

Sultanate of Oman

Ministry of Environment and Climate Affairs (MECA)

Sultanate of Oman

**The Qurm Environmental Information Center
Project**

Final Report

March 2014

Japan International Cooperation Agency (JICA)

Ides Inc.

Appropriate Agriculture International Co., Ltd. (AAI)

GE
JR
14-069

TABLE OF CONTENTS

List of abbreviations

Mangrove sites in Oman

Photos of Project activities

1. OUTLINE OF THE PROJECT	1
1.1 Background of the Project	1
1.2 Objective of the Project	1
1.3 Location of the Project	2
1.4 Facilities of QEIC and construction status	3
1.5 Project period	4
1.6 JICA Expert Team	4
2. OUTPUTS AND RESULTS OF PROJECT ACTIVITIES	5
2.1 Establishment of Project operation unit	5
2.1.1 Establishment of Project implementation body (PDM activity: 0.2)	5
2.1.2 Establishment of Joint Coordinating Committee (PDM activity: 0.4)	5
2.1.3 Amendment of Work Plan and PDM/PO (PDM activity: 0.1)	7
2.1.4 Equipment procured in Japan and Oman	7
2.1.5 Equipment procured for donation (PDM activity: 0.8)	7
2.1.6 Operation plan of QEIC (PDM activity: 0.3, 0.6, 0.7)	8
2.1.7 Monitoring and evaluation of QEIC activities (PDM activity: 0.5)	8
2.2 Development of capacity of training activity	9
2.2.1 Objective of training activity	9
2.2.2 Contents and target groups of training activity (PDM activity: 1.1, 1.2, 1.3)	9
2.2.3 Resource person for training activity (PDM activity: 1.4)	12
2.2.4 Training material (PDM activity: 1.5)	12
2.2.5 Cost and schedule of training activity (PDM activity: 1.6, 1.7)	12
2.2.6 Trial training and evaluation (PDM activity: 1.8, 1.9)	13
2.2.7 Issues and recommendations	16
2.3 Development of mangrove monitoring method	17
2.3.1 Status of MECA's environmental monitoring activities	17
2.3.2 Outline of Mangrove Ecosystem Monitoring Program (PDM activity: 2.1, 2.2)	17
2.3.3 Outline of Transplanted-seedling Monitoring Program (PDM activity: 2.1, 2.2)	26
2.3.4 Implementation of monitoring survey (PDM activity: 2.4, 2.6)	27
2.3.5 Mangrove Monitoring Guideline (PDM activity: 2.3)	38
2.3.6 Management and publication of monitoring data (PDM activity: 2.5)	39
2.3.7 Issues and recommendations	39

2.4	Development of methods and techniques for mangrove plantation	41
2.4.1	Objective of mangrove plantation.....	41
2.4.2	Status of seedling facility and mangrove plantation activities (PDM activity: 3.1).....	41
2.4.3	Improvement of mangrove plantation technique (PDM activity: 3.2)	47
2.4.4	Consideration of mangrove conservation methods (PDM activity: 3.3).....	52
2.4.5	Issues and recommendations.....	54
2.5	Environmental education.....	55
2.5.1	Objective of environmental education.....	55
2.5.2	Target groups of environmental education (PDM activity: 4.1)	55
2.5.3	Methods and tools for environmental education (PDM activity: 4.2).....	56
2.5.4	Environmental education program (PDM activity: 4.3, 4.5, 4.6, 4.8).....	58
2.5.5	Publication materials (PDM activity: 4.4)	69
2.5.6	Exhibition plan (PDM activity: 4.7)	70
2.5.7	Issues and recommendations.....	73
2.6	Database and website of QEIC	75
2.6.1	Database	75
2.6.2	Website	78
2.7	Project training course in Japan and international workshop.....	79
2.7.1	Project training course in Japan	79
2.7.2	International workshop	79
3.	DEGREE OF ACHIEVEMENT OF PROJECT PURPOSE	81
3.1	Degree of achievement of PDM outputs	81
3.2	Capacity assessment of C/P.....	83
3.3	Result of the Joint Terminal Evaluation.....	86
4.	OTHER PROJECT RELATED ACTIVITIES.....	88
4.1	JICA training course	88
4.2	Support for Ramsar registration.....	89
5.	ISSUES AND STRATEGIES ON PROJECT IMPLEMENTATION AND OPERATION.....	90
6.	RECOMMENDATIONS TO ACHIEVE THE OVERALL GOAL OF THE PROJECT.....	92
6.1	Recommendations to enhance the operational capacity of QEIC.....	92
6.2	Recommendations to enhance the technical capacity of C/P.....	93
6.3	Recommendations for disseminating sustainable mangrove ecosystem management.....	94

Appendix

- Appendix 1 Assignment period of JICA Expert Team in Oman
- Appendix 2 Minutes of JCC (1st-4th JCC)
- Appendix 3 Final version of PDM (ver. 2.0) and record of amendment
- Appendix 4 List of donated equipment and handover note
- Appendix 5 QEIC 8-year Operation Plan
- Appendix 6 Photos of fauna identified through the Project
- Appendix 7 Preliminary study on the relationship between light conditions and seedling growth
- Appendix 8 Performance and evaluation results of plantation activities (6 sites)
- Appendix 9 Publication materials prepared through the Project (attached folder)
- Appendix 10 QEIC exhibition plan
- Appendix 11 Database related files (attached CD)
- Appendix 12 Report of Project training courses (1st and 2nd Project phases)
- Appendix 13 Agenda and participant list of international workshop
- Appendix 14 WBS evaluation sheet
- Appendix 15 Questionnaire for capacity assessment

Technical documents (separate document)

- Technical Document 1 Training plan and materials
- Technical Document 2 Mangrove Monitoring Guideline
- Technical Document 3 Mangrove Plantation Guideline
- Technical Document 4 Mangrove Protection Guideline
- Technical Document 5 Guideline for Development of Environmental Education Program

List of Figures

Figure 1.3.1	Area of QNR and location of QEIC.....	2
Figure 1.4.1	Image of QEIC building and floor plan.....	3
Figure 2.3.1	Monitoring framework of “Mangrove Ecosystem Monitoring Program”.....	18
Figure 2.3.2	Basic monitoring procedure of mangrove forest.....	19
Figure 2.3.3	Basic procedure of the fauna monitoring.....	21
Figure 2.3.4	Location of mangrove survey transect.....	28
Figure 2.3.5	NDVI value of QNR in October 2011.....	30
Figure 2.3.6	NDVI value of QNR in September 2012.....	30
Figure 2.3.7	Changes in the NDVI value between October 2011 and September 2012.....	31
Figure 2.3.8	Location of bird survey transect.....	34
Figure 2.3.9	Location of water quality survey.....	36
Figure 2.4.1	Seedling nursery in QNR.....	41
Figure 2.4.2	Evaluation sheet for site selection.....	50
Figure 2.4.3	Plantation performance and evaluation results of khawr Sawadi.....	51
Figure 2.5.1	Flow of program formulation and evaluation.....	66
Figure 2.5.2	Sample worksheet.....	73
Figure 2.6.1	Image of mangrove site database.....	75
Figure 2.6.2	Image of fauna database (in case of bird).....	76
Figure 2.6.3	Image of photo database.....	76
Figure 2.6.4	Image of QEIC website.....	78
Figure 3.1.1	Degree of achievement of each PDM output.....	82

List of Tables

Table 1.6.1	Assigned field and affiliated organization of the JICA experts.....	4
Table 2.1.1	Members of the Project implementation body and assigned field of each member.....	5
Table 2.1.2	Members of JCC.....	6
Table 2.1.3	Main items discussed and approved at each JCC.....	6
Table 2.1.4	Equipment procured and brought from Japan.....	7
Table 2.1.5	Equipment procured in Oman.....	7
Table 2.2.1	Outline of the QEIC training courses.....	11

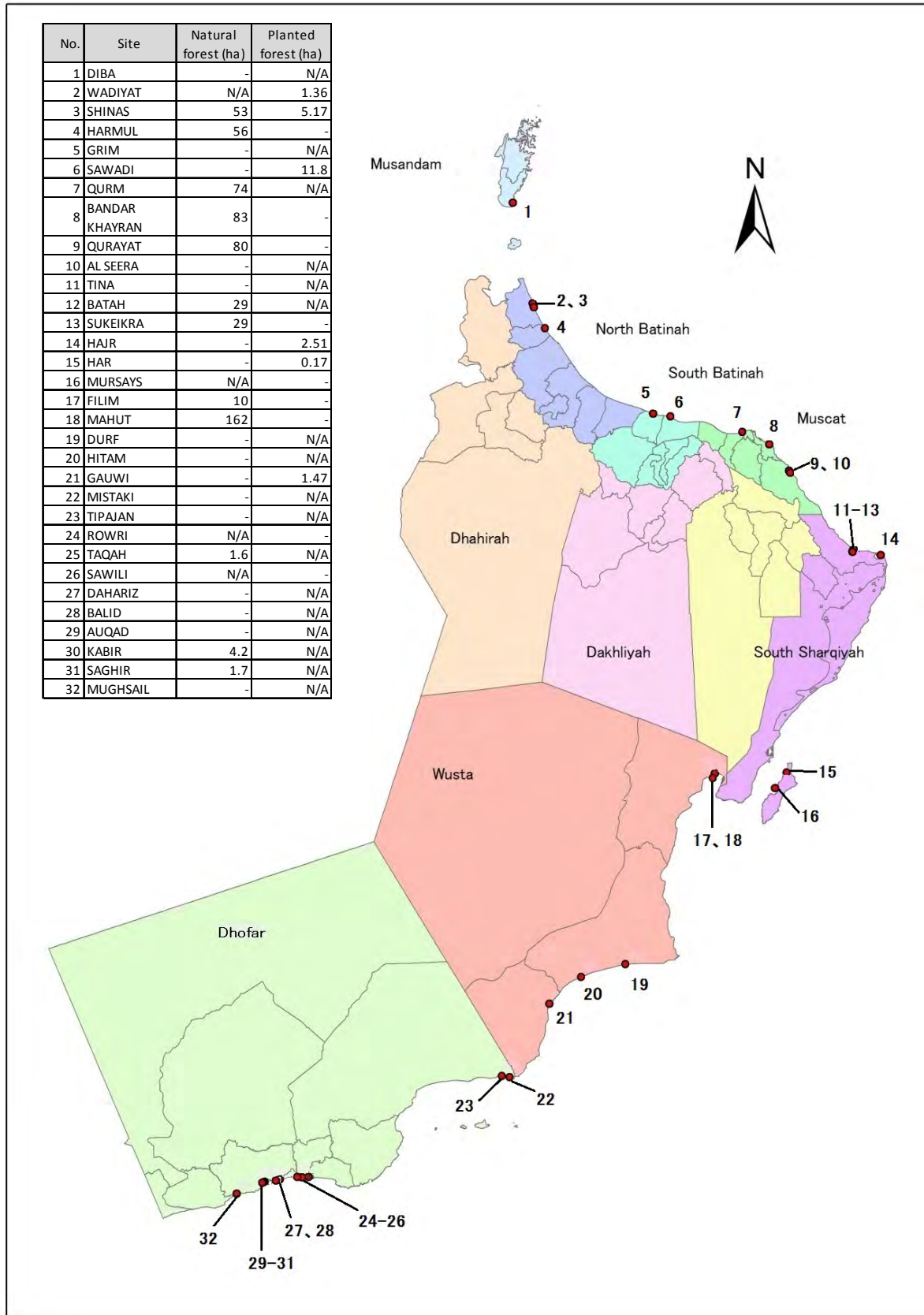
Table 2.2.2	The contents of the trial training programs and the main outputs and issues.....	14
Table 2.3.1	Health assessment criteria of mangrove health indicators	19
Table 2.3.2	Assessment criteria of overall health of mangrove tree	19
Table 2.3.3	Water quality monitoring parameters and outline of measurement methods	22
Table 2.3.4	Water quality monitoring parameters and outline of measurement methods	22
Table 2.3.5	Proposed monitoring frequency of each monitoring item	24
Table 2.3.6	Candidate monitoring sites for the period 2014-2021	24
Table 2.3.7	Implementation schedule of monitoring at QNR (2014-2016)	25
Table 2.3.8	Results of mangrove survey	28
Table 2.3.9	Fish species identified in QNR and Mahut Island.....	32
Table 2.3.10	Crustacean species identified in QNR and Mahut Island.....	32
Table 2.3.11	Gastropod species identified in QNR.....	33
Table 2.3.12	Results of bird survey.....	34
Table 2.3.13	Results of the water quality survey	37
Table 2.3.14	Results of soil quality survey	38
Table 2.3.15	Proposed contents of the annual report	39
Table 2.4.1	Mangrove plantation plan developed through the JICA Master Plan Study	43
Table 2.4.2	Performance of mangrove plantation from 2001-2012	43
Table 2.4.3	Estimated area transition of the plantation site.....	45
Table 2.4.4	Field check list for site selection	50
Table 2.5.1	Suggested contents of environmental education by target group	55
Table 2.5.2	Methods and tools of environmental education for each target group	56
Table 2.5.3	Basic methods of environmental education for each target group	57
Table 2.5.4	Environmental education tools developed by the Project	58
Table 2.5.5	Typical environmental education program conducted at QNR.....	59
Table 2.5.6	Environmental education programs and main improvements made during the Project....	61
Table 2.5.7	Feedbacks obtained through the program evaluation conducted by the Project	63
Table 2.5.8	Main revisions of the environmental education programs	64
Table 2.5.9	Outline of the developed modules.....	65
Table 2.5.10	Example of environmental education program for primary schools	66
Table 2.5.11	Example of environmental education program for private companies.....	67

Table 2.5.12	Example of environmental education program for private companies.....	67
Table 2.5.13	Example of environmental education program for request-based programs in QNR	67
Table 2.5.14	Annual cost required for implementing environmental education program (gifts and food/drinks).....	68
Table 2.5.15	Annual cost required for implementing environmental education program (production of education materials).....	68
Table 2.5.16	Period suitable for implementing the developed modules	69
Table 2.5.17	Proposed implementation frequency of environmental education programs	69
Table 2.5.18	Outline of the prepared publication materials	70
Table 2.5.19	Proposed content of the QEIC exhibition.....	71
Table 2.5.20	Proposed themes for QEIC's special exhibition.....	72
Table 2.6.1	Basic information for establishing QEIC database	77
Table 2.7.1	Outline of the Project training courses in Japan.....	79
Table 3.2.1	Results of the capacity assessment (Individual).....	84
Table 3.2.2	Results of the capacity assessment (Organization)	85
Table 3.3.1	Criteria of evaluation and evaluation results	87
Table 4.1.1	Outline of the JICA training course participated in the 1 st Project phase	88
Table 4.1.2	Outline of the JICA training course participated in the 2 nd Project phase.....	89

List of abbreviations

COD	: Chemical Oxygen Demand
C/P	: Counterpart
CSR	: Corporate Social Responsibility
CUDBAS	: Curriculum Development Based on Vocational Ability Structure
DAC	: Development Assistance Committee
DO	: Dissolved Oxygen
EC	: Electrical conductivity
ESO	: Environmental Society of Oman
GIS	: Geographic Information System
GoO	: Government of Oman
GoJ	: Government of Japan
GPS	: Global Positioning System
ISME	: International Society for Mangrove Ecosystems
IUCN	: International Union for Conservation of Nature
JCC	: Joint Coordinating Committee
JICA	: Japan International Cooperation Agency
MAF	: Ministry of Agriculture and Fisheries
MECA	: Ministry of Environment and Climate Affairs
MECD	: Marine Environment Conservation Department
MSFC	: Marine Science and Fisheries Center
NDVI	: Normalised Difference Vegetation Index
NGO	: Non-Government Organisation
ORP	: Oxidation-reduction Potential
PDM	: Project Design Matrix
PO	: Plan of Operation
QEIC	: Qurm Environmental Information Center
QNR	: Qurm Nature Reserve
R/D	: Record of Discussions
RIS	: Ramsar Information Sheet
ROPME	: Regional Organization for the Protection of the Marine Environment
SQU	: Sultan Qaboos University
UNEP	: United Nations Environment Programme
WBS	: Work Breakdown Structure
WWF	: World Wild Fund for Nature

Mangrove sites of Oman



Photos of Project activities

Status of Qurm Nature Reserve (QNR)



Construction site of QNR



Waterway inside QNR



Boardwalk inside QNR



Nursery inside QNR



Intrusion of halophytes



Overgrowth of algae



Crabs living inside the QNR forest



Migratory birds in QNR (sandpipers)

Status of other mangrove sites



Transplanted mangroves in Sawadi



Mangrove forest in Sur



Mangrove forest in Bandar Khayran



Mangrove forest in Salalah



Dead mangrove in Harmul



Waste dumping in Sur



Attachment of barnacles on branch (Mashirah)



Grazing by camels (Salalah)

Training activities



Workshop to discuss contents of training program



Trial training of monitoring



Training of fauna collection



Discussion of education material



Evaluation of training



Training of seedling measurements



Training of water quality measurements



Training of environmental education

Monitoring activities



Measurement of mangrove



Measurement of water quality



Water quality analysis



Sampling of soil sample



Fish collection with gill net



Measurement of fish size



Observation of birds



Measurement of leaf NDVI values

Plantation activities



Plantation with local students (Mashirah)



Plantation with local women's group (Mashirah)



Growth monitoring of seedling



Treatment of seeds



Preparation of seed pots



Seeding of seeds



Unhealthy seedling



Field reconnaissance of plantation site (Shinas)

Environmental education activities



Explanation of seedling nursery (QNR)



Fauna observation at boardwalk (QNR)



Environmental education with games (QNR)



Bird observation (QNR)



Environmental education at school (Duqm)



Explantaion of mangrove by using poster



Environmental education with quiz (Mashirah)



Cleaning activities (QNR)

Project training course in Japan (1st phase)



Bird observation course



Species identification course



Site visit of rehabilitated river



Observation of leaf color



Course on shell identification



Practice of topographic survey



Diorama of mangrove ecosystem



Practice of chlorophyll analysis

Project training course in Japan (2nd phase)



Water sampling



Quadrat survey



Mangrove survey



Collection of aquatic fauna



Bird observation



Lecture on mangrove physiology



Course on remote sensing



Presentation of certificate at JICA

International workshop



Opening of workshop



Presentation of QEIC by C/P



Presentation by C/P



Presentation by C/P



Questionnaire survey



Group discussion



Site visit of Sawadi plantation site



Presentation of gift and memorial to locals who participated in plantation activities

1. OUTLINE OF THE PROJECT

1.1 Background of the Project

The Sultanate of Oman (hereinafter referred to as “Oman”) has a total coastline of approximately 3,000 km, which is interspersed with patches of mangrove forest. Mangroves in Oman are comprised of a single species, *Avicennia marina*, which is comparatively tolerant to high-salinity environment. Mangroves are particularly important in Oman as they provide: habitats for various animal species, coastal protection function, green landscape and so on. The local people also have used mangroves as building material, livestock feed and medicine. However in recent years, threats to these precious mangrove areas are mounting, due to pressures such as from population growth, livestock grazing, coastal development and tourism. Hence, the Government of Oman (hereinafter referred to as “GoO”) is working actively on the conservation, restoration and management of mangrove ecosystem.

Upon the request of GoO, the Government of Japan (hereinafter referred to as “GoJ”) has dispatched a JICA expert on mangrove reforestation from 2000-2004; providing technical assistance on mangrove restoration and seedling production. From 2002-2003, JICA implemented the “The master plan study on restoration, conservation and management of mangrove in the Sultanate of Oman (hereinafter referred to as “JICA Master Plan Study”)", and the establishment of “Qurm Environmental Information Center (hereinafter referred to as QEIC)” was proposed as a center for mangrove conservation in Oman and the region. The construction of QEIC was decided by GoO in 2003.

The GoO then requested the GoJ to provide technical cooperation for the strengthening of operation capacity and facilities of QEIC. Upon this request, the JICA ex-ante evaluation team was dispatched in 2004 to determine the framework of the cooperation, and was agreed in June 2005 through signing/exchange of Record of Discussions (R/D). However, project implementation was delayed as the preconditions for the implementation—establishment and implementation of QEIC construction—became unclear due to cyclonic activity (inundation of QEIC construction site) and government reorganization.

In April 2011, JICA dispatched an implementation study team to reconfirm the status of QEIC’s establishment and construction with the Ministry of Environment and Climate Affairs (MECA). MECA and JICA agreed to amend the initial R/D by changing the preconditions for the project implementation. In July 2011, MECA reported to JICA that the procedures for the establishment and construction of QEIC had been officially commenced, and since this satisfied the new preconditions for project implementation, “the Qurm Environmental Information Center Project (hereinafter referred to as “the Project”)" officially commenced from 2012.

1.2 Objective of the Project

Following are the overall goal, project goal and expected outputs of the Project. The Project goal was amended during the course of the Project, mainly due to the delay in construction of QEIC building and establishment of QEIC organization (see Section 2.1.3 for reason of amendment).

Overall goal: Dissemination of sustainable mangrove ecosystem management in Oman and in the region

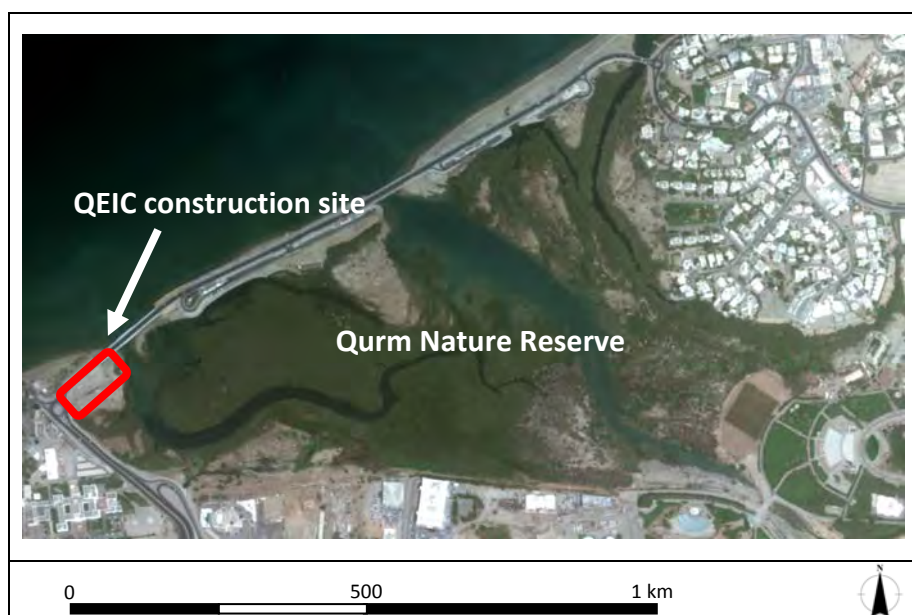
Project goal: QEIC is prepared as the center of promoting sustainable mangrove ecosystem management in Oman

Expected outputs:

- Output 0:** The project operation unit in the QEIC is established
- Output 1:** The capacity of training activity for QEIC to promote sustainable mangrove ecosystem is developed
- Output 2:** The monitoring method for QEIC to promote sustainable mangrove ecosystem management is developed
- Output 3:** Methods and techniques for promoting mangrove reforestation are developed
- Output 4:** The capacity of environmental education programme activity for QEIC to promote sustainable mangrove ecosystem management is improved

1.3 Location of the Project

Project activities were mainly implemented at Qurm Nature Reserve (QNR), which is a protected mangrove area located along the coast of Muscat city. QEIC will be constructed at the north-west edge of QNR. Figure 1.3.1 shows the area of QNR and location of QEIC.



Prepared by JICA Expert Team

Figure 1.3.1 Area of QNR and location of QEIC

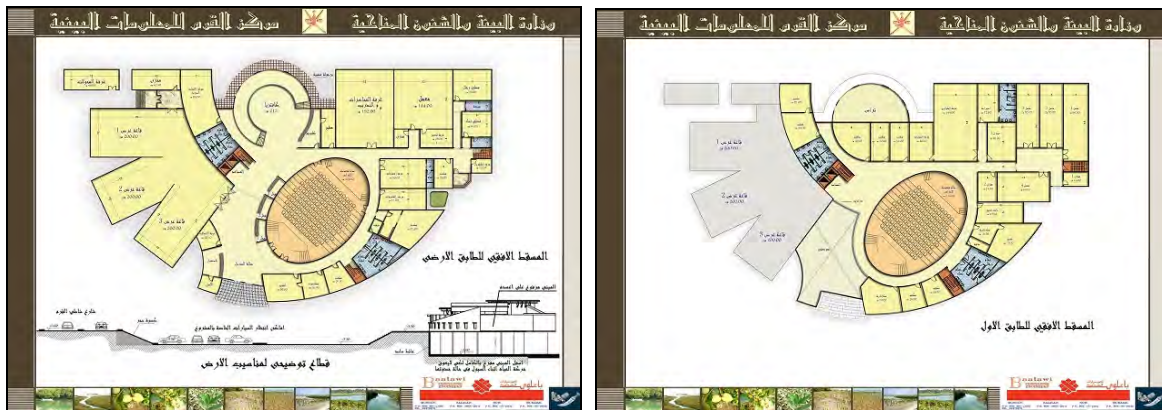
Whenever necessary, Project activities were conducted also at other mangrove sites in Oman.

1.4 Facilities of QEIC and construction status

The QEIC building will include facilities such as conference hall, training room, exhibition hall, laboratory, office room, equipment storage room, library and so on. Figure 1.4.1 shows the image of QEIC building and floor plan.



Image of QEIC building



1st floor

2nd floor

Source: MECA

Figure 1.4.1 Image of QEIC building and floor plan

While the QEIC building was expected to be completed by the end of this Project, the construction is yet to commence as of January 2014. The main reasons behind the delay are due to design changes, additional requirement of traffic study and delay in tender process. At the time of this reporting (February 2014), MECA and the Tender Board (government agency responsible for tendering of public works) is in the process of finalizing the selection of construction contractor. Following are the expected construction schedule according to the C/P:

- The construction contractor should be selected by March 2014 and construction commence by June 2014.
- Construction works should take approximately 18 months. Taking into account additional interior works, the building should be fully completed before the end of 2016.

1.5 Project period

The Project was implemented over 2 years through two phases. The 1st phase was from January 2012 to February 2013, and the 2nd phase from April 2013 to December 2013.

1.6 JICA Expert Team

The JICA Expert Team consisted of five experts. Table 1.6.1 shows the assigned field and affiliated organization of the experts. The assignment period of the experts are shown in Appendix 1.

Table 1.6.1 Assigned field and affiliated organization of the JICA experts

Name	Assigned field	Organization
Mr. Yoichi Harada	Team leader/training	Ides Inc.
Mr. Takeshi Sato	Monitoring (natural condition)	Ides Inc.
Mr. Shigeyasu Tamaei	Monitoring (social condition)/plantation 1	AAI Co., Ltd.
Mr. Akira Koto	Environmental education	AAI Co., Ltd.
Mr. Hiroyasu Onuma	Data analysis/plantation 2	AAI Co., Ltd.

Prepared by JICA Expert Team

2. OUTPUTS AND RESULTS OF PROJECT ACTIVITIES

2.1 Establishment of Project operation unit

2.1.1 Establishment of Project implementation body (PDM activity: 0.2)

Members of the Project implementation body was approved at the 1st JCC held on February 2012. Under the overall supervision of the Project director (Director General of Nature Conservation), the Project implementation body consisted of staffs of Marine Environment Conservation Department (MECD) and JICA Expert Team. Additional members (two GIS specialists) were recruited from the IT Department in May 2012. In July 2013, the initial Project director Mr. Ali Al-Kiyumi was assigned to a new post within MECA; subsequently the Project director was replaced by the new Director General of Nature Conservation, Mr. Mohammed Al-Muharrami. Table 2.1.1 shows the members of the Project implementation body and assigned field of each member.

