedlings already planted and (ii) so that lessons can be learnt to enhance the success of future planting at the same and other sites. The first aspect requires more frequent monitoring to detect and remedy potential problems such as smothering by algae, damage from livestock, exposure to wind etc and could be undertaken by interested members of the local community, where present. The second aspect requires more careful recording of numbers (survival rate), condition and of environmental parameters with the intention of establishing the relationship between environmental conditions (soil type, water depth etc) and success. The exact frequency of monitoring visits will be determined on a site by site basis, in accordance with accessibility, availability of local staff or other interested parties and the perceived need (the environmental conditions at some sites may be more challenging and more frequent inspection and maintenance visits will be beneficial).

Where **other management activities** are being carried out (e.g. (i) provision of observation hides for school and university students and (ii) public awareness programmes to reduce waste problems etc.) simple monitoring procedures should be incorporated into the design of the programme, where practical, to help assess progress in implementation and effectiveness. For example (i) numbers of visitors to bird observation hides could be recorded and (ii) their age, sex, nationality etc and the number of incidents of illegal dumping of waste.

All monitoring activities will be standardised and computerised as far as possible in order to

- make it easier for staff to carry out monitoring at more than one location;
- facilitate training of staff and volunteers;
- to facilitate presentation and analysis of data and comparison of data from different sites;
- to facilitate sharing of data.

The detailed design and co-ordination of such a monitoring programme should be undertaken by the QEIC and the data should be made available at the QEIC and on the internet to members of the public, researchers and other institutions.

4.4.2 Educational Awareness Programmes

a. Education and Awareness Issues

The extent to which both Omani citizens and visitors to Oman, including tourists, are aware of the value and interest of mangroves seems to be variable. In some areas, e.g. Qurayyat (see section 4.1), traditional mechanisms existed to regulate the exploitation of mangroves, which demonstrates a clear awareness of their value - though in "modern" Oman the traditional regulatory mechanism no longer operates and exploitation is reduced, as a result of the availability of more convenient cooking fuels. In other areas, e.g. Dhofar, browsing by camels and lopping of branches by camel owners also show clear awareness of the value of mangroves, but this awareness has not been sufficient to prevent over-exploitation; it appears that traditional mechanisms to control utilisation no longer operate properly and have not been replaced by new mechanisms that are effective.

As described in section 4.2, much of the present day threat to mangroves and mangrove ecosystems comes from modern developments and partly stems from an incomplete understanding and appreciation of their value and sensitivity. For example, the establishment of recreational facilities immediately adjacent to or within areas of mangrove at Khawr Shinas, Khawr Harmul (at Liwa) and Khawr Qurm (Muscat), indicates that those responsible understand how mangroves offer greenery that is of aesthetic and recreational value. But the location and design/implementation of some of these municipal projects also indicate that members of the public, government officials, contractors etc. would benefit from raised awareness of the broader ecological values and sensitivities of mangrove ecosystems. Similarly, some large coastal projects have gone ahead (Sohar Port, the road linking Al Qurm Street and Shati Al Qurm) with inadequate environmental monitoring and mitigation measures in place - awareness needs to be raised so that the location and design of future projects that may affect mangroves and other coastal ecosystems take better account of the value and sensitivity of the environment.

Finally, Omani schoolchildren (many of whom no longer live in close contact with nature) and visitors to Oman of all ages should both enjoy and benefit from learning about mangroves and mangrove ecosystems.

b. Education and Awareness Strategy

From the above analysis it is clear that education and awareness strategy should be to target all sectors of Omani society - the general public (children and adults), government officials and experts - and "visitors" to Oman, both residents and tourists. Awareness-raising is an important part of the overall strategy for the conservation of mangroves. It should be carried out so as to encourage a positive attitude towards mangroves, such that in the longer term the attitudes and understanding result in a desire and willingness to care for and enjoy mangrove ecosystems and to ensure, on a

voluntary basis, that they are kept in good condition. To facilitate conservation with such a "voluntary" approach is far preferable to regulation, control and enforcement.

One part of the strategy is to involve school children, college/university students and teachers in planting activities and for them to use nearby mangrove ecosystems as "living laboratories". The development of educational facilities (see next section 4.4.3) will play a role in implementing the awareness strategy. Particularly important in this regard, at a national level, is the development of the environmental education role of the QEIC. A final part of the strategy is to use mangroves and mangrove ecosystems to introduce the full target audience to the wider aspects of coastal zone management and of other environmental issues, both marine and terrestrial.

4.4.3 Facilities Development

a. Issues - Existing Facilities

The existing facilities related to management, recreation, education, research etc activities at most of the mangrove sites in Oman are limited or non-existent and some of those that do exist are poorly located and designed and even dangerous (e.g. the bridge across Khawr Shinas at its southern end). Account may not have been taken of the sensitivity of some parts of the ecosystem, especially birds, to disturbance. However, there is a need for facilities so that the public, school-children, tourists and researchers can visit and observe the mangroves, their wildlife and scenery without damaging the environment they have come to enjoy. The following list indicates some of the facilities already present and the type of facilities that **may** be required in or near to mangrove ecosystems.

- **Facilities for Mangrove Conservation and Management (Plantations)**
  - Temporary Nursery
  - Small Building for Equipment
  - Fencing
- **Facilities for Recreation/Tourism**
  - Parking
  - Shade
  - Picnic tables
  - Footpaths and Boardwalks
  - Small Boat Access
  - Bird Observation Hide
  - Information Panels and Leaflets
  - Waste Bins and Collection System
  - Toilets

- **Education Facilities**
  - Access to classroom/laboratory with books/leaflets
- **Research Facilities**
  - Access to laboratory, museum collections of flora and fauna
  - Library

Some mangrove ecosystems in Oman may not be well-suited to development for recreational use, either because of their location (far from settlements) or their ecological sensitivity, e.g. importance for rare birds such as the Arabian White-Collared Kingfisher. Budget limitations will also act as a constraint on what facilities can be provided.

b. Provision of Facilities - Strategy

Each site will require its own combination of facilities according to its location and particular characteristics. The facilities proposed should take into account the availability of facilities already in existence and planned for neighbouring sites. The facilities proposed should be planned as an integrated package, even if their construction/implementation has to be phased over a number of years due to budget constraints. In order to protect wildlife and allow some utilisation (e.g. browse for camels) consideration will be given to some sites, or parts of sites, not having any facilities at all. Some management plans/technical specifications may need to include the delineation of zones that show where access and facilities are (and are not) allowed.

Some of these facilities can provide a service to more than one activity (e.g. boardwalks and bird observation hides can be used by tourists, schoolchildren and researchers). Some of the facilities need not provide a service solely related to the mangroves and existing facilities should be used wherever possible, e.g. there is already a school near to Khawr Shinas, so no special classroom/laboratory would be required for Mangrove Education purposes - the existing school facilities should be used.

The proposed QEIC should be a multi-functional facility for supporting Mangrove Conservation and Management, Recreation/Tourism, Education and Research.

Facilities should not be established unless there is a commitment to maintaining them.

4.5 Institutional Context

4.5.1 Information Sharing and Communication

a. Issue

Numerous research, conservation and educational activities related to mangroves in particular, and the coastal environment in general, have taken place over the last 25-30 years. Environmental Impact Assessment studies relating to coastal development

projects (e.g. at Qurayyat, Khawr Qurm and Sohar) have also gathered data on mangrove ecosystems or made reference to them. The studies have been undertaken by a wide range of Omani and international institutions, consulting companies and individuals and various reports and papers have been produced as a result. This reflects the importance of mangroves and the coastal resources to the Omani economy and that they are of great interest to Omani people and organisations and to the international scientific community. Some of the reports and papers are listed in Volume 1, Part 2, Appendix 7.

However, the results/reports of these studies have not all been gathered into a single library and the data has not been collected and collated in standard formats or databases. The absence of a central library and database on Omani mangroves and mangrove ecosystems makes difficult (i) the assessment of the current condition of mangroves and of the growth of any plantations and (ii) the detection of changes that may be occurring as a result of natural processes and human impacts. The ready availability of such information/data to a range of individuals and institutions is important for the planning and management of mangrove areas to be successful, since a number of these institutions and other "stakeholders" have an interest or impact on the mangrove ecosystems. There is also a need for better co-ordination between these stakeholders (see 4.5.2 for more details on this topic), including sharing of information.

b. Information and Communication Strategy

MRMEWR should take the lead in establishing a Mangrove Ecosystem Documentation and Information Unit and Data Network so that relevant information can be made readily available to a wide range of users, in order to support the sustainable management of mangrove ecosystems in Oman.

The **first objective** will be to **obtain and list (on a database) all written documents** relating to Oman's mangroves and mangrove ecosystems, and also relevant international documentation.

The **second objective** will be to **establish an electronic database/Geographic Information System (GIS)** to record and store important data, especially monitoring data, on mangroves and mangrove ecosystems. This could include relevant social and demographic data, information on environmental legislation and regulations, urban and regional development plans etc. The GIS component would allow geo-referenced data to be linked to digital maps, aerial photographs and satellite imagery. Digital photographs, taken as part of monitoring programmes, can also be stored on the GIS - and "historic" photographs can be scanned and added.

The **third objective** is for an **information network to be established** both within MRMEWR (including its different departments and sections in Muscat and its regional offices) and between MRMEWR and other concerned institutions (see 4.5.2 for more details). These institutions will be asked to participate by sharing information that they have gathered or have in their possession, e.g. the bird database of the Oman Bird

Records Committee (OBRC) currently held at SQU. The sharing of information will encourage co-operation in the actual management of mangrove ecosystems.

It is intended that the Mangrove Ecosystem Documentation and Information Unit and Data Network will be based at/operated from the proposed QEIC; in the meantime the initial work designing, establishing and populating the database and GIS can be undertaken at the MRMEWR head office in Al Khuwair.

In due course, once the Mangrove Ecosystem Documentation and Information Unit and Data Network is up and running at the QEIC, the work of the Unit could be steadily expanded to cover information/data on other wetlands in Oman and the coastal zone as a whole. The Unit could also hold information on mangroves within the whole ROPME area (see below).

4.5.2 National & International Co-ordination Network for Mangrove Ecosystems

a. Co-ordination Issues

As was introduced in section 4.2.4, numerous "stakeholders" have an interest in exploiting Oman's mangrove ecosystems in various ways (for recreation, tourism, fisheries, livestock fodder etc, see Chapter 3), while many other local and international institutions and individuals have carried out research, conservation and educational activities related to mangroves over the last 25-30 years (as introduced in section 4.5.1 a). Furthermore, other parties, not even interested in exploiting mangrove ecosystems, have had an impact on them through activities nearby, such as road and harbour construction, while the general public and operators in the private sector sometimes pollute them with solid and liquid waste. Some of these institutions have been mentioned in section 2.4.

Institutions and individuals remain interested in utilising or studying mangroves and the coast because they are seen to be a resource of either direct or indirect benefit or relevance to their responsibilities and/or interests. Therefore, many wish to have some involvement in their planning and management. In general, the MRMEWR is recognised as having responsibility for this planning and management of mangrove and khawr ecosystems but, in practice, others play a major role in some cases, e.g. Office of the Advisor for H.M. the Sultan for Cultural Affairs in managing Khawr Rowri and Khawr Balid as part of the Frankincense Trail World Heritage Site in Dhofar. MRMEWR, through its EIA and Environmental Permitting procedures and Environmental Inspectors, also play an important role in trying to reduce damage from development projects by other parties and from illegal disposal of solid and liquid waste. Therefore, in order to reduce conflicts and duplication, and to ensure the sustainable development of mangrove ecosystems, there is a **pressing need for a mechanism to co-ordinate the interests and enthusiasms of some stakeholders and the damaging activities of others**.

Finally, since the number of mangrove conservation studies and activities conducted in Oman is now quite considerable and probably more than most other countries in the Gulf region, there is an opportunity for Oman to play a lead role in promoting and co-ordinating mangrove conservation on behalf of the Regional Organisation for the Protection of the Marine Environment (ROPME).

b. Co-ordination Strategy

The Oman Mangrove Monitoring and Management Committee (OMMMC) should be established under the auspices of the MRMEWR and with senior representatives and/or experts from the following organisations:

- Sultan Qaboos University - Department of Marine Science and Fisheries; Oman Bird Record Committee; Department of Biology; Environmental Science Centre.
- Ministry of Agriculture and Fisheries - Directorate-General of Fisheries; Marine Science Centre
- Adviser for Conservation of the Environment (Diwan of Royal Court)

The OMMMC would include representatives of MRMEWR's DG of Environmental Affairs, DG for Nature Conservation and DG for Environment, Dhofar. Representatives from Muscat Municipality and the Office of the Advisor for H.M. the Sultan for Cultural Affairs could be co-opted when Khawrs in the Muscat and Dhofar areas respectively are on the agenda.

The OMMMC/its members should co-ordinate the activities of its own and other institutions in relation to mangrove ecosystem management and work together to:

- ensure that the direct or indirect uses of mangroves and the coast, and other development activities (e.g. in the catchment) do not damage the mangrove ecosystems as a whole and the wider resources which they support;
- agree **how** the mangrove ecosystems, the mangroves themselves and the mangrove related resources should be studied, monitored, conserved, managed, utilised and enhanced;
- agree how information should be gathered and shared;
- agree on **suitable roles** for different organisations and individuals with respect to studies/research, monitoring, conservation, management (including enforcement of any regulations), utilisation and enhancement of mangrove ecosystems;
- reduce any institutional or other conflicts in the management and use of mangroves;
- promote sustainable mangrove conservation in particular and coastal zone management in general, both in Oman and in the Gulf Region;

- seek and obtain the necessary financing to support mangrove conservation in particular and coastal zone management in general, in Oman.

The MRMEWR will provide an office and Chairperson for the OMMMC and it should operate from the proposed QEIC when this opens. It is also proposed that the MRMEWR takes the necessary steps for the QEIC to become the ROPME Lead and Secretariat for Mangrove Conservation in the Gulf. The QEIC should also be prepared to provide the office for Oman's Secretariat to the Ramsar Convention (on the Protection of Wetlands of International Importance especially as Waterfowl Habitat), as and when the Sultanate becomes a member.

4.5.3 Omanisation and Training

a. Issue - Omanisation

As a result of improved health care and reduced infant mortality during Oman's renaissance in the 1970's and 1980's, without any meaningful family planning programme, there are large numbers of young Omanis seeking employment. The provision of jobs is therefore of high importance to the government - and to the unemployed.

Other than small-scale artisanal fishing and harvesting of shellfish (for which Omanis already have the necessary skills and opportunities), the only employment opportunities directly related to mangrove ecosystems that might occur in the private sector are in tourism, e.g. as natural history tour guides. The remaining openings are likely to be in the public sector - employed by MRMEWR to work as scientists, technicians, environmental educators or rangers on mangrove conservation and management programmes, and possibly by academic institutions (SQU, the Marine Science Centre, the Natural History Museum) to undertake research. Omani scientists who have worked on mangrove conservation should also be able to use the skills they have developed in the wider areas of marine conservation, environmental management and environmental education - in the public sector and private (oil and gas, environmental consultancy etc).

