List of publication materials

The publication materials are stored in the attached folder and CD.

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.

附属資料 9　　本プロジェクトで作成した出版物一覧

出版物一覧

以下の出版物を巻末のフォルダーおよび CD に収めた。

No	タイトル	様式	内容
1	QEIC Project	Brochure	本プロジェクトの背景や概要を紹介するためのパンフレット。
2	Introduction of Mangrove Ecosystem	Brochure	マングローブやマングローブ生態系について簡単に紹介するブローシャー。環境教育のイベント時などの配布資料として、活用することが期待される。
3	Mangrove Forest in Oman	Booklet	「オ」国の特徴的なマングローブ・サイトを紹介する冊子。
4	Introduction of Mangrove Ecosystem	Booklet	マングローブやマングローブ生態系の特性およびマングローブ生態系の価値や脅威を紹介する一般向け冊子。環境教育を初め、QEIC職員や研修のテキストとしても活用可能。
5	Introduction of Mangrove Ecosystem (for children)	Booklet	マングローブ生態系をイラストなどで紹介する子供向けの冊子。
6	Animals of Mangrove Forest in Oman	Booklet	マングローブ生態系の主要な動物類（魚類、カニ類、貝類、鳥類など）を紹介する冊子。
7	Animals of Mangrove Forest in Oman	Photo sheet	マングローブ生態系の主要な動物類を紹介する下敷き。環境教育の参加者に配布し、動物類を観察する際に使うことを想定。
8	Basic Procedure of Mangrove Seedling Transplanting	Brochure	苗木の植林手順や留意点を、イラストで紹介したブローシャー。
9	QEIC Newsletter (Vol. 1-4)	Brochure	本プロジェクトの主な活動を紹介するニュースレター。

THE QURM ENVIRONMENTAL INFORMATION CENTER (QEIC) PROJECT

Ministry of Environment and Climate Affairs, Sultanate of Oman
Japan International Cooperation Agency (JICA)

Background of the Project:

Conservation of mangrove ecosystem is important for the Sultanate of Oman, as mangrove ecosystem function as nurseries for various marine organisms, including commercially important fishery species. Mangroves also benefit people by providing coastal protection, recreational area and greenery. However, threats to these precious mangrove areas are mounting in recent years, due to pressures such as from population growth, pollution and coastal development.

The Ministry of Environment and Climate Affairs (MECA), with the assistance of JICA, is working actively on the conservation, restoration and management of mangrove ecosystem in Oman. So far, JICA has dispatched experts on mangrove reforestation and also developed a master plan for restoration, conservation and management of mangrove in Oman.

Development of "Qurm Environmental Information Center (QEIC)" was proposed by the master plan, which will be the centre for mangrove conservation in the Sultanate of Oman. QEIC will also actively disseminate sustainable mangrove ecosystem management to other regions.

To assist the establishment and operation of QEIC, JICA and the Government of Oman has agreed to implement "The Qurm Environmental Information Center (QEIC) Project", which commenced in January 2012.

Outputs of the Project:

Output 1: Development of capacity of QEIC staff and training programs for sustainable mangrove ecosystem management

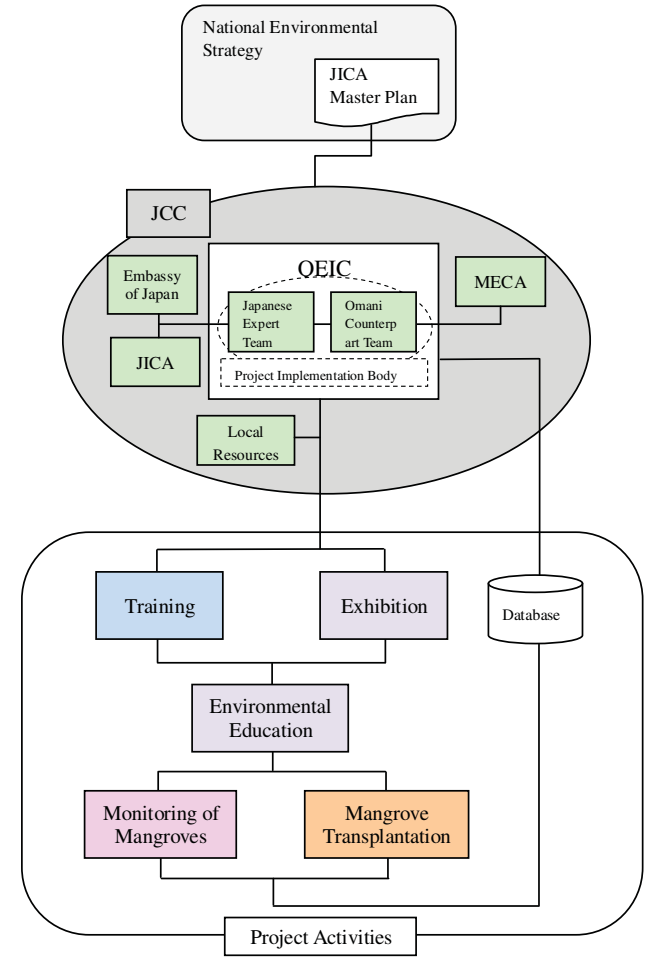
Output 2: Development of methods and guidelines for mangrove ecosystem monitoring