Table 2.1.1 Members of the Project implementation body and assigned field of each member

	Assigned field	Position/name
Oman side	Project Director	Director General of Nature Conservation Mr. Mohammed Al-Muharrami
	Project Manager	Director of MECD Dr. Ahmed Mubarak Al-Saidi
	Training	Environmental planner, MECD Ms. Aziza Said Al-Adhubi
	Monitoring	Nature Reserve Specialist, MECD Mr. Hitham Al-Farqani
		Marine Environment Specialist, MECD Mr. Mohammed Al Rezaqi
	Plantation	Head of Wetland Environment Section, MECD Mr. Badar Al-Balushi
	Environmental education	Marine environment conservation specialist, MECD Ms. Aida Khajaf Al-Jabri
	Information technology	GIS Specialist, IT Department Ms. Zayana Salim Sheikhan
	Information technology	GIS Specialist, IT Department Ms. Moza Khalaf Said Al-Reiamy
JICA Expert Team	Team leader/training	Mr. Yoichi Harada
	Monitoring (natural condition)	Mr. Takeshi Sato
	Monitoring (social condition)/plantation 1	Mr. Shigeyasu Tamaei
	Environmental education	Mr. Akira Koto
	Data analysis/plantation 2	Mr. Hiroyasu Onuma

Prepared by JICA Expert Team

2.1.2 Establishment of Joint Coordinating Committee (PDM activity: 0.4)

Joint Coordinating Committee (JCC) was established as the decision making body of this Project. Members of the JCC was discussed and approved at the 1st JCC held on February 11th, 2012. The Director General of Nature Conservation was assigned as the Chairperson. The Oman side consisted of staffs of MECD, Biodiversity Department and International Cooperation Department. The Japan

side consisted of JICA Expert Team, representative of Japan Embassy and personnel from JICA (on ad hoc basis). Initially, there were plans to include outside organizations into the JCC, but were omitted in accordance to C/Ps decision. Table 2.1.2 shows the members of JCC and their respective organizations and positions.

Table 2.1.2 Members of JCC

	Position	Name
Chairperson	Director General of Nature Conservation	Mr. Ali Amer Al-Kiyumi (replaced later by Mr. Mohammed Al-Muharrami)
Oman side	Deputy Director General of Nature Conservation	Mr. Mohammed Juma Al-Sharyani
	Director of Biodiversity Department	Ms. Thuraya Said Al-Sareari
	Director of MECD	Dr. Ahmed Mubarak Al-Saidi
	Acting Director of International Cooperation Department	Mr. Mohammed Al-Sanadi
	Head of Wetland Environment Section	Mr. Badar Al-Balushi
	Marine conservation specialist	Ms. Aida Khajaf Al-Jabri
	Environmental inspector of Pollution Operation Monitoring Section	Mr. Moza Al-Salami
	Environmental planner of MECD	Ms. Aziza Saud Al-Adhubi
Japan side	JICA Expert Team	-
	Officials of the Embassy of Japan in Oman	-
	Other personnel dispatched by JICA (if necessary)	-

Prepared by JICA Expert Team

JCC was held 4 times during the Project. Table 2.1.3 shows the main items discussed and approved at each JCC. Minutes of each JCC is attached as Appendix 2.

Table 2.1.3 Main items discussed and approved at each JCC

	Date	Items discussed and approved
1 st JCC	Dec. 11 th , 2012	<ul style="list-style-type: none"> • Approval of members of Project implementation body • Approval of members of JCC • Approval of 1st phase Work Plan
2 nd JCC	Feb. 5 th , 2013	<ul style="list-style-type: none"> • Reporting of Project progress and achievements • Necessary equipment required for the Project • Approval of amendment of PDM/PO (ver. 1) to ver. 1.1
3 rd JCC	June 2 nd , 2013	<ul style="list-style-type: none"> • Approval of 2nd phase Work Plan • Confirmation of construction status of QEIC • Reporting of procured equipment • Approval of amendment of PDM/PO (ver. 1.1) to ver. 2.0 • Discussion on international workshop
4 th JCC	Dec. 12 th , 2013	<ul style="list-style-type: none"> • Confirmation of construction status of QEIC • Explanation and approval of QEIC 8-year Operation Plan • Reporting and submission of Joint Terminal Evaluation Report • Explanation of JICA cost-sharing scheme • Handover of equipment

Prepared by JICA Expert Team

2.1.3 Amendment of Work Plan and PDM/PO (PDM activity: 0.1)

Project activities were implemented based on the Work Plan and PDM/PO approved by JCC. PDM/PO was amended twice (from ver. 1.0→ver. 1.1→ver. 2.0) during the Project, mainly due to the delay in QEIC construction. The final PDM/PO (ver. 2.0) and reasons of amendment are shown in Appendix 3.

2.1.4 Equipment procured in Japan and Oman

During the initial phase of the Project, equipment urgently required for monitoring survey was procured and brought from Japan (see Table 2.1.4). Basic office equipment was also procured in Oman (see Table 2.1.5).

Table 2.1.4 Equipment procured and brought from Japan

Equipment	Specification	No.	Purpose
GPS	Portable type	1	Measurement of location
Digital camera	10 m water resistance	2	Photograph
Stereo microscope	7 – 45 x	2	Observation of organisms
Tree measure	12 m	2	Measurement of tree height
Clinometer	± 0.25 degree	2	Measurement of tree height and ground slope
Refractometer	Portable type	2	Measurement of salinity

Prepared by JICA Expert Team

Table 2.1.5 Equipment procured in Oman

Equipment	Specification	No.	Purpose
Personal computer	Windows	1	Documentation, data storage
Scanner	A4, PDF/JPEG	1	Storing documents
Laser printer	A4 color	1	Printing

Prepared by JICA Expert Team

2.1.5 Equipment procured for donation (PDM activity: 0.8)

Donation equipment was procured both in the 1st and 2nd phases of the Project. The equipment procured in the 1st phase was mainly equipment that was required for implementing Project activities. The equipment procured in the 2nd phase was mainly equipment that was required for future QEIC activities. The procured equipment is mainly for training, monitoring, chemical analysis and environmental education. All the procured equipment was officially handed over to MECA with the “handover note” at the 4th JCC held on Dec. 12th, 2013. The final equipment list and handover note is attached in Appendix 4.

The equipment is stored in the storage room inside MECA building or QNR. The C/P will be responsible for equipment maintenance, procurement of consumables and monitoring of usage status. To help manage the equipment, the JICA Expert Team prepared an equipment inventory which includes information on maintenance frequency and supplier contact address, and was handed to the C/P.

2.1.6 Operation plan of QEIC (PDM activity: 0.3, 0.6, 0.7)

To ensure that the various programs and plans developed for QEIC (e.g. training, monitoring, plantation, education, exhibition) will be effectively implemented in the future, it is important to establish an appropriate organizational structure and secure mid- and long term budget for the planned activities. The Project has therefore, developed “QEIC 8-year operation plan”, covering the period from 2014-2021. The basic content of the operation plan was approved at the 4th JCC.

The initial 3-years (2014-2016), which coincide with the QEIC construction period, were termed as the “mini-QEIC phase”. This phase will concentrate on establishing the organizational structure of QEIC and strengthening the capacity of QEIC staff. The developed programs will also be implemented but somewhat on a gradual basis. Development of a temporary facility (termed “mini-QEIC”) is also planned inside MECA’s property (building currently occupied by Bank Dhofar), which will function mainly as a temporary equipment storage, laboratory and small-scale exhibition room. The 5-year period from 2017 is considered as the “full-operation period”, and the planned programs will be implemented on a full-scale basis. Following shows the basic content of the QEIC 8-year operation plan (see Appendix 5 for the full version of the QEIC 8-year operation plan).

- Responsibility of QEIC
- QEIC 8-year action plan (target of activities, implementation schedule)
- Organizational structure of QEIC (organizational chart, responsibility of each section, responsibility and qualification of staffs, staff recruitment plan)
- QEIC 8-year budget plan
- Budget breakdown
- Room layout and facilities required for mini-QEIC

2.1.7 Monitoring and evaluation of QEIC activities (PDM activity: 0.5)

Activities of QEIC should be regularly monitored and evaluated to ensure the activities are implemented as planned as well as to further improve the content of the activities. Monitoring could be done by using the Work Breakdown Structure (WBS) method employed in this Project. Evaluation should be done by establishing an evaluation committee that will consist of relevant staffs of MECA. Evaluation should be conducted at least on an annual basis.

2.2 Development of capacity of training activity

2.2.1 Objective of training activity

The main objective of QEIC's training activity is to enhance the capacity of persons and organizations that are expected to be involved in the various QEIC activities (monitoring, plantation, environmental education, exhibition, etc.) planned for the conservation and management of mangrove ecosystem.

2.2.2 Contents and target groups of training activity (PDM activity: 1.1, 1.2, 1.3)

A workshop was held with the C/P and other MECA staffs on February 7th, 2012, to discuss the training needs and to determine the target groups for training activities. The workshop was implemented by employing Curriculum Development Based on Vocational Ability Structure (CUDBAS¹) method.

Based on the outcomes of the workshop and other Project activities, the necessary training courses, their contents and target groups were determined. The training course is divided into seven categories, namely 1) general, 2) monitoring, 3) plantation, 4) conservation, 5) database, 6) education and 7) exhibition. QEIC/MECA staffs, research institute (including university), students, NGOs, local community and private sector were selected as the main target groups, based on the following reasons:

- QEIC/MECA staff: Capacity enhancement of QEIC/MECA staffs is required so to ensure that the activities and operation of QEIC are implemented effectively.
- Research institute: There is possible collaboration regarding monitoring and research activities.
- Students: They are expected to be the driving force for mangrove ecosystem conservation in the future.
- NGO\local community: They are expected to be the driving force for mangrove ecosystem conservation in the future. There is also possible collaboration regarding monitoring and plantation activities.
- Private sector: Active participation of private sectors in the conservation and management of mangrove ecosystem is expected as part of Cooperate Social Responsibility (CSR).

The training courses in the "general" category mainly aim's to introduce the facilities and activities of QEIC, as well as to introduce the basics of mangrove ecosystem, which is fundamental knowledge required for further learning in the other training courses. Therefore, all target groups are covered.

¹ CUDBAS stands for Curriculum Development Based on Ability Structure, which is a method to develop training curriculum. The CUDBAS method was developed in order to establish training curriculum with considering structure of necessary abilities for training targets (trainees).

The training courses in the “monitoring” category mainly aim’s to train the QEIC/MECA staffs so that the developed monitoring programs can be implemented effectively. NGOs, local community and students are also target groups, as these groups are potential collaborators in future monitoring activities.

The training courses in the “plantation” category mainly aim’s to learn all the necessary methods and procedures required for plantation including: site selection, seedling production and transplantation. The course also covers potential landownership issues associated with plantation. It targets QEIC/MECA staffs and potential collaborators of plantation activities (e.g. NGOs, local community and private sector).

The training courses in the “protection” category mainly aim’s to learn the relevant laws/regulations and measures for mangrove ecosystem conservation. It targets QEIC/MECA staffs and potential collaborators of conservation activities (e.g. NGOs, local community and private sector).

The training courses in the “database” category mainly aim’s to learn the structure and usage of the planned QEIC database. It basically targets only QEIC/MECA staffs.

The training courses in the “education” category mainly aim’s to learn the methods of material and program development, as well as the procedures to implement the programs. It targets QEIC/MECA staff and potential collaborators of education activities such as NGOs.

The training courses in the “exhibition” category mainly aim’s to learn about the QEIC exhibition. It targets QEIC/MECA staffs and potential collaborators such as NGOs.

Table 2.2.1 shows the outline (e.g. target group, learning goals, location, duration, lecturer) of the training courses. The contents of the training courses should be reviewed and updated periodically based on the status of future QEIC activities.

Table 2.2.1 Outline of the QEIC training courses

Category	Course title	Target Group						Learning Goals	Location		Duration (day)	No. of modules	Lecturer	
		QEIC/MECA staff	Research organizations	Students	NGO	Local community	Private sector		Lecture room	Field				
I	General	1. Function of QEIC	x	x	x	x	x	x	To introduce activities, facilities and equipment of QEIC, as well as case studies of similar institutions.	x		1.5	6	Q
		2. Introduction on mangrove ecosystem	x	x	x	x	x	x	To obtain a basic understanding on mangrove ecosystem, importance of conservation and the various threats.	x	x	1.0	2	Q
II	Monitoring	1. Introduction on Mangrove Ecosystem Monitoring Program	x		x	x	x		To learn how to monitor and assess the status of mangrove ecosystem.	x	x	4.0	4	Q, E
		2. Introduction on mangrove health assessment using remote sensing	x		x				To learn how to monitor and assess mangrove forest health with remote sensing technology.	x	x	3.0	3	Q, E
		3. Introduction on Transplanted-seedling Monitoring Program	x		x	x	x		To learn how to monitor the growth and health status of transplanted seedling.	x	x	1.0	2	Q
III	Plantation	1. Method of mangrove tree plantation	x			x	x	x	To learn necessary processes for mangrove tree plantation such as site selection, seed collection/treatment, nursery operation and transplanting procedure. The course also covers landownership issues associated with plantation.	x	x	3.0	4	Q
IV	Protection	1. Introduction on mangrove ecosystem protection	x			x	x	x	To learn practical and regulatory measures to protect mangrove ecosystem.	x		0.5	1	Q
V	Database	1. Introduction of QEIC database	x						To learn the structure and how to use QEIC database.	x		0.5	1	Q
VI	Education	1. Producing education materials	x			x			To learn how to produce education materials.	x		2.0	7	Q
		2. Implementing education programs	x			x			To learn how to implement education programs.	x	x	1.0	2	Q
VII	Exhibition	1. Introduction of QEIC exhibition	x			x			To learn about the QEIC exhibition, as well as methods to enhance visitors understanding. The course also introduces examples of other similar exhibitions.	x		0.5	3	Q, E

E: Expert from outside organization, Q: QEIC staff (incl. MECA staff)

Prepared by JICA Expert Team

2.2.3 Resource person for training activity (PDM activity: 1.4)

Although the lecturer of most training courses are expected to be QEIC staff, some courses may require assistance from outside experts as they require special expertise. Following are the relevant courses and candidate lecturers.

- Training for mangrove health monitoring using remote sensing (candidate lecturer: professor of Remote sensing and GIS Center, SQU)
- Training for bird monitoring and identification (candidate trainer: a bird expert from other government agencies or NGO)
- Training for fauna identification (candidate trainer: staff of MSFC)
- Training for exhibition (candidate trainer: staff from the company contracted for planning and installation of the QEIC exhibition)

2.2.4 Training material (PDM activity: 1.5)

A syllabus (outline of the training course), trainer's manual and training materials were prepared for each training course, which are all compiled into Technical Document 1 "Training Plan and Training Material".

2.2.5 Cost and schedule of training activity (PDM activity: 1.6, 1.7)

Training schedule for each course was planned for each target group. In the initial 3 years (mini-QEIC phase from 2014-2016), the main focus of the training activities will be to enhance the capacity of potential lecturers and prepare for the full operation from 2017. The training courses on the database and exhibition is planned to start after 2016, when its contents and facilities are expected to be established. The training courses should be revised and updated based on new developments and feedbacks from participants, which should be implemented at least every three-years. The cost of training activities was estimated, which includes the following items:

- Printing cost of training materials
- Cost for outsourcing lecturers: cost after 2017 is not included as all courses are expected to be implemented by QEIC staff after full operation (except exhibition course).
- Invitation cost of trainees to QEIC: invitation cost for regional NGOs and communities, who are expected to be important players of mangrove ecosystem conservation. Invitation costs for MECA staffs (including regional staffs) are not included.
- Cost for review and update of training course: cost for joint meeting with outside organizations.

The schedule and budget of the training activities are described in detail in the QEIC 8-year Operation Plan.

2.2.6 Trial training and evaluation (PDM activity: 1.8, 1.9)

To confirm the appropriateness of the planned training programs and materials, trial trainings were conducted three (3) times. The participants were limited to C/P and staffs from MECA's headquarters and regional offices, who are expected to be trainers in the future. A questionnaire survey was conducted after each training course to confirm the understanding of the trainees and to collect opinions about the training programs and materials for further revision. Table 2.2.2 summarizes the content of the trial training programs, and the main outputs and issues identified in the process.

The main issues and opinions raised were: to have more training programs in the field and programs to enhance basic knowledge; appropriate allocation of training time and period; and to prepare trainer's manual. Especially, the duration and timing of the field training must be planned carefully, considering the climate in Oman (high air temperature and high humidity) and its effect on the health of the participants. Therefore, the duration of the training course was shorten to a maximum of 5 hours a day. Also the courses were combined and simplified; and trainer's manuals were prepared for each training course.

Table 2.2.2 The contents of the trial training programs and the main outputs and issues

No.	Date	Target	Category	Program title	Contents	Major output and issues
1	7-9 Oct., 2012	C/P, MECA central and regional staffs	General	- Introduction of mangrove ecosystem	<ul style="list-style-type: none"> JICA expert lectured about mangrove ecosystem. 	<p>[General]</p> <ul style="list-style-type: none"> Most participants felt that the training programs were beneficial. <p>[Monitoring]</p> <ul style="list-style-type: none"> All participants could not perform the monitoring activity due to time limitation. Hence, the training schedule and number of participants should be carefully considered. Lecture on data analysis and evaluation is necessary. <p>[Environmental education]</p> <ul style="list-style-type: none"> Although the program was conducted in the lecture room, field practices of education programs will be required in the coming training courses.
			Plantation	- Methods of seedling production and transplantation	<ul style="list-style-type: none"> C/P introduced the efforts of mangrove plantation in Oman. 	
			Monitoring	<ul style="list-style-type: none"> - Introduction of QEIC's mangrove monitoring programs - Monitoring of health of mangrove forest - Monitoring of mangrove fauna 	<ul style="list-style-type: none"> The outline of the mangrove monitoring program was introduced by JICA expert. Field practice of mangrove health survey and fauna survey. 	
			Education	<ul style="list-style-type: none"> - Producing education materials - Implementing education programs 	<ul style="list-style-type: none"> Introduction of how to prepare education materials and designing of programs were lectured by JICA expert. 	
2	10-11 Feb., 2013	C/P, MECA central and regional staffs	General	- Report of the JICA training courses	<ul style="list-style-type: none"> Action plan on ecosystem conservation, prepared in the JICA Training Courses was presented by the C/P. 	<p>[General]</p> <ul style="list-style-type: none"> Training was performed by C/Ps as lecturers. The necessity of systematized trainer's manual and materials was realized. <p>[Monitoring]</p> <ul style="list-style-type: none"> Course to enhance basic knowledge on mangrove and birds was requested Equipment purchased by the project was useful and effective. <p>[Environmental education]</p> <ul style="list-style-type: none"> More practical training in the field
			Monitoring	<ul style="list-style-type: none"> - Introduction of monitoring of mangrove forest in Japan - Introduction of transplanted-seedling monitoring program - Introduction of bird watching, including photo shooting 	<ul style="list-style-type: none"> A method of mangrove monitoring was introduced by a C/P from the experience of overseas education in Japan. Lecture and field practice about measurement of transplanted mangrove seedlings were performed by a C/P. Field practice about bird observation and photographing were conducted by C/Ps. 	

No.	Date	Target	Category	Program title	Contents	Major output and issues
			Education	- Producing education materials - Implementing education programs	<ul style="list-style-type: none"> Various environmental education materials were introduced by C/P. New program for environmental education was introduced by JICA expert. 	was requested
3	29-30 May, 2013	C/P	General	- Introduction of training programs of QEIC - Introduction on mangrove ecosystem	<ul style="list-style-type: none"> JICA expert lectured about the function and plan of QEIC training activity JICA expert lectured about mangrove ecosystem, which is necessary as basic knowledge. 	[General] <ul style="list-style-type: none"> The hot climate should be considered when timing the field training. Information on climate change should be included in the presentation. [Monitoring] <ul style="list-style-type: none"> Provision of standards for sediment texture and odor was requested. Usefulness of procured equipment was recognized.
			Monitoring	- Introduction of mangrove ecosystem monitoring program	<ul style="list-style-type: none"> Field practice for water and soil quality survey. Lecture on chemical analysis was performed by JICA expert. 	

Prepared by JICA Expert Team

2.2.7 Issues and recommendations

Since the QEIC staffs are expected to be lecturers for most of the training courses, enhancement of their capacity is necessary especially regarding basic knowledge of mangrove ecosystem and presentation skills. Furthermore, it is essential that the lecturer has a thorough understanding on the activities of the responsible course, which is acquired by gaining experiences from being continuously involved in the actual activity.

Basic knowledge of mangrove ecosystem should be enhanced through internal training such as by using the training courses (e.g. Introduction on mangrove ecosystem) and materials developed by the Project. Participating in field activities such as monitoring is also just as important.

Presentation skills should be enhanced by gaining experiences through conducting regular trial training courses. In addition, QEIC staffs could participate in training courses for enhancing presentation skills, by contracting a company that specializes in such training.

Some courses will require assistance from outside experts as these require special expertise. Therefore, MECA should establish a cooperation scheme with relevant personal as soon as possible.

The mini-QEIC phase (from 2014 to 2016) will be an important period for enhancing the capacity of QEIC staffs, which should be supported through technical assistance from outside experts.

2.3 Development of mangrove monitoring method

Based on discussions with the C/P, mangrove monitoring activities will consist of two programs: monitoring of the status of existing mangrove ecosystem (hereinafter termed as “Mangrove Ecosystem Monitoring Program”) and monitoring of transplanted mangrove seedlings (hereinafter termed as “Transplanted-seedling Monitoring Program”). The monitoring methods were developed based on the lessons learnt from trial monitoring and by consulting Japanese experts (Dr. Shigeyuki Baba (ISME), and Dr. Yoshinobu Kawamitsu (Ryukyu University)). The trial monitoring process was particularly considered as an important activity, as it will enable the C/P to be fully involved in the development process. The original PDM (ver. 0.1) was hence amended accordingly. The monitoring methods of both programs are described in detail in Technical document 2 “Mangrove Monitoring Guideline”.

The ensuing Sections provide descriptions of MECA’s present environmental monitoring activities, outline of the developed monitoring programs, results of monitoring survey, the “Mangrove Monitoring Guideline” and method of data management and publication.

2.3.1 Status of MECA’s environmental monitoring activities

1) Mangrove related monitoring activities

Although the JICA Master Plan emphasizes the importance of monitoring, very little monitoring has been conducted thus far, except for some temporary and preliminary measurements conducted at some transplantation sites. The collected data are also not effectively managed and utilized. Therefore, to ensure that monitoring is conducted regularly and effectively, it is necessary to establish a systematic monitoring program and data management system.

2) Other monitoring activities

MECA currently implements air quality and marine pollution monitoring. The marine pollution monitoring program monitors heavy metals and hydrocarbon levels in coastal water, bottom sediment and rock oyster. There are 13 monitoring stations and is implemented 1/year. Since mangrove ecosystem is vulnerable to air and marine pollution, these monitoring data could be referred if any abnormalities are identified with the mangrove ecosystem.

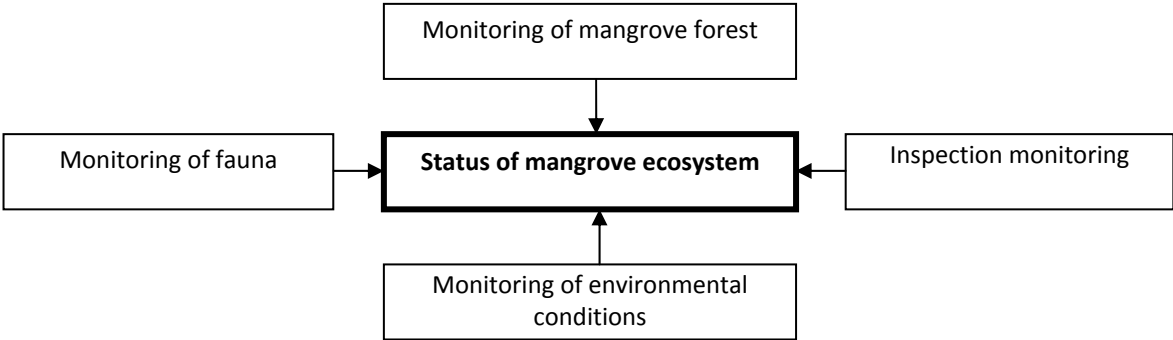
2.3.2 Outline of Mangrove Ecosystem Monitoring Program (PDM activity: 2.1, 2.2)

1) Objective and framework

Mangroves in Oman grow under stressful natural conditions and threats to these mangroves and its ecosystem are mounting mainly due to recent population growth, economic development and coastal development. The “Mangrove Ecosystem Monitoring Program” was developed so to monitor the status of mangrove ecosystems that are under threat from natural and human impacts, and to

implement conservation and management measures in accordance to the monitoring results. Data, photos and other information that will be acquired through monitoring will also be utilized for QEIC’s exhibition, training and environmental education programs.

The status of mangrove ecosystems is assessed in an integrated manner by monitoring the various components that constitute and sustain mangrove ecosystems. It consists of monitoring of mangrove forest, fauna and environmental conditions. In addition, regular inspection monitoring is included so to detect of any presence of human or natural threats. Figure 2.3.1 shows the monitoring framework of “Mangrove Ecosystem Monitoring Program”.



Prepared by JICA Expert Team

Figure 2.3.1 Monitoring framework of “Mangrove Ecosystem Monitoring Program”

2) Outline of monitoring method

The monitoring methods were developed under the policy that it should be as simple as possible, as future monitoring activities are expected to be implemented through partnership with NGOs and local community. All the equipment required for monitoring was procured through the Project. The ensuing sections outlines the monitoring methods.

a. Monitoring of mangrove forest

The main objective of mangrove forest monitoring is to assess the health status of the mangrove forest. Monitoring is conducted by field survey and when necessary by using remote sensing technology.

Field survey monitoring is implemented by first selecting representative monitoring trees. The growth and health status of the selected trees are then surveyed. Tree growth survey involves the measurements of tree height and trunk circumference. Tree health is surveyed by observing set health indicators (e.g. leaf/branch density, leaf health, tree-top dieback). Each health indicator is rated as either “Good”, “Fair” or “Poor” by referring to the assessment criteria shown in Table 2.3.1. Then based on the rating of each health indicator, the overall health of the tree is rated as “Good”, “Fair” or “Poor” by referring to the health assessment criteria shown in Table 2.3.2.

Table 2.3.1 Health assessment criteria of mangrove health indicators

Health indicator	Health assessment criteria		
	Good	Fair	Poor
1 Leaf/branch density	High	Moderate	Low
2 Leaf health	Most leaves are healthy (e.g. > 80%)	Mixture of unhealthy leaves	Most leaves are unhealthy (e.g. > 80%)
3 Tree-top dieback	No dieback	Some dieback	Significant or complete dieback
4 Flowering*	Abundant	Less abundant than usual	Very few or none

*: Applicable only in flowering season

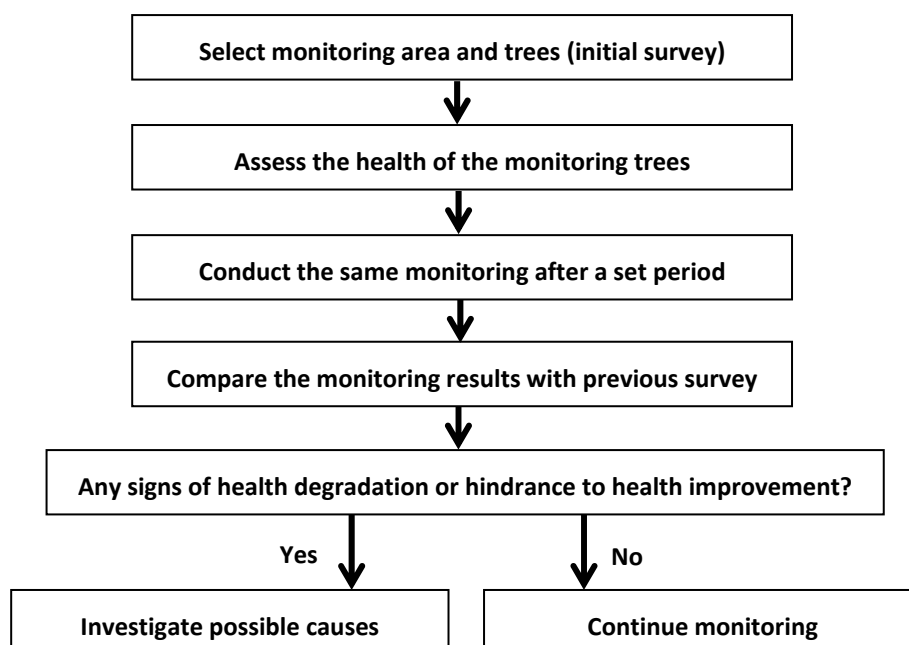
Prepared by JICA Expert Team

Table 2.3.2 Assessment criteria of overall health of mangrove tree

Good	Fair	Poor
All health indicators rated as "Good"	One or more health indicators rated as "Fair" but no "Poor"	One or more health indicators rated as "Poor"

Prepared by JICA Expert Team

Once the health status of individual trees is determined, the next step will be to assess the health status of the surrounding forest based on the obtained results. In this program, the health status of the forest will in general be assessed by comparing the health between successive surveys. If any significant health degradation (or no health improvement of unhealthy tree) is identified between successive surveys, this will imply that the forest is under a degraded or stressful state. In such case, the cause of such degradation should be investigated and appropriate measures implemented accordingly. Figure 2.3.2 shows the basic monitoring procedure of mangrove forest.