The reality is that the government is unlikely to fund very many jobs involving mangrove ecosystems, and most of these may be attached to the proposed QEIC, so it will be important to maximise the proportion of Omanis occupying those jobs. Where Omanisation does take place and the staff involved in managing, planting and monitoring is enthusiastic and committed, it should have the positive advantage that the staff will have "ownership" of the work they are doing. They should have a desire to see thrive the seedlings that they have planted and the trees and ecosystem they have protected.

b. Omanisation Strategy - Human Resource Development

The medium- to long-term objective should be for all permanent and part-time government jobs related to mangroves to be filled by Omanis. Investing in a Human Resource Development (HRD) Programme, of which training is a key component, is believed to be the best way of achieving this Omanisation. For most positions, from technicians/rangers (involved in collecting seeds, setting up temporary nurseries, planting and tending seedlings and regular monitoring of the sites) to biology and computing graduates (involved in the scientific monitoring programme and the GIS), it is preferable that the training takes two forms:

(1) Formal training and

(2) Less formal "on-the-job" training.

For the higher level posts (managers, scientists and some technicians) the formal training should be selected from short courses, diplomas and Master's Programmes; these are likely to be in the English language and outside Oman and sponsorship should be sought. Other technical and ranger level training should be organised and delivered locally, if possible by the more senior Omanis.

The on-the-job training should be carried out in Oman, for senior scientific staff by foreign counterparts and for technicians and rangers by both senior Omanis and foreign counterparts. The foreign experts that are expected to be assigned to the QEIC should play a key role in the on-the-job training.

Chapter 5: Mangrove Conservation and Management

5. Mangrove Conservation and Management

5.1 Conservation and Management Programme

It is highly desirable to conserve and manage mangrove ecosystems and other coastal areas for the benefit of present and future Omani generations. The following legal instruments and measures are among those which may be required for successful conservation and management; some are already in place:

- Arrangement of laws and regulations related to the conservation activities
- Execution of patrol and enforcement
  - Daily patrol by a police office of Wilayat
  - Inspection of facility conditions and waste disposal on the ground and water by implementing agency of conservation and management
- Establishment of signs and information boards (direction signs, guide signs and information boards for visitors etc.)
- Implementation of restoration and rehabilitation work
- Implementation of public awareness programme such as education and campaigns
- Plantation of new mangrove areas
- Maintenance of nursery and facilities
- Implementation of monitoring activities

Table 5.1.1 shows items and implementing agencies in short, medium and long terms in each site.

Table 5.1.1 Conservation and Management Programme

No.	Site Name	Conservation/ management item	Implementing Agency		
			Short Term	Medium Term	Long Term
1	Khawr Shinas	For existing mangrove/ new plantation	MRMEWR/ Wilayat Shinas/ Local schools	Wilayat Shinas/ Local schools	Local schools
2	Khawr Harmul & Nabr	For existing mangrove	MRMEWR/ Wilayat Liwa	MRMEWR/ Wilayat Liwa	Wilayat Liwa
3	Khawr Sawadi	For existing mangrove/ new plantation	MRMEWR/ Sawadi Hotel	Sawadi Hotel	Sawadi Hotel
4	Khawr Haradi	For coastal management	MRMEWR/ Wilayat Barka/ Locality Haradi	Wilayat Barka/ Locality Haradi	Locality Haradi
5	Khawr Qurm	For existing mangrove/ new plantation	MRMEWR	MRMEWR	MRMEWR
6	Bandar Khayran	For existing mangrove/ new plantation	MRMEWR/ Locality Al Khayran	MRMEWR/ Locality Al Khayran	Locality Al Khayran
7	Qurayyat	For existing mangrove/ new plantation	MRMEWR/ Wilayat Qurayyat	MRMEWR/ Wilayat Qurayyat	Wilayat Qurayyat
8	At Tina (Site No.2)	For existing mangrove/ new plantation	MRMEWR in Sur	MRMEWR in Sur	MRMEWR in Sur
	(Site No.3)	For existing mangrove/ new plantation	MRMEWR in Sur	MRMEWR in Sur	MRMEWR in Sur
9	Batah (Site No.4 and No.5)	For existing mangrove/ new plantation	MRMEWR in Sur	MRMEWR in Sur	MRMEWR in Sur
10	Khawr Quq	For new plantation	MRMEWR in Sur/ Locality Ras Al Had	MRMEWR in Sur/ Locality Ras Al Had	Locality Ras Al Had
11	Khawr Hajar - East shore	For new plantation	MRMEWR in Sur/ Locality Las Al Had	MRMEWR in Sur/ Locality Ras Al Had	Locality Ras Al Had
12	Wadi Muraysis (Masirah)	For new plantation	MRMEWR/ Wilayat Masirah	MRMEWR/ Wilayat Masirah	Wilayat Masirah
13	Filim – Eastern Beach	For existing mangrove/ new plantation	MRMEWR/ Wilayat Muhut	MRMEWR/ Wilayat Muhut	Wilayat Muhut
14	Mahawt Island	For existing mangrove	MRMEWR/ Wilayat Muhut	MRMEWR/ Wilayat Muhut	Wilayat Muhut
15	Al Demer	For coastal management	MRMEWR in Dhofar/ Wilayat Mirbat	MRMEWR in Dhofar/ Wilayat Mirbat	MRMEWR in Dhofar/ Wilayat Mirbat
16	Khawr Rowri	For coastal management	MRMEWR in Dhofar/ Wilayat Mirbat	MRMEWR in Dhofar/ Wilayat Mirbat	MRMEWR in Dhofar/ Wilayat Mirbat
17	Qurm Taqah	For existing mangrove/ new plantation	MRMEWR in Dhofar/ Wilayat Taqah	MRMEWR in Dhofar/ Wilayat Taqah	Wilayat Taqah
18	Khawr Dahariz	For coastal management	MRMEWR in Dhofar/ Wilayat Salalah	Wilayat Salalah	Wilayat Salalah
19	Khawr Balid	For new plantation	MRMEWR in Dhofar	MRMEWR in Dhofar	MRMEWR in Dhofar
20	Khawr Kabir	For existing mangrove	MRMEWR in Dhofar	MRMEWR in Dhofar	MRMEWR in Dhofar
21	Khawr Saghir	For existing mangrove	MRMEWR in Dhofar/ Hilton Hotel	Hilton Hotel	Hilton Hotel

5.2 Planting Plan

5.2.1 Planting Schedule

The following 13 sites have the potentiality for mangrove plantation as shown in Table 5.2.1.

Table 5.2.1 Potentiality for Mangrove Plantation in Each Proposed Site

No.	Site Name	Present mangrove	Potentiality for plantation	Estimated Area (ha)	Remarks
1	Khawr Shinas	Yes	◎	2.5	Potential area in the north khawr
2	Khawr Harmul & Nabr	Yes	●	-	No space for new plantation, Sand deposition on mangrove vegetation
3	Khawr Sawadi	New	◎	10.4	Wide potential areas
4	Khawr Haradi	No	●	-	Mouth of the Khawr is closed, No water in khawr
5	Khawr Qurm	Yes	◎	4.0	Plantation for QIC project
6	Bandar Khayran	Yes	◎	3.7	Potential area in front of fishery port
7	Qurayyat	Yes	◎	1.0	Sand deposition on mangrove vegetation, Plantation for training dike project
8	At Tina (Site No.1)	New	●	-	New plantation was already implemented by MRMEWR
	(Site No.2)	New	◎	5.6	New plantation was already implemented by MRMEWR, Wide tidal area
	(Site No.3)	No	◎	2.5	Medium size tidal area, Stony soil in Eastern area
9	Batah (Site No.4 and No.5)	Yes	◎	2.1	Natural regeneration, Wide tidal area in front of vegetation
	(Hismah)	Yes	●	-	Natural regeneration, Stony tidal area
10	Khawr Quq	No	◎	0.6	Medium size tidal area
11	Khawr Hajar - East shore	No	◎	11.9	Wide tidal area
12	Wadi Muraysis (Masirah)	No	◎	1.0	Long coast and tidal zone
13	Filim – Eastern Beach	Yes	○	1.0	Wide tidal area, poor natural regeneration
14	Mahawt Island	Yes	●	-	Coastal area mostly covered by natural vegetation
15	Al Demer	No	●	-	Sand protection area
16	Khawr Rowri	No	●	-	World heritage, potential area only on the sandbar
17	Qurm Taqah	Yes	○	0.2	Very small area
18	Khawr Dahariz	No	●	-	Mouth of the Khawr is closed, Small potential area near khawr mouth, but in danger of flash flood
19	Khawr Balid	New	◎	0.4	Plantation for a new project
20	Khawr Kabir	Yes	●	-	Already planted by MRMEWR in a potential area
21	Khawr Saghir	Yes	●	-	Already planted by MRMEWR in a potential area

Remarks: ◎: High potential site for new plantation ○: Fair potential site with some constraints
●: No potential site for new plantation

5.2.2 Seedling Supply and Nursery Plan

The basic concept for location of seed collection is as follows:

- Site with existing mangrove: the seeds for plantation should be collected at the site.
- Site with no mangrove: the seeds for plantation should be collected at the nearest existing mangrove site.

The location of seed collection for plantation is shown in Table 5.2.2. These seeds should be grown at the nursery. There are 3 nurseries in Qurm, Sur and Khawr Kabir in Salalah at present. The construction of 3 temporary nurseries is required in Khawr Shinas, Ras Al Had, and Mahawt Island (Table 5.2.2). Since Khawr Shinas is far from Qurm nursery, a temporary nursery is required at Khawr Shinas. The potential area for plantation in Ras Al Had is so wide that a temporary nursery is required in Ras Al Had,

too. The fact that Wusta Zone has no nursery at present also demands a temporary nursery in Wusta Zone. The location of a temporary nursery in Wusta Zone is proposed at Mahawt Island, which is a site where mangroves already exist. The implementation agencies for seed collection and nursery management/propagation are MRMEWR for Batinah, Muscat and Wusta Region, MRMEWR in Sur for Sharqiyah Region, and MRMEWR in Dhofar for Dhofar Region (Table 5.2.2).

Table 5.2.2 Location of Seed Collection/ Nursery and Implementing Agencies

No.	Site Name	Seed Collection				Nursery			
		Location of Seed Collection	Implementing Agency			Nursery	Implementing Agency		
			Short Term	Medium Term	Long Term		Short Term	Medium Term	Long Term
1	Khawr Shinas	Khawr Shinas	MRMEWR/ Wilayat Shinas	Wilayat Shinas	-	Temporary nursery at Khawr Shinas	MRMEWR/ Wilayat Shinas	Wilayat Shinas	-
2	Khawr Harmul & Nabr	-	-	-	-	-	-	-	-
3	Khawr Sawadi	Khawr Qurm	MRMEWR/ Sawadi Hotel	MRMEWR/ Sawadi Hotel	MRMEWR/ Sawadi Hotel	Khawr Qurm	MRMEWR	MRMEWR	MRMEWR
4	Khawr Haradi	-	-	-	-	-	-	-	-
5	Khawr Qurm	Khawr Qurm	MRMEWR	MRMEWR	MRMEWR	Khawr Qurm	MRMEWR	MRMEWR	MRMEWR
6	Bandar Khayran	Bandar Khayran	MRMEWR	MRMEWR/ Locality Al Khayran	MRMEWR/ Locality Al Khayran	Khawr Qurm	MRMEWR	MRMEWR	MRMEWR
7	Qurayyat	Qurayyat	MRMEWR	MRMEWR/ Wilayat Qurayyat	MRMEWR/ Wilayat Qurayyat	Khawr Qurm	MRMEWR	MRMEWR	MRMEWR
8	At Tina (Site No.2)	Sur	MRMEWR in Sur	MRMEWR in Sur	MRMEWR in Sur	Sur	MRMEWR in Sur	MRMEWR in Sur	MRMEWR in Sur
	(Site No.3)	Sur	MRMEWR in Sur	MRMEWR in Sur	MRMEWR in Sur	Sur	MRMEWR in Sur	MRMEWR in Sur	MRMEWR in Sur
9	Batah (Site No.4 and No.5)	Sur	MRMEWR in Sur	MRMEWR in Sur	MRMEWR in Sur	Sur	MRMEWR in Sur	MRMEWR in Sur	MRMEWR in Sur
10	Khawr Quq	Sur	MRMEWR in Sur	MRMEWR in Sur/ Locality Ras Al Had	Locality Ras Al Had	Temporary nursery at Ras Al Had	MRMEWR in Sur	MRMEWR in Sur/ Locality Ras Al Had	Locality Ras Al Had
11	Khawr Hajar - East shore	Sur	MRMEWR in Sur	MRMEWR in Sur/ Locality Ras Al Had	Locality Ras Al Had	Temporary nursery at Ras Al Had	MRMEWR in Sur	MRMEWR in Sur/ Locality Ras Al Had	Locality Ras Al Had
12	Wadi Muraysis	Mahawt Island	MRMEWR/ Wilayat Muhut	Wilayat Muhut	-	Temporary nursery at Mahawt Island	MRMEWR/ Wilayat Muhut	Wilayat Muhut	-
13	Filim – Eastern Beach	Mahawt Island	MRMEWR/ Wilayat Muhut	Wilayat Muhut	-	Temporary nursery at Mahawt Island	MRMEWR/ Wilayat Muhut	Wilayat Muhut	-
14	Mahawt Island	-	-			-	-		
15	Al Demer	-	-			-	-		
16	Khawr Rowri	-	-			-	-		
17	Qurm Taqah	Qurm Taqah	MRMEWR in Dhofar	MRMEWR in Dhofar	MRMEWR in Dhofar	Khawr Kabir	MRMEWR in Dhofar	MRMEWR in Dhofar	MRMEWR in Dhofar
18	Khawr Dahariz	-	-			-	-		
19	Khawr Balid	Khawr Kabir	MRMEWR in Dhofar	MRMEWR in Dhofar	-	Khawr Kabir	MRMEWR in Dhofar	MRMEWR in Dhofar	-
20	Khawr Kabir	-	-			-	-		
21	Khawr Saghir	-	-			-	-		

The related works, such as planning and construction, and plantation schedule is shown in Table 5.2.3. The capacities of temporary nurseries should be 5,000 pots/year in Khawr Shinas, 15,000 pots/year in Ras Al Had, and 5,000 pots/year in Mahawt Island.