Output 3: Development of methods and techniques for mangrove plantation

Output 4: Development of environmental education and exhibition programs

Project schedule:

1st phase: January 2012 to December 2012
2nd phase: February 2013 to December 2013



General framework of the Project

Implementing organization: Directorate of Nature Conservation, Ministry of Environment and Climate Affairs

Contact Address: P.O.Box 323, Postal Code 100, Al-Khuwair, Muscat, Sultanate of Oman
Tel: 00968-24404756, Fax: 24602283

مشروع مركز القرم للمعلومات البيئية

وزارة البيئة والشؤون المناخية
الوكالة اليابانية للتعاون الدولي

خلفية المشروع:

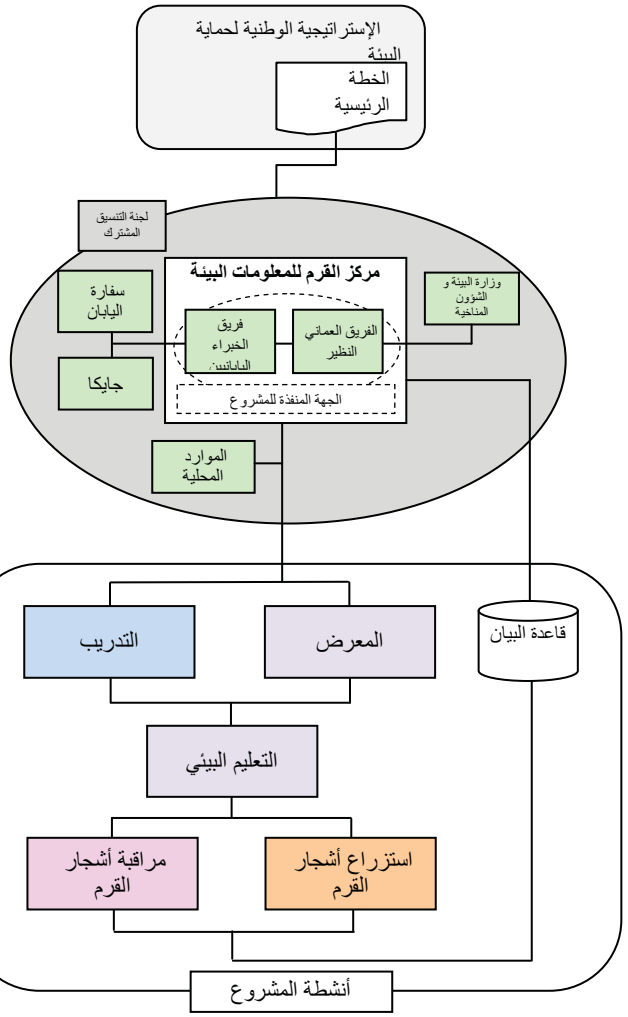
الحفاظ على النظام البيئي لغابات القرم مهم جدا بالنسبة لسلطنة عُمان, بحيث أن النظام البيئي لأشجار القرم يعتبر كحضانة بالنسبة للكائنات البحرية المختلفة, بما في ذلك أنواع الاسماك ذات الاهمية التجارية. من فوائد اشجار القرم انها توفر الحماية للمناطق الساحلية ومناظر طبيعية خضراء. وعلى كل فإن التهديدات التي تتعرض لها مناطق أشجار القرم ذات القيمة العالية تزايد في السنوات الأخيرة، نتيجة للضغوط الناتج عن النمو السكاني ورعي الماشية والتنمية الساحلية ، وبالتالي فإن حكومة سلطنة عمان تعمل بفعالية على صون واستعادة وإدارة النظام البيئي لأشجار القرم. في إطار التعاون الدولي تقوم حكومة اليابان بتقديم المساعدة الفنية للسلطنة من خلال الوكالة اليابانية للتعاون الدولي (جايكا) وذلك بإيفاد خبراء في استزراع أشجار القرم ووضع خطة رئيسة لدراسة استعادة وصون وادارة اشجار القرم في سلطنة عُمان. حيث اقترحت الخطة الرئيسية إنشاء "مركز القرم للمعلومات البيئية" كمركز لصون أشجار القرم في السلطنة والمناطق الاخرى، وقد تقرربناءًا على ما سبق تنفيذ مشروع للتعاون الفني خاص بإنشاء مركز القرم للمعلومات البيئية من خلال بناء القدرات وتعزيز المرافق التابعة للمركز و التي بدأت في يناير من هذا العام.