Prepared by JICA Expert Team

Figure 2.3.2 Basic monitoring procedure of mangrove forest

Following are possible factors that may affect mangrove health:

- Drying of soil due to lack of seawater supply
- Degradation of water quality due water stagnation
- Increase of soil salinity
- Erosion or sedimentation of soil
- Entanglement of garbage or algae
- Intrusion of other plant species
- Grazing by domestic animals
- Cutting and damage by people
- Increase of insect pests and fungi

Remote sensing monitoring assesses the health status of mangrove forest by using satellite image and vegetation health indicator such as Normalized Difference Vegetation Index (NDVI)². Since there are no established NDVI health standard for *Avicennia marina*, forest health will be assessed by comparing NDVI values with baseline or previous surveys. Remote sensing monitoring should be applied for large forests or when field survey is insufficient. The methodology was developed jointly with a local expert (professor of SQU), and a guideline (“Guideline for Mangrove Health Assessment using Remote Sensing”) was developed in the process. The guideline is attached in the appendix of the “Mangrove Monitoring Guideline”.

b. Monitoring of fauna

A wide diversity of fauna inhabits mangrove forests, such as fishes, crustaceans, molluscs and birds. Each of these fauna plays an important role in maintaining the health of the mangrove ecosystem, and any significant changes in the fauna population may indicate that the ecosystem is under a degraded state. Therefore, fauna monitoring will focus on monitoring the population of mangrove fauna. However, since it is impractical to monitor all fauna species, monitoring will be conducted by selecting “indicator species³”.

In order to select indicator species, it is first necessary to understand the characteristics of the fauna species found at each monitoring site. The initial years (e.g. 2-3 years) of the monitoring program will hence focus on developing a fauna inventory, by collecting or observing as much species as possible along major habitats of the mangrove ecosystem such as in mudflats, inside mangrove forest and waterways. Once the inventory is completed, an appropriate indicator species will be selected, and from then on, monitoring will focus on the selected indicator species. If any significant reduction or increase of an indicator species is identified, its cause should be investigated and appropriate measures

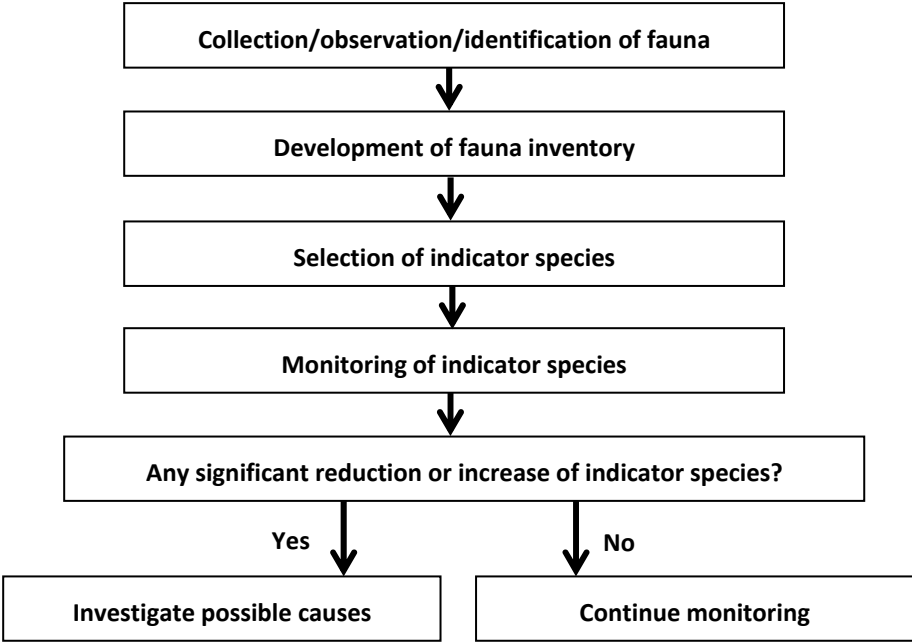
² An indicator of vegetation health. Estimated by using the spectral reflectance measurements of visible (red) and near-infrared.

³ An indicator species is defined as any fauna species/community that is characteristic of the environment, and its loss, reduction or abnormal increase may act as a signal of mangrove ecosystem degradation.

implemented accordingly. Selection of indicator species should be based on sound reasoning and national or international experts should be consulted in the process. Following are some options and factors that should be considered when selecting indicator species:

- Fauna that belong to the top of the food chain (e.g. herons (bird), swimming crabs (crab), sea breams (fish))
- Fauna that play an important role in the material cycle of the mangrove ecosystem (e.g. herbivores fauna such as Sesarmidae crabs, mudwhelks)
- Fauna that is relatively easy to observe, collect and identify
- The ecology and habitat of the fauna is well known
- Fauna that is sensitive to pollution or environmental impacts

Figure 2.3.3 shows the basic procedure of the fauna monitoring program.



Prepared by JICA Expert Team

Figure 2.3.3 Basic procedure of the fauna monitoring

c. Monitoring of environmental condition

Monitoring of environmental condition is important, as mangrove ecosystems are dependent or influenced by the conditions of the ambient environment. Of particular importance are water quality, soil quality, topography and water level. The monitoring results may be compared with relevant standards or past results. If any significant pollution or degradation is identified, its cause should be investigated and appropriate measures implemented accordingly. Following are brief descriptions of the monitoring methods of water quality, soil quality, topography and water level.

Water quality

Water quality monitoring consists of parameters that directly or indirectly affect mangrove and aquatic organisms. Table 2.3.3 shows the monitoring parameters and outline of measurement methods.

Table 2.3.3 Water quality monitoring parameters and outline of measurement methods

Parameter	Measurement method
Water temp.	<i>In situ</i> measurement with portable water quality meter
Salinity	
pH	
Dissolved oxygen (DO)	
Chemical Oxygen Demand (COD)	Collection of sample and measurement at lab with water quality meter
Inorganic nutrients	
Nitrate (NO ₃ -N)	
Nitrite (NO ₂ -N)	
Ammonium (NH ₄ -N)	
Phosphate (PO ₄ -P)	

Prepared by JICA Expert Team

Soil quality

Soil quality monitoring consists of parameters that affect mangrove growth. Table 2.3.4 shows the monitoring parameters and outline of measurement methods.

Table 2.3.4 Water quality monitoring parameters and outline of measurement methods

Parameter	Measurement method
Soil texture	Determine by rubbing with finger
Soil color	Determine by visual observation or by using soil color chart
Soil temp.	<i>In situ</i> measurement with soil thermometer
Oxidation-reduction Potential (ORP)	<i>In situ</i> measurement with portable ORP meter
Electrical conductivity (EC)	<i>In situ</i> measurement with portable water quality meter after preparing 1:5 soil/water mixture.
Salinity	
pH	
Nitrate (NO ₃ -N)	Analysis of supernatant of 1:5 soil/water mixture with lab water quality meter.
Phosphate (PO ₄ -P)	

Prepared by JICA Expert Team

Topography

Since Oman's coastline is subject to frequent beach erosion or accretion, there is a relatively high risk of closure or shifting of the position of the mouth of mangrove lagoons. If such closure occurs, it will have significant impacts on mangrove ecosystem as water exchange will be inhibited. The topography of the mouth of mangrove lagoons will be monitored through the following methods:

- Photo monitoring: Taking of photographs of the lagoon mouth from a fixed point at regular intervals.
- Sedimentation monitoring: Installation of permanent stakes along the cross-section of the lagoon mouth and measuring the distance between soil surface and top of the stake. A reduction in the distance will indicate that the mouth is under sedimentation trend.

An autolevel (procured through the Project) may be used, if a more detailed cross-section profile of the lagoon mouth is necessary.

Water level

Long-term elevation of water level may have adverse impacts on mangroves, for example by suffocating the aerial roots. Such elevation may occur at mangrove sites of Salalah, as the khawr is blocked from the sea by a wide sandy beach, preventing discharge of inflowing water from the hinterland area.

Water level is monitored by fixing a permanent stake inside the waterway, and then regularly measuring the fluctuation relative to the initial water level. Note that this method is only applicable to sites with no tidal fluctuation such as in the khawrs of Salalah.

d. Inspection monitoring

In order to conserve and manage mangrove ecosystem, it is important to detect, as early as possible, any natural or human threats, and take proactive measures before irreversible damage is done. Therefore, the mangrove forest will be regularly inspected (e.g. every 2 months) through visual observation to detect of any presence of natural or human threats. Inspection of regional mangrove sites is expected to be implemented by the MECA regional staff. Common natural or human threats are explained in the Mangrove Protection Guideline (Technical Document 4).

3) Monitoring schedule

Table 2.3.5 shows the proposed monitoring frequency for each monitoring item. For items that tend to have short-term variation (e.g. topography, water level) should be monitored frequently such as every two months. On the other hand, monitoring could be less frequent for items that have relatively low risk of short-term variation such as mangrove monitoring. However, the frequency and timing of monitoring should be determined by considering the status and characteristics of the target site: such as weather pattern, animal migration season and regional characteristics. Note also that it is not always necessary to monitor all items and parameters, and should be selected flexibly by taking into account the status of the target site.

Table 2.3.5 Proposed monitoring frequency of each monitoring item

Monitoring item		Frequency
Mangrove forest	Tree growth	1/year (2/year in initial year)
	Tree health (visual assessment)	1/year (2/year in initial year)
	Tree health (remote sensing)	1/year
Fauna		2/year
Environmental condition	Water quality	2/year
	Soil quality	2/year
	Topography	6/year
	Water level	6/year
Inspection		6/year

Prepared by JICA Expert Team

Monitoring should be implemented with priority on mangrove sites vulnerable to natural/social impacts or have high conservation values. The number of monitoring sites should be gradually increased and the current plan is to cover 20 sites by 2017. Table 2.3.6 shows the candidate monitoring sites for the period 2014-2021. Note that the monitoring sites from 2017 are not listed as they should be determined in accordance to the monitoring results of 2014-2016 and the latest situation.

Table 2.3.6 Candidate monitoring sites for the period 2014-2021

Year	No. of sites	Candidate site		Main threats
		Region	Site name	
2014	1	Muscat	QNR	Coastal development and urban activities
2015	5	North Batinah	Shinas, Harmul	Coastal development
		South Batinah	Sawadi	Coastal development
		Muscat	QNR	Coastal development and urban activities
		South Sharqiyah	Sur	Urban activities
2016	10	North Batinah	Shinas, Harmul	Coastal development
		South Batinah	Sawadi	Coastal development
		Muscat	QNR	Coastal development and urban activities
		South Sharqiyah	Sur	Urban activities
		Al Wusta	Gauwi, Durf	Animal grazing
		Dhofar	Kabir, Saghir, Auqad	Animal grazing, coastal development
2017-2021	20	To be determined later		

Prepared by JICA Expert Team

Monitoring activities are expected to be implemented in QNR from 2014. Table 2.3.7 shows the proposed implementation schedule for the period 2014-2016.

2.3.3 Outline of Transplanted-seedling Monitoring Program (PDM activity: 2.1, 2.2)

1) Objective and framework

Mortality or stunted growth of transplanted seedlings is a relatively common occurrence among some of the transplanted sites, but the cause and status of such occurrences are unclear due to lack of monitoring. Furthermore, such occurrences could have been prevented or minimized if proactive measures were taken through monitoring. Hence, the main objectives of the “Transplanted-seedling Monitoring Program” will be as follows:

- To monitor the growth and health status of the transplanted seedlings and if unhealthy seedlings are identified, to implement protective measures by investigating possible causes.
- Increasing the success rate of future transplantation activities through utilizing the data and findings acquired through monitoring

The “Transplanted-seedling Monitoring Program” will consist of monitoring of growth and health status of the transplanted seedlings and environmental conditions.

2) Outline of monitoring method

The following sections outlines the monitoring method.

a. Monitoring of growth and health status of transplanted seedlings

Since it is unrealistic to monitor all the seedlings, monitoring will be conducted by establishing a monitoring quadrat at a representative area of the transplanted site, and the seedlings within the quadrat will be monitored. Growth status is monitored by measuring the stem height and diameter of the seedling. Health status is monitored by visually estimating the ratio of unhealthy seedling (including dead seedlings) within the quadrat. Unhealthy seedling will generally have low leaf density, small and curled leaves and yellowish leaf color.

If there is a significant ratio of unhealthy seedlings, the spatial distribution and cause should be investigated by referring also to the data of environmental condition monitoring. Following are some common factors that could affect seedling health:

- Entanglement of algae and garbage
- Animal grazing
- High soil salinity

b. Monitoring of environmental condition

In general, water and soil quality should be monitored. If possible, measure all the monitoring parameters covered in the “Mangrove Ecosystem Monitoring Program”. However, if that is difficult, try at least to monitor parameters that can be measured in situ with portable meters. Topography and water level should also be monitored if considered necessary.

3) Monitoring schedule

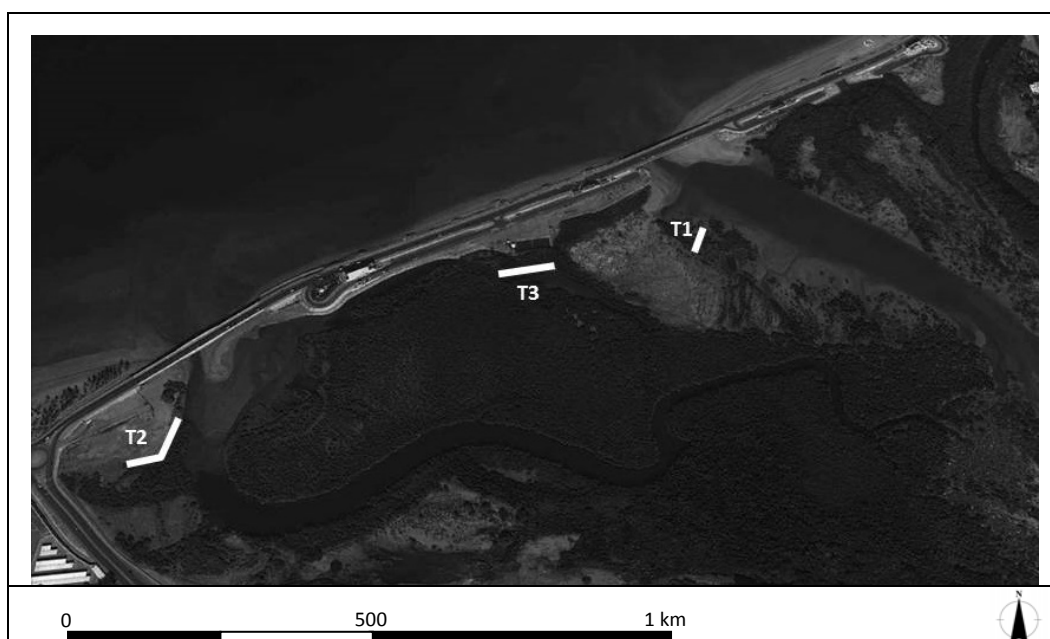
Monitoring should be conducted at least 1/month, as seedlings are vulnerable to natural and human stresses, and because their health status may change over a relatively short period. Monitoring should be continued until the seedlings are considered to have stabilized in the new environment (e.g. confirmation of aerial roots). The monitoring sites should be determined in accordance to the plantation schedule.

2.3.4 Implementation of monitoring survey (PDM activity: 2.4, 2.6)

Monitoring surveys were conducted with the C/P mainly at QNR. The monitoring survey focused on the mangrove forest, fauna and environmental condition components of the “Mangrove Ecosystem Monitoring Program”. The results of the survey and main issues are summarized in the ensuing sections.

a. Monitoring of mangrove forest

Mangrove forest survey was conducted at QNR on May 8-9th, 2013. Survey was conducted at three sites, where access was relatively easy. At each site, a 50-100 m transect was set. Within each transect, 7-8 trees were selected and their health status was observed. Tree height and trunk circumference were also measured. Figure 2.3.4 shows the location of the survey transects. Table 2.3.8 shows the survey results.



Prepared by JICA Expert Team

Figure 2.3.4 Location of mangrove survey transect

Table 2.3.8 Results of mangrove survey

Transect no.	Tree no.	Tree height (cm)	Stem circumference (cm)*	Health status
T1	1	258	5.5	Good
	2	376	15.8	Fair
	3	382	17.5	Good
	4	257	3.0	Fair
	5	292	9.5	Fair
	6	278	8.5	Fair
	7	241	4.0	Fair
T2	1	345	8.4	Good
	8	360	6.2	Good
	9	287	6.4	Fair
	4	350	8.6	Fair
	7	265	8.8	Fair
	10	280	6.2	Fair
	11	200	5.3	Fair
	12	235	8.6	Fair
T3	13	506	18.6	Fair
	2	214	3.3	Good
	14	446	11.0	Good
	15	484	8.2	Good
	16	410	21.5	Good
	17	332	12.0	Good
	18	345	9.5	Good

*: Measured at 130 cm height above ground level

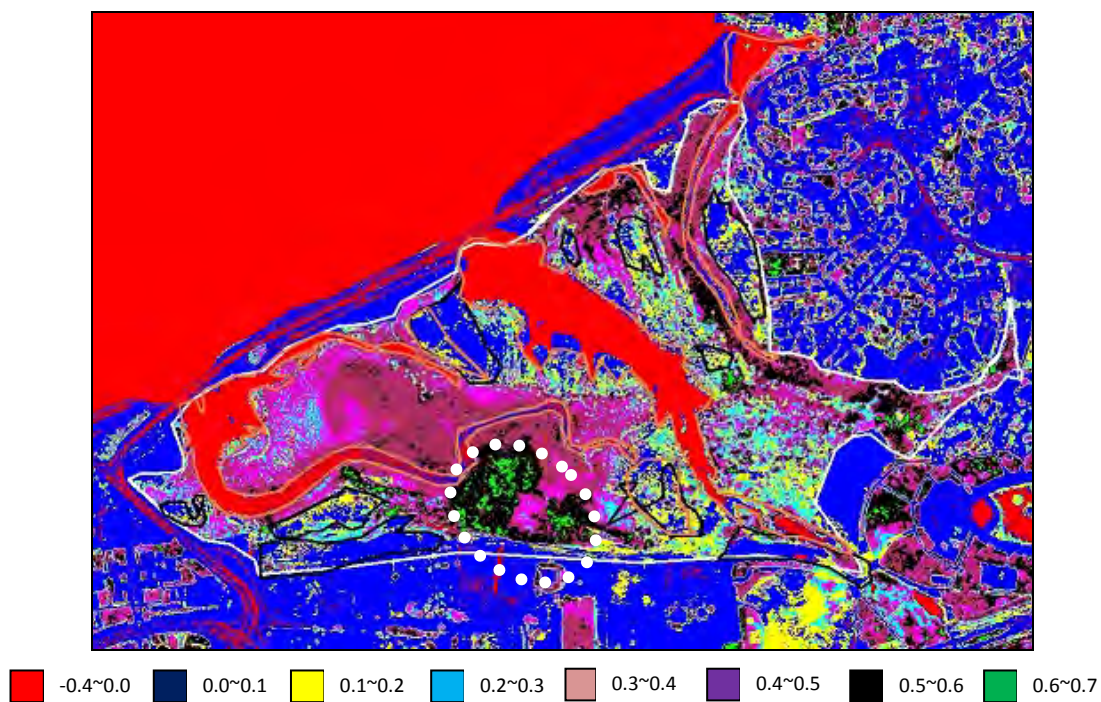
Prepared by JICA Expert Team

According to the survey results, the health of approximately 70% of the trees at transects T1 and T2 were rated as “Fair” and the remaining tree as “Good”. At transect T3, seven out eight trees were rated as “Good” and the remaining one tree as “Fair”. The results imply that, trees in transect T3 are growing in relatively stress-free environment compared to trees in transects T1 and T2. The following issues were also identified regarding the survey methodology:

- It was sometimes difficult to differentiate between “Good” and “Fair” with some trees. Overall assessment was also made difficult due to the many health indicators and variation in their importance in terms of tree health. Due to such problems, the assessment method was revised by reducing the number of indicators and giving equal importance between the indicators (see Tables 2.3.1 and 2.3.2 for the final version).
- Access to the inner forest area was sometimes extremely difficult, especially where tree density was high. In such areas, survey will only be possible along the fringe of the forest such as like transects T1 and T2, and hence, for some sites it may be difficult to survey sufficient quantity of representative sites and trees. In such case, remote sensing monitoring should be considered to supplement the field survey.

b. Monitoring of mangrove forest with remote sensing

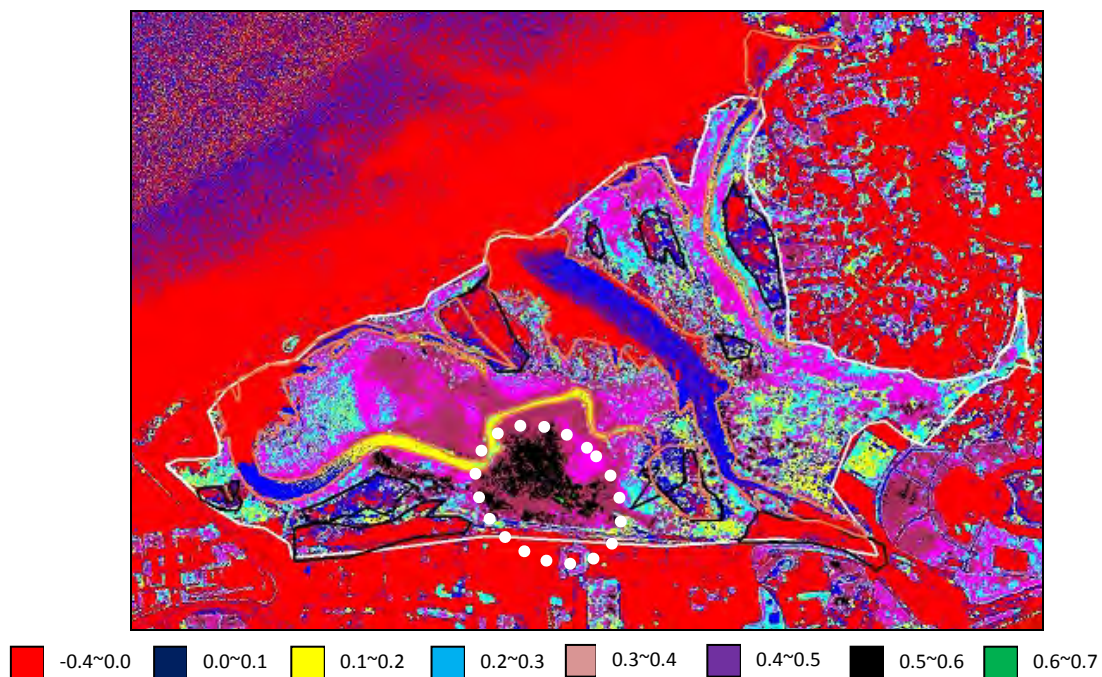
To assess the health status of QNR mangrove forest, the NDVI values of October 2011 and September 2012 were compared, with technical assistance from SQU expert. NDVI values were calculated by using GeoEye images and image processing software ENVI. Figures 2.3.5 and 2.3.6 show the NDVI values of QNR in October 2011 and September 2012, respectively. Figure 2.3.7 shows the changes in the NDVI value between October 2011 and September 2012.



Note: The white line shows the boundary of QNR

Prepared by JICA Expert Team

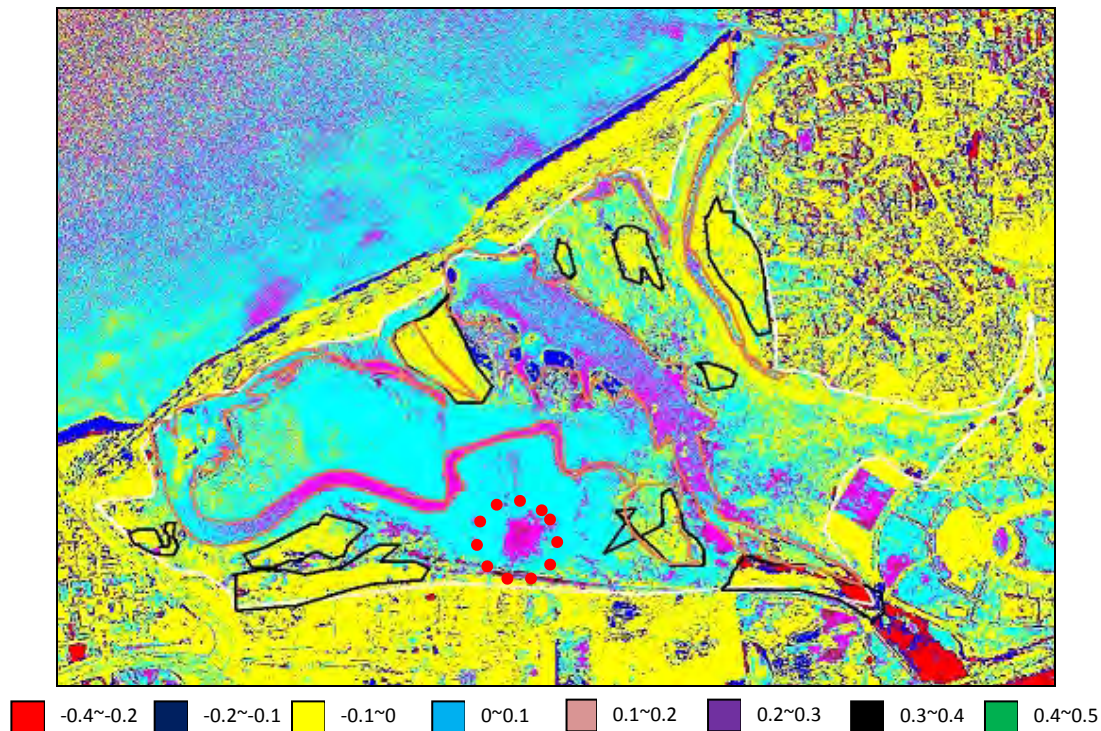
Figure 2.3.5 NDVI value of QNR in October 2011



Note: The white line shows the boundary of QNR

Prepared by JICA Expert Team

Figure 2.3.6 NDVI value of QNR in September 2012



Note: The white line shows the boundary of QNR

Prepared by JICA Expert Team

Figure 2.3.7 Changes in the NDVI value between October 2011 and September 2012

Following is a summary of the main results and issues:

- The NDVI values of the main mangrove area ranged between 0.3~0.5 for both years. However, within this main mangrove area, the NDVI value of one area (area circled by white-dotted line in Figures 2.3.5 and 2.3.6) was slightly higher than the rest (0.5~0.7) for both years. The cause of such elevation was investigated by visiting the area. While it was only possible to observe the edge, there was a mixture of non-mangrove species and this was considered as the main reason. Implying from this result, NDVI may also be used to monitor the intrusion of non-mangrove species.
- Within the main mangrove area, the change in NDVI value between 2011 and 2012 was relatively small, which ranged between -0.1~0.1. However, as an exception, one area inside the white-dotted line (area circled by red-dotted line in Figure 2.3.7) had NDVI change values of 0.1~0.3. This may imply that non-mangrove species have increased in this area, and should be investigated in the future.
- Since, experiences in remote sensing monitoring of mangrove is still limited in Oman, the methods of monitoring and assessment will require further improvement by continuing monitoring and accumulating experience and knowledge in the process.

c. Monitoring of fauna

Monitoring of aquatic fauna

Inventory surveys of aquatic fauna were conducted in QNR and Mahut Island. Fauna were collected by using seine net, gill net, fish cage as well as by hand. The collected fauna were identified by consulting Marine Science and Fisheries Center (MSFC) and Japanese experts. The collected specimens were fixed in ethanol or formalin solution, and are stored in MSFC. Tables 2.3.9-2.3.11 show the identified fishes, crustaceans and gastropods, respectively. Photos of the identified species are attached in Appendix 6.