Table 5.2.3 Plantation Schedule

Study Khawr /Island	Priority of plantation	Estimated Area (ha)	1st year (2005)	2nd year (2006)	3rd year (2007)	4th year (2008)	5th year (2009)	6th year (2010)	7th year (2011)	8th year (2012)	9th year (2013)	10th year (2014)	To.
1. Khawr Shinas	Medium	2.5	temporary nursery construction	5,000	5,000	5,000	5,000	5,000	0	0	0		25,000
2. Khawr Harmul & Nabr	-	-	-	-	-	-	-	-	-	-	-	-	-
(Temporary nursery at Khawr Shinas)			**0**	**5,000**	**5,000**	**5,000**	**5,000**	**5,000**	**0**	**0**	**0**	**0**	**25,000**
3. Khawr Sawadi	High	10.4	10,400	10,400	10,400	10,400	10,400	10,400	10,400	10,400	10,400	10,400	104,000
4. Khawr Haradi	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Khawr Qurm	High	4.0	planning	pond construction	10,000	10,000	10,000	10,000	0	0	0	0	40,000
6. Bandar Khayran	Medium	3.7	7,400	7,400	0	0	0	0	7,400	7,400	7,400	0	37,000
7. Qurayyat	High	1.0	planning	dike construction	2,000	2,000	2,000	2,000	2,000	0	0	0	10,000
(Nursery at Khawr Qurm)			**17,800**	**17,800**	**22,400**	**22,400**	**22,400**	**22,400**	**19,800**	**17,800**	**17,800**	**10,400**	**191,000**
8. At Tina	High	8.1	9,500	9,500	7,200	7,200	7,200	7,200	7,200	7,200	7,200	7,200	76,600
9. Batah	Medium	2.1	2,300	2,300	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	19,000
(Nursery at Sur)			**11,800**	**11,800**	**9,000**	**9,000**	**9,000**	**9,000**	**9,000**	**9,000**	**9,000**	**9,000**	**95,600**
10. Khawr Quq	Low	0.6	temporary nursery construction	1,000	1,000	1,000	1,000	1,000	1,000		0	0	6,000
11. Khawr Hajar – East Shore	Low	11.9	0	14,000	14,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	119,000
(Temporary nursery at Ras Al Had)			**0**	**15,000**	**15,000**	**14,000**	**14,000**	**14,000**	**14,000**	**13,000**	**13,000**	**13,000**	**125,000**
12. Wadi Muraysis	Low	1.0	**0**	2,500	2,500	2,500	2,500	0	0	0	0	0	10,000
13. Filim – Eastern Beach	High	1.0	**0**	2,500	2,500	2,500	2,500	0	0	0	0	0	10,000
(Temporary nursery at Mahawt Island)			**0**	**5,000**	**5,000**	**5,000**	**5,000**	**0**	**0**	**0**	**0**	**0**	**20,000**
14. Mahawt Island	-	-	temporary nursery construction	-	-	-	-	-	-	-	-	-	-
15. Al Demer Beach	-	-	-	-	-	-	-	-	-	-	-	-	-
16. Khawr Rowri	-	-	-	-	-	-	-	-	-	-	-	-	-
17 .Qurm Taqah	Medium	0.2	2,000	0	0	0	0	0	0	0	0	0	2,000
18. Khawr Dahariz	-	-	-	-	-	-	-	-	-	-	-	-	-
19. Khawr Balid	High	0.4	planning	pond construction	4,000	0	0	0	0	0	0	0	4,000
20. Khawr Kabir	-	-	-	-	-	-	-	-	-	-	-	-	-
21. Khawr. Saghir	-	-	-	-	-	-	-	-	-	-	-	-	-
(Nursery at Saghir in Salalah)			**2,000**	**0**	**4,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**6,000**
To.			19,800	22,800	31,400	27,400	27,400	22,400	19,800	17,800	17,800	10,400	217,000

5.3 Monitoring Programme

5.3.1 Environmental Monitoring

Environmental monitoring is an important and indispensable activity for effective conservation and management of mangrove forest and coastal areas. The objectives of environmental monitoring are as follows:

- Evaluation of the existing conditions at the study sites
- Protection from illegal use of the resources such as mangrove forest and coastal areas
- Adequate implementation of conservation and management through the warning to users
- Verification of the impacts by coastal and marine pollution
- Evaluation of the present policies, legal instruments and measures to conserve and manage the mangrove forest and coastal areas

The monitoring items are as follows:

- Ecological condition of mangrove forest
- Mangrove planting condition
- Mangrove conservation and management condition
- Flora
- Fauna
- Water quality
- Soil condition
- Social condition
- Laws and regulation
- Development plan
- Utilisation of mangrove forest and coastal areas
- Unusual Marine Events such as incidents of mass marine mortalities, linked to hypoxia and Harmful Algal Blooms (HABs), and outbreaks of green tide and jellyfish

Some of monitoring items would contribute to a comprehensive baseline monitoring programme along the Oman coastline, which would be one of the functions of the proposed Environmental Information Centre at Qurm.

Environmental monitoring should be implemented at various levels. The central government should play the most important role in environmental monitoring. The

local government also has an important role. However, local residents have a role to play in their own way, because they are living beside the sites. It is necessary to report the results of these environmental monitoring to provide feedback to the public.

The details of a monitoring system are shown in Technical Specification of each site. The overall baseline data collected during surveys of fauna and flora in this project are given below.

a. Fauna and Flora

In order to monitor the health of the mangrove ecosystem, it is first necessary to build up a baseline picture of the fauna and flora to be expected at each site. The decline or absence of expected species at a mangrove site can then provide a warning of impacts on the system that need to be investigated further. However, it can be difficult to distinguish whether changes are due to natural variation or man-made impacts. For this reason it is important to collect data over several years so that trends in the flora and fauna can be followed. Environmental impacts on a mangrove system may also take many years to show themselves and repeated site visits will be needed to detect them.

Proposed monitoring therefore consists of regular visits to study sites once or twice a year (summer and winter) to record the abundance of the different species and gradually provide a picture of the expected plants and animals at each site. The easiest organisms to use for monitoring are members of the macro fauna, namely birds, crabs and molluscs. The flora can also be monitored to check the condition of the vegetation whether grazed, cut or disturbed in some way. The water quality and any indication of pollution should also be reported.

The use of indicator species is one way to determine the health of an ecosystem. However, this means that the relationship between the species or group of species with a set of environmental conditions has been demonstrated. This requires long-term detailed ecological studies for each region. In this study, an attempt is made to identify characteristic species and to propose species for monitoring but it should be remembered that very few organisms are restricted to mangroves.

Plant species are listed in Appendix 1.4, including the table of survey results, and on the monitoring sheets. The best information for identification is found at the National Herbarium, Oman Natural History Museum, Ministry of Heritage and Culture. There are pressed specimens and books to help identification. Vegetation maps are shown in Appendix 1.9. The condition of the mangroves should be regularly recorded.

Birds are relatively well studied and the guidebook, *Birds of Oman* by M. Gallagher & M Woodcock (1980), combined with the *Bird Watching Guide to Oman* by H & J Eriksen and P & D Sargeant (2001) and the Oman Bird Lists (Edition 6, November 2003, published by the Centre for Environmental Studies and Research, Sultan Qaboos University) provide information on identification, status and distribution of species. These records are from the database of the Oman Bird Records Committee collected over many years. This historical data is shown in Appendix 1.5 for study sites where

available. The monitoring sheets for each site give a record of birds recorded during the JICA study surveys. Several species are expected at all sites and are not specifically mangrove associates. The seabirds such as Gulls and Terns occur along sea beaches generally and large flocks can fly in or out of a site quite rapidly. For this reason seabird counts are not a good indicator of the health of the mangroves. However, if they were completely absent, it may indicate an environmental change or problem – which could be local, more widespread or elsewhere (such as breeding grounds). The following species occur at all sites:

Seabirds:		
Sooty Gull	present all year	on sea beach and sandbars
Slender-billed Gull	Sep – Apr	on sea beach and sandbars
Siberian Gull	Sep – Apr	on sea beach and sandbars
Swift Tern	present all year	on sea beach and sandbars
Lesser Crested Tern	present all year	on sea beach and sandbars
Sandwich Tern	present all year	on sea beach and sandbars
Herons:		
Western Reef Heron	present all year	at edge of sea and water channels
Little Egret	Sep – Apr (not summer)	edge of sea and channels
Great White Egret	Sep – Apr	at edge of sea and channels
Grey Heron	Sep – Apr	at edge of sea and channels
Waders:		
Kentish Plover	present all year	at edge of sea and water channels
Lesser Sand Plover	Sep – Apr	at edge of sea and channels
Greater Sand Plover	Sep – Apr	at edge of sea and channels
Sanderling	Sep – Apr	at edge of sea and channels
Little Stint	Sep – Apr	at edge of sea and channels
Redshank	Sep – Apr	at edge of sea and channels
Greenshank	Sep – Apr	at edge of sea and channels
Common Sandpiper	Sep – Apr	at edge of sea and channels

The Striated Heron (present all year) and the Night Heron (Sep – Apr) are associated with mangroves and can occur at all sites among the mangroves. The Night Heron is regularly recorded roosting in the trees at Rowri and Taqah. The Clamorous Reed Warbler (present all year) is found in small numbers at all sites with mangroves or reeds.

Some birds are associated with particular sites, as follows:

Yellow Bittern	in reeds at Khawr Dahariz
White-collared Kingfisher	on branches over water at Shinas, Liwa, Mahawt
Crab Plover	on sandflats at Quq, Hajar, Muraysis, Filim, Mahawt
	(Breeds in burrows on Muraysis (Shagpah) Island.)
Sykes's Warbler	among mangroves at Shinas, Liwa
Oriental White-eye	among mangroves at Mahawt

Spoonbill and Greater flamingo are conspicuous winter visitors found in shallow water especially at Sur, Hajar, Filim and the khawrs of Salalah.

The khawrs of Salalah have characteristic species during the migration period and over winter. These include Ducks (e.g. Teal, Pintail, Garganey, Shoveller) on open water, Moorhen, Coot, Pheasant-tailed Jacana and Glossy Ibis at the water edge.

Fish have been studied at various locations and the data are summarised in Appendix 1.6. Most species depend on a periodic connection to the sea for juveniles to enter and adults to leave. Only two species could breed in freshwater (*Aphanius dispar* and *Ophiocara procephala*) and were the only species in Khawr Balid. The mudskipper (*Periopthalmus koelreuteri*) was only found at Mahawt but has now spread to Filim.

Crabs are less well known but form a significant part of the mangrove fauna. Two field guides (*A field guide to the sea shores of Kuwait and the Arabian Gulf*, Jones D. 1986; *A guide to the seashores of Eastern Africa,* Richmond, M. 1997) help with some species but identification can be difficult. For this reason a reference collection of mangrove crabs has been deposited at the Natural History Museum, Ministry of Heritage & Culture, Muscat. An identification manual has also been prepared for the commoner species that are potential indicators and is deposited at the Natural Historical Museum. Mangrove crabs are an important part of the mangrove ecosystem. They aerate the mud with their burrows, breakdown organic matter while feeding to release plant nutrients and provide food for birds and fish. Their populations depend on a connection to the sea at least on a regular basis to allow larvae to leave and to allow young crabs to enter. Species are shown in Appendix 1.7 on crustaceans, including survey results, and on the monitoring sheets. Two species of crab were only found at Mahawt Island. These were *Neoepisesarma versicolor* (Tweedie, 1940) and *Parasesarma plicatum* (Latreille 1803). Dr P.J. Hogarth of York University, UK, identified these species. *Neoepisesarma versicolor* is a new record for Oman only recorded for Pakistan and East Africa previously.

In Qatar, a comparison of the macrofauna of natural and replanted *Avicennia marina* mangroves was made by Al-Khayat and Jones in 1999 (*Estuarine, Coastal and Shelf Science* vol 49). At two natural and four planted (10 years growth) mangrove sites, several crustacean species were present at all sites. On the upper intertidal zone, *Scopimera crabricauda* and *Metopograpsus messor* were always present. Other species included *Balanus amphitrite, Penaeus semisulcatus, Macrophthalmus*

depressus, and *Eurycarcinus orientalis*.. *Serenella leachii* preferred mud banks and was only found at two replanted sites. The mudskipper *Boleophthalmus boddarti* was only found at natural mangrove sites as well as in a salt marsh creek. *Ocypode rotundata* was only found where sand was present at the top of the shore. *Nasima dotilliformis* was associated with salt marsh and only occurred at mangrove sites with this habitat.

Molluscs are relatively well known and are described in *Seashells of Southern Arabia* by Bosch D & E (1989) and most of the mangrove specialists are described in *Seashells of the Sultan Qaboos Nature Reserve at Qurm* by K. Smythe (1983). Species are shown in Appendix 1.8 on molluscs, including a table showing survey results, and on the monitoring sheets (Technical Specifications) for each site.

(a) Example of a Significant Species

The large mud snail, *Terebralia palustris*, provides an example of a potential indicator species. This would be an ideal animal to use, as it is quite large and easily observed living on the mud surface in the mangroves. It produces free-swimming veliger larvae, which leave the khawr on the tide and return from the sea when ready to settle. The adults take 3 or 4 years to mature and live in the upper intertidal zone preferring shade from mangroves where available. It feeds on organic matter and algae on the mud surface. However, *T. palustris*, does not always occur with mangroves. Feulner (2000) found it at khawr Jizzi, near Ras Sallan and at the mouths of Wadi Mayh and Wadi Jibbah at Yiti, where there are no mangroves. Generally *T. palustris*, appears to be found at intertidal sites that receive some freshwater inflow, even if it is not continuous (Feulner 2000). The occurrence or absence of this species may depend on several factors such as success or failure of spawning or larval recruitment, or over-collection by people for food or fish bait.

During the current surveys (2003) it was only recorded alive in three sites, all in the north-west (Shinas, Liwa and al Qurm, Muscat). However, a few dead shells were found at Bandar Khayran and on Mahawt Island. Museum collections show that this species was more widespread (Ras a'Suwadi, Seeb beach, and Sukaykira creek, Sur, 1986). An environmental impact study for the port at Qurayyat (1993) also recorded *Terebralia* in the mangroves at Khawr Majlis. It seems that *Terebralia* is now found in fewer locations than a few years ago, which represents a loss in biodiversity. It is not known why this species has declined, whether through natural causes (e.g. lack of freshwater input) or through human impacts (e.g. collection for fish bait, food, etc). It prefers to live under the canopy of mangrove trees and on mud rather than sand. In areas where mangrove trees are now expanding (e.g. Sur, Filim), it is expected that *Terebralia palustris* should recolonise the areas.

(b) Implementing Agencies and Training

Identification of the fauna and flora in the field can be difficult especially during short field visits. If specialist staff are not available in the Directorate of Environmental Affairs, then outside expertise may be necessary. For birds, an arrangement with an ornithological group such as the Oman Bird Records Committee should be made. This

is especially important for the rare or threatened birds such as the white-collared kingfisher at Shinas, Harmul and Mahawt, the white-eye on Mahawt and the waterbirds of Dhofar. Sultan Qaboos University is another institution that may be able to co-operate. If student training courses could include field trips to different mangrove sites in rotation, then monitoring and training could both be achieved.

5.3.2 Establishment of Computerised Environmental Monitoring System

In general terms, the environmental information system should ideally be able to deliver information relating to primary and immediate environmental management concerns, (updated, developed and upgraded continuously). A computerised environmental monitoring system shall be established (in order to evaluate degree of success or failure including the consequent benefits or losses of the environmental management measures). The environmental monitoring programme shall be so designed such that the environmental agency receives environmental management reports, which will assure that necessary environmental management actions are carried out. A review to develop the following is undertaken:

- A computerized system of nationwide environmental information stations;
- Databases for the following:
  - Profiles of study sites regarding items on the Mangrove observation record and field monitoring sheet such as characteristics of Mangrove (size, shape, history and health), Fauna and Flora (vegetation and bird contents) and pollution (garbage and wastes); and
  - Social and demographic conditions of the study sites including laws, regulations and regional development plans, compiled environmental monitoring results so that not only the MRMEWR but also other public agencies and environmental private organisations can readily access data as needed.

It should be noted that the actual implementation of the database would be only possible at a later date once the necessary equipment and associated laboratory facilities for environmental monitoring are in-place.