النتائج المتوقعة:

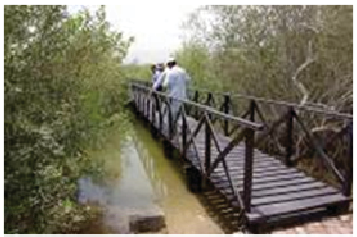
1: تطوير وبناء القدرات في مجال التدريب لمركز القرم للمعلومات البيئية وذلك لتعزيز الإدارة المستدامة للنظام البيئي لأشجار القرم.
2: تطوير أسلوب الرصد والرقابة لمركز القرم للمعلومات البيئية وذلك لتعزيز الإدارة المستدامة للنظام البيئي لأشجار القرم.
3: تطوير الأساليب والتقنيات الخاصة بتعزيز استزراع أشجار القرم.
4: تحسين قدرات نشاط برنامج التعليم البيئي الخاص بمركز القرم للمعلومات البيئية وذلك لتعزيز الإدارة المستدامة للنظام البيئي لأشجار القرم.

مدة المشروع:

يتكون المشروع من مرحلتين (2):
المرحلة الأولى: من يناير 2012 إلى ديسمبر 2012.
المرحلة الثانية: من فبراير 2013 إلى ديسمبر 2013.



المفهوم العام للمشروع



الجهة المسئولة: المديرية العامة لصون الطبيعة،
وزارة البيئة والشؤون المناخية
عنوان الاتصال: ص. ب. 323، رمز بريدي 100، الخوير
مسقط، سلطنة عُمان، هاتف: 24404756 00968، فاكس: 24602283

Ministry of Environment and Climate Affairs (MECA), Sultanate of Oman
Japan International Cooperation Agency (JICA)

IMPORTANCE OF MANGROVE ECOSYSTEM

What is mangrove?

Mangroves are trees that grow along the boundary between land and sea (i.e. intertidal zone). While most plants cannot live in such environment due to high salinity conditions, mangroves are able to because they have special desalination systems in their roots and leaves. If you look carefully, you can see small salt crystals that were secreted from the leaves. Mangroves also have aerial roots (roots protruding from the soil), which transports above-ground oxygen to the underground roots.

Although there are many species of mangrove in the world, only one mangrove species grow naturally in Oman, which is grey mangrove (*Avicennia marina*).

Characteristics of mangrove ecosystem:

Various animals live in mangrove forest such as shells, crabs, fish and birds. Many of them are adapted to live in both land and sea, by changing their behavior in accordance to the tide. Mangrove forests are also nursery for many young marine species, as the forest provides abundant food and places to hide from larger predators.

Food chain in the mangrove ecosystem:

Mangrove leaves are the main starting point of the mangrove food chain. Firstly, fallen leaves are consumed by leaf-eating crabs and snails. Then, their wastes and leaf fragments become food for other organisms such as small shrimps and worms. These are consumed by larger animals such as fishes and birds. The droppings of these animals then become important sources of nutrients for mangrove trees. Everything is recycled and nothing goes wasted in mangrove ecosystem, which is sustained by animals of varying sizes and types, each playing an important role in keeping the mangrove and ecosystem healthy.