Table 2.3.9 Fish species identified in QNR and Mahut Island

Location	Family name	Scientific name	Common name
QNR	Cyprinodontidae	<i>Aphanius dispar</i>	Killifish
	Terapontidae	<i>Terapon jarbua</i>	Jarbua terapon
	Gerreidae	<i>Gerres acinaces</i>	Longtail silverbidy
		<i>Gerres</i> sp.	Silverbidy
	Ambassidae	<i>Ambassis gymnocephalus</i>	Glass fish
	Mugilidae	<i>Moolgarda seheli</i>	Bluespot mullet
		Unidentified	Mullet
	Gobiidae	<i>Oxyurichthys ophthalmonema</i>	Eyebrow goby
		<i>Favonigobius rechei</i>	Indo-Pacific tropical sand goby
		<i>Cryptocentroides insignis</i>	Insignia prawn-goby
Cichlidae	<i>Oreochromis niloticus</i>	Nile tilapia	
Sparidae	<i>Acanthopagrus</i> sp.	Seabream	
Mahut	Sparidae	<i>Acanthopagrus latus</i>	Yellowfin seabream
	Mugilidae	<i>Ellochelon vaigiensis</i>	Squaretail mullet
	Sillaginidae	Unidentified	Whiting

Prepared by JICA Expert Team

Table 2.3.10 Crustacean species identified in QNR and Mahut Island

Location	Family name	Scientific name	Common name
QNR	Ocypodidae	<i>Ocypode saratan</i>	Ghost crab
		<i>Macrophthalmus</i> sp.	Sentinel crab
		<i>Uca lactea</i>	Milky fiddler crab
		<i>Uca</i> sp.1	Fiddler crab
		<i>Uca</i> sp.2	Fiddler crab
	Grapsidae	Unidentified	-
		<i>Metopograpsus</i> sp.	Climber crabs
	Sesarmidae	<i>Perisesarma</i> sp.	-
	Portunidae	<i>Thalamita crenata</i>	Mangrove swimming crab
	Alpheidae	<i>Alpheus</i> sp.	Pistol shrimp
Mahut	Sesarmidae	<i>Episesarma</i> sp.	Tree climbing crab
		<i>Perisesarma guttatum</i>	-
	Ocypodidae	<i>Macrophthalmus</i> sp.1	Sentinel crab
		<i>Macrophthalmus</i> sp.2	Sentinel crab
		<i>Uca</i> sp.1	Fiddler crab
		<i>Uca</i> sp.2	Fiddler crab
	Portunidae	<i>Portunus segnis</i>	Blue swimming crab
		<i>Thalamita crenata</i>	Mangrove swimming crab
<i>Portunus</i> sp.		Swimming crab	

Prepared by JICA Expert Team

Table 2.3.11 Gastropod species identified in QNR

Location	Family name	Scientific name	Common name
QNR	Potamididae	<i>Terebralia palustris</i>	Mangrove whelk
		<i>Cerithidea</i> sp.	-

Prepared by JICA Expert Team

Following is a summary of the main results and issues:

- A total of 12 fish species was identified in QNR, which included gobies, mullets and silverbiddy. Since most of the collected species were juveniles, QNR can be considered to be functioning as an important nursery for various fishes. One tilapia species was also identified, which in general is considered as an invasive species. Since, tilapia may compete with the native species and affect the QNR mangrove ecosystem, its presence should be continuously monitored.
- All the identified crab species belonged either to the family Ocypodidae, Grapsidae, Sersarmidae or Portunidae. While these crab species are relatively common in mangrove areas, some individuals were not identifiable to the species level. Therefore, it is necessary to improve the quality of species identification, by cooperating with other national and international experts and institutions. Crab species often play an important role in the material cycle of mangrove ecosystem, hence could be strong candidates as an indicator species.
- In regards to gastropods, mangrove whelk (*Terebralia palustris*) and *Cerithidea* sp. were identified in QNR, which were abundant throughout the forest. Mangrove whelk is known to eat and decompose mangrove leaf litter, hence plays an important role in the material cycle of mangrove ecosystem; and therefore could be strong candidate as an indicator species.
- Due to limited time and manpower, the number of identified species was limited. Hence, further surveys will be required to improve the inventory. Since MECA lacks the capacity to identify species, for the time being, assistance from institutions such as MSFC will be required. QEIC should also consider recruiting a marine biologist, so that identification works could be done in house. Such recruitment has been incorporated into the QEIC 8-year Operation Plan.

Monitoring of birds

Bird inventory surveys were conducted on May 5-6th and December 3rd, 2013 in QNR, with the assistance of a local bird expert. The surveys were conducted at 6 transects as shown in Figure 2.3.8. The species and abundance were recorded by using binocular, scope and camera.



Note: Survey on December 3rd was conducted only along transects T2, T3 and T5.

Prepared by JICA Expert Team

Figure 2.3.8 Location of bird survey transect

Table 2.3.12 shows the results of the bird survey. Bird photos taken during the survey are shown in Appendix 6.

Table 2.3.12 Results of bird survey

		Scientific name	Common name	Count
May 2013	1	<i>Francolinus pondicerianus</i>	Grey Francolin	2
	2	<i>Plegadis falcinellus</i>	Glossy Ibis	2
	3	<i>Nycticorax nycticorax</i>	Black-crowned Night Heron	1
	4	<i>Butorides striata</i>	Striated Heron	2
	5	<i>Ardea cinerea</i>	Grey Heron	9
	6	<i>Ardea purpurea</i>	Purple Heron	1
	7	<i>Egretta alba</i>	Western Great Egret	1
	8	<i>Egretta gularis</i>	Western Reef Heron	2
	9	<i>Gallinula chloropus</i>	Common Moorhen	1
	10	<i>Himantopus himantopus</i>	Black-winged Stilt	10
	11	<i>Vanellus indicus</i>	Red-wattled Lapwing	18
	12	<i>Charadrius alexandrinus</i>	Kentish Plover	1
	13	<i>Charadrius mongolus</i>	Lesser Sand Plover	4
	14	<i>Charadrius leschenaultii</i>	Greater Sand Plover	5
	15	<i>Limosa limosa</i>	Black-tailed Godwit	3
	16	<i>Numenius phaeopus</i>	Whimbrel	1
	17	<i>Numenius arquata</i>	Eurasian Curlew	10
	18	<i>Actitis hypoleucos</i>	Common Sandpiper	1
	19	<i>Tringa totanus</i>	Common Red Shank	1
	20	<i>Tringa nebularia</i>	Common Greenshank	4
	21	<i>Larus hemprichii</i>	Sooty Gull	1
	22	<i>Larus cachinnans</i>	Caspian Gull	1

		Scientific name	Common name	Count
	23	<i>Sterna sandvicensis</i>	Sandwich Tern	39
	24	<i>Sterna hirundo</i>	Common Tern	6
	25	<i>Sterna repressa</i>	White-cheeked Tern	4
	26	<i>Spilopelia senegalensis</i>	Laughing Dove	20
	27	<i>Psittacula krameri</i>	Rose-ringed Parakeet	26
	28	<i>Merops persicus</i>	Blue-cheeked Bee-eater	1
	29	<i>Merops orientalis</i>	Green Bee-eater	4
	30	<i>Lanius isabellinus</i>	Daurian Shrike	1
	31	<i>Lanius meridionalis</i>	Southern Grey Shrike	1
	32	<i>Corvus splendens</i>	House Crow	18
	33	<i>Pycnonotus (leucogenys) leucotis</i>	White-eared Bulbul	22
	34	<i>Galerida cristata</i>	Crested Lark	3
	35	<i>Ptyonoprogne (fuligula) obsoleta</i>	Pale Crag Martin	8
	36	<i>Hirundo rustica</i>	Barn Swallow	7
	37	<i>Prinia gracilis</i>	Graceful Prinia	10
	38	<i>Phylloscopus trochilus</i>	Willow Warbler	1
	39	<i>Phylloscopus collybita</i>	Common Chiffchaff	2
	40	<i>Acridotheres tristis</i>	Common Mynah	38
	41	<i>Pastor roseus</i>	Rose-coloured Starling	1
	42	<i>Muscicapa striata</i>	Spotted Flycatcher	2
	43	<i>Cinnyris asiaticus</i>	Purple Sunbird	13
	44	<i>Passer domesticus</i>	House Sparrow	13
	45	<i>Lonchura malabrica</i>	Indian Silverbill	15
Dec. 2013	1	<i>Francolinus pondicerianus</i>	Grey Francolin	10
	2	<i>Anas platyrhynchos</i>	Mallard	1
	3	<i>Anas acuta</i>	Northern Pintail	3
	4	<i>Anas crecca</i>	Eurasian Teal	5
	5	<i>Plegadis falcinellus</i>	Glossy Ibis	1
	6	<i>Ardea cinerea</i>	Grey Heron	4
	7	<i>Ardea purpurea</i>	Purple Heron	1
	8	<i>Egretta alba</i>	Western Great Egret	1
	9	<i>Bubulcus ibis</i>	Western Cattle Egret	1
	10	<i>Egretta gularis</i>	Western Reef Heron	3
	11	<i>Pandion haliaetus</i>	Osprey	4
	12	<i>Circus aeruginosus</i>	Western Marsh Harrier	3
	13	<i>Gallinula chloropus</i>	Common Moorhen	3
	14	<i>Fulica atra</i>	Eurasian coot	1
	15	<i>Himantopus himantopus</i>	Black-winged Stilt	2
	16	<i>Vanellus indicus</i>	Red-wattled Lapwing	5
	17	<i>Pluvialis squatarola</i>	Grey Plover	9
	18	<i>Pluvialis fulva</i>	Pacific Golden Plover	10
	19	<i>Charadrius alexandrinus</i>	Kentish Plover	1
	20	<i>Gallinago gallinago</i>	Common Snipe	9
	21	<i>Numenius phaeopus</i>	Whimbrel	2
	22	<i>Numenius arquata</i>	Eurasian Curlew	6
	23	<i>Actitis hypoleucos</i>	Common Sandpiper	4
	24	<i>Tringa ochropus</i>	Green Sandpiper	4
	25	<i>Tringa totanus</i>	Common Red Shank	1
	26	<i>Tringa nebularia</i>	Common Greenshank	4
	27	<i>Alcedo atthis</i>	Common Kingfisher	1
	28	<i>Chroicocephalus genei</i>	Slender-billed Gull	5

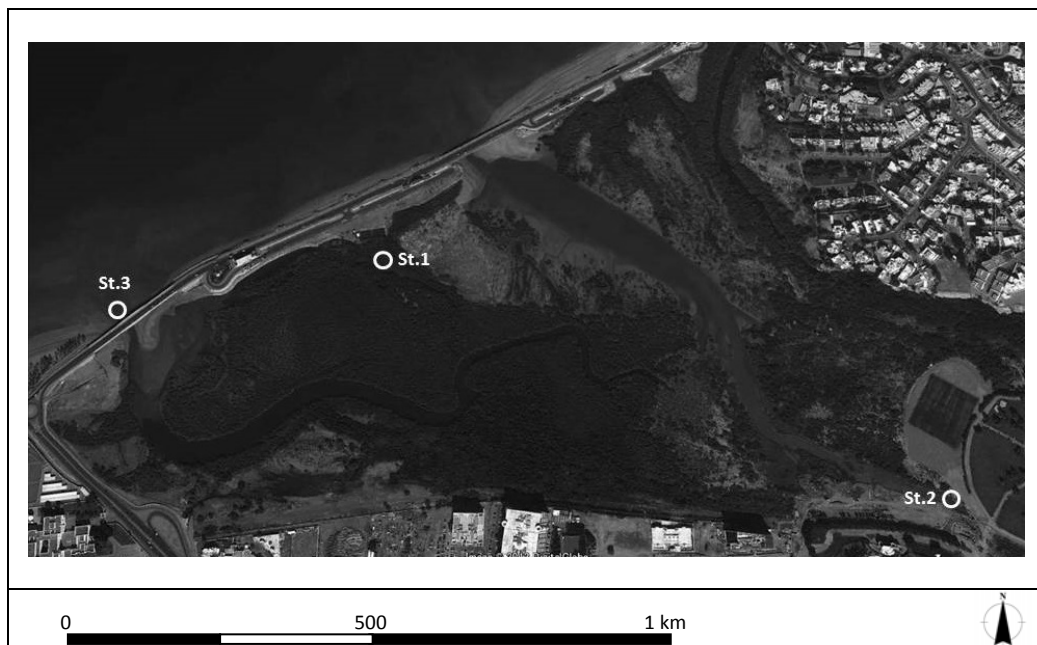
Prepared by JICA Expert Team

A total of 45 and 28 bird species were identified in the May and December surveys, respectively. Common birds included herons, sandpipers, plovers and terns. The number of identified bird species in December was less than May probably due to less survey effort and because the survey focused mainly on water birds. Since MECA lacks bird identification skills, for the time being, assistance from local expert will be required.

d. Monitoring of environmental conditions

Monitoring of water quality

Water quality survey was conducted at three locations on May 30th, June 18th and October 1st, 2013. Figure 2.3.9 shows the survey location.



Prepared by JICA Expert Team

Figure 2.3.9 Location of water quality survey

Table 2.3.13 shows the results of the water quality survey. Physical parameters (water temp. salinity, pH, DO) were measured at the site by using the donated portable water quality meters. COD and inorganic nutrients were analysed at the lab by using the donated water quality meter (HACH DR/890 Portable Colorimeter).

Table 2.3.13 Results of the water quality survey

Parameter	Results						Standards of other countries
	St.1			St.2		St.3	
Date	2013/05	2013/06	2013/10	2013/06	2013/10	2013/06	-
Water temp (C°)	32.0	33.2	30.9	34.8	33.5	36.2	-
Salinity (‰)	36.0	34.0	37.8	3.12	7.11	35.0	-
pH	7.59	7.57	7.74	7.78	7.82	7.65	7.8-8.4 ^{*1}
DO sat. (%)	47.9	80.2	57.9	112.7	131.3	83.5	> 90 ^{*2}
DO conc. (mg/l)	3.34	5.56	4.37	7.80	10.85	5.78	> 6 ^{*1}
COD (mg/l)	-	190	-	10	-	188	2 ^{*1}
NO ₃ -N (mg/l)	-	<D.L.	0.01	0.55	>0.5	0.01	(NO _x) 0.008 ^{*2}
NO ₂ -N (mg/l)	-	0.007	0.003	0.008	0.025	0.013	
NH ₄ -N(mg/l)	-	<D.L.	<D.L.	<D.L.	<D.L.	1.00	0.01 ^{*2}
PO ₄ -P (mg/l)	-	0.13	0.11	0.23	0.05	0.15	0.005 ^{*2}

*1: Japanese Fisheries Water Quality Standard

*2: Australian and New Zealand Guidelines for Fresh and Marine Water Quality (tropical inshore waters)

<D.L.: below detection limit

Note: COD and nutrients were not analyzed on May 2013 survey as analysis equipment was not yet available. COD was not analyzed on October 2013 survey due to lack of time.

Prepared by JICA Expert Team

Following is a summary of the main results and issues:

- While the salinity at St.1 and St.3 was around 35 ‰ (similar level to sea), the salinity at St. 2 was between 3-7 ‰. This results show that there is freshwater inflow into the waterway from the upstream wadi.
- pH values were within acceptable range, based on comparison with Japanese Fisheries Water Quality Standard.
- DO concentration was below the Japanese Fisheries Water Quality Standard at St.1 and St.2. These areas probably had lower DO concentration as they are located near the end of the waterway, where water exchange is limited compared to more open areas.
- COD and phosphate levels were significantly higher than the respective standards, which may be due to some error in the analysis process.
- Analysis of COD and inorganic nutrients requires certain level of experience in chemical analysis. Therefore, for the time being, analysis results should be cross-checked with a certified laboratory. QEIC should also recruit a chemical analysis expert. Such recruitment has been incorporated into the QEIC 8-year Operation Plan.

Monitoring of soil quality

Soil quality survey was conducted at one site (St.1 of water quality survey) on May 30th, 2013. Table 2.3.14 shows the survey results. The soil condition appeared to be in a reduced state as ORP value was

negative, but this is common in mangrove area. While salinity and EC were relatively high, they are probably not at a critical level, as the surrounding mangroves were in good condition.

Table 2.3.14 Results of soil quality survey

Parameter	Layer	Results
Soil temp (C°)	Surface (10 cm)	29.9
	Middle (40 cm)	28.6
Texture	Surface (10 cm)	Silt/clay
	Middle (40 cm)	Fine sand
Color	Surface (10 cm)	10YR 3/1
	Middle (40 cm)	10YR 6/1
Smell	Surface (10 cm)	H ₂ S smell
	Middle (40 cm)	No smell
ORP (mV)	Surface (10 cm)	-87
	Middle (40 cm)	-75
Salinity (‰)	Surface (10 cm)	4.61
	Middle (40 cm)	-
EC	Surface (10 cm)	8.4 mS/cm
	Middle (40 cm)	-
pH	Surface (10 cm)	7.95
	Middle (40 cm)	-
NO ₃ -N (mg/l)	Surface (10 cm)	-
	Middle (40 cm)	-
PO ₄ -P (mg/l)	Surface (10 cm)	-
	Middle (40 cm)	-

Note: Inorganic nutrients were not surveyed as analysis equipment was not yet available.

Prepared by JICA Expert Team

Monitoring of topography

To monitor the sedimentation rate of the mouth of one of the waterway in QNR, PVC stakes were installed along the edge of the waterway entrance. However, monitoring was not possible as the stakes were intentionally removed or stolen immediately after installation. Measures to prevent such occurrences must be considered when implementing sedimentation monitoring.

2.3.5 Mangrove Monitoring Guideline (PDM activity: 2.3)

Technical Document 2 “Mangrove Monitoring Guideline” is a guideline for QEIC staff that describes in detail the monitoring and assessment methodologies of “Mangrove Ecosystem Monitoring Program” and “Transplanted-seedling Monitoring Program”. The guideline was finalized after incorporating the lessons learnt through the trial monitoring activities. The guideline also includes as an attachment the following:

- Guideline for Mangrove Health Assessment using Remote Sensing
- Sample field sheet and data-entry format

- Calibration procedures of portable water quality meters
- Manual for water quality analysis

2.3.6 Management and publication of monitoring data (PDM activity: 2.5)

1) Management of monitoring data

All monitoring data (including photos) should be stored and managed through QEIC’s database, as this will prevent data loss and also enable data sharing between staffs. The IT Section of QEIC, should be responsible for managing the database. Basic information required for developing the QEIC database was also prepared (see Section 2.6.1 for details). In addition, a data-entry format was prepared for each monitoring item, which is attached in the “Mangrove Monitoring Guideline”.

2) Publication of monitoring data

In general, monitoring data will be publicized through preparing an annual report, which will be accessible through QEIC’s website. Table 2.3.15 shows the proposed contents of the annual report.

Table 2.3.15 Proposed contents of the annual report

	Content	Information to be included
Mangrove ecosystem monitoring	Objective of monitoring	Describe survey objective
	Monitoring method	Describe survey method, location
	Monitoring results	Show the results with table/graph and compare with past results
	Discussion of results	Summarize the condition of the mangrove ecosystem and points of concern.
Transplanted-seedling monitoring	Objective of monitoring	Describe survey objective
	Monitoring method	Describe survey method, location
	Monitoring results	Show results of seedling growth, survival rate and environmental condition.
	Discussion of results	Summarize the condition of the seedling growth and points of concern.

Prepared by JICA Expert Team

2.3.7 Issues and recommendations

Following are issues and recommendations for future QEIC activities:

- The capacity of the C/P has been enhanced significantly in regards to basic field survey skills (e.g. measurement of water quality, fauna collection). However, the C/P will need more experiences and training especially in the field of monitoring planning, data analysis and assessment, species identification, equipment maintenance and chemical analysis (in regards to chemical analysis, improving the accuracy of COD and inorganic nutrients analysis is of

particular importance as the analysis results were not accurate during the trial monitoring; consult laboratories such as of Ministry of Regional Municipality and Water Resource for technical assistance). Since these skills cannot be acquired overnight, it is necessary to be continuously involved in monitoring works and learn through trial and error.

- To appropriately analyze and assess the monitoring results, it is necessary to enhance knowledge on mangrove ecosystem and environmental science. Such knowledge should be acquired through training and self-learning, as well as by actually visiting and observing the mangrove ecosystem.
- Assistance from outside experts or organizations should be considered for species identification, remote sensing monitoring and chemical analysis, as these require highly specific skills. Also experts of mangrove ecosystem (i.e. marine biologist/ecologist) and chemical analysis should be recruited for QEIC as soon as possible.
- In case any serious adverse impacts on mangrove ecosystem are identified, a scientific committee (including relevant experts) should be established to discuss the causes and appropriate countermeasures.
- Since monitoring works require a lot of effort and time, monitoring should be implemented jointly with NGOs and/or local residents. It will also be an excellent opportunity for the participants to learn and experience mangrove ecosystem.

2.4 Development of methods and techniques for mangrove plantation

2.4.1 Objective of mangrove plantation

While mangrove plantation is being practiced mainly to increase greenery, additional benefits are also expected to arise through increase of mangrove area such as: protection of coastal area from natural disasters, carbon fixation, increase in fishery resources, enhancement of tourism and regional vitalization. Mangrove plantation is also practiced as one of the restoration measures for mangrove forests damaged by natural and/or human impacts.

2.4.2 Status of seedling facility and mangrove plantation activities (PDM activity: 3.1)

1) Status of seedling nursery

MECA currently operates four seedling nurseries (2 in QNR, 1 in Sur and 1 in Salalah). All nurseries are equipped with a shade net. Figure 2.4.1 shows the seedling nursery in QNR.



Prepared by JICA Expert Team

Figure 2.4.1 Seedling nursery in QNR

Each nursery has 20 nursery beds of 8 m² size and one bed can produce around 600 seedlings annually. One nursery can therefore produce around 12,000 seedlings/year. Therefore, a total of around 48,000 seedlings can be annually produced from the 4 nurseries. In order to understand the present situation of the 4 nurseries and also to formulate improvement strategies, the JICA Expert Team surveyed in detail these nursery facilities. The results of the survey are as follows:

- The nurseries in QNR and Sur are equipped with tidal-irrigation system which was established by MECA during JICA's past technical cooperation project. The nursery is connected with the

water channel in the mangrove forest by a pipe and the seedlings are irrigated automatically through tidal fluctuation. It is an outstanding system as it requires very little maintenance and comparatively low operational cost. Hence the tidal-irrigation system should be promoted to related organizations of other countries. Information regarding the structure and design of the tidal-irrigation system is explained in the “Mangrove Plantation Guideline” (Technical Document 3) prepared under the Project.

- Pump-irrigation system is employed at the nursery in Salalah, as the adjacent water channel is isolated from the sea, hence the tidal-irrigation system is inapplicable. According to the local staff, water supply into the nursery was sometimes unstable due to insufficient output power of the pump and inappropriate level of the water intake point. The Project therefore purchased a new pump and also suggested an appropriate level for water intake.
- All nurseries are currently equipped with a shade-net. Although the shade-net is useful for windbreak and light shielding, concerns were raised that such functions could promote spindly growth⁴ of seedlings. The Project therefore implemented some preliminary studies to examine the validity of the shade-net (see Section 2.3.4 and Attachment 7 for details on the study).
- Since some of the shade-nets were clogged by dust, periodical cleaning was suggested to prevent excessive shielding. Some of the iron poles supporting the shade-net were also corroded by sea water. Maintenance of such poles was suggested through rust removal, necessary welding and painting. In case of the nursery in QNR, the lower part of the iron poles that are inundated by sea water was reinforced by concrete. Necessary maintenance of the nursery facility is explained in the “Mangrove Plantation Guideline”.
- Some nurseries seeded 2-3 seeds per pot. However, since the germination rate of *Avicennia marina* is very high, thinning practice will often become necessary which is a time consuming process. Therefore, it was suggested to standardize the seeding practice to 1 seed per pot.

2) Plantation activities

a. Status of plantation activities

A mangrove plantation plan (2005-2014) was developed through the JICA Master Plan Study. The plan was formulated by considering factors such as plantation potential and priority. Table 2.4.1 shows the mangrove plantation plan.

⁴ Spindly growth: Plants growing under insufficient sunlight and excess fertilization may become overly tall. Such plants tend to be weak against diseases and other stresses.

Table 2.4.1 Mangrove plantation plan developed through the JICA Master Plan Study

Name of Mangrove Forest	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)	Total
1. Khawr Shinas	Medium	2.5	nursery	5,000	5,000	5,000	5,000	5,000	0	0	0	-	25,000
2. Khawr Harmul & Nabr	-	-	-	-	-	-	-	-	-	-	-	-	-
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	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. Qurayat	High	1	planning	dike	2,000	2,000	2,000	2,000	2,000	2,000	0	0	10,000
8. 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
10. Khawr Quq	Low	0.6	nursery	1,000	1,000	1,000	1,000	1,000	1,000	0	0	0	6,000
11. Khawr Hajr - 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
12. Wadi Mursays	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
14. Mahut Island	-	-	-	-	-	-	-	-	-	-	-	-	-
15. Al Demer Beach	-	-	-	-	-	-	-	-	-	-	-	-	-
16. Khawr Rowri	-	-	-	-	-	-	-	-	-	-	-	-	-
17. Qurm Tagah	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	4,000	0	0	0	0	0	0	0	4,000
20. Khawr Kabir	-	-	-	-	-	-	-	-	-	-	-	-	-
21. Khawr Saghir	-	-	-	-	-	-	-	-	-	-	-	-	-
Total:			19,800	22,800	31,400	27,400	27,400	22,400	19,800	17,800	17,800	10,400	217,000

Prepared by JICA Expert Team

Table 2.4.2 shows the actual performance of mangrove plantation from 2001-2012. The data was extracted from “Mangroves in the Sultanate of Oman” issued by MECA on 2010. The data of 2011 and 2012 are based on interview with the C/P.