5.4 Institutional Arrangement

5.4.1 Establishment of Information Centre

a. Background

Economic development and conservation of the natural environment and cultural/ historical heritage is one of the national development goals stated clearly in the National Development Plan. The Ministry of Regional Municipalities, Environment and Water Resources (MRMEWR) has made considerable efforts to conserve the natural

environment. Mangrove forests in Oman have been recognised as an important environmental resource and major mangrove forests located in the country have been designated as protected areas.

Conservation of natural environment as well as restoration or plantation areas should be implemented at various levels of administration, organisations and peoples of Oman. Participation and co-ordination of all relevant agencies and peoples are most important for effective conservation activities. The establishment of the Qurm Environmental Information Centre (QEIC), which is intended by the Ministry, will provide the opportunity to co-ordinate activities for all people and organisations.

The ministry proposed to locate the QEIC at Khawr Qurm, designated as a Nature Reserve and one of the most popular recreational areas in Muscat. The area of the proposed site of Khawr Qurm covers 100 hectares, of which 60 hectares are already covered by mangrove forest. In addition to that, the Muscat Municipality is implementing recreational development along the Muscat area coast. Provided that the project is implemented with due care to the value and sensitivity of the existing environment (including the sabkha, mangroves and other coastal vegetation), the site is a suitable location for the QEIC, because of its accessibility to a large population and the attractive surrounding environment. However, the sensitivity of the site and the potentially large number of visitors that it may attract means that an environmental assessment study of the project is required; this will propose mitigation measures and an environmental management plan that should be followed by the contractor and the MRMEWR. See Figure 5.4.1 for general plan of the QEIC.

b. Objectives of the QEIC

QEIC will carry out the following activities:

- Establish an information and monitoring centre to collect and compile necessary information and data concerning conservation and management of the mangrove forests in Oman;
- Provide necessary facilities and materials for implementation of public awareness and education programmes on mangrove and coastal environment for school children as well as residents, visitors, and tourists;
- Co-operate with or assist those who study and investigate mangrove and the coastal environment of Oman;
- Train personnel engaged in the activities, concerning mangrove ecosystem conservation.

c. Organisation

(a) Responsible Agency and relevant organisations

- Responsible Agency:
  - MRMEWR
- Relevant public agencies/ organisations:
  - Ministry of Education
  - Sultan Qaboos University
  - Ministry of Agriculture and Fisheries, including Marine Science Centre
  - Ministry of Heritage and Culture
  - Ministry of Commerce and Industry, including Director-General of Tourism
  - Diwan of Royal Court, Office of the Adviser for Conservation of the Environment
  - Muscat Municipality
- Affiliate/ supporting members:
  - Associations and Organisations concerning coastal environmental conservation as affiliate members
  - Private enterprises conscious on the environment in Oman

(b) Implementing Organisation

The organisation of the Centre will be as follows.

- Name of Organisation: The Qurm Environmental Information Centre (QEIC)
- Management Body: Directorate General of Environmental Affairs, MRMEWR
- Sections in the Centre: The functional sections to be established are as follows.
  - Monitoring and Information
  - Training and Education
  - Mangrove Plantation (experimental field operation and maintenance)
  - Exhibition/ Public Relations
- Personnel: The positions of personnel to be assigned are as follows.
  - Director (one manager of the QEIC)
  - Clerical staff (2 persons)

- Section heads (4 persons)
- Assistants (3 persons)

- Total of ten persons will be allocated for operation and management

d. Role and Function of the Centre

- Natural environmental information will be available to the public, government agencies and academic organisations. Monitoring and data collection, compilation and database maintenance should be carried out by the QEIC.
- Exhibition and events, lecture and presentations related to public relations and implementation of public awareness programmes will be held in the QEIC. At the same time, experimental facilities will be provided for natural environmental study.
- Provide laboratory facilities for preliminary analysis and processing/ treatment of specimens for study and investigation for environmental education and research. A classroom for field study for school children should also be available. Some basic equipment and tools for field survey and studies by researchers from various organisations and countries will be leased to support them.
- Co-ordination and support activities of individuals, governmental organisations and agencies as well as private enterprises on coastal environmental conservation and pubic awareness events and programmes.
- Training of personnel of public agencies, schoolteachers and anybody who is interested in participating in the actual conservation, and restoration of mangrove forest in Oman.

5.4.2 Organisation in MRMEWR

For the implementation of mangrove restoration, conservation and management, it is necessary to establish an appropriate institutional arrangement in MRMEWR (Head Office, Branch Offices, internal organisation). The MPCZM section in MRMEWR, which is the main responsible agency for the mangrove conservation/ management, should continuously play a leading role. The establishment of QEIC is an important issue for the arrangement of organisations in MRMEWR. The QEIC will have many activities and thus need quick responses to them. Therefore it should have enough authority to perform its responsibilities by holding a key position in MRMEWR. It is more efficient that the QEIC be subject directly to the Directorate General of Environmental Affairs in MRMEWR. However, it requires a Royal Decree to establish a new department with proof of national benefits and consensus among the

ministries. It also takes a long time. Therefore, the QEIC should be established as an attached function to the section of Marine Pollution and Coastal Zone Management at the initial stage and mainly focused on the mangrove ecosystem and environment. In the long run, the centre will play a much wider role of environmental education and training covering coastal environmental management. Figure 5.4.2 shows proposed organisation arrangement of MRMEWR. The QEIC organisation chart is shown in Figure 5.4.3.

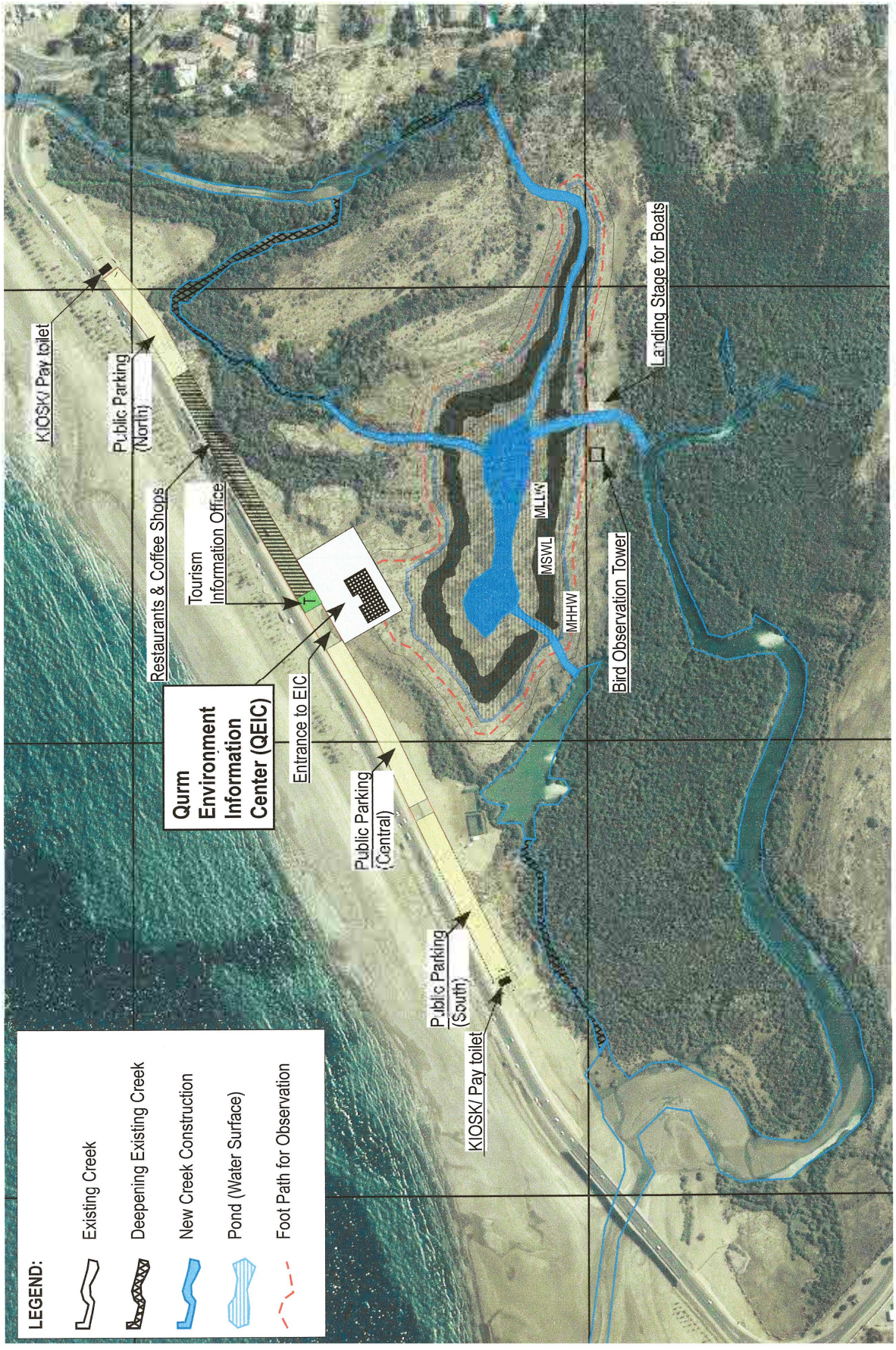

Figure 5.4.1 Qurm Nature Reserve Conservation and the QEIC Development

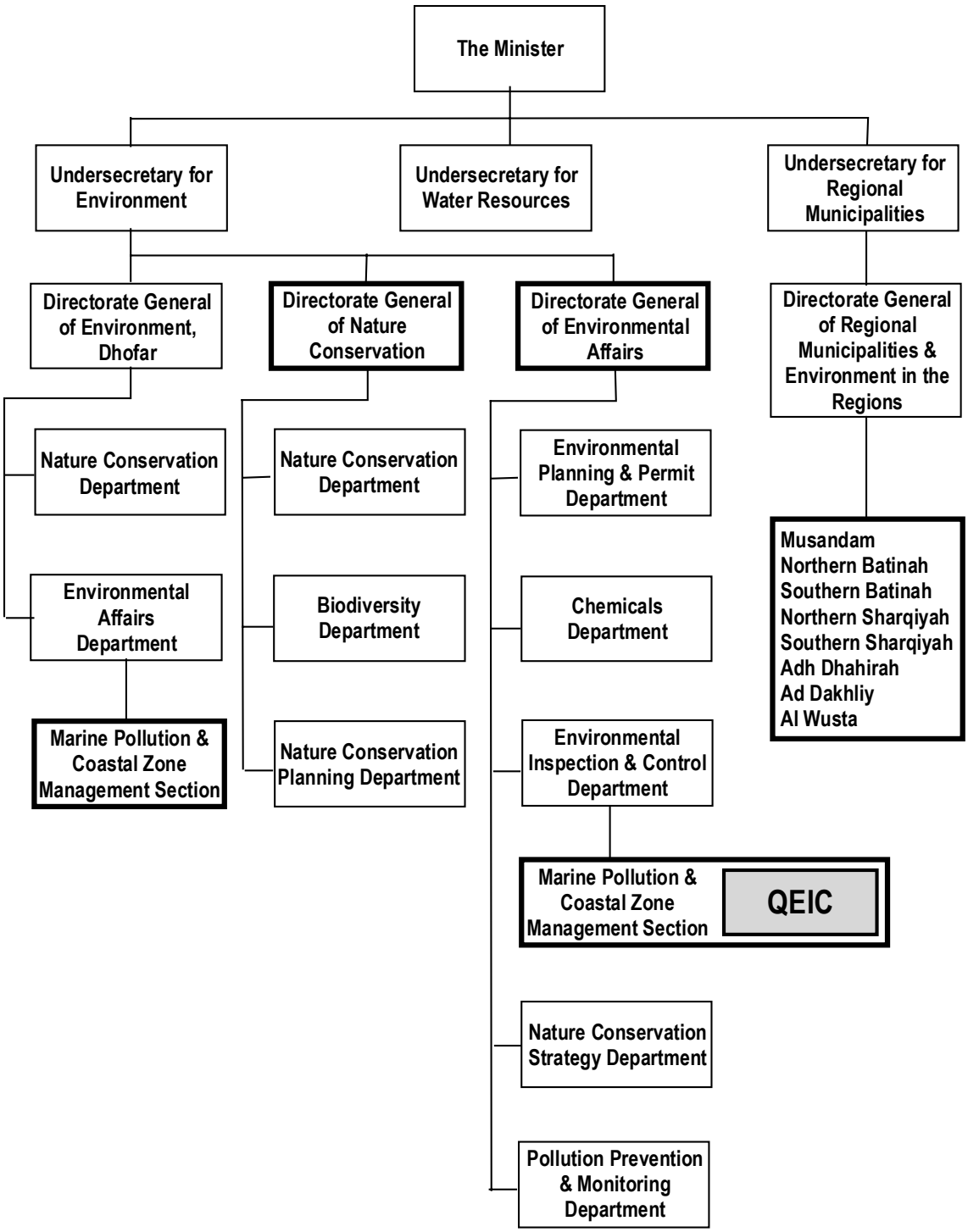

Figure 5.4.2 Arrangement of Organisation Chart of MRMEWR

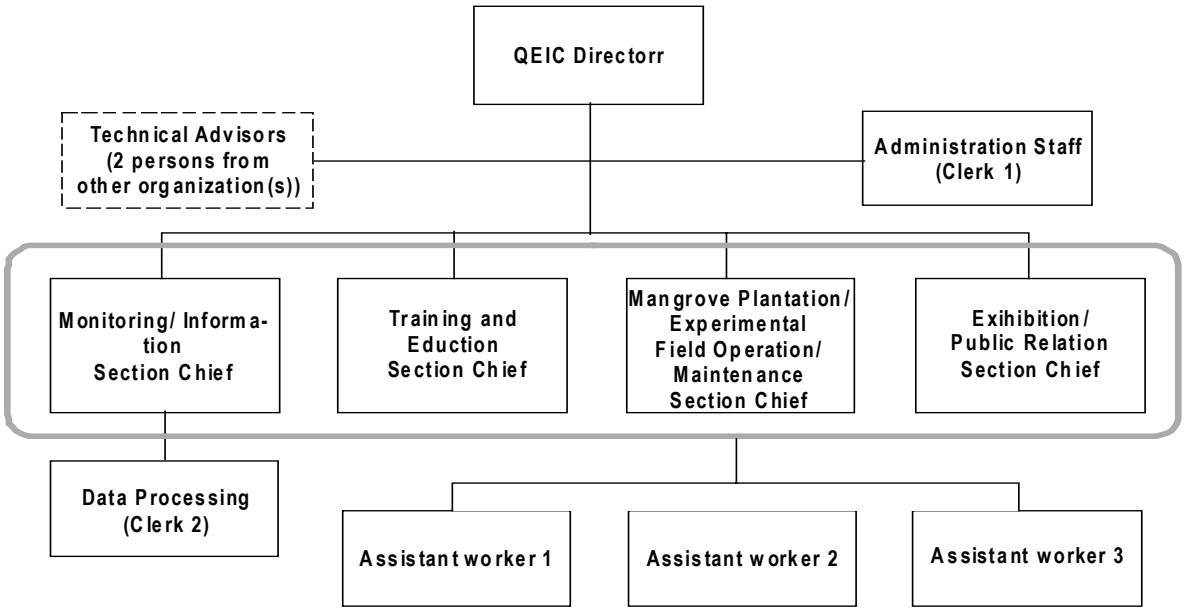

Figure 5.4.3 Organisation Chart of QEIC

5.4.3 Relevant Agencies and Organisation

Following Public agencies should be involved to the activities of the QEIC; their co-operation and co-ordination will ensure the functions and results of the activities of QEIC.