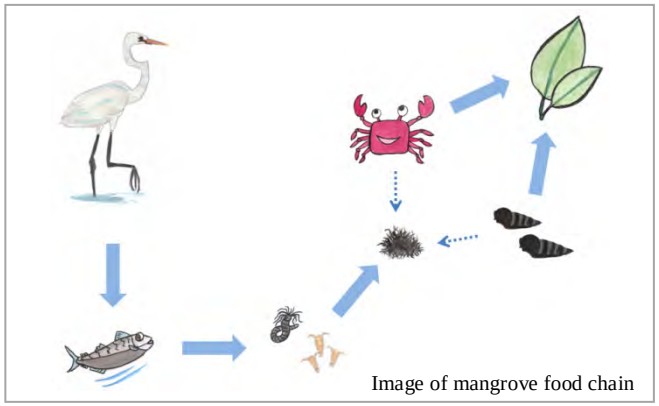


Image of mangrove food chain

Benefits of the mangrove ecosystem:

Mangroves are important to the coastal ecosystem and fisheries, as they provide food and shelter to juveniles of many types of animals such as fish, crabs and shrimps.

Mangroves can also improve coastal water quality, protect land from waves as well as provide places for relaxation and tourism. Mangroves can also contribute in reducing global warming by absorbing CO_2.

Threats to mangrove ecosystem:

Threats to the mangrove ecosystem are increasing mainly due to human pressures. The main threats in Oman are; coastal development (e.g. road and port construction), wastewater discharge, dumping of wastes, grazing by domestic animals, illegal fishing and so on.

In order to protect the mangrove ecosystem from such pressures, we are implementing various conservation measures as well as creating new forests by planting mangrove seedlings.

Common animals you can find in mangrove forests:

Birds

Western Great Egret

Grey Heron

Great Cormorant

Eurasian Curlew

Eurasian Spoonbill

Greater Flamingo

Kentish Plover

Little Grebe

Blue-cheeked Bee-eater

Fishes

Goby

Juvenile sea bream

Killifish

Juvenile mullet

Crabs & Gastropods

Swimming crab

Fiddler crab

Mangrove whelk

Responsible Organization: Directorate of Nature Conservation, Ministry of Environment and Climate Affairs

Contact Address: P.O.Box 323, Postal Code 100, Al-Khuwair, Muscat, Sultanate of Oman
Tel: 00968-24404756, Fax: 24602283

وزارة البيئة والشؤون المناخية
سلطنة عُمان
الوكالة اليابانية للتعاون الدولي

أهمية النظام البيئي لأشجار القرم

ما هي أشجار القرم؟

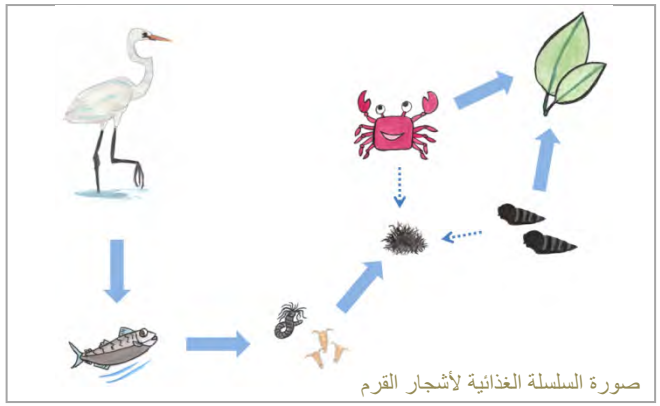
هي أشجار تنمو على طول الحدود بين اليابسة والبحر. تستطيع أشجار القرم العيش في البيئات شديدة الملوحة وذلك العكس من معظم النباتات التي لا تستطيع العيش في مثل تلك البيئات وذلك لأن لها أنظمة خاصة لتصفية المياه في جذورها وأوراقها تقوم بالتخلص من الملح الزائد لذلك إذا أمعنت النظر ستلاحظ بلورات ملحية صغيرة تفرزها الأوراق. ويميز هذه الأشجار(جذور هوائية بارزة من التربة) تعمل على نقل الأكسجين الموجود فوق سطح الأرض إلى الجذور الموجودة تحت الأرض. وعلى الرغم من وجود العديد من أنواع أشجار القرم في العالم إلا أن نوع واحد فقط ينمو بشكل طبيعي في سلطنة عمان وهو القرم الرمادي(أفاسينا مارينا).