Table 2.4.2 Performance of mangrove plantation from 2001-2012

Name of mangrove forest	Region	Number of seedling per year												Total
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	
Khasab	Khasab/Musandam	0	0	0	0	0	0	0	0	1,000	0	0	0	1,000
Diba	Diba/Musandam	0	0	0	0	0	0	0	1,000	1,200	2,000	0	0	4,200
Wadiyat	Shinas/Al-Batinah	0	0	0	14,625	13,200	18,000	18,000	8,000	13,200	12,000	0	0	97,025
Shinas	Shinas/Al-Batinah	0	0	0	0	0	0	0	0	0	0	11,000	12,000	23,000
Sawadi	Al-Sawadi/Al-Batinah	17,250	0	18,000	18,000	19,200	13,500	14,400	0	0	0	0	0	100,350
Grim	Musanaa/Al-Batinah	0	0	15,000	4,875	0	0	0	0	0	0	0	0	19,875
Hafri	Al-Batinah	0	0	0	0	0	180	0	0	0	0	0	0	180
QNR	Muscat	0	500	0	0	0	0	0	0	600	0	1,600	1,700	4,400
Al-Seera	Qurayat/Muscat	0	0	0	0	0	300	0	0	0	0	0	0	300
Sukeikra	Sur/Al-Sharqiya	16,500	0	18,000	18,000	14,625	7,500	0	0	0	0	0	0	74,625
Batah	Sur/Al-Sharqiya	0	0	0	0	0	0	13,950	5,000	0	0	0	0	18,950
Hajr	Sur/Al-Sharqiya	0	0	0	0	0	0	0	3,000	8,000	9,000	19,000	0	39,000
Har	Masirah/Al-Sharqiya	0	0	0	0	0	0	4,200	2,000	0	1,500	0	0	7,700
Durf	Duqm/Al-Wusta	0	0	0	0	900	0	0	0	2,800	1,200	1,200	0	6,100
Gauwi	Al-Jazer/Al-Wusta	0	0	0	0	1,800	3,600	3,600	2,000	1,200	5,000	3,400	0	20,600
Hitam	Duqm/Al-Wusta	0	0	0	0	0	0	0	0	1,200	0	0	0	1,200
Kabir	Dhofar	0	0	7,200	0	0	0	0	0	0	0	0	0	7,200
Saghir	Dhofar	0	0	10,800	2,700	0	0	0	0	0	0	0	0	13,500
Balid	Dhofar	0	0	900	0	0	0	0	0	0	0	0	0	900
Mughsayl	Dhofar	0	0	900	7,650	10,800	17,850	0	0	0	0	0	0	37,200
Taqa	Dhofar	0	0	0	0	1,800	0	0	0	0	0	0	0	1,800
Auqad	Dhofar	0	0	0	0	0	150	18,000	11,000	0	0	0	0	29,150
Tipajan	Sharbathat/Dhofar	0	0	0	0	0	0	0	0	800	4,000	0	0	4,800
Dahariz	Salalah/Dhofar	0	0	0	0	0	0	0	0	0	8,000	11,000	0	19,000
Mistki	Sharbathat/Dhofar	0	0	0	0	0	0	0	0	0	0	1,000	0	1,000
Total		33,750	500	70,800	65,850	62,325	61,080	72,150	32,000	30,000	42,700	48,200	13,700	533,055

Prepared by JICA Expert Team

The above plantation performance was compared with the initial plantation plan of the JICA Master Plan Study. Followings are the main findings:

- Although there were no initial plans for plantation in the Musandam Region, small-scale plantation activities were conducted at 2 locations during 2008-2010.
- In the Batinah Region, large-scale plantation (total of around 100,000 seedlings) was conducted in Khawr Sawadi. Large-scale plantation (more than 100,000 seedlings) was also conducted in Shinas (Khawr Wadiyat and Shinas) during 2004-2012, even though priority of plantation in this area was initially rated as medium.
- In the Muscat Region, plantation of 40,000 seedlings was planned at QNR from 2007-2010. However, plantation was not conducted as the planned plantation area was inundated by the flood caused through Cyclone Gonu in 2007. Small scale plantation was conducted from 2009 to recover the mangrove areas that were lost through the cyclone. Although plantation at Bandar Khayran and Qurayat were initially prioritized as medium/high, plantation was conducted only at Qurayat (300 seedlings in 2006). Based on field reconnaissance at Bandar Khayran, the site was considered unsuitable for plantation for the following reasons:
 - Potential area for plantation is very limited due to the narrow tidal flat.
 - The soil has low water holding capacity mainly due to the shallow bedrock and thin sand layer. The area is therefore not suitable for mangrove growth as the soil is prone to desiccation during low tide and consequently a tendency to become high in salinity.
- In the Sharqiyah Region, a total of around 130,000 seedlings were planted in Sur from 2001-2010, where the priority of plantation was rated medium/high. In Filim, where the priority of plantation was rated high, no plantation activity was implemented because natural regeneration was observed in the area. In Masirah Island, where the priority of plantation was rated low, small-scale plantation was conducted in 2007 at a newly discovered site (Al-Har).
- In the Al Wusta Region, where there were no initial plantation plans, around 2,000 seedlings were planted per year after 2005, at newly discovered sites (Durf and Gauwi).
- In the Dhofar Region, plantation was initially planned only for khawrs Taqah and Balid. However, plantation was conducted at 9 khawrs after 2003.
- A total of more than 500,000 seedlings have been planted as of 2012. According to the C/P, the final goal is to plant a total of 1 million seedlings.

According to the findings mentioned above, MECA has conducted its plantation activities by flexibly modifying the initial plantation plan of the JICA Master Plan Study, by taking into account changes in the situation of the plantation sites and by discovering new sites.

b. Evaluation of plantation activities

In order to evaluate MECA's plantation activities of the past decade, the survival status of the transplanted seedlings and the area transition of the plantation sites were studied.

The survival status of the transplanted seedlings was first intended to be estimated by comparing the quantity of the transplanted seedlings and the quantity of the currently standing trees. However, this was not possible, as it was difficult to differentiate whether the standing trees were planted or naturally regenerated trees. Therefore, in order to study the survival status, it was considered necessary to tag the seedlings at the time of transplantation, so that they could be traced continuously.

Based on the above experiences, the JICA Expert Team and C/P have decided to conduct survival rate monitoring at Khawr Durf by randomly tagging 100 seedlings out of the 775 newly transplanted seedlings. The JICA Expert Team and C/P returned to the site after one year to monitor the survival rate, but unfortunately many of the tags were either lost or buried inside the stem, and therefore it was not possible to conduct any meaningful monitoring. Therefore, it was considered necessary to improve the tagging methods as well as the need for more frequent checking of the tags. Based on these learnt lessons, the monitoring method of transplanted seedlings was developed, which is described in the “Mangrove Monitoring Guideline” (Technical Document 2).

The area transition of the plantation site was estimated by comparing the surface area of the existing forest and the surface area of the plantation site. The study was conducted at 6 plantation sites (Wadiyat, Shinas, Sawadi, Hajr, Har and Gauwi). Following are the methods employed to estimate the surface areas:

- Surface area of existing forest: Coordinates of the major points along the forest perimeter were recorded with GPS. The forest area was then estimated by using GIS software and satellite image.
- Surface area of plantation site: As surface area data was unavailable, surface area was instead estimated by using data of the “total number of planted seedlings” and average planting density (85 cm x 85 cm).

Table 2.4.3 shows the estimated area transition of the plantation site.

Table 2.4.3 Estimated area transition of the plantation site

Name of mangrove forest		Wadiyat	Shinas	Sawadi	Hajr	Har	Gauwi
Region		Batinah	Batinah	Batinah	Sharqiyah	Sharqiyah	Wusta
Wilayat		Shinas	Shinas	Barka	Sur	Masirah	Duqm
Plantation schedule	Priority	Medium	Medium	High	Low	Low	No plan
	Number of seedlings	25,000	25,000	104,000	119,000	10,000	-
	Planting density (m ²)	1.00	1.00	1.00	1.00	1.00	1.00
	Area scheduled (ha)-A	2.50	2.50	10.40	11.90	1.00	-
Plantation performed	Number of seedlings	97,025	23,000	100,350	39,000	7,700	20,600
	Planting density (m ²)	0.85	0.85	0.85	0.85	0.85	0.85
	Area planted (ha)-B	7.01	1.66	7.73	2.82	0.56	1.49
Area of existing forest (ha)-C		5.17	1.36	11.80	2.51	0.17	1.47
Activity performance	B/A*100	280.4	66.5	74.3	23.7	55.6	-
Plantation performance	C/B*100	73.8	81.8	152.7	89.0	30.3	98.8

Prepared by JICA Expert Team

Following are the main findings of the study:

- In case of Wadiyat, most seedlings can be considered to have rooted since the existing forest area was more than 70% of the planted area. On the other hand, the potential for future expansion was considered limited because the forest area has not expanded more than the planted area, despite the fact that plantation was initiated since 2004.
- In case of Shinas, most seedlings can be considered to have rooted since the existing forest area was more than 80% of the planted area. Since plantation was initiated only after 2011, the forest area should be monitored in order to see whether the forest area will further expand through natural regeneration.
- In case of Sawadi, the existing forest area was more than 1.5 times of the planted area. This shows that the planted area has expanded through natural regeneration.
- In case of Hajr, most seedlings can be considered to have rooted since the existing forest area was around 90% of the planted area. Since natural regeneration was also observed, it is possible that the forest area will further expand.
- In case of Har, the existing forest area was only 30% of the planted area, and also the existing trees were mostly unhealthy. This implies that the planted site was not suitable for plantation.
- In case of Gauwi, most seedlings can be considered to have rooted since the existing forest area was near 100% of the planted area. On the other hand, the potential for future expansion was considered limited because the forest area has not expanded more than the planted area, despite the fact that plantation was initiated since 2005.

According to the above findings, except Har, the transplanted seedlings seem to have rooted successfully as the existing forest area was close or exceeded the planted area. This implies that MECA has more or less selected appropriate sites for plantation. The cause for the low rooting rate at Har should be investigated, and the findings should be referred when selecting future plantation sites. Note also that there might have been some inaccuracy in the estimation of the area transition as the surface area of the planted site was not based on actual measurement. It is therefore important to measure and record the surface area of the planted site at the time of plantation, so that area transition can be traced more accurately. It is also important to manage the series of information related to the plantation activity (e.g. plantation plan, plantation performance and plantation area) by storing the data into a common database (see Section 2.4.3 for details).

c. Issues after plantation

There were some cases where the growth of the planted seedlings was hindered by natural and human impacts. Following are some common impacts:

- Animal grazing by domestic goats and camels was observed in some plantation sites especially in the regional areas. Although mangroves in nature reserves are protected by

fencing, it is difficult to install fencing at all plantation sites. Animal grazing may be minimized by seeking cooperation from livestock keepers through environmental education and awareness activities.

- At some of the plantation sites, seedlings were stressed by entanglement of algae. MECA has installed nets at some of the plantation sites to prevent algae intrusion, which has been effective to a certain degree. However, since it is difficult to install nets at all the plantation sites, algae should be regularly removed by hand as well.
- At some of the plantation sites, seedlings were stressed by entanglement of garbage, especially plastic bags. It is therefore important to control waste dumping through environmental education and awareness activities. Such garbage should be regularly removed by hand as well.

Although mangrove plantation is generally considered as a “good thing”, the following issues have occurred in some of the plantation sites.

- In Sur, due to the receding of the coastline, mangrove plantation was unintentionally conducted over private land. No solutions have been reached thus far regarding this problem.
- In Sur, a part of the planted site was previously used as a recreational area (e.g. football playground), but is no longer usable due to the growth of mangroves.
- Planation activities may have adverse impacts on some bird species, as it will reduce the area of exposed mudflats which is important feeding area for many birds.

As mangrove plantation have potential negative effects, plantation sites should be selected after thorough consideration of potential negative impacts. The local people should also be consulted in the selection process.

2.4.3 Improvement of mangrove plantation technique (PDM activity: 3.2)

1) Technique of seedling production

a. Light conditions and seedling growth

Seedlings in the nursery were observed to be generally spindly compared to natural seedlings, which was presumed to have been due to the shading effect of the shade net (seedlings tend to become spindly under insufficient light conditions). A preliminary study was therefore conducted to investigate the relationship between light conditions and seedling growth by comparing the growth of seedlings in shaded and non-shaded condition. As an indicator of spindly growth, “comparative

seedling height⁵” (the ratio between stem height and stem diameter) was measured. Followings are the main findings of the study (methods and results of the study are described in detail in Appendix 7).

- According to the study, comparative seedling height was generally lower with seedlings grown under non-shade conditions. Therefore, it was preliminary concluded that stronger seedlings can be produced without shade-net. However, since young seedlings are prone to sunburn, shading is required during the initial growth period (e.g. until 1 month after germination). To satisfy both conditions, installation of a mobile shade-net was proposed an option.
- However, since the study was conducted with limited samples and under non-uniform growth conditions between non-shade and shaded seedlings, additional studies should be implemented for further verification, perhaps as part of QEIC research program. The following factors should be taken into account when conducting the additional studies:
 - Sufficient number of samples should be secured.
 - Other than light conditions, growth conditions (e.g. soil quality, irrigation period) should be uniform between non-shade and shaded seedlings.
 - The validity of comparative seedling height should be verified by continuously monitoring the growth of the seedlings after transplantation.
 - The installation cost and stress on the nursery structure of mobile shade-net should also be investigated.

If installation of mobile shade-net is unfeasible, as an alternative option, a temporary nursery (without shade-net) may be constructed at the plantation site. The procedure for the establishment of the temporary nursery is described in the “Mangrove Plantation Guideline” (Technical Document 3).

b. Nutrient supply and seedling growth

Sufficient supply of nutrients to the seedlings is important for the production of healthy seedlings. Installation of a water tank for fish culture and sandpit for crabs and shells could be an effective way to supply nutrients to the seedlings. Use of chemical fertilizer is not recommended because of possible impacts to mangrove ecosystem.

2) Selection of appropriate plantation site

Appropriate site selection for plantation is important to increase the success rate of plantation as well as to avoid any negative social and natural impacts after plantation, as experienced before (e.g. plantation over private land, alteration of existing land use, reduction of bird feeding ground). The Project therefore developed guides and certain procedures to assist QEIC staff make appropriate

⁵ Comparative seedling height: The ratio between stem height and stem diameter. Seedling with lower comparative seedling height is generally considered as a stronger seedling.

decisions during the site selection process (see “Mangrove Plantation Guideline” for details). Following is a list of factors that should be considered when determining the appropriateness of the candidate site:

Natural condition

- Meteorology (temperature, wind direction, wind speed etc.)
- Hydrology (seawater exchange, current regime, wave etc.)
- Intertidal zone (slope, width etc.)
- Soil property (soil depth, soil quality etc.)
- Water quality (salinity, dissolved oxygen etc.)
- Fauna (characteristics of animals in the intertidal area, bird feeding areas etc.)

Social condition

- Risk of damage from animal grazing
- Impact on existing land use (boat anchoring, recreation etc.)
- Future development plan

Others

- Past distribution of mangrove forest
- Future expansion potential of mangrove forest
- Accessibility and necessary cost

To simplify the procedure, a field check list was prepared (Table 2.4.4), which is intended to be used when evaluating the candidate plantation site at the field. Each check item is evaluated by 5 different levels by referring to the set criteria. The appropriateness of the candidate site is then determined by comprehensive evaluation of all check items. Figure 2.4.2 is a sample evaluation sheet that could be used for the comprehensive evaluation. The radar chart in the evaluation sheet enables the evaluator to visibly understand the appropriateness of the site. The evaluation sheet can also be used a tool when explaining the validity of the site selection to the concerned local people.


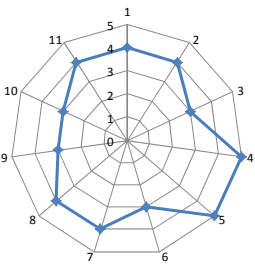
Table 2.4.4 Field check list for site selection

Attachment-1: Field Checklist for Site Selection (Observation Sheet)

Date:		GPS Northing:		Tide during survey (hig/low):						
Location:		GPS Easting:		Existing mangrove tree (matured tree/seedlings):						
No.	Points to be checked	Favorable condition for plantation (5 point)	Medium condition for plantation (3 point)	Unfavorable condition for plantation (1 point)	Evaluation			Note		
1	Situation of the mouth of khawr	Mouth of khawr is opened throughout the year	Mouth of khawr is occasionally closed	Mouth of khawr is closed throughout the year	5	4	3	2	1	
2	Situation of the tidal current and ocean wave	Tidal current and wave are calm throughout the year	Tidal current and wave are occasionally strong	Tidal current and wave are strong throughout the year	5	4	3	2	1	
3	Extent of intertidal zone	Intertidal zone is wide and flat	Intertidal zone is medium and rather slopy	Intertidal zone is narrow and steep	5	4	3	2	1	
4	Thickness of the soil layer	Enough soil depth for root growth more than 15cm	Limited soil depth for root growth less than 15cm	No soil layer at all	5	4	3	2	1	
5	Smell of hydrogen sulfide from subsurface soil layer	No smell of hydrogen sulfide from soil layer at all	Some smell of hydrogen sulfide in some places	Strong smell of hydrogen sulfide at everywhere	5	4	3	2	1	
6	Salinity level of water	Average water salinity is very low (less than 2%)	Average water salinity is similar to ordinary sea water (3-4%)	Average water salinity is very high (more than 5%)	5	4	3	2	1	
7	Situation of the grazing activity potential	No grazing activity potential at all	Occasional grazing activity potential seasonally	Heavy grazing activity potential due to the situation	5	4	3	2	1	
8	Land use situation by the local community	No human activity in the site	Occasional human activity in the site	Heavy human activity in the site	5	4	3	2	1	
9	Access from the main road to the site for plantation and maintenance	Easy access from the main road to the site by road	Moderate access from the main road to the site with rough road	Difficult access from the main road to the site without road	5	4	3	2	1	
10	Utilization as birds feeding ground	No use as birds feeding ground	Some use as birds feeding ground	High use as birds feeding ground	5	4	3	2	1	
11	Coastal development plan	No plan for future development	Some paper plan for future development	Practical plan for future development	5	4	3	2	1	

Prepared by JICA Expert Team

Field Checklist for Site Selection (Sample Evaluation Sheet)

Date: 2013/10/4		GPS Northing:563513		Tide during survey (hig/low): Surveyed during low tide		
Location: Grim		GPS Easting:2630736		Existing mangrove tree: Both matured trees and seedlings were available		
No.	Points checked	Evaluation	Note	Satellite Image or Google Earth Image		
1	Situation of the mouth of khawr	4	Better to ask local people			
2	Situation of the tidal current and ocean wave	4	Generally calm but some wind ripple was observed			
3	Extent of intertidal zone	3	Generally flat and more or less wide area			
4	Thickness of the soil layer	5	Deep enough			
5	Smell of hydrogen sulfide from subsurface soil layer	5	No smell at all			
6	Salinity level of water	3	Better to check several places			<p>Evaluation Result</p> 
7	Situation of the grazing activity potential	4	No symptom was observed on mangrove leaves			
8	Land use situation by the local community	4	Site is adjacent to the residential area of the local people			
9	Access from the main road to the site for plantation and maintenance	3	Need to pass rough road			
10	Utilization as birds feeding ground	3	Several species of birds were observed			
11	Coastal development plan	4	Better to ask local people			

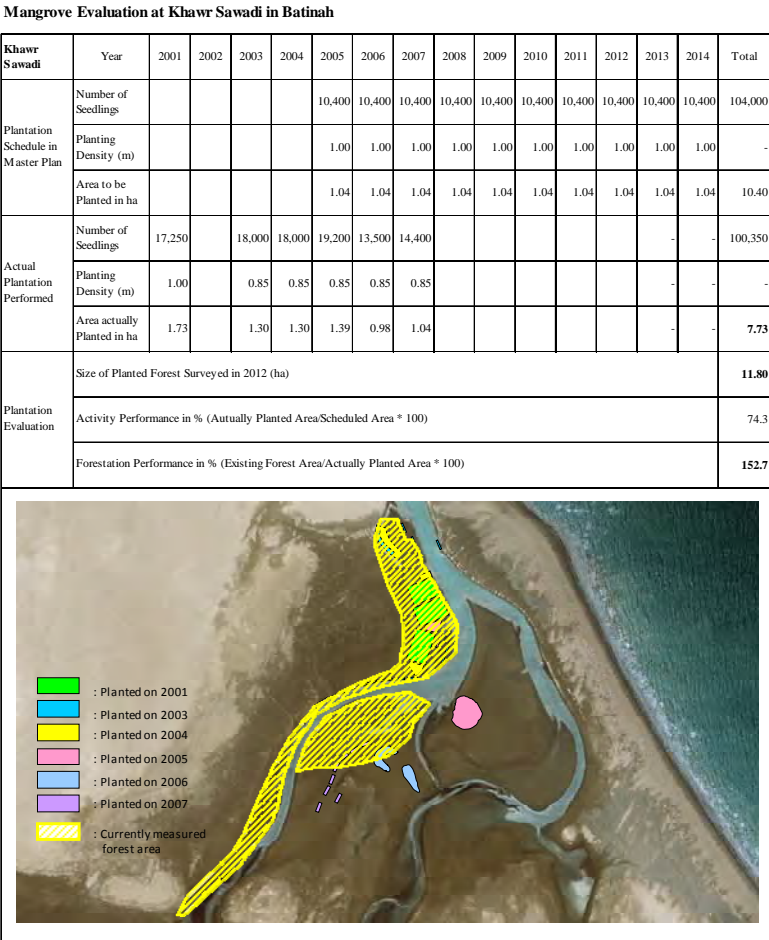
Prepared by JICA Expert Team

Figure 2.4.2 Evaluation sheet for site selection

Once the plantation sites are determined, estimate the area available for plantation for each site. The number of required seedlings can then be estimated and seedling production planned accordingly. By this, it is possible to minimizing excessive seedling production.

3) Evaluation of plantation activities

MECA currently does not have a systematic method for evaluating the success of the plantation activities. One option to measure such success is to monitor the transition of mangrove area after transplantation, which has been trialed through this Project as described in Section 2.4.2. To assist the evaluation process, the Project has developed a database format that could be used for recording the plantation data and evaluation results. The format also includes a satellite image where area transition could be visibly presented by using GIS software. Figure 2.4.3 shows the plantation performance and evaluation results of khawr Sawadi using the database format (see Appendix 8 for plantation performance and evaluation results of the 6 plantation sites that were evaluated). The Project also procured Geo Eye image⁶ for all 32 mangrove sites in Oman and the image files are kept by MECA’s IT Department.



Prepared by JICA Expert Team

Figure 2.4.3 Plantation performance and evaluation results of khawr Sawadi

⁶ Commercial satellite image with a resolution of 0.4 m.

4) Mangrove Plantation Guideline

The “Mangrove Plantation Guideline (Technical Document 3)” provides in detail all the necessary procedures required for mangrove plantation. Although it is fundamentally based on the current guideline “Technical Guideline for Afforestation”, developed through the JICA Master Plan Study, the new guideline incorporates new findings obtained through the Project such as site selection procedure. The guideline also includes the direct sowing method as an alternative cost effective method although this method is not common in Oman.

The Mangrove Plantation Guideline should be revised in accordance to the experiences gained through future plantation activities and should also be made available to public. The guideline can also be used as a textbook for QEIC’s training program on mangrove plantation.

2.4.4 Consideration of mangrove conservation methods (PDM activity: 3.3)

1) Laws and regulations relevant to mangrove conservation

Oman’s laws and regulations relevant to mangrove conservation were studied through interviews with the C/P and relevant departments of MECA. Relevant sections of the available laws and regulations are summarized below:

- The Law on Conservation of the Environment and Prevention of Pollution: Royal Decree No. 114/2001
 - This law is the basic environmental law of Oman. Article 21 prohibits cutting down, uprooting or damage of any tree, shrub or grass in public forests, without obtaining a permit from the Ministry. Article 33 penalizes anyone who cuts down tree in conservation area by either imprisonment for a term not exceeding one month or with fine not less than RO 10 and not more than RO 500. Since mangroves are basically public forests, these articles are applied.
- The Law on Nature Reserves and Wildlife Conservation: Royal Decree No. 6/2003
 - This law is the basic law regarding nature reserves and wildlife conservation. Nature reserves are designated by Royal Decree as stipulated in Article 10. QNR and khwars of the Dhofar region are nature reserves with mangrove distribution, which are designated through Royal Decree 38/75 and Royal Decree 49/97, respectively.
 - Article 13 stipulates the development of management plan. The management plan is required to designate the nature reserve into public zone, specially protected zone and zone for research/education purposes.
- Decision No 20/90 regarding the rules regulating and specifying coastal setbacks

- The Decision specifies setbacks for coastal areas including sandy beaches and khwars, which is where mangroves are commonly distributed. Setbacks of sandy beaches and khwars are specified as 150 m from the maximum end of tidemark. However, setbacks may be specified as 50 m for beaches where the construction developments have limited impact on the environment.

According to the study, laws and regulations for mangrove conservation is relatively well established in Oman. While these laws and regulations should continue to be properly enforced, it may also be necessary to update them or apply flexibly in accordance to the circumstances of recent years. Following are some factors that are suggested to be considered in the future:

- Although cutting of mangrove is prohibited by Royal Decree No. 114/2001, cutting or pruning may be necessary in some cases to maintain the health of the forest and ecosystem. Therefore, a mangrove ecosystem management plan should be developed for concerned sites, and cutting or pruning should be permitted in case such activities are considered to be in conformance to the management plan and beneficial to the forest and ecosystem.
- QNR has been designated as a nature reserve through Royal Decree 38/75. However, the content of the decree should be revised as it does not include the requirements stipulated in Royal Decree No. 6/2003, in particular the establishment of a management plan including zoning plan. Development of such management plan is also recommended by Ramsar Convention, hence should be prepared as soon as possible.
- From the perspective of wise use, the use of mangrove by the locals should be allowed to a certain degree at some sites (e.g. Mahut Island) as long as it is sustainable. In such case, a management plan (including a zoning plan) should be prepared together with relevant organizations and local residents.

2) Laws and regulations on land ownership

It is important to understand the laws and regulations on land ownership, as plantation activities may sometimes face problems with land ownership issues as experienced in the past. However, the C/P had no information as such laws and regulations are not under the jurisdiction of MECA. Therefore, it will be necessary to collect such information in the future, and to ensure that plantation activities do not lead to any land ownership issues.

3) Mangrove Protection Guideline

The “Mangrove Protection Guideline” (Technical Document 4) was prepared mainly to assist the staffs of QEIC responsible for managing and protecting the mangrove ecosystem in Oman. The Guideline explains potential threats to mangrove ecosystems in Oman and recommended measures to counter against these threats, which includes practical as well as regulatory measures.

2.4.5 Issues and recommendations

Following are issues and recommendations for future QEIC activities:

- Although there are no major improvements required regarding the current plantation method, to raise the success rate of plantation, the quality of the seedlings should be further improved. While the Project conducted preliminary studies to investigate the effect of shade net on seedling quality, additional studies should be implemented for further verification as a research theme of QEIC.
- The Project established the procedures for selecting appropriate plantation site. However, to make appropriate and scientific-based decisions, the capacity of QEIC staff should be further enhanced.
- Seedlings are currently produced each year at full production capacity, which was probably required as demand for plantation was high. However, in the coming years, demand for plantation is likely to decrease, as area available for plantation in Oman will become less. Therefore, to avoid excessive seedling production, in the future, seedlings should be produced on a necessity basis by first estimating the number of seedlings required for each plantation site.
- In order to effectively implement future plantation activities and related research, QEIC should recruit an expert on plant biology.

2.5 Environmental education

2.5.1 Objective of environmental education

The objective of environmental education is to introduce to the various target groups the characteristics and value of mangrove ecosystem, and thereby enhance their awareness on the importance of mangrove ecosystem conservation and ultimately to drive them to take action. The main focus of this Project was to improve and enhance the effectiveness of MECA's existing environmental education programs, by developing new education methods, tools and programs.

2.5.2 Target groups of environmental education (PDM activity: 4.1)

In order to discuss the target groups, and methods and tools for QEIC's environmental education, a workshop was held on February 8th, 2012. The participants were C/P and the central and regional staffs of MECA. The objectives of the workshop were to identify target groups of environmental education and to share common idea about necessary contents and tools of environmental education for each target group. The identified target groups were: 1) Students (primary, secondary, high schools and university), 2) Private Sector, 3) Local Community, 4) Chamber of Commerce and Industry, 5) Media, 6) Government Sector, and 7) NGOs. Table 2.5.1 shows the suggested contents of environmental education for each identified target group.

Table 2.5.1 Suggested contents of environmental education by target group

Target group	Contents
Students (primary, secondary, high schools and university)	<ul style="list-style-type: none"> - Importance and value of mangrove ecosystem - Current situation of mangrove ecosystem in Oman and the world - Relationship between human and mangrove ecosystem
Private sector	<ul style="list-style-type: none"> - Legal and institutional framework for mangrove ecosystem - Function of mangrove ecosystem and its economic value - Current situation of mangrove ecosystem in Oman and the world - Potential of mangrove ecosystem for ecotourism - Impacts of company activities on mangrove ecosystem
Local community	<ul style="list-style-type: none"> - Importance and value of mangrove ecosystem - Current situation of mangrove ecosystem in Oman - Benefits of mangrove for fishery industry and increasing marine biodiversity - Honey production and the production of natural products from mangrove
Chamber of Commerce and Industry	<ul style="list-style-type: none"> - Investment opportunities that mangrove can provide such as the production of natural products and medicine - Function of mangrove ecosystem and its economic value - Legal and institutional framework for mangrove ecosystem - Current situation of mangrove ecosystem in Oman and the world
Media	<ul style="list-style-type: none"> - Importance and value of mangrove ecosystem - Current situation of mangrove ecosystem in Oman and the world - Relationship between human and mangrove ecosystem - Legal and institutional framework for mangrove ecosystem - Role of the Ministries for raising public awareness on mangrove conservation
Government sector	<ul style="list-style-type: none"> - Importance and value of mangrove ecosystem - Economic value of mangrove ecosystem - Current situation of mangrove ecosystem in Oman and the world - Relationship between human and mangrove ecosystem

Target group	Contents
	- Role of the Ministries for raising public awareness on mangrove conservation
NGO	- Importance and value of mangrove ecosystem - Economic value of mangrove - Current situation of mangrove ecosystem in Oman and the world - Relationship between human and mangrove ecosystem - Role of NGO to raise public awareness on mangrove conservation

Prepared by JICA Expert Team

Based on the results of the workshop, the Project focused on students (primary, secondary and high schools), local community, and private companies as major target groups of environmental education. The reasons are stated below:

- Students: Students are expected to play a central role in mangrove ecosystem conservation in the future.
- Local community: Enhancing the awareness of the local people on the importance of mangrove ecosystem, is vital for the conservation of regional mangrove ecosystems.
- Private company: Corporate activities may have adverse impacts on mangrove ecosystem, and therefore, enhancing the awareness of company staff may lead to the conservation of mangrove ecosystem.