- Ministry of Education
- Ministry of Agriculture and Fisheries
- Ministry of Culture and National Heritage
- Ministry of Industries
- Muscat Municipality

Co-operating and supporting members should be organised for sustainable operation and management of the centre. Wide range of network should be formulated in Oman as well as international members and organisations.

- Environmental conservation related Associations and Organisations as affiliate members
- Private enterprises that are conscious on environment in Oman

Oman will be a secretariat of Mangrove section of Regional Organisation for the Protection of the Marine Environment (ROPME) in Gulf Co-operation Council (GCC).

5.4.4 Public and Private Participation

Public and private participation in the following should be involved to the activities on mangrove management and coastal management.

a. Co-ordination with Ministry of Education

Environmental education for the coming generation is a very important issue. In this Master Plan, the participation to mangrove afforestation, conservation and management of pupils of primary and secondary schools around Khawr Shinas as a part of class is proposed. For this purpose, the co-operation with the Ministry of Education in Al Batinah Region is indispensable. This participation of student at Khawr Shinas is a first step for expansion of nationwide activity.

b. Co-ordination and consignment with Locality

Daily inspection and attention is most effective activities for mangrove management. The MPCZMS in MRMEWR should be responsible agency for mangrove management, and implementing agency at short term. However, the transfer of implementing power is required for the continuation of mangrove management activity. Locality would have important role at medium or long term.

c. Establishment of Fund for Private Enterprises

All activities for mangrove management need budget. Participation of private enterprises should be required. The establishment of fund for mangrove management is effective for continuous acquisition of the budget.

d. Consignment with Tourism Agent

In this Master Plan, the consignment to mangrove afforestation, conservation and management to the Sawadi Hotel at Khawr Sawadi and Hilton Salalah Hotel at Khawr Saghir is proposed. Mangrove is one of tourism resources; therefore it becomes a business opportunity. The MRMEWR would request to manage mangrove to these tourism agents, and give it the utilisation permission of mangrove.

Chapter 6: Action Plan

6. Action Plan

6.1 Projects and Programmes

After deliberate consideration, the Study proposes the 33 projects and programmes as follows:

Type of Projects and Programmes	No. of Projects and Programmes
1. Legal Set up Programme	3
2. Stakeholder Co-ordination Programme	1
3. Facility Development Control Programme	1
4. Facility Development Project	8
5. Restoration and Afforestation Project	4
6. Monitoring Programme	9
7. Public Awareness Programme	5
8. Implementation Programme of Further Study	2
Total	33

The proposed projects and programmes with implementing schedule are listed in Table 6.1.1. The cost for the projects and programmes are shown in Table 6.1.2. These projects and programmes are to be implemented to form the basic framework and core roles of the Master Plan. The implementation schedule of the projects and programmes are divided into the following three terms:

- Short term (2 years): Up to 2006
- Mid term (5 years): Up to 2009
- Long term (10 years): Up to 2014

Detailed implementation plan for each project/ programme is compiled as the Technical Specifications for each study site included in this study.

For the implementation of these projects/ programmes, quick response to set up institutional arrangement is the most important matter. It is especially urgent to implement the institutional arrangements for QEIC.

Some of the programmes listed in the tables (Table 6.1.1 and 6.1.2) mentioned above are supposed to be implemented within the capacity and budget of the ordinary administrative work in the public agencies, or recommended to be undertaken as daily activities of the organisations such as schools, local offices and police department, and

specific budgeting for the implementation of the programmes does not seem necessary. The costs for projects/programmes by implementing agency are shown in Table 6.1.3. The cost for all projects/ programmes is estimated at about R.O. 4.5 million.

Table 6.1.1 Lists of Projects and Programmes

Project/ Programme Name	Batinah Zone				Muscat Zone			Sharqiyah Zone				Wusta Zone			Dhofar Zone							Implementing Schedule		
	Khawr Shinas	Khawr Harmul & Nabr	Khawr Sawadi	Khawr Haradi	Khawr Qurm	Bandar Khayran	Qurayyat	At Tina	Batah	Khawr Quq	Khawr Hajar - East Shore	Wadi Murayisis	Filim - Eastern Beach	Mahawt Island	Al Demer Beach	Khawr Rowri	Qurm Taqah	Khawr Dahariz	Khawr Balid	Khawr Kabir	Khawr Saghir	Short-term Phase I (2005~2006)	Mid-term Phase II (2007~2009)	Long-term Phase III (2010~2014)
1: Legal Set-up Programme	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
1-1: Legal Set-up Programme for Land Use Control	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
1-2: Institutional Set-up Programme for Protected Areas	X					X								X										
1-3:Land Use Control Planning Project																X								
2: Stakeholder Coordination Programme	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
3: Facility Development Control Programme	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
4: Facility Development Project																								
4-1: Temporary Nursery Construction Project	X									X				X										
4-2: Visitor Service and Information Facility Development Project	X	X	X	X		X	X	X	X	X	X	X	X	X		X	X	X						
4-3: Facility Arrangement Project	X	X	X	X										X			X	X			X			
4-4: Bird Hide Arrangement Project																		X						
4-5: Qurm Environmental Information Centre (QEIC) Project					X																			
4-6: Training Dyke Construction Project							X																	
4-7: Eco-Tourism Development Project														X										
4-8: Mangrove Plantation Experimental Centre (MPEC) Project																			X					
5: Restoration and Afforestation Project																								
5-1: Mangrove Planting Project	X		X			X	X	X	X	X	X	X	X				X		X					
5-2: Mangrove Maintenance Project		X												X						X	X			
5-3: Watercourse Bank Restoration Project	X																							
5-4: Sabkha Area Mangrove Planting Project					X																			
6: Monitoring Programme																								
6-1: Mangrove Monitoring Programme	X	X	X		X	X	X	X	X	X	X	X	X	X			X		X	X	X			
6-2: Soil Condition & Water Quality Monitoring Programme	X	X	X		X	X	X	X	X	X	X	X	X	X			X		X	X	X			
6-3: Flora & Fauna Monitoring Programme	X	X	X		X	X	X	X	X	X	X	X	X	X			X		X	X	X			
6-4: Pollution Monitoring Programme	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X			
6-5: Monitoring Programme on Legal Set-up and Development Plans	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X			
6-6: Management Programme for Sustainable Use	X						X	X	X															
6-7: Water Pollution Control & Solid Waste Management Programme				X				X	X															
6-8: Protection Project from Livestock Damage						X	X									X	X	X						
6-9: Resource Management Programme						X										X			X	X	X			
7: Public Awareness Programme																								
7-1: Educational Programme for Pupil	X	X	X	X		X	X	X	X	X	X	X	X	X		X	X	X	X	X	X			
7-2: Public Awareness Programme People in Oman					X																			
7-3: Conservation Campaign Programme for Residents	X	X	X	X		X	X	X	X	X	X	X	X	X		X	X	X	X	X	X			
7-4: Pamphlets & Posters Distribution Programme for Residents	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X			
7-5: Information Boards Establishment Project	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X			
8: Implementation Programme of Further Study																								
8-1: Environmental Impact Study	X	X				X		X	X	X	X		X	X		X								
8-2: Study on Sand Dune															X									

Table 6.1.2 List of Cost for Projects and Programmes

Project/ Programme Name	Batinah Zone				Muscat Zone			Sharqiyah Zone				Wusta Zone			Dhofar Zone							Cost ('000 R.O.)			
																						Long-term			
																						Mid-term			
	Khawr Shinas	Khawr Harmul & Nabr	Khawr Sawadi	Khawr Haradi	Khawr Qurm	Bandar Khayran	Qurayyat	Al Tina	Batah	Khawr Quq	Khawr Hajar - East Shore	Wadi Murayris	Filim - Eastern Beach	Mahawt Island	Al Demer Beach	Khawr Rowri	Qurm Taqah	Khawr Dahariz	Khawr Balid	Khawr Kabir	Khawr Saghir	Short-term Phase I (2005~2006)	Phase II (2007~2009)	Phase III (2010~2014)	Total
1: Legal Set-up Programme	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)				0.0
1-1: Legal Set-up Programme for Land Use Control	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)				0.0
1-2: Institutional Set-up Programme for Protected Areas	(*1)					(*1)								(*1)											0.0
1-3:Land Use Control Planning Project																(*1)									0.0
																									0.0
2: Stakeholder Coordination Programme	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)				0.0
																									0.0
3: Facility Development Control Programme	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)				0.0
																									0.0
4: Facility Development Project																									0.0
4-1: Temporary Nursery Construction Project	3.5									4.0				4.0								11.5			11.5
4-2: Visitor Service and Information Facility Development Project	17.8	17.8	17.8	17.8		17.8	17.8	17.8	17.8	17.8	17.8	17.8	17.8	17.8		17.8	17.8	17.8				142.4	142.4		284.8
4-3: Facility Arrangement Project	17.8	17.8	17.8	17.8										17.8			17.8	17.8			17.8	71.2	71.2		142.4
4-4: Bird Hide Arrangement Project																		17.8					17.8		17.8
4-5: Qurm Environmental Information Centre (QEIC) Project					2,481.0																	1,142.0	779.0	560.0	2,481.0
4-6: Training Dyke Construction Project							500.0															500.0			500.0
4-7: Eco-Tourism Development Project														300.0								300.0			300.0
4-8: Mangrove Plantation Experimental Centre (MPEC) Project																			500.0			500.0			500.0
																									0.0
5: Restoration and Afforestation Project																									0.0
5-1: Mangrove Planting Project (*3)	1.5		6.3			2.4	0.6	4.8	1.2	0.6	7.2	0.6	0.6				0.3		0.3			5.3	7.9	13.2	26.4
5-2: Mangrove Maintenance Project		---(*1)												(*1)						(*1)	(*1)				0.0
5-3: Watercourse Bank Restoration Project	---(*1)																								0.0
5-4: Sabkha Area Mangrove Planting Project (*3)					2.4																	2.4			2.4
																									0.0
6: Monitoring Programme																									0.0
6-1: Mangrove Monitoring Programme	(*1)	(*1)	(*1)		(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)			(*1)		(*1)	(*1)	(*1)				0.0
6-2: Soil Condition & Water Quality Monitoring Programme	(*1)	(*1)	(*1)		(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)			(*1)		(*1)	(*1)	(*1)				0.0
6-3: Flora & Fauna Monitoring Programme (*4)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0			1.0		1.0	1.0	1.0	28.8	43.2	72.0	144.0
6-4: Pollution Monitoring Programme	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)		(*1)	(*1)	(*1)	(*1)	(*1)	(*1)				0.0
6-5: Monitoring Programme on Legal Set-up and Development Plans	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)	(*1)		(*1)	(*1)	(*1)	(*1)	(*1)	(*1)				0.0
6-6: Management Programme for Sustainable Use	(*1)						(*1)	(*1)	(*1)																0.0
6-7: Water Pollution Control & Solid Waste Management Programme				(*1)				(*1)	(*1)																0.0
6-8: Protection Project from Livestock Damage						(*1)	(*1)									(*1)	(*1)	(*1)							0.0
6-9: Resource Management Programme						(*1)										(*1)			(*1)	(*1)	(*1)				0.0
																									0.0
7: Public Awareness Programme																									0.0
7-1: Educational Programme for Pupil	(*2)	(*2)	(*2)	(*2)		(*2)	(*2)	(*2)	(*2)	(*2)	(*2)	(*2)	(*2)	(*2)		(*2)	(*2)	(*2)	(*2)	(*2)	(*2)				0.0
7-2: Public Awareness Programme People in Oman					(*2)																				0.0
7-3: Conservation Campaign Programme for Residents	(*2)	(*2)	(*2)	(*2)		(*2)	(*2)	(*2)	(*2)	(*2)	(*2)	(*2)	(*2)	(*2)		(*2)	(*2)	(*2)	(*2)	(*2)	(*2)				0.0
7-4: Pamphlets & Posters Distribution Programme for Residents (*5)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0	20.0			20.0
7-5: Information Boards Establishment Project (*6)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1		0.1	0.1	0.1	0.1	0.1	0.1	2.0			2.0
																									0.0
8: Implementation Programme of Further Study																									0.0
8-1: Environmental Impact Study (*4)	10.0	10.0				10.0		10.0	10.0	10.0	10.0		10.0	10.0		10.0						100.0			100.0
8-2: Study on Sand Dune (*4)															10.0							10.0			10.0
Cost ('000 R.O.)	61.7	56.7	53	46.7	2494.5	41.3	529.5	43.7	40.1	43.5	46.1	29.5	39.5	360.7	10	28.9	38	54.5	502.4	2.1	19.9	3,197.60	1,061.50	645.2	4,542.3

(*1): Most of activities to be handled within routine works
(*2): Most of activities to be handled by QEIC
(*3): R.O. 10 per worker per day (10 workers per day), R.O. 100 per car for 5 workers, 5,000 seedlings to be planted per day
(*4): Sub-contructed work
(*5): R.O. 10 per 100 copies of brochure
(*6): R.O. 75 steel sign board

Cost (000 R.O.)