خصائص النظام البيئي لأشجار القرم

يعيش في غابات أشجار القرم مختلف الحيوانات مثل الأصداف والسرطانات والأسماك والطيور التي تكيفت العديد منها للعيش في كل من اليابسة والبحر وذلك بتغيير سلوكها وفقاً للمد والجزر. وتعد غابات القرم حضانة للعديد من الأنواع البحرية الصغيرة بحيث توفر هذه الغابات طعامًا وفيرًا وأماكن للاختباء من الحيوانات المفترسة الكبيرة.

السلسلة الغذائية في النظام البيئي لأشجار القرم

إن أوراق أشجار القرم هي نقطة البداية الرئيسية للسلسلة الغذائية لهذه الأشجار. أولاً ، تقتات السرطانات والحلزونات على الأوراق المتساقطة، بعدها تصبح مخلفاتها وفتات الأوراق طعاماً لمخلوقات أخرى مثل الربيان والديدان التي يعد روثها من المصادر الرئيسية المغذية لأشجار القرم. إن كل شي يتم إعادة تدويره باستدامة في النظام البيئي لأشجار القرم وذلك لكون جميع الحيوانات التي تعيش في هذا النظام بمختلف أنواعها وإحجامها تلعب دوراً مهماً في المحافظة على صحة أشجار القرم ونظامها البيئي.



صورة السلسلة الغذائية لأشجار القرم

فوائد النظام البيئي لأشجار القرم

إن أشجار القرم مفيدةً للنظام البيئي الساحلي والثروة السمكية حيث توفر الطعام والغذاء لصغار العديد من أنواع الحيوانات مثل الأسماك والسرطانات والروبيان. وتعمل أشجار القرم على تحسين جودة المياه الساحلية وتحمي اليابسة من الأمواج كما توفر أماكن للراحة والسياحة. وقد تساهم أشجار القرم في التقليل من الاحتباس الحراري وذلك بامتصاص غاز ثاني أكسيد الكربون.

التهديدات التي تواجه النظام البيئي لأشجار القرم

تتزايد التهديدات التي تواجه النظام البيئي لأشجار القرم بشكل أساسي بسبب الضغوطات البشرية. ومن أهم التهديدات في سلطنة عمان: التنمية الساحلية (مثل إنشاء الطرق الموانئ)، وتصريف مياه المخلفات، وطمر المخلفات، والرعي الجائر من الحيوانات المحلية والصيد غير المشروع وغيره. ومن أجل حماية النظام البيئي لأشجار القرم من هذه الضغوطات فإننا نقوم بتنفيذ مختلف تدابير الصون بالإضافة لإنشاء غابات جديدة وذلك بزراعة شتلات القرم.

الحيوانات الشائعة الموجودة في غابات أشجار القرم

الطيور

غراب البحر الكبير

البلشون الرمادي

البلشون الأبيض الكبير

طائر النخام الكبير

أبو ملعقة

القطقاط الإسكندري

آكل النحل الأخضر\ الورور

الغطاس الصغير

الكروان الأوراسي

الأسماك

سمك الجوبي (نبت)

كوفر

السرطانات والحلزونات

بادح

السرطانات والحلزونات

سرطان البحر

سرطان من نوعية Uca sp.