2.5.3 Methods and tools for environmental education (PDM activity: 4.2)

Methods and tools for environmental education were also discussed in the above-mentioned workshop. Table 2.5.2 shows the suggested methods and tools for each target group.

Table 2.5.2 Methods and tools of environmental education for each target group

Target group	Methods and tools
Students (primary, secondary, high schools and university)	- Provide brochure, booklet, guidebook regarding mangrove and its ecosystem - Aware students through books by drawing cartoon pictures for the primary students - By competition in different games that shows the importance of the mangrove areas - Invite students for plantation programs in order to take care of their own trees - Educate students through lectures, researches and presentations - Provide research opportunities in the field of mangrove ecosystem
Private sector	- Provide brochure, booklet, guidebook regarding mangrove and its ecosystem - Encourage eco-tourism to the place of mangrove forest - Provide P.S. with rules and regulations regarding the importance and protection of mangrove - Invite private sector to attend exhibition and workshop - Involve private sector to participate in transplanting activities - Train the decision makers about the effects to the environment - Arrange awareness posters for the tourists about the mangroves - Award for environmental consciousness, such as introduction the firms in the homepage
Local community	- Make some educational films to show the importance of mangrove - Provide brochure and booklet regarding mangrove and its ecosystem - Invite fishermen and local people to workshop about mangroves - Make environmental note boards in the location of mangrove habitats - Invite them in the mangrove transplanting activities - Involve the community in the eco-tourism to increase their income

Chamber of Commerce and Industry	<ul style="list-style-type: none"> - Provide the investors the leaflets and programs showing the importance of the mangrove forest - Make some educational films to show the importance of mangrove - Award for environmental consciousness, such as introduction the firms in the homepage
Media	<ul style="list-style-type: none"> - Cooperate with TVs to present awareness programs and subjects about mangroves - Cooperate with newspapers to write articles and show pictures of mangrove in newspapers - Distribute an advertising boards in the main roads to increase local awareness about mangrove - Provide educational films about mangrove habitat - Supply media with information materials about mangrove ecology - Invite the media in conferences, meetings and workshops - Arrange competition programs through TV and radio to different target people
Government sector	<ul style="list-style-type: none"> - Create a committee with focus of the protection and importance of mangrove with other ministries - Involve them in the educational programs regarding mangrove - Make conference, meeting & workshop regarding the importance of mangrove habitat and way of protect it - Decide the mangrove habitats as national reserves - Encourage investment in the mangrove ecosystem to produce honey and medicine - Encourage the ministry of tourism to promote environmental tourism
NGOs	<ul style="list-style-type: none"> - Invite them in the transplanting campaign - Provide them with leaflet, booklets and stickers regarding mangrove ecosystem - Involve them in the exhibitions and conferences - Encourage them to make more activities related to mangrove - Provide them presentation and lectures about importance of mangrove forests

Prepared by JICA Expert Team

The JICA Expert Team participated in various education programs held by the C/P, and in the process developed various methods and tools to improve the programs. The Project also prepared newsletters and brochures to inform the public about the Project activities and topics related to mangroves. Based on these experiences and feedback from the participants, the Project developed methods and tools that could be used for future education activities. Table 2.5.3 shows the basic method of environmental education for each target group. Table 2.5.4 shows the environmental education tools developed by the Project.

Table 2.5.3 Basic methods of environmental education for each target group

Target group	Method
Students (primary and secondary schools)	Visiting schools to explain students about mangroves and mangrove ecosystem by presentation, showing movie and performing quiz and games. Inviting school children to mangrove forest such as QNR, in order to actually experience the mangrove ecosystem in the field.
Private company	Visiting companies and/or inviting employees to mangrove forest, and explaining about mangroves and mangrove ecosystem including the importance of mangrove ecosystem conservation and various threats of human activities to the ecosystem. Inviting them to transplanting, monitoring and cleaning activities as a part of conservation activities.
Local community	Inviting local residents of coastal areas to mangrove forest in the regions, in order to raise awareness about mangroves and mangrove ecosystem including the importance of mangrove ecosystem conservation and various threats of human activities to the ecosystem. Inviting them to transplanting, monitoring and cleaning activities as a part of conservation activities.

Prepared by JICA Expert Team

Table 2.5.4 Environmental education tools developed by the Project

Category	Item	Description	Target group		
			Students	Private company	Local community
Education materials	Brochure	Information about the QEIC Project. Introduction of mangrove ecosystem. Basic procedure of mangrove seedling transplanting.	x	x	x
	Poster	Introduction of mangrove forests in Oman. Explaining food chain in the mangrove ecosystem.	x	x	x
	Photo list	Photos of animals of mangrove forests in Oman, including birds, fishes, crabs and shells.	x	x	
	Card puzzle	A photograph of water bird was cut in pieces which shall be assembled to complete the original photo as a puzzle.	x		
	Booklet	A booklet for children describing mangroves and mangrove ecosystem. The booklet consists of 12 pages with simple explanation and many drawings, so that small children can enjoy to study about mangroves.	x		
	Learning book	A learning book to study about mangroves and mangrove ecosystem, which helps visitors deepen their understanding of the topics exhibited by letting them answer pre-set questions.	x		
	QEIC Newsletter	Providing news about QEIC Project activities and information regarding mangroves and mangrove ecosystem.		x	x
Games	Mangrove quiz	Environment quiz regarding mangroves and mangrove ecosystem.	x		
	Nature game (Role play)	Each component of mangrove ecosystem is drawn on a plate and distributed to children, so that they can learn the relationship among these components through the game.	x		
	Nature game (Searching cards)	Searching cards and making a sentence which describes characteristics of mangrove.	x		
	Field bingo	Field bingo card including mangrove, fish, crab, shrimp, shell, and bird as components of mangrove ecosystem.	x		

Prepared by JICA Expert Team

2.5.4 Environmental education program (PDM activity: 4.3, 4.5, 4.6, 4.8)

1) Current status of environmental education program

MECA currently conducts various mangrove-related education programs, including programs in connection with “Oman Environment Day” (January 8th every year) and “World Wetlands Day” (January 2nd every year). MECA also conducts environmental education programs in QNR mainly on a request basis.

a. Environmental education programs conducted at QNR

Environmental education programs in QNR consists of mainly the following activities: 1) introduction of mangroves and mangrove ecosystem, 2) observing mangrove forest, 3) visiting mangrove nursery, 4) transplanting mangrove seedlings, and 5) cleaning transplanted site. Common target groups are students of primary, secondary and high schools as well as university students. Table 2.5.5 shows the contents of a typical program conducted at QNR.

Table 2.5.5 Typical environmental education program conducted at QNR

No	Title	Content
1	Introduction of mangrove and mangrove ecosystem	Providing general information on mangroves and mangrove ecosystem
2	Observing mangrove forest	Observing mangrove forest through walking along the boardwalk
3	Visiting mangrove nursery	Visiting mangrove nursery and providing mangrove seedlings
4	Transplanting mangrove seedlings	Transplanting mangrove seedlings and cleaning the planting site

Prepared by JICA Expert Team

QNR will continue to be an important base for environmental education activities. However, to improve the current program, greater emphasis should be placed on introducing in more detail the biodiversity and ecosystem of mangrove forests, which is relatively brief at the moment. In addition, despite its popularity among the participants, transplantation programs in QNR should be restricted in the future as it will reduce the mudflat areas that many birds prefer to feed. As an alternative program, the Project developed a module “Mangrove monitoring”, where the participants will be involved in mangrove monitoring activities. The following environmental education programs were also conducted with the support of the JICA Expert Team.

b. Environmental education programs conducted with schools

Many of the environmental education programs were conducted at QNR by receiving school children from different schools in Muscat. In the regional areas, an environmental education program was conducted in Shamukh school of Duqm in May 2013, in which C/P explained the importance of mangroves and mangrove ecosystem. Prior to the program, mangrove seedling plantation was conducted in the Durf site. In Salalah, Indian school children enjoyed bird watching and mangrove seedling transplanting in February 2013. In addition, the “First Family Forum” was held by the Ministry of Education in Mutrah school in April 2013, and MECA staff conducted environmental education activities such as environment quiz, jigsaw puzzle game, and picture drawing.

c. Environmental education programs conducted with private companies

On the occasion of the World Wetlands Day in February 2013, employees of a construction company were invited to the event, and they conducted mangrove seedling planting and cleaning activity at QNR. In May and November 2013, Al Bustan Palace Hotel employees participated in education programs at QNR, which included explanation of mangroves, observing nursery and mangrove forest, bird watching, mangrove plantation, and cleaning activity. Later, the hotel guests of Al Bustan Palace

Hotel were also invited to QNR, and participated in similar activities. Potential for ecotourism was realized through such experiences.

2) Improvement of environmental education program

In order to diversify and improve the existing education program, the Project developed new education materials and tools. For example, nature games and/or environment quiz related to mangrove ecosystem were developed, which was aimed for the participating children to understand in more detail the mangrove ecosystem. Newly purchased equipment was also used effectively. For example, bird watching activity was more effectively conducted by using new telescopes and binoculars, as well as by distributing photo sheet of common birds. Furthermore, participants were able to transplant mangrove seedlings in correct way, by following the procedures set out in the brochure of mangrove seedling plantation. Table 2.5.6 lists the environmental education programs conducted during the Project and improvements made through Project.

Table 2.5.6 Environmental education programs and main improvements made during the Project

No	Date	Type of event	Contents of the program	Target group (no. of participants)	C/Ps	Materials used	Points of improvement
1	February 6, 2012	World Wetlands Day	Environmental education program on mangroves and their ecosystem at the QNR	Students of Omani, International, Indian, and Philippine schools (more than 200 students)	Dr. Ahmed, Badar, and Aida	Nature game set 1 & 2, drawings & puzzle supplied by Ramsar	1) Conducting nature games 2) Conducting a questionnaire survey as feedback.
2	February 18, 2012	Mangrove trees transplantation campaign	Environmental education program on mangroves and their ecosystem at the QNR	Primary school students of the American International School, Muscat (60 students)	Badar		
3	February 20, 2012	Mangrove trees transplantation campaign	Environmental education program on mangroves and their ecosystem at the QNR	Kindergarten of the American International School, Muscat (40 children + parents)	Badar		
4	February 22, 2012	Lecture on mangroves & mangrove ecosystem	Introduction of mangroves & mangrove ecosystem in Oman	Students of SQU (25 students)	Badar	Mangroves in the Sultanate of Oman (MECA)	
5	October 20, 2012	Educational Site Visit at QNR	Introduction of mangroves & mangrove ecosystem in Oman	Primary school students from British School Muscat (40 children)	Badar, Aziza and Mohammed	Mangrove quiz (type 1)	Conducting mangrove quiz.
6	January 8, 2013	Plantation & Env. Education at Shinas	Introduction of Mangroves & Mangrove ecosystem in Oman	Members of Oman Women Society (15 members + 15 children) Students of Sohar University (10 male and 25 female).	Badar, Mohammed Al Booti (Shinas)	Mangrove quiz (type 2)	
7	February 2, 2013	World Wetlands Day	Introduction of mangroves & mangrove ecosystem, mangrove transplantation, bird watching, environmental game.	Students of Omani schools and students of SQU (Total of around 80.)	Badar, Aida and Aziza	Photo list of birds, telescopes, drawings & puzzle supplied by Ramsar	Conducting bird watching by using donated equipment and newly prepared photo list.
8	February 7, 2013	Environment day at Qurayat	1) Mangrove transplantation 2) Children programs (quiz and games) 3) Presentation on wetlands and mangroves	1) Local students (around 40) 2) Many local children 3) Staffs of different ministries (30 - 40 attendants)	Dr. Ahmed, Badar, Aida, and Aziza	Mangrove quiz (type 1)	
9	February 17, 2013	Plantation & Environmental Education at Salalah	Introduction of mangroves & mangrove ecosystem, mangrove transplantation, and bird watching.	Students of Indian school (around 40)	Badar, Issam (Salalah)	Photo list of birds in Salalah, Telescope	Conducting bird watching at Salalah by using donated equipment and photo list prepared by CPs.
10	April 30, 2013	Environmental Education at Mutrah	Event conducted by Ministry of Education	Many local children	Aida	Environmental quiz, jigsaw puzzle, and	

No	Date	Type of event	Contents of the program	Target group (no. of participants)	C/Ps	Materials used	Points of improvement
		school				drawings	
11	May 14 - 17, 2013	Plantation & Environmental Education at Duqm	1) Mangrove transplantation and bird watching 2) Presentation on mangroves to children	1) Students of elementary & secondary schools (13) 2) School children (55)	Badar, Aida	1) Brochure of mangrove transplantation, telescope 2) PPT & movie	Using transplantation brochure with drawings. Using donated equipment at Duqm, Wusta.
12	May 20, 2013	Environmental Education at QNR	Introduction of mangroves & mangrove ecosystem, mangrove transplantation, bird watching and cleaning.	Staffs of Al Bustan Palace Hotel (30)	Badar, Aida	QEIC Project brochure, transplanting brochure with drawings, photo list, telescope	Using transplantation brochure with drawings & Photo list. Using donated equipment. Conducting a questionnaire survey.
13	October 30, 2013	Environmental Education at QNR (for cub scouts)	Introduction of mangroves & mangrove ecosystem, fish catching and field bingo.	Cub scouts aged 8 – 10 (35)	Badar	Poster of “Food chain”, photo list, and bingo card	Using poster of “Food chain”. Conducting feedback survey using stickers.
14	November 11, 2013	Environmental Education at QNR (for Hotel staff)	Introduction of mangroves & mangrove ecosystem, mangrove transplantation, bird watching and cleaning.	Staffs of Al Bustan Palace Hotel (11)	Badar	Posters of “Mangrove forests in Oman” and “Food chain”. Brochure on mangrove ecosystem, photo list, and telescope.	Using poster of “Mangrove forests in Oman”. Distributing brochure on mangrove ecosystem. Conducting feedback survey
15	November 11, 2013	Environmental Education at QNR (for HTC students)	Introduction of mangroves & mangrove ecosystem, showing monitoring equipment, and bird watching.	Female students of Higher Tech College (17) with 2 teachers	Badar, Mohammed	Posters of “Mangrove forests in Oman” and “Food chain”. Brochure on mangrove ecosystem, photo list, and telescope.	- ditto -
16	November 13, 2013	Environmental Education at QNR (for GCC sports women)	Introduction of mangroves & mangrove ecosystem, mangrove transplantation, bird watching and cleaning.	Women’s sports organization in GCC (50 participants)	Badar, Aida	- ditto -	- ditto -
17	November 25, 2013	Environmental Education at QNR (for Guests and staff of Al Bustan Hotel)	Introduction of mangroves & mangrove ecosystem, mangrove transplantation, bird watching and cleaning.	Guests and staffs of Al Bustan Palace Hotel (around 25 participants)	Badar, Aida	Posters of “Mangrove forests in Oman” and “Food chain”. photo list, and telescope.	Using poster of “Mangrove forests in Oman”. Conducting feedback survey.
18	November 25, 2013	Environmental Education at QNR (for International Volunteers)	Introduction of mangroves & mangrove ecosystem, mangrove transplantation, bird watching and cleaning.	International Volunteers in Arab countries (around 40 participants)	Badar, Aida	- ditto -	- ditto -

Prepared by JICA Expert Team

3) Monitoring and evaluation of environmental education program

Evaluation of environmental education program is important to identify its effectiveness as well as aspects that require improvement. Since MECA had no established method for program evaluation, the Project introduced different types of evaluation method such as questionnaire, putting-a-sticker method and evaluation quiz. The evaluation formats along and results of questionnaire survey are attached to the Technical Document 5 “Guideline for Development of Environmental Education Program”. Table 2.5.7 shows the feedbacks obtained through the program evaluation conducted by the Project.

Table 2.5.7 Feedbacks obtained through the program evaluation conducted by the Project

No	Date	Target group	Method of evaluation	Feedback
1	FEB. 6, 2012	Students of Philippine school	Questionnaire	<ul style="list-style-type: none"> - Learnt many things about mangroves. - Should provide boots / protective gloves.
2	MAY 20, 2013	Employees of Al Bustan Palace Hotel	Questionnaire	<ul style="list-style-type: none"> - Learnt many things about mangroves. - Should put more sign boards and info around the reserve - Set the activity in winter time.
3	OCT. 30, 2013	Cub scouts	Putting-sticker	<ul style="list-style-type: none"> - Playing in the mud and catching fish were very popular activities.
4	NOV. 11, 2013	Employees of Al Bustan Palace Hotel	Questionnaire	<ul style="list-style-type: none"> - Bird watching was very interesting. - Want to attend the activity again.
5	NOV. 11, 2013	Students of HTC (Higher Tech College)	Questionnaire	<ul style="list-style-type: none"> - Irrigation system and animals of mangrove forest were interesting. - Need to build more boardwalk.
6	NOV. 13, 2013	GCC sports women	Questionnaire	<ul style="list-style-type: none"> - Learnt new information about mangroves. - Seeing the animals was interesting.
7	NOV. 25, 2013	Employees and guests of Al Bustan Palace Hotel	Questionnaire	<ul style="list-style-type: none"> - Great experience. - Want to attend the activity again.
8	NOV. 25, 2013	International Volunteers in Arab countries	Questionnaire	<ul style="list-style-type: none"> - Planting mangrove trees was interesting. - More time is needed. - Add a boat tour

Prepared by JICA Expert Team

The planned environmental education programs were revised in accordance to the obtained feedback as shown in Table 2.5.8.

Table 2.5.8 Main revisions of the environmental education programs

Item	Revised points
Content of program	Posters were prepared to enhance understanding of mangrove ecosystem.
	Field activities such bird watching, fish collection, kayak tours were incorporated.
	Quiz and games were prepared to enhance understanding of mangrove ecosystem
Materials	Photo sheets of birds, fish, crabs were prepared to enhance understanding of the biodiversity of mangrove ecosystem.
Timing	Programs involving field activities were planned in winter seasons.
Equipment	Boots and gloves were purchased to enhance safety during field trips and plantation activities.
Evaluation	Methods of evaluation were developed to obtain opinions from participants and further improvement of the programs.

Prepared by JICA Expert Team

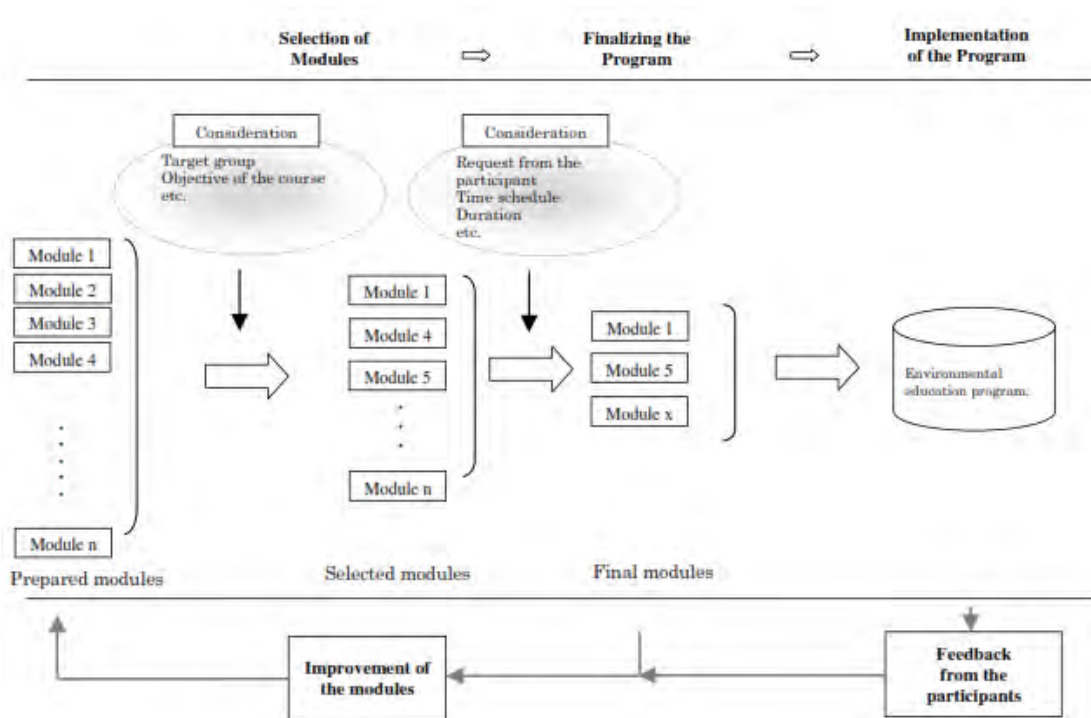
4) Development of environmental education program

Environmental education programs should be developed flexibly by considering factors such as the objective, target group and season. The programs should also be reviewed and amended based on feedbacks from the participants. The Project developed various modules, which can be combined to establish a full program. Each module is attached with an activity sheet, which describes expected target group and goal of the program, timetable, and materials to be used, so as to conduct the module effectively (see “Guideline for Environmental Education Program” for the activity sheet). Table 2.5.9 shows the outline of the developed modules. Figure 2.5.1 shows the flow of program formulation and evaluation, by using the developed modules. As the first step, suitable modules will be selected from the proposed program modules with meeting these requirements. Then, considering the contents of program and time limitation, the program will be finalized. Feedback to the program is also very important, and some kind of program evaluation will be included to the program. The result of program evaluation will be analyzed, which will be utilized to improve existing education program and/or to create a new education program in future.

Table 2.5.9 Outline of the developed modules

No	Module name	Contents	Objective	Target group	Timing
1	Nature game: Role play	Teaching the relationship of each component of mangrove ecosystem through role play using drawings of the components.	Understanding relationship of components of mangrove ecosystem	Students	Throughout the year
2	Nature game: Searching cards	Searching cards and making a sentence which describes characteristics of mangrove.	Understanding mangroves	Students	Throughout the year
3	Card puzzle	Completing a photo of common birds of mangrove forest by combining pieces of the photo.	To learn common birds of mangrove forest	Any target group	Throughout the year
4	Jigsaw puzzle	Completing a drawing of mangrove ecosystem by combining jigsaw puzzle pieces.	To learn animals of mangrove ecosystem	Any target group	Throughout the year
5	Field bingo	Field bingo card including mangrove, fish, crab, shrimp, shell, and bird as components of mangrove ecosystem.	To learn animals of mangrove ecosystem	Any target group	Except for summer
6	Mangrove quiz	Asking questions regarding mangroves and mangrove ecosystem.	Understanding mangroves and mangrove ecosystem	Any target group	Throughout the year
7	Bird watching	Observing birds in mangrove forest.	To learn common birds of mangrove forest	Any target group	Except for summer
8	Fish catching	Catching fish and other aquatic fauna by using cage or seine net.	To learn common aquatic fauna of mangrove forest	Students	Throughout the year
9	Mangrove cultivation in a plastic bottle	Growing a mangrove seedling by hydroponics using a plastic bottle.	Understanding mangrove growth process	Any target group	July – Sep. (when seeds are available)
10	Drawing competition	Drawing a painting of mangroves and mangrove ecosystem.	Understanding mangroves and mangrove ecosystem	Students	Except for summer
11	Introduction of mangrove ecosystem	Explanation of mangroves and mangrove ecosystem, and observing them.	Understanding mangroves and mangrove ecosystem	Any target group	Except for summer
12	Introduction of mangrove nursery	Explanation of mangrove nursery and important points of seedling transplantation.	To learn how to plant mangrove seedlings	Any target group	Except for summer
13	Mangrove plantation	Planting mangrove seedlings and monitoring their growth by tagging.	To learn how to plant mangrove seedlings	Any target group	October - April
14	Observation of planted seedlings	Observing planted mangrove seedlings at the planted site.	Understanding mangroves	Any target group	Except for summer
15	Cleaning	Cleaning the planted site, and observing the planted seedlings.	Maintaining growing environment of mangroves	Any target group	Except for summer
16	Mangrove monitoring	Participants will select a mangrove tree to monitor its growth. Participants will receive a certificate for their tree.	Enhancing awareness to conserve mangrove forest	Any target group	Except for summer

Prepared by JICA Expert Team



Prepared by JICA Expert Team

Figure 2.5.1 Flow of program formulation and evaluation

The Project formulated sample environmental education programs for each target group and for request-based programs in QNR by combining suitable modules. Tables 2.5.10-2.5.13 show the formulated programs.

Table 2.5.10 Example of environmental education program for primary schools (conducted at school)

Time	Activity	Module no.*	Required materials	Venue
09:00 – 09:10	Introduction of mangrove forest in Oman	11	Poster	Class room
09:10 – 09:40	Understanding mangrove ecosystem through role play	1	Card	Class room
09:40 – 10:00	Understanding animals of mangrove ecosystem	3	Card puzzle	Class room
10:00 – 10:15	Evaluation by participants		Feedback sheet	Class room

*: Details of the module are described in Table 2.5.9.

Prepared by JICA Expert Team

**Table 2.5.11 Example of environmental education program for private companies
(conducted at QNR)**

Time	Activity	Module no.*	Required materials	Venue
09:00 – 09:10	Introduction of mangrove forests in Oman	11	Poster	Shade hall
09:10 – 09:20	Understanding food chain in mangrove ecosystem	11	Poster Brochure	Shade hall
09:20 – 09:30	Visiting mangrove nursery	12	-	Nursery
09:30 – 09:45	Observing mangrove forest	11	Photo list	Boardwalk
09:45 – 10:15	Monitoring of mangrove	16	Tree measure	Mangrove area
10:15 – 10:30	Evaluation by participants		Feedback sheet	Shade hall

*: Details of the module are described in Table 2.5.9.

Prepared by JICA Expert Team

**Table 2.5.12 Example of environmental education program for local community
(conducted at mangrove plantation site)**

Time	Activity	Module no.*	Required materials	Venue
09:00 – 09:15	Introduction of mangrove forests in Oman	11	Poster	Planting site
09:15 – 09:30	Understanding food chain in mangrove ecosystem	11	Poster Brochure	Planting site
09:30 – 09:40	Planting mangrove seedlings	13	Brochure	Planting site
09:40 – 09:50	Cleaning the planting site	15	-	Planting site
09:50 – 10:00	Evaluation by participants		Feedback sheet	Planting site

*: Details of the module are described in Table 2.5.9.

Prepared by JICA Expert Team

**Table 2.5.13 Example of environmental education program for request-based programs in
QNR**

Time	Activity	Module no.*	Required materials	Venue
09:00 – 09:10	Introduction of mangrove forests in Oman	11	Poster	Shade hall
09:10 – 09:20	Understanding food chain in mangrove ecosystem	11	Poster Brochure	Shade hall
09:20 – 09:30	Visiting mangrove nursery	12	-	Nursery
09:30 – 09:45	Observing mangrove forest	11	Photo list	Boardwalk
09:45 – 10:15	Bird watching	7	Photo list, telescope	Mudflat
10:15 – 10:30	Evaluation by participants		Feedback sheet	Shade hall

*: Details of the module are described in Table 2.5.9.

Prepared by JICA Expert Team

5) Cost of environmental education program

The main costs required for environmental education are: gifts and food/drinks that will be provided to the participants, and cost for producing education materials. The cost for gifts and food/drinks was estimated by assuming that the annual total number of participants is 500 persons (see Table 2.5.14). According to the estimation, the annual cost will be around US\$ 17 per person. The cost required for producing education materials was estimated to be around US\$ 4,600 per year, which is mainly printing cost (see Table 2.5.15).