Project/ Programme Name	MRMEWR				Regional Office of MRMEWR				Wilayat				Other agencies (*4)				Total	
	Long-term				Long-term				Long-term				Long-term					
	Mid-term				Mid-term				Mid-term				Mid-term					
	Short-term			Total	Short-term			Total	Short-term			Total	Short-term			Total		Grand Total
	Phase I (2005~2006)	Phase II (2007~2009)	Phase III (2010~2014)		Phase I (2005~2006)	Phase II (2007~2009)	Phase III (2010~2014)		Phase I (2005~2006)	Phase II (2007~2009)	Phase III (2010~2014)		Phase I (2005~2006)	Phase II (2007~2009)	Phase III (2010~2014)			
4: Facility Development Project																		
4-1: Temporary Nursery Construction Project	11.5			11.5				0.0				0.0				0.0	0.0	11.5
4-2: Visitor Service and information Facility Development Project				0.0	71.2	71.2		142.4	71.2	71.2		142.4				0.0	0.0	284.8
4-3: Facility Arrangement Project				0.0	35.6	35.6		71.2	35.6	35.6		71.2				0.0	0.0	142.4
4-4: Bird Hide Arrangement Project				0.0				0.0	17.8			17.8				0.0	0.0	17.8
4-5: Ourm Environmental Information Centre (QEIC) Project (*5)	1,142.0	779	560	2,481.0				0.0				0.0	500.0			500.0	500.0	2,481.0
4-6: Training Dike Construction Project (*4)				0.0				0.0				0.0				0.0	500.0	500.0
4-7: Eco-Tourism Development Project				0.0	300.0			300.0				0.0				0.0	0.0	300.0
4-8: Mangrove Plantation Experimental Centre (MPEC) Project				0.0	500.0			500.0				0.0				0.0	0.0	500.0
5: Restoration and Afforestation Project																		
5-1: Mangrove Planting Project (*1)				0.0	2.7	3.9	6.6	13.2	2.6	4.0	6.6	13.2				0.0	0.0	26.4
5-4: Sabkha Area Mangrove Planting Project (*1)	2.4			2.4				0.0				0.0				0.0	0.0	2.4
6: Monitoring Programme																		
6-3: Flora & Fauna Monitoring Programme (*2)				0.0	14.4	21.6	36.0	72.0	14.4	21.6	36.0	72.0				0.0	0.0	144.0
7: Public Awareness Programme																		
7-4: Pamphlets & Posters Distribution Programme for Residents (*3)	20.0			20.0				0.0				0.0				0.0	0.0	20.0
7-5: Information Boards Establishment Project (*6)				0.0				0.0	2.0			2.0				0.0	0.0	2.0
8: Implementation Programme of Further Study																		
8-1: Environmental Impact Study (*2)				0.0	50.0			50.0	50.0			50.0				0.0	0.0	100.0
8-2: Study on Sand Dune (*2)				0.0	10.0			10.0				0.0				0.0	0.0	10.0
Cost (000 R.O.)	1175.9	779	560	2514.9	983.9	132.3	42.6	1158.8	193.6	132.4	42.6	368.6	500	0	0	500	500	4542.3

(*1): R.O. 10 per worker per day (10 workers per day), R.O. 100 per car for 5 workers, 5,000 seedlings to be planted per day, (*2): Sub-contracted work, (*3): R.O. 10 per 100 copies of brochure, (*4): Muscat Municipality,
(*5): construction cost+operation cost including foreign aid assistance (*6): R.O. 75 per steel sign board

6.2 Contents of Projects and Programmes

The following describes the contents of each project/programme. The detailed plan of Qurm Environmental Information Centre (QEIC) project is shown in Part 2 in this Volume. The outlines of the main projects/ programmes are as follows:

Project 1-2: Institutional Set-up Programme for Protected Areas

Project 1-2-1: Institutional Set-up Programme for Protected Areas at Khawr Shinas & Bandar Khayran

One way to have better control over development in a sensitive environmental area is to declare it a Nature Reserve as at Khawr Shinas and Bandar Khayran. The boundaries would exclude the village and make the fishermen's beach where huts are built and boats are hauled out a utility zone. The mudflats and mangroves are valuable wildlife habitat that can be damaged by too much boat traffic and overuse, especially at Bandar Khayran.

Project 1-2-2: Institutional Set-up Programme for Protected Areas at Mahawt Island

The natural system around Mahawt Island needs protection to prevent the loss of species and productivity from over-utilisation, pollution and damage from development projects. The protected area status should allow proper management and is expected to be proclaimed soon (2003).

Project 4-3: Facility Arrangement Project

Project 4-3-1 & 4-3-2: Facility Arrangement Project for Recreation at Khawr Shinas & at Khawr Harmul and Nabr

In the long term, a boardwalk and bird hide as a nature trail and Display boards explaining the mangroves and their importance would be useful at Khawr Shinas and Khawr Harmul and Nabr. The pedestrian bridge is (re)constructed to improve the water environment in the existing mangrove area. The existing pedestrian bridge at Khawr Shinas is shown in Figure 6.2.1, and the proposed ones at Khawr Shinas and Harmul/Nabr in Figure 6.2.2.

Project 4-3-3: Facility Arrangement Project for Eco-tourism at Khawr Sawadi

The Pre-feasibility study of tourism development at Sawadi by Entec (1995) for the Directorate of Tourism recommended that the islands off Ras Sawadi and the Khawr Sawadi should form part of a scenic reserve. Trails and bird hides would allow visitors to enjoy the wildlife at Khawr Sawadi.

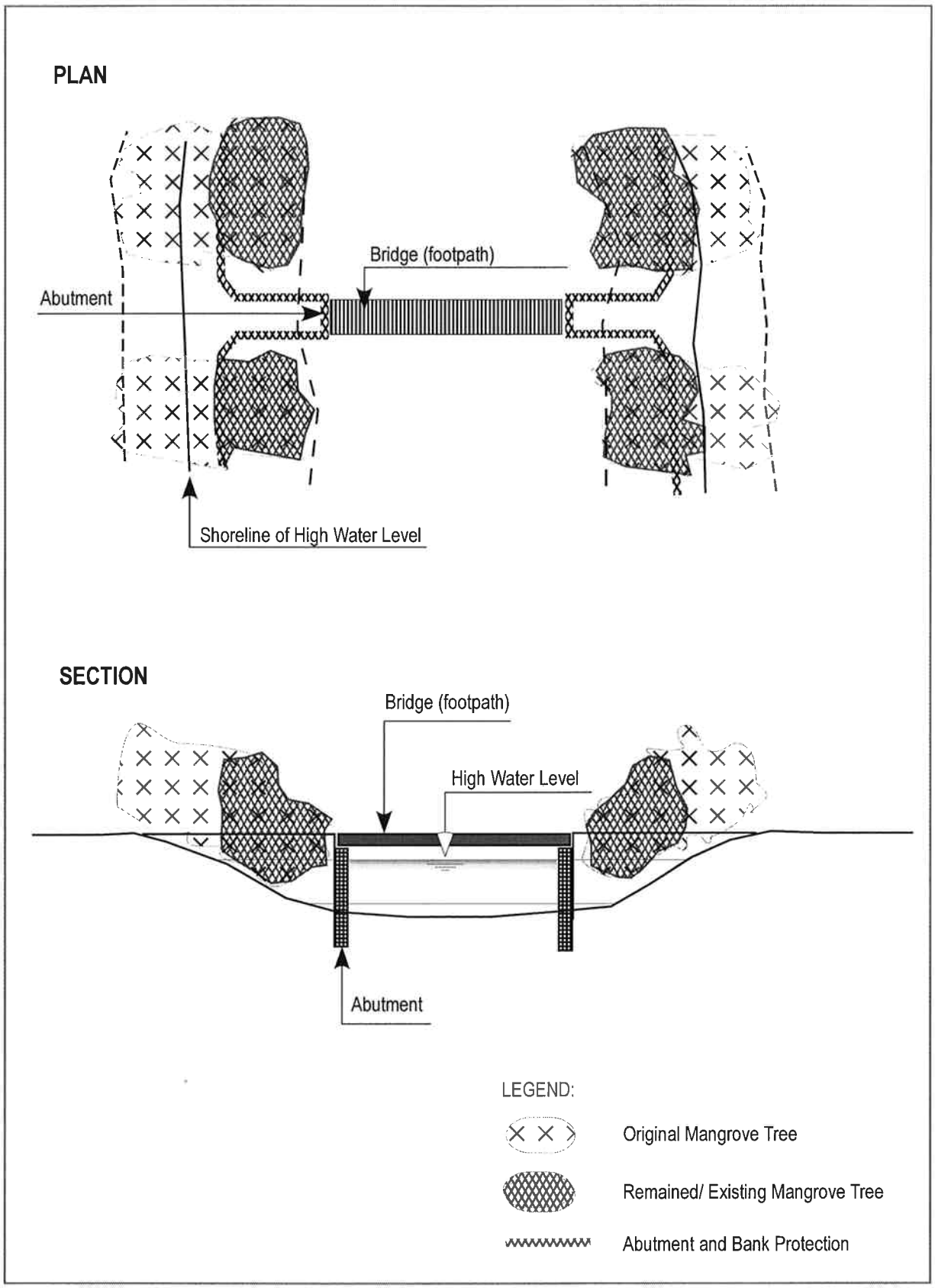

Figure 6.2.1 The Existing Pedestrian Bridge at Khawr Shinas

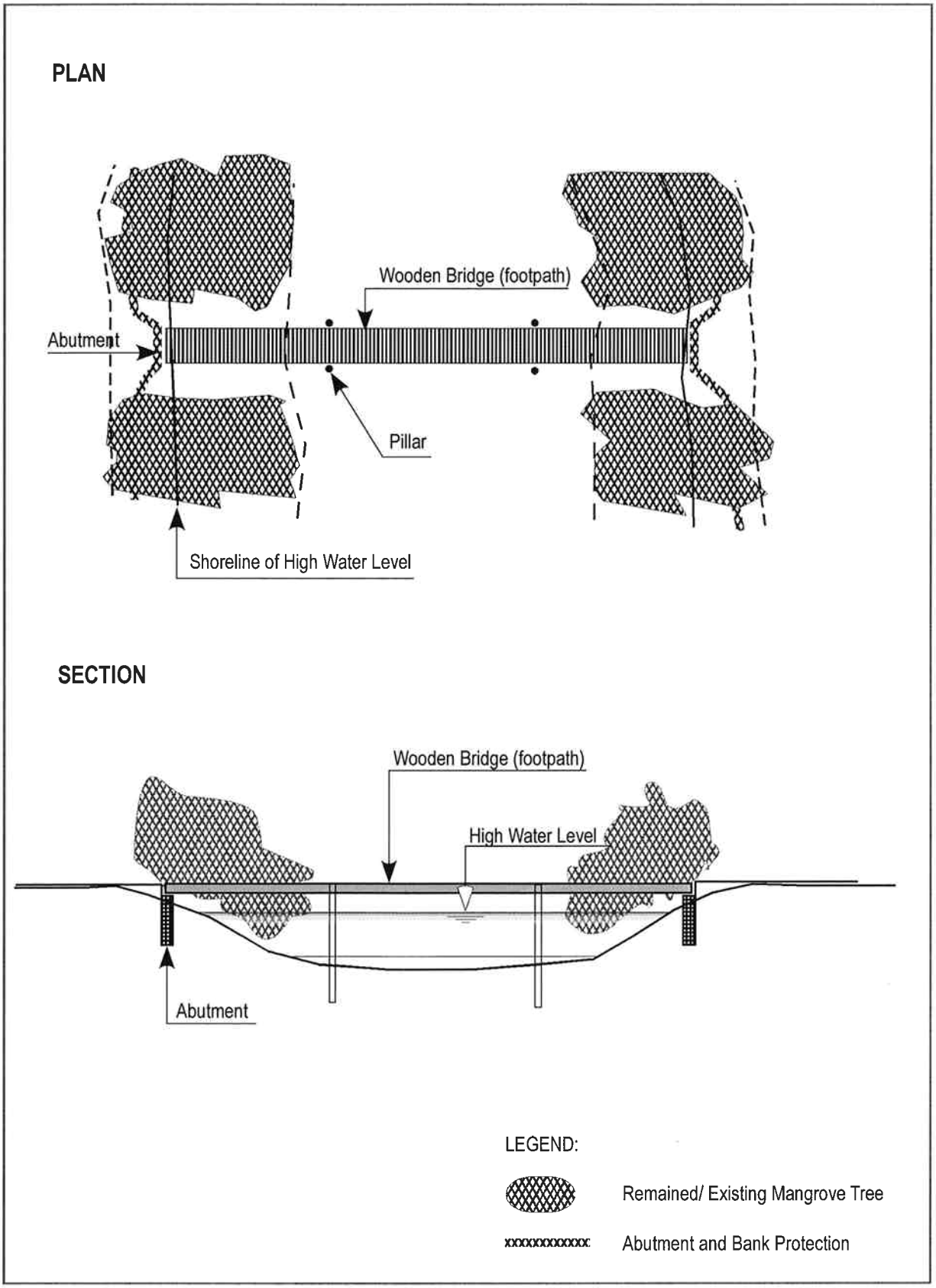

Figure 6.2.2 The Proposed Pedestrian Bridge at Khawr Shinas & Harmul/Nabr

Project 4-3-4: Facility Arrangement Project for Recreation at Khawr Haradi

The mouth of this khawr is almost closed by the sandbar. The illegal dumping and waste water discharging have occurred in this khawr, and caused the water pollution. Recreational facilities including football ground are recommended to be allocated based on adequate landuse at Khawr Haradi.

Project 4-3-5: Facility Arrangement Project for Eco-tourism at Mahawt Island

The local governmental regulation prohibits people to live in the Mahawt Island. However, there are many illegal residents in this area, and the pressure of development is brought out for the promotion of tourism. The local government is also planning the development of transport system including road or causeway constructions between Mahawt island and the mainland.

A road proposed to allow access to the island would be very costly and would damage the productive ecosystem. Improved facilities on the mainland would be preferable to a road. Instead of a road to improve access, it is recommended that long jetties are built on the island, either at Filim or Bar al Hikman. A development plan for the area needs to be produced at Mahawt Island. The proposed tourism development plan in Mahawt Island is shown in Figure 6.2.3.

Project 4-3-6: Facility Arrangement Project for Recreation at Qurm Taqah

According to the original Land Use, Development and Management Proposals (PCDEGD, 1993), any recreation facilities (if required) should not be established between Qurm Taqah and the main part of Khawr Taqah, but should be sited to the east of Khawr Taqah and immediately adjacent to the settlement of Taqah. Here the facilities will be more easily accessible to the inhabitants of Taqah and should not interfere with the natural attributes of the Khawr system.

Project 4-3-7: Facility Arrangement Project for Recreation at Khawr Dahariz

The pressure of development is high, because this khawr is located near Salalah city. The adequate protection of ecosystem is required. Bird hide is recommended at the southwest area at Khawr Dahariz.

Project 4-3-8: Facility Arrangement Project Managed by Private Sector at Khawr Saghir

The mangrove at Khawr Saghir serves for the recreation of tourists, because it is located next to the Hilton Hotel. The manager of this hotel has intention to manage the mangrove area, if local government allows the hotel to use this area. A resthouse or coffee shop is recommended at eastern area next to Hilton Hotel at Khawr Saghir.