البطنيات

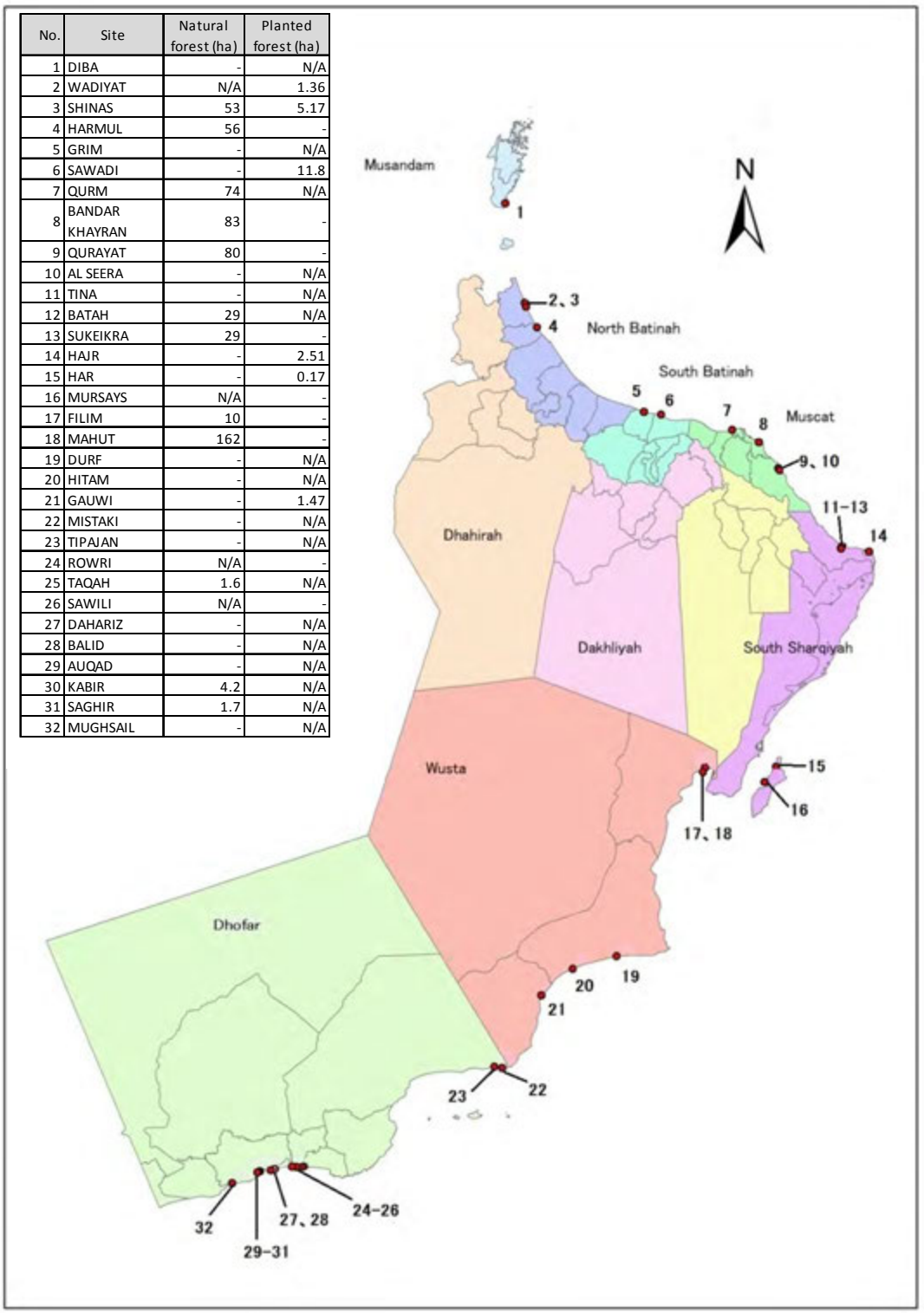
الجهة المسئولة: المديرية العامة لصون الطبيعة
وزارة البيئة والشؤون المناخية
عُمان عنوان الإتصال: ص.ب.323، رمز بريدي100، الخوير مسقط سلطنة
هاتف: 24404756 00968، فاكس: 24602283

Mangrove Forests in Oman

Qurm Environmental Information Center (QEIC)

Distribution of mangrove forests in Oman

No.	Site	Natural forest (ha)	Planted forest (ha)
1	DIBA	-	N/A
2	WADIYAT	N/A	1.36
3	SHINAS	53	5.17
4	HARMUL	56	-
5	GRIM	-	N/A
6	SAWADI	-	11.8
7	QURM	74	N/A
8	BANDAR KHAYRAN	83	-
9	QURAYAT	80	-
10	AL SEERA	-	N/A
11	TINA	-	N/A
12	BATAH	29	N/A
13	SUKEIKRA	29	-
14	HAJR	-	2.51
15	HAR	-	0.17
16	MURSAYS	N/A	-
17	FILIM	10	-
18	MAHUT	162	-
19	DURF	-	N/A
20	HITAM	-	N/A
21	GAUWI	-	1.47
22	MISTAKI	-	N/A
23	TIPAJAN	-	N/A
24	ROWRI	N/A	-
25	TAQAH	1.6	N/A
26	SAWILI	N/A	-
27	DAHARIZ	-	N/A
28	BALID	-	N/A
29	AUQAD	-	N/A
30	KABIR	4.2	N/A
31	SAGHIR	1.7	N/A
32	MUGHSAIL	-	N/A