Table 2.5.14 Annual cost required for implementing environmental education program (gifts and food/drinks)

No	Item	Number	Unit cost (RO)	Total cost (RO)	Total cost (US\$)
1	T-shirt	500	1.775	887.500	2,307.5
2	Cap	500	0.750	375.000	975.0
3	Bag	500	0.600	300.000	780.0
4	Drinks	500	0.150	75.000	195.0
5	Snacks	500	0.500	250.000	650.0
6	Cup	200	2.000	400.000	1,040.0
7	Crystal gift	10	12.000	120.000	312.0
	TOTAL	—	—	2,407.500	6,259.5

Note: Calculated at rate of 1 R.O. = US\$ 2.6

Prepared by JICA Expert Team

Table 2.5.15 Annual cost required for implementing environmental education program (production of education materials)

No	Item	Number	Unit cost (RO)	Total cost (RO)	Total cost (US\$)
1	Poster	3	30.000	90.000	234.0
2	Poster (panel)	3	40.000	120.000	312.0
3	Rollup banner	4	50.000	200.000	520.0
4	Brochure	500	1.000	500.000	1,300.0
5	Puzzle	200	2.000	400.000	1,040.0
6	Color paper	200	0.600	120.000	312.0
	TOTAL	—	—	1,770.000	4,602.0

Note: Calculated at rate of 1 R.O. = US\$ 2.6

Prepared by JICA Expert Team

The budget for the QEIC 8-year Operation Plan was prepared based on the above cost estimation.

6) Schedule of environmental education program

When planning the content and schedule of environmental education program, it is important to consider factors such as: mangrove reproductive cycle (e.g. timing of flowering), transplantation season, bird migratory season and weather conditions. Outdoor activities are especially unsuitable during the summer season due to high temperatures. Table 2.5.16 shows the period suitable for implementing the developed modules.

Table 2.5.16 Period suitable for implementing the developed modules

Module	1	2	3	4	5	6	7	8	9	10	11	12
	Transplanting			Flowering			Seed collection				Transplanting	
Nature game: Role play												
Nature game: Searching cards												
Card puzzle												
Jigsaw puzzle												
Field bingo												
Transplanting												
Mangrove quiz												
Bird Watching												
Fish Catching												
PET Bottle Cultivation												
Drawing / Sketching												
Introduction of mangrove ecosystem												
Introduction of mangrove nursery												
Mangrove plantation												
Observation of planted seedlings												
Cleaning												
Mangrove monitoring												

Prepared by JICA Expert Team

Table 2.5.17 shows the proposed implementation frequency of environmental education programs for each target group. The detailed schedule is shown in the QEIC 8-year Operation Plan.

Table 2.5.17 Proposed implementation frequency of environmental education programs

Category	Target	Frequency
Programs for primary schools	Schools in Muscat	5 schools/year
	Schools in six coastal regions	2 schools/region/year
Programs for private sector	e.g. service, transportation, waste sectors	Once a year for each sector
Programs for local community	7 coastal regions (Musandam, North Batinah, South Batinah, Muscat, Sharqiyah, Al Wusta, Dhofar)	1 community/region/year
Request-based programs in QNR	All target groups	Around eight times a year

Prepared by JICA Expert Team

7) Guideline for Development of Environmental Education Program

Technical Document 5 “Guideline for Development of Environmental Education Program” was prepared through the Project, which describes the procedures for developing education materials and programs, and also provides examples prepared through the Project (the prepared education materials are included in the CD attached to the Guideline).

2.5.5 Publication materials (PDM activity: 4.4)

The Project prepared various publication materials including: brochures/booklets to disseminate Project activities and conservation of mangrove forest and ecosystem. Table 2.5.18 shows the outline of the prepared publication materials. A hard copy of the publication materials is attached as Appendix 9 in a separate folder.

Table 2.5.18 Outline of the prepared publication materials

No	Title	Format	Content
1	QEIC Project	Brochure	The brochure introduces the background and outline of the QEIC Project.
2	Introduction of Mangrove Ecosystem	Brochure	The brochure provides brief explanations on mangrove trees, mangrove ecosystem, its benefits and the threats that these mangrove ecosystem face. This brochure is a useful handout for public awareness and education programs.
3	Mangrove Forest in Oman	Booklet	The booklet introduces characteristics of different mangrove forests in Oman.
4	Introduction of Mangrove Ecosystem	Booklet	The booklet provides basic information on mangrove trees, mangrove ecosystem, its benefits and the threats that these mangrove ecosystem face. It can be used for environmental education as well as a text book for QEIC staff and trainees.
5	Introduction of Mangrove Ecosystem (for children)	Booklet	The booklet introduces the characteristics of mangrove ecosystem through using many illustrations. It is mainly intended for children.
6	Animals of Mangrove Forest in Oman	Booklet	The booklet provides basic information on the common fauna (fish, crabs, shells, birds) that are found in mangrove forests of Oman.
7	Animals of Mangrove Forest in Oman	Photo sheet	The photo sheet shows the common animals of mangrove forest in Oman. It can be used in the field during environmental education, so to assist the participants identify the animals they encounter.
8	Basic Procedure of Mangrove Seedling Transplanting	Brochure	The brochure explains the basic procedures of seedling transplantation. It shows both good and bad examples by illustration, so that even small children can understand easily.
9	QEIC Newsletter (No. 1-4)	Brochure	The QEIC Newsletter was published four times during the Project, introducing the various Project activities conducted during the process.

Prepared by JICA Expert Team

2.5.6 Exhibition plan (PDM activity: 4.7)

Three exhibition halls will be established inside QEIC, with an area of 200 m² each. The main objective of the exhibition is to introduce to the public and children the characteristics and values of mangrove ecosystem, in a manner that will be clear even for visitors who have little background knowledge. The exhibition also aims to enhance visitors understanding on the present situation of mangrove forests in Oman and the importance of conserving the precious natural resources of the country. Although the exhibition of QEIC will be developed by contracting a private company, the Project compiled “QEIC Exhibition Plan” which describes the basic content and exhibition methods for QEIC (see Appendix 10).

1) Contents of exhibition

The exhibition of QEIC will mainly focus on introducing the following topics:

- Characteristics of mangrove tree
- Characteristics of mangrove ecosystem
- Benefits of mangrove ecosystem
- Threats to mangrove ecosystem
- QEIC's activities to protect mangrove ecosystem

Table 2.5.19 shows the proposed content of the QEIC exhibition.

Table 2.5.19 Proposed content of the QEIC exhibition

No	Topic	Proposed content
1	Characteristics of mangrove tree	What is mangrove?
		Mangrove diversity
		Mangrove distribution in Oman and the world
		Characteristics of <i>Avicennia marina</i>
		Adaptation to stressful environment (high salinity, low oxygen)
		Reproduction of mangrove (viviparous seeds)
2	Characteristics of mangrove ecosystem	Fish (e.g. main types, what they eat, many juvenile fish)
		Crabs (e.g. main types, main habitats, what they eat)
		Snails (e.g. main types, main habitats, what they eat)
		Birds (e.g. residential and migratory birds, migratory route/season)
		Other fauna (worms, insects, microorganisms)
		Food chain of mangrove ecosystem
3	Benefits of mangrove ecosystem	Provides precious greenery
		Nursery for various fauna
		Feeding and resting area for birds
		Coastline protection
		Place for relaxation
		Potential source of income for locals (e.g. ecotourism, honey production)
		Water purification
		CO ₂ fixation
4	Threats to mangrove ecosystem	Animal grazing
		Overgrowth of algae
		Intrusion of invasive species
		Coastal development (e.g. ports and roads)
		Discharge of wastewater
		Waste dumping
5	QEIC's activities to protect mangrove ecosystem	Plantation activity
		Environmental education activity
		Training activity
		Monitoring activity

Prepared by JICA Expert Team

Presentation methods should be considered by referring to similar exhibition events and facilities. The Project has provided some examples in the "Exhibition Plan for QEIC", by referring to Yoesu EXPO in Korea and visitor centers in Japan.

2) Permanent and special exhibition

QEIC should have two types of exhibition: permanent exhibition and special exhibition. The permanent exhibition will focus on presenting basic information regarding mangroves and mangrove ecosystem (such as proposed in the previous Section), so that visitors are able to obtain a basic understanding of the subject. On the other hand, the special exhibition provides more detailed information and/or more advanced knowledge that cannot be covered by the permanent exhibition, and should be updated regularly to attract repeaters. Holding of special events will also be an option of special exhibition. For the special exhibition, it may be necessary to cooperate with other exhibitions and organizations, as information within QEIC may be limited for certain themes. Table 2.5.20 shows proposed themes for QEIC's special exhibition.







Table 2.5.20 Proposed themes for QEIC's special exhibition

Category	Contents
Detailed information on animals of mangrove ecosystem	Introduction of migratory birds in Oman and in Middle East region
	Introduction of animals in mangrove forests in Oman and in the Middle East region
	Introduction of animals in mangrove forests of the world
	Introduction of microorganism and insects in mangrove forests
Advanced knowledge on mangroves	Latest information on physiology and ecology of mangroves
	Introduction of mangrove forests in Oman and in the Middle East region
	Introduction of mangrove forests of the world
	Introduction of how mangroves have been used in people's life.
Progress of QEIC activities	Introduction of results of monitoring and research activities
	Introduction of threats to mangrove ecosystem and implemented conservation measures.
	Results of environmental education events.
Events	Photo, drawing, and poster competition with public participation
	Handy craft and/or dyeing workshop using mangroves
	Presentation of research activities regarding mangrove ecosystem
	Cooking class using animals and plants in mangrove forests

Prepared by JICA Expert Team

3) Utilization of worksheet

A worksheet contains questions related to an exhibition material, so as to enhance visitors understanding of the topic. Through answering questions of the worksheet, the visitors can learn in more depth and also observe exhibition materials more actively, not passively. The questions of worksheet shall be determined based on the contents of exhibition material. Figure 2.5.2 is a sample work sheet.

Write the name of the following animals and plants which are displayed in the center.	
 1) _____	 2) _____
 3) _____	 4) _____
 5) _____	 6) _____

Prepared by JICA Expert Team

Figure 2.5.2 Sample worksheet

4) Maintenance of exhibition

Exhibition facilities (e.g. aquarium) and materials (e.g. dioramas and animal specimen) must be maintained regularly. A maintenance manual and training program should be provided to QEIC staff by the contractor of the exhibition.

2.5.7 Issues and recommendations

Following are issues and recommendations for future QEIC activities:

- To improve the current program at QNR, greater emphasis should be placed on introducing in more detail the biodiversity and ecosystem of mangrove forests, which is relatively brief at the moment. In addition, despite its popularity among the participants, transplantation programs in QNR should be restricted in the future as it will reduce the mudflat areas that many birds prefer to feed. Therefore, an alternative program should be developed.
- Environmental education programs should be expanded to the regional areas in the future, where MECA's regional staffs are expected to become as facilitators. Hence, training programs should be implemented to enhance the capacity of the regional staffs.
- To keep the education programs attractive and attract repeat visitors, the education materials and programs should be constantly updated by regularly monitoring and evaluating the existing programs.
- MECA plans to expand the existing boardwalk and establish a new observation hut for bird watching at QNR. At that time, signboards with descriptions of the fauna and ecosystem should be set-up at appropriate locations. Other facilities such as toilets and garbage boxes should also be installed.
- It is recommended to visit and observe similar exhibitions such as the Mangrove Information Center in Bali, Indonesia. Such experiences will be useful when planning the exhibition of QEIC.

2.6 Database and website of QEIC

2.6.1 Database

Vast amount of data will be accumulated through future QEIC activities. In order to effectively utilize these data, they should be stored and managed in a systematic manner by establishing a database system. The database should be managed by the IT Section of QEIC. For QEIC, the following database should be established:

- Monitoring database
- Mangrove site database
- Fauna database
- Photo database

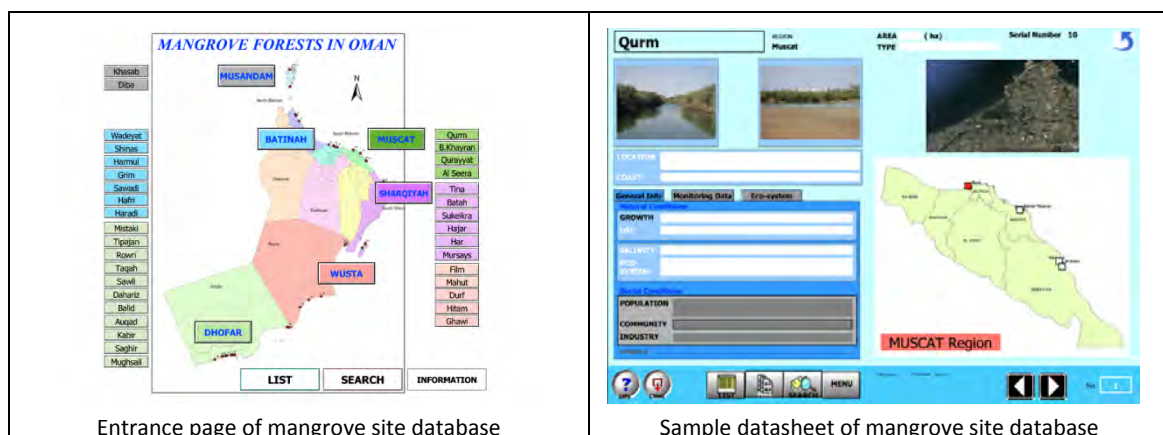
The following Sections describe the proposed contents of each database.

1) Monitoring database

The monitoring database stores and manages the data collected through the “Mangrove ecosystem monitoring” and “Transplanted-seedling monitoring” programs. The database will be utilized mainly for data searching purposes. Analysis works should be conducted with Excel.

2) Mangrove site database

The mangrove site database stores relevant information of all the mangrove sites in Oman. It includes information such as: site photographs, satellite image, surface area, number of planted seedlings, natural and social conditions, and so on. Figure 2.6.1 shows an image of the mangrove site database (the database file (File Maker) is included in the attached CD Appendix 11).

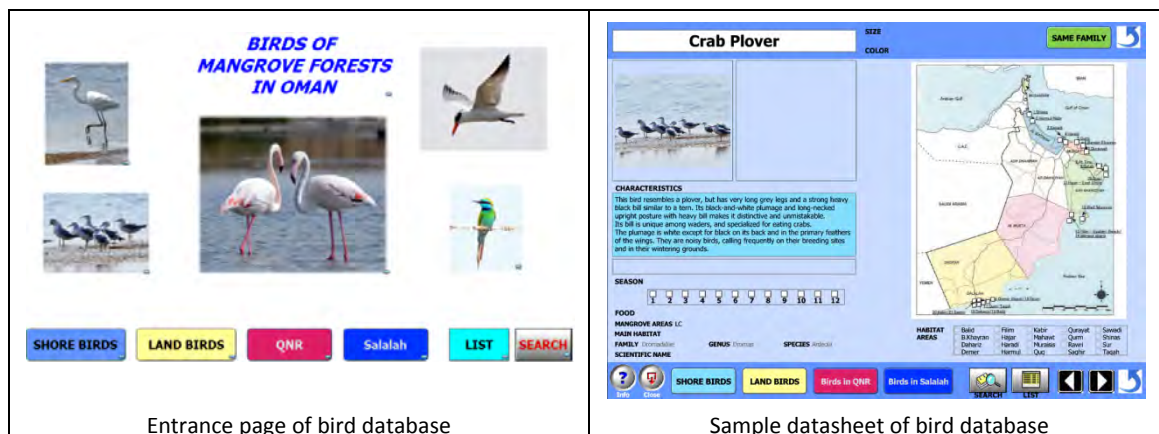


Prepared by JICA Expert Team

Figure 2.6.1 Image of mangrove site database

3) Fauna database

The fauna database stores information on mangrove fauna such as birds, fish, crabs and shells. It will include information such as: photographs, ecological characteristics and identified sites. Figure 2.6.2 shows an image of the fauna database (the database file (File Maker) is included in the attached CD Appendix 11).

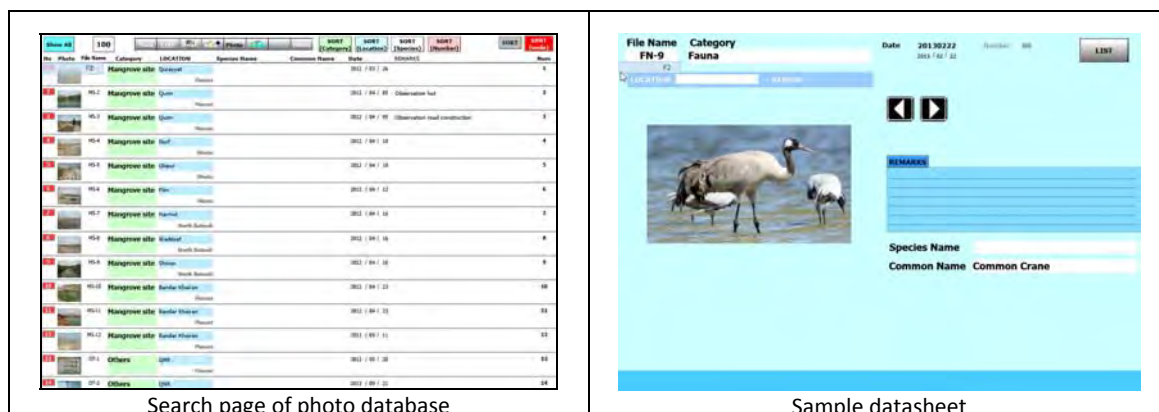


Prepared by JICA Expert Team

Figure 2.6.2 Image of fauna database (in case of bird)

4) Photo database

Photographs taken through QEIC activities (e.g. photos of mangrove and fauna) should be stored in a common database, so that they can be easily searched later and used for exhibition and other purposes. The photos that were taken by the C/P and JICA Expert Team were compiled into a database, which can be searched by date, location, category and so on. Figure 2.6.3 shows an image of the photo database (the database file (File Maker), photo files and photo list (Excel) are included in the attached CD Appendix 11).



Prepared by JICA Expert Team

Figure 2.6.3 Image of photo database

While the above mentioned database will be developed by contracting a private company, the Project prepared a table (Table 2.6.2) that summarizes the necessary basic information (e.g. data type, quantity, format) required for establishing the QEIC database.

Table 2.6.1 Basic information for establishing QEIC database

Category	Item	Parameter	Data specification						Media	
			No. of parameter	No. of sites	No. of station	No. of layer	Frequency	Format		
Monitoring	Mangrove survey	Tree growth	Height, diameter	2	32	5/site	-	1/year	Digit	EXCEL
		Tree health	Health	1	32	5/site	-	1/year	Letters	EXCEL
	Fauna survey	Fauna inventory	Fish, crab, snail, bird	4	32	-	-	-	Letters	EXCEL
		Survey of indicator species	Fish, crab, snail, bird	4	32	5/site	-	2/year	Digit	EXCEL
	Environmental condition survey	Water quality	Temp., salinity, pH, DO, COD, NO ³⁻ , NO ²⁻ , NH ⁴⁺ , PO ₄ ³⁻	9	32	5/site	2/site	2/year	Digit	EXCEL
		Soil quality	Texture, color, temp, ORP, EC, salinity, pH, NO ₃ ⁻ , PO ₄ ³⁻	9	32	5/site	2/site	2/year	Digit	EXCEL
		Topography	Sedimentation	1	32	5/site	-	6/year	Digit	EXCEL
			Photo	1	32	5/site	-	6/year	JPEG	Photo folder
	Water level	Level	1	32	5/site	-	6/year	Digit	EXCEL	
	Inspection survey	Visual inspection	Impact factors	1	32	-	-	6/year	Letters	EXCEL
	Transplanted-seedling survey	Seedling growth	Height, diameter	2	32	5/site	-	12/year	Digit	EXCEL
		Seedling health	Survival rate	1	32	5/site	-	12/year	Digit	EXCEL
Environmental condition		Water and soil quality	18	32	5/site	2/site	12/year	Digit	EXCEL	
Mangrove site	General	Location	Coordinates	1	32	-	-	1/2-3years	Digit	EXCEL
		Surface area	-	-	32	-	-	1/2-3years	Digit	EXCEL
		Satellite image	-	-	32	-	-	1/2-3years	JPEG	GIS
	Plantation performance	Location	Coordinates	1	32	-	-	1/2-3years	Digit	EXCEL
		Surface area	-	1	32	-	-	1/2-3years	Digit	EXCEL
		No. of seedling	-	1	32	-	-	-	Digit	EXCEL
	Natural condition	Meteorology	Temp., wind direction/speed	3	32	-	-	-	Digit	EXCEL
		Hydrology	Water exchange, wave	2	32	-	-	-	Letters	EXCEL
		Intertidal zone	Slope, width	2	32	-	-	-	Letters	EXCEL
		Soil	Soil depth and quality	5	32	-	-	-	Letters	EXCEL
		Water quality	Salinity, DO	2	32	-	-	-	Digit	EXCEL
		Fauna	-	-	32	-	-	-	Letters	EXCEL
	Social condition	Animal grazing	-	-	32	1/site	-	-	Letters	EXCEL
		Land use	-	-	32	1/site	-	-	Letters	EXCEL
		Development plan	-	-	32	1/site	-	-	Letters	EXCEL
Fauna	Bird	Photo, identified sites, ecological characteristics	3	32	-	-	-	Letters, JPEG	EXCEL, Photo folder	
	Fish									
	Crustacean									
	Gastropod									
Photo	Fauna	Fish, bird, crab etc.	Name, date, location	3	-	-	-	-	JPEG	Photo folder
	Mangrove site	-	Date, location	2	-	-	-	-	JPEG	Photo folder
	Activity	QEIC activities	Training, monitoring, plantation, education	4	-	-	-	-	JPEG	Photo folder
	Others	Other photo	-	-	-	-	-	-	JPEG	Photo folder

Prepared by JICA Expert Team

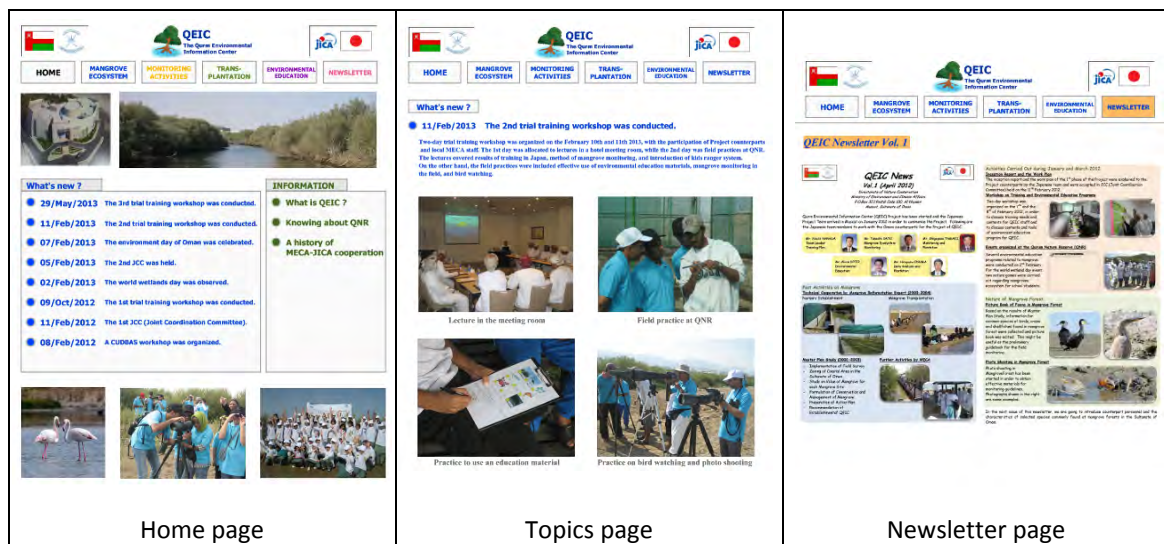
The mangrove site and fauna database may also be utilized by the visitors of QEIC exhibition, by for example using touch panel. The database may also be used in the field by downloading onto tablet-type PC such iPad.

2.6.2 Website

In general, the data acquired through QEIC activities will be publicized through QEIC website. Following are some of the proposed content of the QEIC website:

- Introduction of QEIC and QNR
- Latest news of QEIC activities
- Explanation of the characteristics of mangrove ecosystem
- Information on planned events and exhibition

Figure 2.6.4 shows an image of QEIC website.



Prepared by JICA Expert Team

Figure 2.6.4 Image of QEIC website

2.7 Project training course in Japan and international workshop

2.7.1 Project training course in Japan

The Project organized training courses in Japan for the C/P and MECA staffs, once during each Project phase. Table 2.7.1 shows the outline of the Project training courses. See the report attached as Appendix 12 for details and main outputs of each training course.

Table 2.7.1 Outline of the Project training courses in Japan

	1 st phase	2 nd phase
Objective	To learn methods of conservation and management, monitoring and educational campaigns related to mangrove ecosystem through lectures, practical training and site visits.	To acquire basic knowledge and experience required for implementing mangrove ecosystem monitoring and plantation activities
Period	Nov. 10-Dec. 2, 2012	June 17-July 5, 2013
Participant	- Dr. Ahmed Mubarak Al-Saidi (Director of MECD) - Mr. Badar Al-Balushi (Head of Wetland Environment Section, MECD) - Mr. Issam Al Boosi (MECD, Salalah)	- Mr. Haitham Said Al-farqani (Nature reserve specialist, MECD) - Mr. Mohammed Abood Al-washahi (MECD, Shinas) - Mr. Mohammed Salim Hardan (MECD, Salalah) - Mr. Yareb Ali Khadam Al-Hashmi (MECD, Sur)
Location	Tokyo, Okinawa	Okinawa, Tokyo

Prepared by JICA Expert Team

2.7.2 International workshop

Prior to the end of the Project, an international workshop was held at Crown Plaza Hotel, Muscat, for 3 days (9-11 December 2013). The objective and main participants of the workshop are shown below. The agenda and the participant list are attached as Appendix 13.

Objective:

- To inform about QEIC and share the outputs of the Project activities
- To exchange information regarding mangrove ecosystem conservation and management
- To share expectations for future QEIC activities

Participants:

- Keynote lecturer from Japan: 2
- Invitee from GCC countries: 14 (Kuwait, Saudi Arabia, UAE, Bahrain, Iran, Iraq, Yemen)
- Invitee from international organization: 4 (WWF, Ramsar, UNEP, IUCN)

- Representatives from JICA headquarters: 1
- Representatives from the Embassy of Japan in Oman: 2
- Invitee from related organizations in Oman: 35
- C/P and MECA staff
- JICA Expert Team

During the workshop, the following topics were discussed with the participants at the end of each day:

- Issues of conservation and management of mangrove ecosystem
- Expectations towards future QEIC activities

The main results of the discussions are summarized below:

- Major issues raised by the participants regarding conservation and management of mangrove ecosystem were: insufficient capacity and awareness of staff, lack of staffs and budget, and lack of equipment.
- Based on these issues, the following activities were suggested for QEIC:
 - To offer technical assistance such as for plantation, monitoring and environmental education
 - To collect and store information regarding conservation and management of mangrove ecosystem
 - To conduct activities through cooperation with NGOs and other organizations
 - To actively disseminate conservation and management of mangrove ecosystem through exhibition, environmental education and workshops
 - To provide mangrove seedlings and to conduct plantation

Based on the opinions obtained, it was realized that the expectations from the participants were basically consistent with the activities planned for QEIC.

3. DEGREE OF ACHIEVEMENT OF PROJECT PURPOSE

The degree of achievement of the Project purpose was evaluated from the perspectives of: 1) degree of achievement of PDM outputs, 2) capacity assessment of C/P and 3) results of the Joint Terminal Evaluation. Each evaluation result is described below:

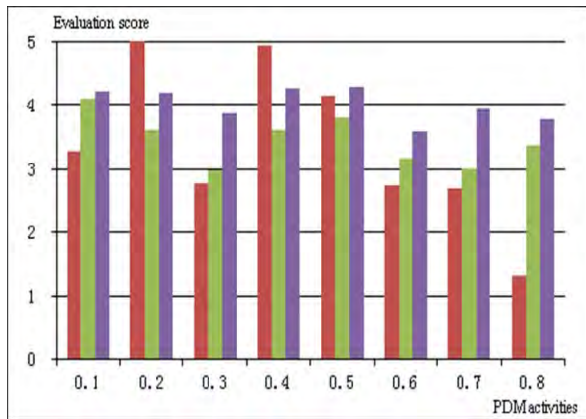
3.1 Degree of achievement of PDM outputs

The degree of achievement of each PDM output was evaluated regularly with the C/P using Work Breakdown Structure⁷ (WBS) method. The PDM activities were broken down into specific tasks and the degree of achievement of each task was evaluated by the C/P using six grades (0: no achievement, 5: achieved) (see Appendix 14 for WBS evaluation table).