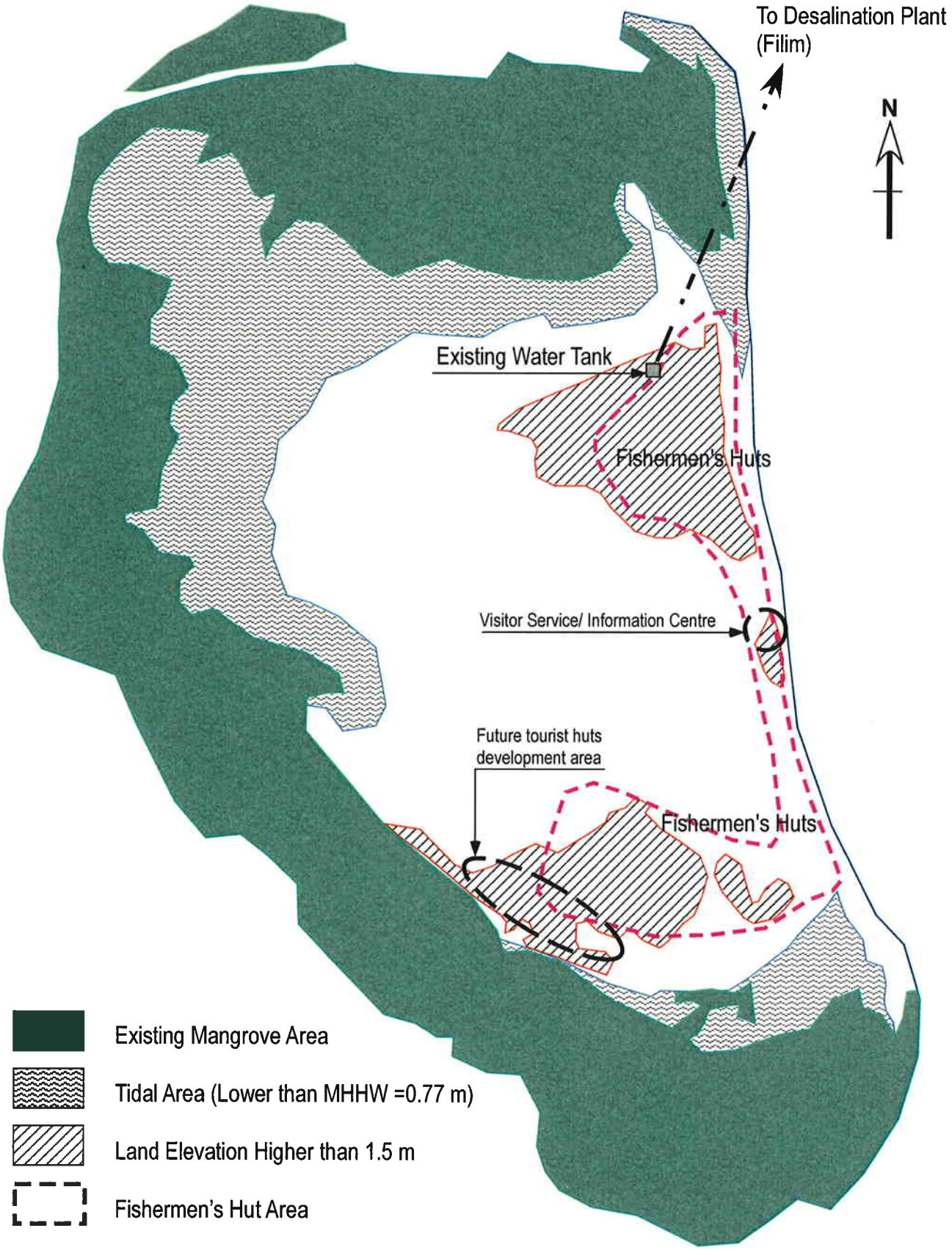

Figure 6.2.3 The Proposed Tourism Development Plan in Mahawt Island

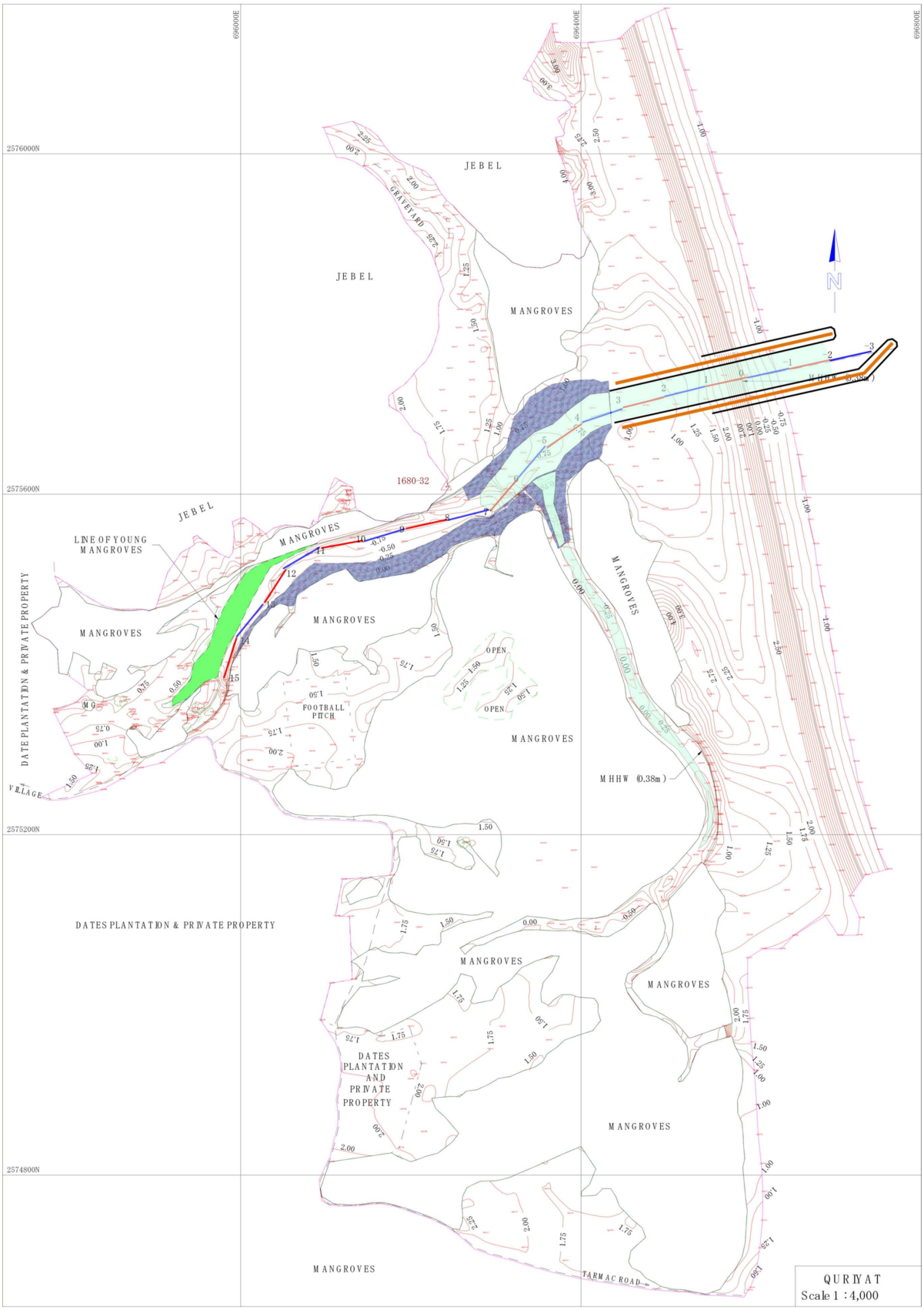

Figure 6.2.4 (1) Proposed Training Dyke at Qurayyat (Plan)

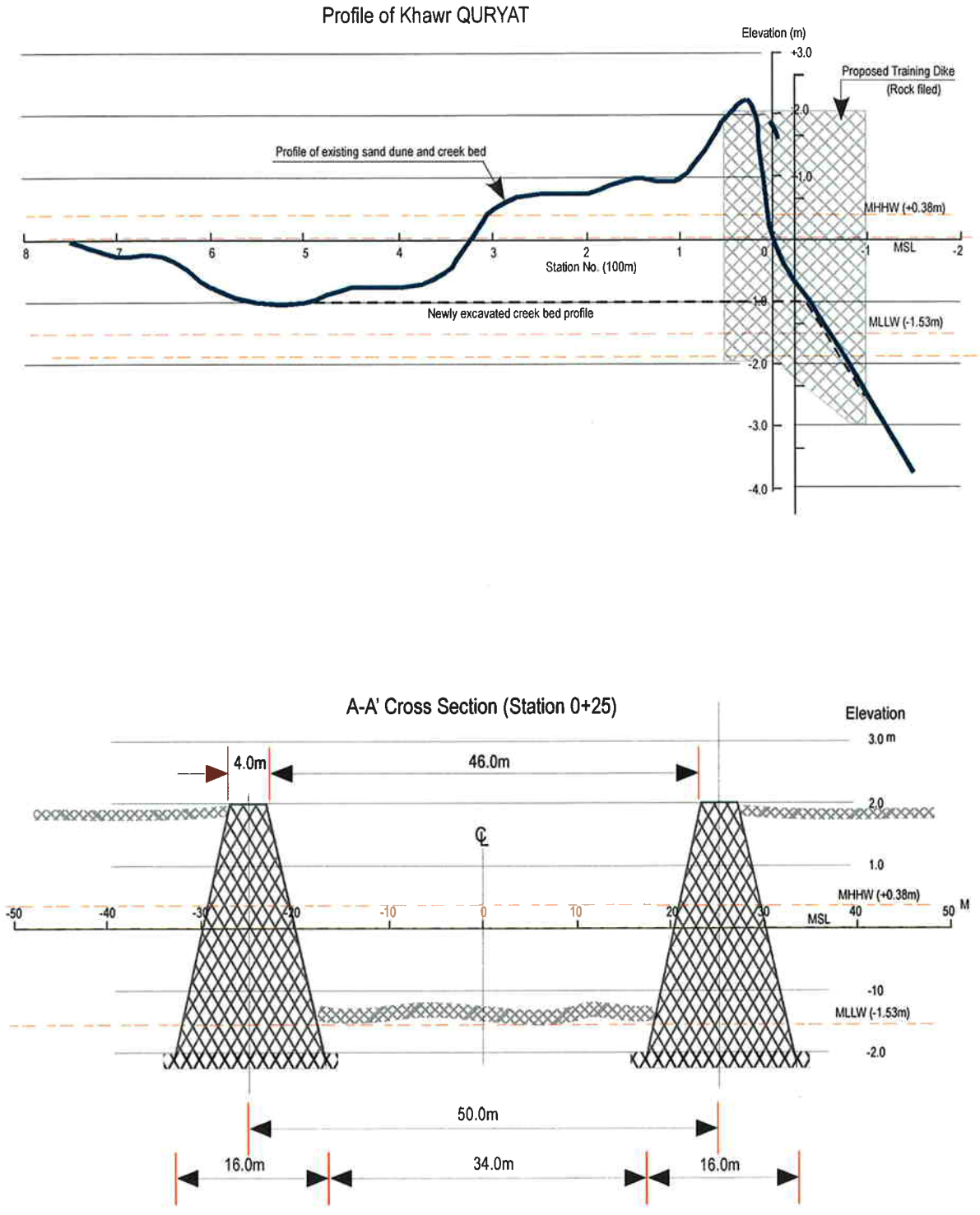

Figure 6.2.4 (2) Proposed Training Dike at Qurayyat (Profile and Cross Section)

Project 4-5: Qurm Environmental Information Centre (QEIC) Project

(See Appendix 6)

Project 4-6: Training Dyke Construction Project

Monitoring of the khawr mouth at Qurayyat is needed to record when the mouth opens to the sea. Modelling of sedimentation patterns between the harbour and the mangrove khawr should be carried out. Training dykes could be constructed to maintain a connection to the sea (Figure 6.2.4)

Project 4-8: Mangrove Plantation Experimental Centre (MPEC) Project

When only *Avicennia marina* is to be planted, in future, at Khawr Balid and since there is now a Mangrove Nursery at Khawr Qurm Kabir (Thet) and mangroves are growing well at that location (now that a fence provides protection from livestock), there is less need for the establishment of a "Mangrove Plantation Experimental Centre" (MPEC) with water being pumped from the sea to a series of ponds etc.

Instead, a small "Botanical Garden" is proposed to display native plants and to include a nursery for their propagation. Since visitors will be entering the Park at its NE corner near the Visitor Centre, a small area could be allocated near here for this purpose (unless the Archaeological Park Plan has specified all the area for other essential uses). The location proposed for the MPEC at the SE corner of the Nature Reserve is probably less suitable for a Botanical Garden (at least for plants from the Jabal areas) being close to the sea and exposed to a salty atmosphere and soil; it is also too far (over 1 km) to be reached easily on foot from the Visitor Centre. If not proposed for other uses (e.g. exhibitions) by the detailed plan for the Archaeological Park then the natural vegetation for this area could be allowed to recover and be part of a "nature trail"; a bird hide could be included to provide views of the open water in the khawr.

The nearby Crown Hotel may be interested in participating in such proposal. This would be consistent with the management of the site as a Nature Reserve. To promote public awareness of the environment at the Archaeological Park, so that it can provide environmental education for both school children and visitors, a display should be developed at the Visitor Centre (if not already designed). This should focus on the coastal environment, including mangroves, and on the local (Dhofari) flora and fauna.

However, prior to implementing any such actions, the first step for MRMEWR is to obtain (i) from OACA (and/or Ministry of Heritage and Culture) any Management Plan(s) that may have been prepared for the Frankincense Trail World Heritage Sites of Khawr Rowri, Al Balid and Wadi Dawkah (since UNESCO normally require Management Plans to be prepared) and (ii) from OACA the Detailed Designs for Buildings, Landscaping and Exhibitions. A review of these will then provide the foundation for the development of the above proposals. The location of the proposed mangrove research centre is shown in Figure 6.2.5, cross section in Figure 6.2.6 and proposed plan in Figure 6.2.7.