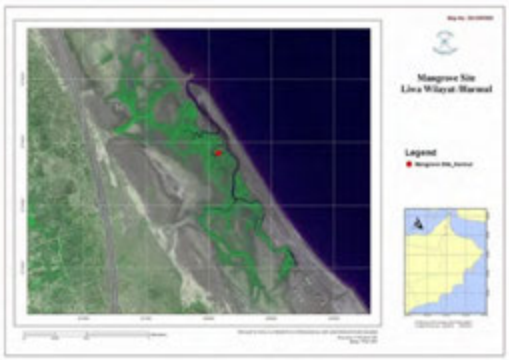


Basic information on mangrove forests in Oman

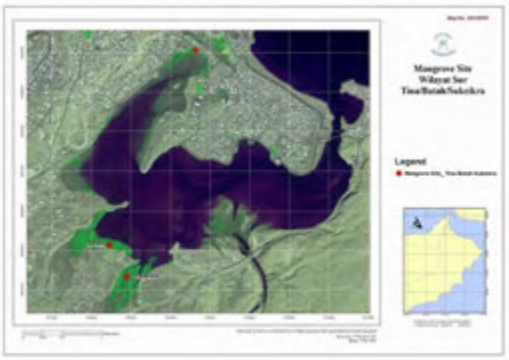
NO.	SITE	REGION	WILAYAT	Natural Forest (ha)	Planted Forest (ha)	No. of Planted Trees by 2012
1	DIBA	MUSANDAM	DIBA	-	N/A	4,200
2	WADEYAT	NORTH BATINAH	SHINAS	N/A	1.36	97,025
3	SHINAS	NORTH BATINAH	SHINAS	53	5.17	23,000
4	HARMUL	NORTH BATINAH	LIWA	56	-	-
5	GRIM	SOUTH BATINAH	MUSANAAH	-	N/A	19,875
6	SAWADI	SOUTH BATINAH	BARKA	-	11.8	100,350
7	QURM	MUSCAT	MUTRAH	74	N/A	4,400
8	BANDAR KHAYRAN	MUSCAT	MUSCAT	83	-	-
9	QURAYYAT	MUSCAT	QURAYYAT	80	-	-
10	AL SEERA	MUSCAT	QURAYYAT	-	N/A	300
11	TINA	SOUTH SHARQIYAH	SUR	-	N/A	74,625
12	BATAH	SOUTH SHARQIYAH	SUR	29	N/A	18,950
13	SUKEIKRA	SOUTH SHARQIYAH	SUR	29	-	-
14	HAJAR	SOUTH SHARQIYAH	SUR	-	2.51	39,000
15	HAR	SOUTH SHARQIYAH	MASIRAH	-	0.17	7,700
16	MURSAYS	SOUTH SHARQIYAH	MASIRAH	N/A	-	-
17	FILM	AL WUSTA	MAHAWT	10	-	-
18	MAHUT	AL WUSTA	MAHAWT	162	-	-
19	DURF	AL WUSTA	AD DUQM	-	N/A	6,100
20	HITAM	AL WUSTA	AD DUQM	-	N/A	1,200
21	GHAWI	AL WUSTA	AL JAZER	-	1.47	20,600
22	MISTAKI	DHOFAR	SHALIM	-	N/A	1,000
23	TIPAJAN	DHOFAR	SHALIM	-	N/A	4,800
24	ROWRI	DHOFAR	MIRBAT	N/A	-	-
25	TAQAH	DHOFAR	TAQAH	1.6	N/A	1,800
26	SAWLI	DHOFAR	TAQAH	N/A	-	-
27	DAHARIZ	DHOFAR	SALALAH	-	N/A	19,000
28	BALID	DHOFAR	SALALAH	-	N/A	900
29	AUQAD	DHOFAR	SALALAH	-	N/A	29,150
30	KABIR	DHOFAR	SALALAH	4.2	N/A	7,200
31	SAGHIR	DHOFAR	SALALAH	1.7	N/A	13,500
32	MUGHSAIL	DHOFAR	SALALAH	-	N/A	37,200