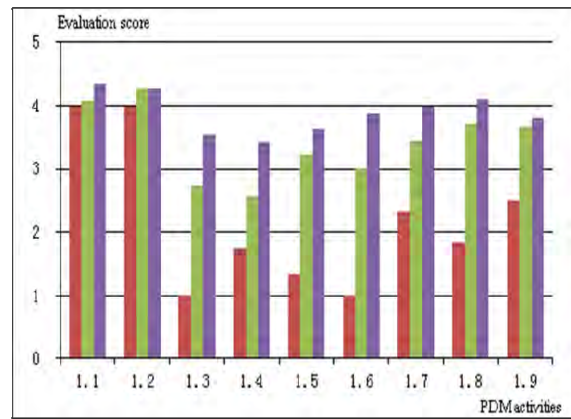
The evaluation was conducted three (3) times: November 2012 (9 months after the Project started), June 2013 (1 year and 4 months after the Project started) and November 2013 (1 month before the end of the Project). The degree of achievement of each PDM output is shown in Figure 3.1.1 (the score is the average of C/P's evaluations).

Note that the evaluation score of some activities is lower in June 2013 compared to November 2012, implying that the progress of these activities have reversed during the course of the Project. However, this is mainly because the second and the third evaluation (June 2013 and November 2013) were conducted under a stricter criteria than the first evaluation (November 2012), and also because some of the activities required re-evaluation in the 2nd Phase based on the results of the 1st Phase activities (note that the PDM activities were not modified).

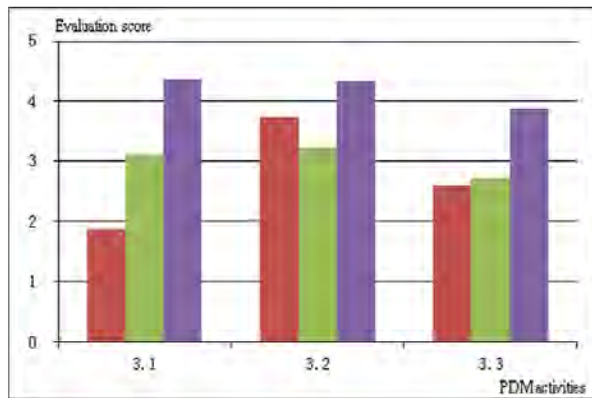
⁷ WBS is a deliverable oriented decomposition of a project into smaller components. It defines and groups a project's discrete work elements in a way that helps organize and define the total work scope of the project.



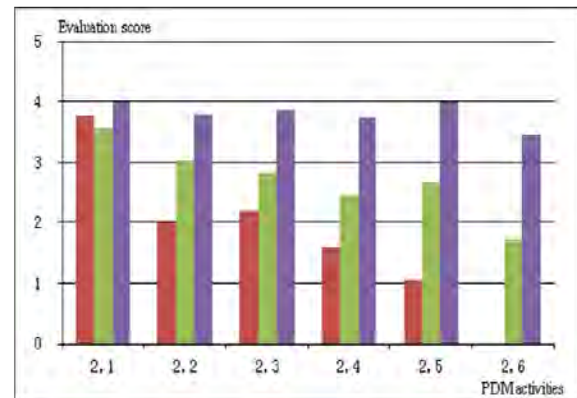
Output 0



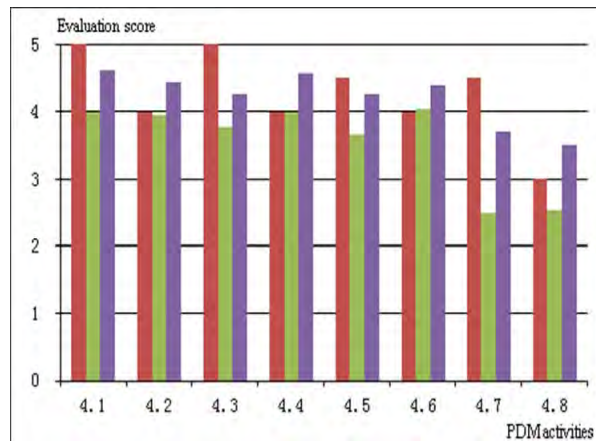
Output 1



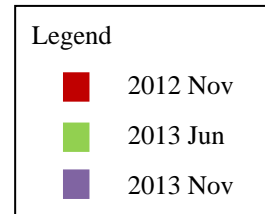
Output 2



Output 3



Output 4



Note: The score in the figure is the average of the C/P (7 members)

Prepared by JICA Expert Team

Figure 3.1.1 Degree of achievement of each PDM output

Since the final evaluation was conducted before the termination of the Project (November, 2013), it was agreed with the C/P that the evaluation should not be scored 5 until it is confirmed through the final report, even if the PDM activity was considered to be at a satisfactory level. Instead, the

evaluation was scored above 4, if the PDM activity was considered to be at a satisfactory level. The degree of achievement of each PDM output is summarized below.

Output 0: PDM activities related to QEIC operation and equipment procurement (Activities 0.3, 0.6-0.8) were scored in the 3 range at the final evaluation. Since then, the QEIC 8-Year Operation Plan was approved by the JCC and also all the equipment was procured. Therefore, it can be considered that Output 0 was achieved.

Output 1: PDM activities related to the training plan was scored in the 3 range at the final evaluation, which was because the training plan was not finalized at that time. However, the outline of the training plan has been discussed and agreed with C/P, and it can be considered that Output 1 will be achieved through the finalization of the training plan.

Output 2: PDM activities related to the monitoring guideline (Activities 2.2-2.4, 2.6) was scored in the 3 range at the final evaluation, which was mainly because the monitoring methods and the guideline were not finalized at that time. However, the outline of the monitoring guideline has been discussed and agreed with C/P, and it can be considered that Output 2 will be achieved through the finalization of the monitoring guideline.

Output 3: At the final evaluation, the score of all PDM activities exceeded 4 except the activity related to Mangrove Protection Guideline (Activity 3.3). However, the outline of the Mangrove Protection Guideline has been discussed and agreed with C/P, and it can be considered that Output 3 will be achieved through the finalization of the guideline.

Output 4: PDM activities related to the exhibition plan (Activity 4.7) and program evaluation (Activity 4.8) were scored in the 3 range at the final evaluation. However, the outline of the exhibition plan has been discussed and agreed with C/P, and it can be considered that Output 4 will be achieved through the finalization of the exhibition plan.

Based on the above evaluation results, it can be concluded that all the PDM outputs have been achieved at a satisfactory level.

3.2 Capacity assessment of C/P

According to JICA's handbook⁸, capacity development is defined as “development process of capacity (to solve the problems) of an individual, organization, system or society by solving the problems or by achieving the goal set by themselves through their roles individually or collectively”. In this Project, capacity assessment was conducted for “Individual” and “Organization”, considering the Project purpose.

⁸ Capacity Development Handbook for JICA staff (2004)

Capacity assessment was conducted by distributing questionnaires (the questionnaires are attached in Appendix 15) to the C/P at the beginning of the Project (February 2012) and before the end of the Project (November 2013), and each C/P rated the capacity level into 5 grades (score 0-4) through self-assessment. Tables 3.2.1 and 3.2.2 show the results of capacity assessment for “Individual” and “Organization” respectively.

Table 3.2.1 Results of the capacity assessment (Individual)

	Item	Feb. 2012	Nov. 2013
Output 1	Technical knowledge and skill on identifying training needs	2.4	3.2
	Technical knowledge and skill on preparing training curriculum	2.2	2.8
	Technical knowledge and skill on preparing teaching material	2.1	3.0
	Administrative capability for training course management	2.2	3.0
	Technical knowledge and skill as a trainer	1.9	3.0
	Evaluation of training course efficiency and trainer performance	1.7	3.2
Output 2	Sense of understanding and responsibility on monitoring	2.4	3.0
	Technical knowledge and capability on monitoring parameter for natural condition	1.7	2.7
	Technical knowledge and capability on monitoring parameter for social condition	2.0	3.0
	Technical knowledge and capability on monitoring methods and schedule	1.6	2.8
	Technical skill and capability on conducting monitoring	1.9	2.8
	Technical skill on analyzing & reporting monitoring results	1.8	2.2
	Administrative capability	2.0	3.0
Output 3	Sense of understanding and responsibility	2.3	3.0
	Technical knowledge and skill on nursery management (raising seedlings)	2.7	3.2
	Techniques on mangrove reforestation	2.7	3.0
	Technical knowledge and skill on the management of reforested areas	2.7	2.8
	Sense of understanding and responsibility on legal framework and regulations	2.4	3.3
Output 4	Technical knowledge and skill on preparing environmental education program	2.2	3.0
	Technical knowledge and skill on implementing environmental education program	2.3	2.8
	Monitoring and evaluation of environmental education program	1.9	3.2
	Technical knowledge and skill on preparing materials for environmental education	2.2	3.0
	Administrative capability of the exhibition management for environmental education	1.9	3.0
	Technical knowledge and skill as a facilitator of environmental education program	2.0	3.0

Note: The score in the figure is the average of the C/P (7 members)

Prepared by JICA Expert Team

Table 3.2.2 Results of the capacity assessment (Organization)

	Item	Feb. 2012	Nov. 2013
Output 1	Allocation of human resources	2.0	2.6
	Accumulation of experience and knowledge	2.6	3.2
	Human resources development	2.0	2.6
	Working space and IT property	2.1	2.4
	Training tools	1.6	2.4
	Capability for acquiring necessary information	1.9	2.6
	Framework for the next generation	1.8	2.2
	Structure of Working Group	2.3	3.2
	Clear demarcation between central and regional organizations in MECA	2.1	3.4
	Collaboration between MECA and related organizations	2.2	2.8
Output 2	Allocation of human resources	1.9	2.4
	Accumulation of experience and knowledge	2.7	2.8
	Human resources development	1.8	2.4
	Working space and IT property	2.6	2.6
	Capability for acquiring necessary information	2.4	2.8
	Structure of Working Group	2.6	3.2
	Clear demarcation between central and regional organizations in MECA	2.2	3.4
	Management system for monitoring	2.1	2.8
	Collaboration between MECA and related organizations	2.2	2.8
Output 3	Allocation of human resources	1.9	3.0
	Accumulation of experience and knowledge	2.6	3.4
	Human resources development	1.8	3.0
	Framework for the next generation	1.7	3.4
	Facility, equipment	1.9	3.0
	Supply of consumables	1.8	2.8
	References and manuals	2.0	3.0
	Structure of Working Group	2.3	3.4
	Clear demarcation between central and regional organizations in MECA	2.1	3.6
	Collaboration between MECA and related organizations	1.9	3.2
Output 4	Allocation of human resources	1.8	2.6
	Accumulation of experience and knowledge	2.3	3.2
	Human resources development	1.8	2.6
	Framework for the next generation	1.8	2.6
	Facility, equipment	1.9	3.4
	References and manuals	2.2	3.2
	Structure of Working Group	2.2	3.0
	Clear demarcation between central and regional organizations in MECA	2.1	3.0
	Collaboration between MECA and related organizations	2.2	2.6

Note: The score in the figure is the average of the C/P (7 members)

Prepared by JICA Expert Team

Regarding the “Individual”, all assessment items showed an increase in the evaluation score, meaning that the capacity of individuals was enhanced. Especially, the capacity related to technical knowledge and methodology in each output was greatly enhanced, implying that technical transfer through the Project was effectively conducted. On the other hand, the evaluation score of items that are mostly acquired through implementation experiences, such as formulation and modification of training programs, evaluation of monitoring results, management of mangrove plantation area and implementation skills of environmental education programs, were comparatively lower than the items related to the knowledge and methodology. While the capacity on technical knowledge and methodology were sufficiently enhanced through the Project, the C/P expressed the need to further enhance their capacity by gaining experiences through continuous implementation of the planned activities.

Regarding the 'Organization', all assessment items showed an increase in the evaluation score, suggesting that the capacity of the organization was enhanced. However, the final evaluation score of most items did not exceed 3 (75% of the maximum score), which is considered to be mainly due to the delay in the official establishment of QEIC organization. To further enhance the organization capacity, MECA is planning to establish mini-QEIC, as well as to establish and strengthen the QEIC organizational structure based on the QEIC 8-year Operation Plan.

In summary, although the capacity of individuals and organization was enhanced through the Project, the need for further capacity enhancement still remain for some items, which will naturally be acquired through mainly by gaining experiences through continuous implementation of the planned activities.

3.3 Result of the Joint Terminal Evaluation

From November 20th, 2013 to December 12th, 2013, the Project was evaluated by establishing Joint Evaluation Committee, consisting of 3 members from JICA headquarters and 1 member from MECA. The evaluation was performed from the perspective of 'Relevance', 'Effectiveness', 'Efficiency', 'Impact' and 'Sustainability'. Table 3.3.1 shows the criteria of evaluation and evaluation results.

Table 3.3.1 Criteria of evaluation and evaluation results

	Evaluation criteria	Evaluation results
Relevance	Relevance is reviewed by the validity of the Project Purpose and Overall Goal in light of Oman’s development policies and needs as well as the Japanese cooperation policy.	High
Effectiveness	Effectiveness is assessed to what extent the Project has achieved its Project Purpose, clarifying the relationship between the Project Purpose and Outputs.	High
Efficiency	Efficiency is analyzed with emphasis on the relationship between Outputs and Inputs in terms of timing, quality, and quantity.	High to medium
Impact	Impact is assessed in terms of positive/negative and intended/unintended influence caused by the Project.	High to medium
Sustainability	Sustainability is assessed in terms of institutional, financial, and technical aspects by examining the extent to which the achievements of the Project will be sustained after the Project is completed.	Medium

Source: Joint Terminal Evaluation Report, December 2013

As a result of the evaluation, “Relevance”, “Effectiveness”, “Efficiency” and “Impact” were rated as either “High” or “High to medium”. However, “Sustainability” was evaluated as “Medium” providing that 1) conservation and management of mangrove is included in the National Biodiversity Strategy and Action Plan (2015-2020) and 2) the QEIC 8-Year Operation Plan is incorporated into the MECA’s Five-Year Plan (2015-2020). The Joint Evaluation Committee also stressed the importance of continuous capacity enhancement of QEIC staffs.

Conclusion

Based on the above evaluation, despite some concerns on sustainability, the Project purpose will be achieved providing that the organization and technical capacities are further enhanced through future activities.

4. OTHER PROJECT RELATED ACTIVITIES

4.1 JICA training course

A total of six C/Ps participated in five JICA training courses through the Project period. Tables 4.2.1 and 4.2.2 show the outline and main outputs of the training courses participated in the 1st and 2nd phases of the Project, respectively.

Table 4.1.1 Outline of the JICA training course participated in the 1st Project phase

Course title	Conservation and Sustainable Management of Mangrove Ecosystem	Environmental Education for Sustainable Development - Conservation of Coastal Ecosystem for Lives of Local Communities -
Participant	Mr. Mohammed Al Rezaiki	Ms. Aida Khajaf Al-Jabri
Period	May 23-August 11, 2012 (Due to the delay in receiving the application form and administrative procedure, actual participation was from 15th June, 2012)	September 19-November 3, 2012
Abstract	<ul style="list-style-type: none"> • Lecture and practice on importance of mangrove ecosystem, general information on the ecosystem, methodology for flora survey, general information on remote sensing and environmental education. • Lecture and practice on management technique for mangrove ecosystem, mangrove plantation and regional development, categorization of composition in mangrove forest and examples from the world of mangrove plantation. • Lecture and practice on environmental assessment and coral reef, management of fisheries resources in shallow sea area and ecosystem in seaweed and sea grass bed. • Technique for presentation and photography, preparation and presentation of project proposal and preparation and presentation of action plan. 	<ul style="list-style-type: none"> • Lecture and practice on mangrove ecosystem, ecosystem in shallow water area such as tidal flat and seaweed/sea grass bed and feature, function and importance of coral reef ecosystem. • Lecture and practice on sustainable utilization of above mentioned ecosystems and relationship between inhabitant livelihood. • Lecture and practice on understanding of environmental education and its facilitation. • Lecture and practice on simplified monitoring methodology and utilization of eco-tourism. • Preparation of an action plan for familiarization of knowledge and technique regarding environmental education.
Main output	<ul style="list-style-type: none"> • The participant reported that the all basic information necessary for the conservation of mangrove were covered, which is useful for them to understand. • An action plan for development of mangrove environmental education and assessment of mangrove status in Oman was prepared by the participant and presented to the JICA Expert Team. This will be utilized for the future plan of QEIC activity. 	<ul style="list-style-type: none"> • The participant reported that the all basic information necessary for the conservation of ecosystem and environmental education were covered, which is useful for them to understand. • An action plan for environmental education for sustainable development and conservation of coastal ecosystem in Oman was prepared by the participant and presented to the JICA Expert Team. This will be utilized for the future plan of QEIC activity.

Prepared by JICA Expert Team

Table 4.1.2 Outline of the JICA training course participated in the 2nd Project phase

Course title	Biodiversity information system	Remote sensing of forest resources	Comprehensive training for conservation of coastal ecosystem such as coral reef and its sustainable utilization
Participant	Ms. Aziza Saud Al-Adhoobi	Ms. Aida Khajaf Al-Jabri Ms. Moza Khalaf Al-Riyami	Mr. Mohammed Al Rezaiqi
Period	4 August - 13 September, 2013	18 September - 6 November, 2013	6. November - 21 December, 2013
Abstract	The objective of the course was to learn the technique of collecting, analyzing, and sharing information after analysis using GIS with digitized and visualized information through web technology to enhance the conservation of biodiversity.	This course is conducted to transfer remote sensing technology in the forest sector for supporting the approach to REDD to contribute the promotion of moderation for climate change, countermeasures to illegal tree trimming and sustainable forest management.	Issue-and-solution training is conducted to learn technique of coastal area management, balancing between conservation of coastal ecosystem and improvement of resident's livelihood, based on the lectures regarding conservation activities for coastal ecosystem and impacts on the ecosystem by industrial activities including primary industry, aiming sustainable utilization of coastal ecosystem including coral reef.
Main output	GIS will be used to manage mangrove forest. Utilization of the experience of the course is expected.	The participants established an action plan to use remote sensing technique for environmental education and understanding of transition of mangrove forest. Utilization of the experience of the QEIC activities is expected.	Conservation of coastal ecosystem is a future target by MECA. It is expected the experience of the course would be utilized for the QEIC activities.

Prepared by JICA Expert Team

4.2 Support for Ramsar registration

MECA is preparing Ramsar Information Sheet (RIS) for the registration of QNR as Ramsar site. Although the RIS was previously submitted to the Ramsar secretariat, the secretariat requested to supplement the RIS by adding environmental data such water quality and key fauna species. Therefore, the JICA Expert Team provided data obtained from the Project and supported MECA to finalize the RIS. Currently, updating the RIS of QNR is the responsibility of MECD and Department of Nature Reserves, but QEIC is expected to replace MECD once established. Since the Ramsar Convention encourages the member states to develop a management plan for the designated sites, MECA should develop as soon as possible a management plan for QNR based on the procedures stipulated in Royal Decree No. 6/2003 (e.g. establishment of intergovernmental committee).

5. ISSUES AND STRATEGIES ON PROJECT IMPLEMENTATION AND OPERATION

The Project was implemented under the following limitations:

- Delay of QEIC construction and official establishment of QEIC organization
- C/Ps were not officially assigned as QEIC staff
- Project activities in Oman had to be terminated at the end of 2013, as Oman was removed by Development Assistance Committee (DAC) in 2010 from the ODA eligible countries list.

Due to such limitations, the Project faced the following implementation and operational issues:

- Due to the delay in QEIC construction and uncertainties in the future post of the C/P, the C/P were sometimes understandably not fully motivated towards the Project activities, and also the level of ownership towards the Project appeared to be relatively low.
- Due to the relatively short Project period and assignments of the JICA experts, as well as due to the daily commitments of the C/P, it was sometimes difficult to arrange the schedule of the Project activities with the responsible C/P.

To counter against such issues, the Project has adopted various strategies. Following outlines the adopted strategies and the resultant effects:

- In order to maintain the motivation of the C/P and sustain the continuity of the Project, the Project decided to expand the target period of the QEIC Operation Plan to 8 years, where the initial three years (2014-2016) are regarded as an important preparation and capacity building period prior to the full operation from 2017. Furthermore, to assist the continuity of the planned QEIC activities, establishment of mini-QEIC was proposed within MECA property, which will possess some of the functions of QEIC. As a result, the C/P have raised their motivation towards QEIC activities, and also have recognized the importance of establishing the QEIC organizational structure as soon as possible.
- In order to raise the motivation and ownership towards the QEIC activities, facilitation and presentation activities at the international workshop was primarily assigned to the C/P. In addition, discussion sessions were held to obtain opinions from the participants regarding future expectations towards QEIC activities, which as a result have led to enhance the awareness of the C/P as various positive expectations were raised by the participants.
- Since the C/P were not always available for their assigned Project activities, the Project were conducted by involving the other available C/P, even if the activity was not necessarily their assigned field. The Project outputs were then shared within the C/P by holding meetings. As a result of adopting such flexibility, the C/P have enhanced their understanding on the activities that are outside of their assigned fields, and consequently the capacity of the whole C/P team was raised.

Following are the main lessons learnt through the above mentioned experiences:

- In order to maintain the motivation and ownership towards the project, greater emphasis should be placed to encourage the C/P to take the initiative on project activities.
- If there are uncertainties in the future post of the C/P, the capacity building activities should place more emphasis on strengthening a wider range of C/P and possibly other ministry staffs, instead of focusing only on individual C/P. This as a consequence, will strengthen the capacity on an organizational level. Subsequently, this will enable the ministry to be more adaptable towards future issues and uncertainties.
- If the period for technical transfer is limited as in the case of this Project, a detailed future plan should be devised so that the C/Ps can continue to develop their capacity even after the project terminates.

6. RECOMMENDATIONS TO ACHIEVE THE OVERALL GOAL OF THE PROJECT

In order to achieve the overall goal of the Project, QEIC must first become established as a center with sufficient technical and operational capacity. For this, QEIC must establish an appropriate operational structure, and the QEIC staffs should be capable of implementing the planned activities and programs in an effective manner. The QEIC staffs should also be capable of revising and updating the activities and programs by themselves. The following Sections provide recommendations to further enhance the operational and technical capacity of QEIC, as well as recommendations for disseminating sustainable mangrove ecosystem management.

6.1 Recommendations to enhance the operational capacity of QEIC

- MECA should incorporate the QEIC 8-year Operation Plan into MECA's 5-year plan (2015-2020), and subsequently establish the organizational structure of QEIC, and officially assign and recruit QEIC staffs as soon as possible. Following are experts that should be recruited (see Appendix 5, QEIC 8-year Operation Plan for more details):
 - Expert on marine biology/ecosystem for monitoring and conservation of mangrove ecosystem
 - Expert on chemical analysis for water quality analysis works
 - Expert on plant biology to improve technology on seedling production and plantation
 - Expert on designing to produce attractive education materials and publications
- Budget for QEIC activities should be secured on a mid- to long-term basis, based on the budget plan of QEIC 8-year Operation Plan.
- The mini-QEIC should be established as soon as possible, so that the activities and programs developed through this Project can be implemented smoothly. The main functions required for mini-QEIC are laboratory for chemical and biological analysis works, space for equipment storage and management and small exhibition room.
- Until the QEIC database is established, data should be stored and managed systematically by using the temporary database developed through the Project.
- Since some QEIC activities will require technical assistance from other organizations, it is necessary to further strengthen ties with relevant national and international organizations (e.g. MSTC, SQU, ESO, ISME, Ramsar) as well as similar centers (e.g. Mangrove Information Center in Bali). To ensure smooth cooperation, it may be necessary to secure budget for the following activities:
 - Outsourcing of lecturer for training activities (especially regarding monitoring)
 - Survey and species identification for fauna monitoring

- Water quality analysis
- Development of exhibition plan
- The QEIC activities should be regularly evaluated and revised by establishing an evaluation committee that consist of relevant MECA staffs.
- In case any serious adverse impacts on mangrove ecosystem are identified, a scientific committee (including relevant experts) should be established to discuss the causes and appropriate countermeasures.

6.2 Recommendations to enhance the technical capacity of C/P

1) General

In order to accurately and appropriately implement the QEIC activities, it is of high priority that all QEIC staffs acquire a basic and common understanding on mangrove ecosystem. To acquire basic knowledge on mangrove ecosystem, MECA should hold internal training activities by using the training courses (e.g. training course: Introduction on mangrove ecosystem) and materials developed through the Project, and also encourage the staffs to participate in field activities such as monitoring.

2) Training activity

Since the QEIC staffs are expected to be lecturers for most of the training courses, enhancement of their capacity is necessary especially in the field of basic knowledge of mangrove ecosystem and presentation skills. Hence, trial training activities should be frequently held to enhance the C/P's experience and skills as a lecturer.

3) Monitoring activity

The capacity for monitoring planning, data analysis and assessment, species identification, equipment maintenance and chemical analysis should be further enhanced. The capacity for adaptive management should also be further enhanced. However, since such capacity cannot be acquired overnight, it is necessary to be continuously involved in monitoring and management works, and learn through trial and error. Furthermore, the C/P should receive training from outside experts especially for highly specialized fields such as species identification.

4) Plantation activities

The capacity for selecting appropriate plantation sites should be further enhanced. To make appropriate and scientific-based selection, basic knowledge on natural conditions such as hydrology, water and soil quality and ecosystem should be acquired through training and self-learning.

5) Environmental education and exhibition

Skills required to facilitate environmental education programs should be further enhanced. It is especially important that the facilitator has an accurate and broad knowledge of mangrove ecosystem, which should be acquired through training and self-learning, as well as by participating in field activities such as monitoring.

Additional recommendations:

In order to further enhance the operational capacity of QEIC and technical capacity of the C/P, a technical adviser should be recruited to supervise the activities. More specifically, the following experts should be recruited on a long-term basis:

- Technical advisor 1: Supervision of monitoring and plantation activities
- Technical advisor 2: Supervision of education and exhibition activities

Note that some highly specialized fields (e.g. database development, chemical analysis, exhibition) may be beyond the capacity of the above experts. In such case, assistance from additional experts may be required on a temporary basis.

6.3 Recommendations for disseminating sustainable mangrove ecosystem management

In order to disseminate sustainable mangrove ecosystem management in Oman and the region, QEIC should actively and strategically implement dissemination and awareness-raising activities by cooperating with international organizations such as ROPME. Following are some specific recommendations for QEIC:

1) Dissemination activities

- QEIC should disseminate the importance of mangrove ecosystem conservation and management to the general public by implementing activities, such as monitoring, with local NGOs and communities. For this, QEIC should actively approach these groups to build a mutual understanding on the significance of such cooperation and also invite representatives of such groups for training.
- The various guidelines that were developed through this Project should be publicized through QEIC's website and also should be distributed to concerned national and international organizations (e.g. environmental agencies, NGOs and developers) in occasions such as international conferences. QEIC should also establish a support service (e.g. establishment of an inquiry hotline in QEIC website and training program) so that these organizations can eventually implement plantation, monitoring and other conservation and management activities by themselves.

- QEIC should actively approach and promote to ROPME the functions of QEIC as a basis for promoting mangrove ecosystem conservation in the Gulf region. Some of the main functions that QEIC can play are hosting of regular international seminars and holding of training programs for international trainees. QEIC may also trigger further cooperation within the Gulf countries by playing such role.

2) Awareness-raising activities

- QEIC should promote the importance of mangrove ecosystem by utilizing its website. To attract the attention of the public, the contents and design of the website should be of high quality. Following are some websites that could be referred:
 - Mangrove Action Project (<http://mangroveactionproject.org/>)
 - Mangrove World (<http://www.mangrove-world.com/main.html#study>)
- Environmental education activities should be implemented in a strategic and active manner by actively and continuously inviting and visiting target groups such as schools, local communities and private companies.
- QEIC should promote the importance of mangrove ecosystem through utilizing the media such as TV, newspaper and radio. Due to its general popularity, TV is especially effective for attracting people that currently have little interest in mangrove ecosystem conservation.

3) Other activities

- In order to promote the importance of mangrove conservation, it is also important to have a scientific basis for to be convincing. Hence QEIC should conduct research activities on such topics. Following are some recommended research topics:
 - How biodiversity and environment changes with increase in mangrove
 - Contribution of mangrove ecosystem on coastal fishery resources
 - Contribution of mangrove on CO₂ fixation
- Incorporate mangrove ecosystem conservation into the National Biodiversity Strategy and Action Plan (2015-2020) as a high priority matter.