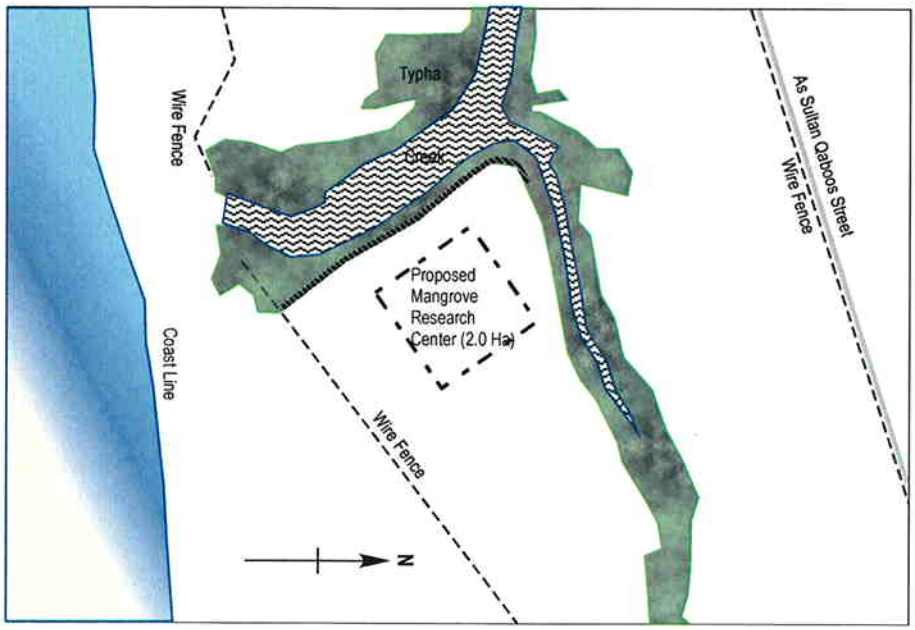

Figure 6.2.5 Location of Proposed Mangrove Research Centre

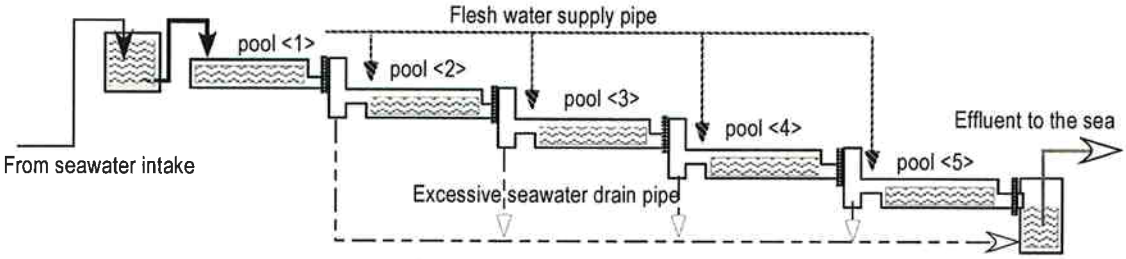

Figure 6.2.6 Cross Section of Proposed Mangrove Research Centre

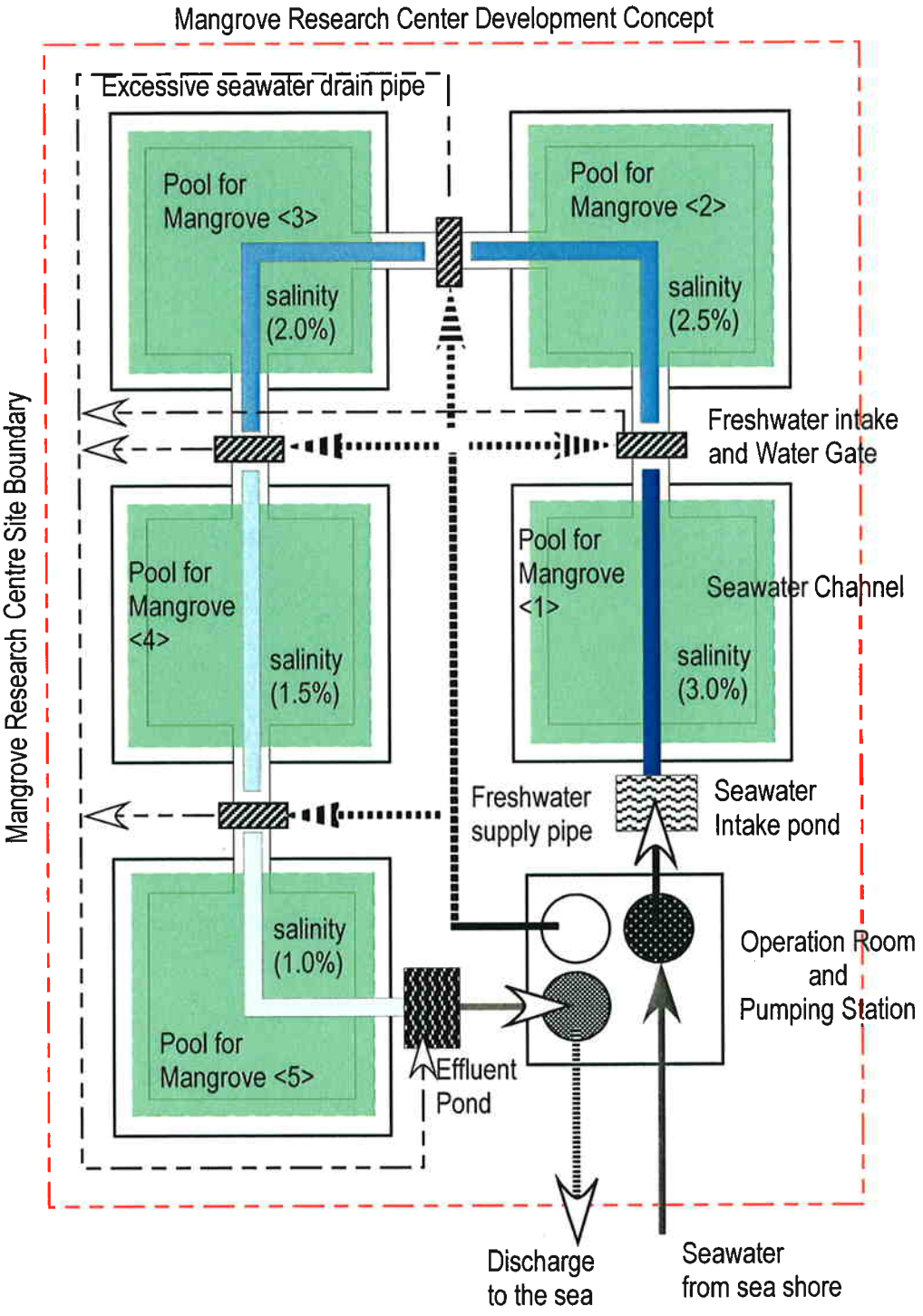

Figure 6.2.7 Proposed Plan of Mangrove Research Centre

Project 5-1: Mangrove Planting Project

Project 5-1-1: Mangrove Planting Project at Khawr Shinas

The pupils and teachers near this khawr, and the authority concerned have the willingness to join the mangrove planting activities. The west arm offers opportunities for planting of seedlings and could involve the local schools. A school environmental education programme could monitor the mangroves in conjunction with Directorate of Environment at Khawr Shinas.

Project 5-1-2: Mangrove Planting Project at Sawadi

Further planting should follow the contours of the channel to give the most attractive appearance. Monitoring of the khawr (invertebrate and bird studies) would provide useful information about the environmental conditions at Khawr Sawadi.

Project 5-1-3: Mangrove Planting Project at At Tina

Various sites have been used for mangrove planting trials. More transects are needed to determine the best locations and water levels. As well as the north side (At Tina), there is some scope for planting on the southeast side at the mouths of smaller wadis. Regular clearing of algae will prevent seedlings being smothered.

Project 5-1-4: Mangrove Planting Project at Wadi Muraysis

This is a difficult site due to strong winds and water currents but using barriers to protect the seedlings may allow some success. The Masirah Island means "green island" by local word, because this island had been covered by mangrove before 1977. The willingness to plant mangrove by local people is strongest among the social survey sites at Wadi Muraysis.

Project 5-1-5: Mangrove Planting Project at Filim-Eastern Beach

Mangrove planting may speed up the recovery of the trees at Filim-Eastern Beach. Potentially this could become the large space of mangrove forest in Oman. Many mangrove species would quickly colonise the area from Mahawt as demonstrated by the mudskipper.

Project 5-1-6: Mangrove Planting Project at Qurm Taqah

The lagoons at Qurm Taqah West should be considered as potential sites for mangrove planting trials, using only *Avicennia marina* seeds/seedlings of pure Dhofari provenance.

Project 6-6: Management Programme for Sustainable Use

A setback to prevent further buildings near the mangroves (MD 20/90 gives a set back of 150m) is needed and observed at all sites, which have existing mangrove or plan to plant mangrove, especially at Khawr Shinas, Qurayyat, At Tina and Khawr Batah. At Qurayyat, boats and fishing equipment should be kept at the back of the khawr next to the houses. It is important to maintain the area in a healthy condition so that it can function as a provider of fish, fodder and recreation. In the future the mangroves may form part of the scenic attractions for tourism. A community ranger is required to advise people the best use of the khawr.

- Project 6-6-1: Management Programme for Sustainable Use at Khawr Shinas
- Project 6-6-2: Management Programme for Sustainable Use at Qurayyat
- Project 6-6-3: Management Programme for Sustainable Use at At Tina
- Project 6-6-4: Management Programme for Sustainable Use at Batah

Project 6-7: Water Pollution Control & Solid Waste Management Programme

Project 6-7-1: Water Pollution Control & Solid Waste Management Programme at At Tina and Batah

Management of waste discharge into the lagoon is required at At Tina and Khawr Batah. The old septic tanks in old Sur town and old sewage pipelines need to be assessed and sealed if leakage is found. The new housing development proposed on the headland near existing mangrove nursery should have a sewage collection system that prevents any leakage into the lagoon. Water quality needs to be measured on a regular basis to monitor nutrient levels and coliform bacteria counts at least once a year. Landfill and garbage also should not encroach onto the lagoon.

Project 6-8: Protection Project from Livestock Damage

Project 6-8-1: Protection Project from Livestock Damage at Bandar Khayran

There is no urgent need to plant mangroves but young seedlings should be monitored as well as the extent of the forest. It may be necessary to provide some form of temporary protection from goats to selected areas if regeneration is not occurring at Bandar Khayran.

Project 6-8-2: Protection Project from Livestock Damage at Qurayyat

Goats should be kept away from the overgrazed eastern side at Qurayyat, while fodder can be collected from the healthy trees along the channels. Garbage should be collected and dogs should be removed, as they constitute a health risk (attacks on children and rabies).

Project 6-8-3: Protection Project from Livestock Damage at Khawr Rowri

Some areas along the eastern and western sides of Khawr Rowri where muddy tracks have formed would benefit from protection from livestock grazing for at least a few years. Selected areas of the surrounding vegetation should also be protected in rotation. These invasive trees, *Prosopis juliflora,* should be removed from nature reserves. Because of the sensitive environment this should be done by hand or using a systemic poison in the nature reserve not by using a bulldozer. Dead *Prosopis juliflora* (without seeds or pods) could make an effective thorn barrier next to the water in these areas. A fence on the boundary of the protected area is proposed in the management plan. If this is carried out a permit system could allow local livestock owners to collect fodder while the vegetation is monitored.

Project 6-8-4: Protection Project from Livestock Damage at Qurm Taqah

Urgent action is required to provide at least temporary protection (for 2-5 years) to the younger mangroves and seedlings, so that they can become fully established, and to the mature mangroves, so that re-growth of the damaged parts can take place at Qurm Taqah. If at least temporary protection can be provided then the ability of the mangroves to provide browse (leaves) for livestock should increase, i.e. the primary production of mangroves will increase.

When healthy growth of the mangroves has been re-established, then controlled access by camels, and/or harvesting of stems and leaves for use as camel feed, should be viable – without endangering the future survival of the mangroves and the khawr ecosystem. Since fencing (i) can be costly (ii) can result in tensions with local land users (camel owners) because perceived as the government permanently preventing free access to the khawr and its resources (iii) can spoil the visual appearance of a natural area, an alternative method of protection is proposed on a trial (experimental) basis.

It is proposed that a thorn fence be established adjacent to selected parts of the khawr. The thorn fence should consist primarily of dead *Prosopis juliflora* trunks, branches and twigs that would otherwise have been burnt as part of the eradication campaign. It is essential that the dead trees selected and collected for this purpose do not bring with them seed pods and seeds from living (or dead) *P. juliflora* trees, i.e. younger trees that have not yet fruited and/or trees that have already been 'bulldozed', and from which seed pods have already fallen, should be used. Most of the trees could be collected from the Ayn Humraan to Taqah area.

In order to obtain local support for this task, it is recommended that the traditional users of the area are employed (temporarily), and are also paid to provide vehicles (pick-ups) to transport the dead trees to the site. The livestock owners have skills in making enclosures from tree branches which can be applied to this 'thorn fence' and the height and thickness (width) of the fence should be agreed with them. As part of the recruitment process, the purpose of the task (to improve the condition of the mangrove

vegetation and allow subsequent controlled exploitation) would be discussed with these users; suggestions made by them should be taken into consideration.

Project 6-8-5: Protection Project from Livestock Damage at Khawr Dahariz

The spread of the exotic tree, *Prosopis juliflora,* is undesirable as it gradually displaces natural vegetation changing the eco-system at Khawr Dahariz. Removal of these trees (but not native species) is already a management objective. Because of the sensitive environment this should be done by hand not using a bulldozer.

Project 6-9: Resource Management Programme

Project 6-9-1: Resource Management Programme at Bandar Khayran

The Ministry of Agriculture and Fisheries need to regulate fishing for the fishery resource management at Bandar Khayran. One method is to close certain areas to allow stocks to recover and eventually repopulate surrounding areas.

Project 6-9-2: Resource Management Programme at Khawr Rowri

Small-scale use of gill nets can continue by permit although the catch and fish populations should be monitored to ensure that they are used sustainably at Khawr Rowri. An alternative site should be proposed and discussions with the people involved need to be undertaken to shift the activity for manure collection and distribution outside the Nature Reserve boundaries.

Project 6-9-3: Resource Management Programme at Khawr Balid

Urgent action for vegetation management is required by MRMEWR to stop any further destruction and removal of terrestrial, coastal dune and aquatic vegetation, unless clearly justified and essential for the Visitor Centre and access to the archaeological site at Khawr Balid. If at certain points along the Khawr it is necessary to remove the vegetation to make space, e.g. a bridge, this would be acceptable, but at other sections where improved visibility was required it would be better just to cut to a low height the reed vegetation, making the cut material available to livestock. This would keep the border of the lagoon green and attractive, reduce erosion and provide some habitat for wildlife. Such action has already been set out in the MRMEWR Management Plan. Therefore, as recommended in the U.S. DINPS Development Concept Plan, a Natural Resources (including vegetation management) plan needs to be prepared by MRMEWR and explained to and agreed with OACA.

Project 6-9-4 & 6-9-5: Resource Management Programme at Khawr Kabir and at Khawr Saghir

As stated in the management plan, when the mangroves and reeds recover, permits can be issued to allow local people to harvest fodder for livestock at Khawr Kabir and

Khawr Saghir. This should be done through the local sheiks. Harvesting needs to be monitored. Some reeds and mangroves should be allowed to flower and set seed each year. Leaves should only be cut from larger trees. Limited fishing can continue at the khawr using cast net.

Project 8-1: Environmental Impact Study

Project 8-1-1: Environmental impact study at Khawr Shinas

Some environmental impacts are caused by the construction of the local park located beside the khawr. Further development that will affect the Khawr Shinas should be reviewed for environmental impact.

Project 8-1-2: Environmental impact study at Khawr Harmul & Nabr

It needs further study on sedimentation, and the monitoring programme for Sohar Port Project (Atkins) should establish the cause of increased sand deposition at the mouth and propose mitigation measures if needed at Khawr Harmul & Nabr. Unfortunately, the Municipality has spoilt part of the edge to the khawr. Plans for development need to be assessed for environmental impact and when carried out the bulldozer driver needs to be supervised.

Project 8-1-3: Environmental impact study at Bandar Khayran

At Bandar Khayran, these require careful planning to avoid pollution and disturbance to the enclosed bays. The Muscat Municipality have carried out an Environmental Impact Assessment for the coastal road (Atkins 2003). This report recommends that the original alignment should be changed to avoid Bandar Khayran completely. It returns to the coast further south and crosses the road to the village on the landward side. If people are visiting the area they can take the road to the small bays north of Bandar Khayran, thus avoiding the mangrove bays and the village. This is where small boats giving rides to tourists could also operate from to avoid the shallow mudflats and mangroves further south.

Project 8-1-4: Environmental impact study at At Tina and Batah

Sedimentation rates should be monitored to determine if the lagoon is becoming shallower at At Tina and Khawr Batah.

Project 8-1-5-: Environmental impact study at Khawr Quq and Khawr Hajar – East Shore

The management plan for the Ras al Had reserve is as an important bird protection area. Traditional use of the khawr can continue but tourism development projects within the reserve boundaries need to be assessed for environmental impact (RD 6/2003). Borrow pits for fill material along roads should be correctly sited and their use

supervised. If large-scale hotel development is considered financially feasible, it should be planned outside the reserve boundaries away from the natural and scenic values of the area. Inside the reserve, small-scale accommodation could be provided by villagers in Ras al Had.

Project 8-1-6: Environmental impact study at Khawr Quq and Filim-Eastern Beach and Mahawt Island

The coastal areas around Filim, Bar al Hikman and Mahawt Island are part of a proposed protected area (2003). Proper environmental impact assessments are required for any development in Film-Eastern Beach and Mahawt Island

Project 8-1-7: Environmental impact study at Khawr Quq and Khawr Rowri

The management plan discusses the need for information and proper trails to guide visitors to the archaeological site at Khawr Rowri.