Characteristics of Mangrove Forests in Oman

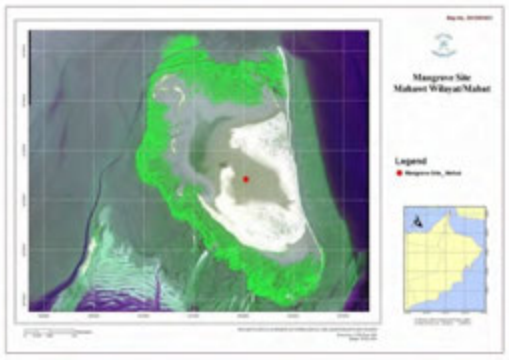
Natural mangrove forests in Oman are comprised of one species *Avicennia marina*. They are mainly distributed in khawrs (lagoons) and inner-bay areas dotted along the mainland coast. Mangrove forests are also occasionally found along the coasts of offshore islands such as Mahut Island. Mangrove forests in the Dhofar region are unique, as they are often isolated from the sea by sandy beach. Followings are typical topographical features of Oman's mangrove forest.



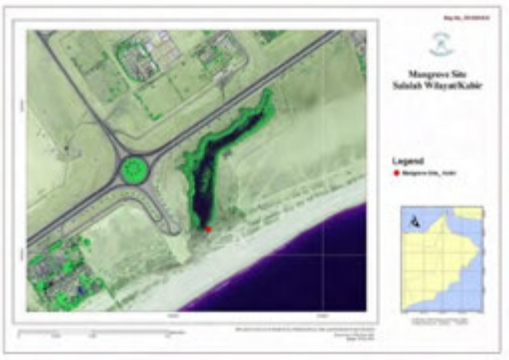
Type-1: Mangrove forest along khawrs



Type-2: Mangrove forest in inner-bay



Type-3: Mangrove forest in island



Type-4: Mangrove forest in closed khawrs

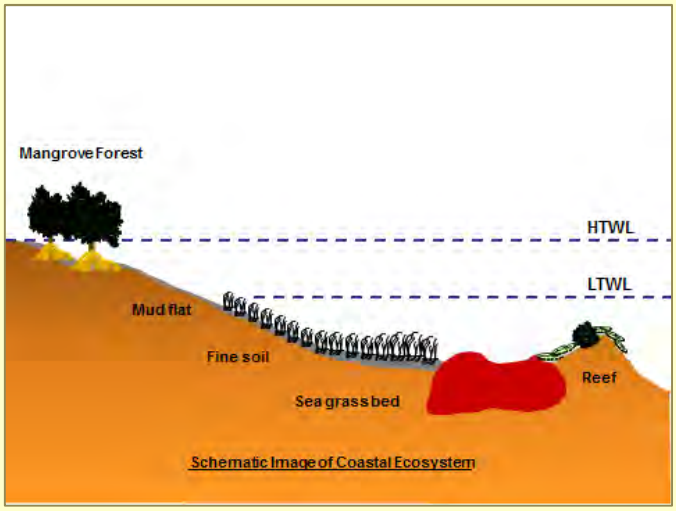
This booklet introduces some mangrove forests in Oman that are typical of the above four types. Following are the selected mangrove forests:
Type-1: Mangrove forests in Khawr Harmul, Khawr Sawadi, Khawr Qurm
Type-2: Mangrove forests in khawrs of Sur
Type-3: Mangrove forests in Mahut Island
Type-4: Mangrove forests in khawrs of Salalah

Mahut Island

Mahut Island is located approximately 2 km offshore from the mainland. Its mangrove forest is the largest in Oman, and is surrounded by a wide mud flat and extensive seagrass bed. The lives of the islanders are strongly dependent on the bounties provided by this unique and productive ecosystem. Mahut Island provides an excellent example of wise use of resources and how people and mangroves can coexist in a sustainable manner.

Biodiversity in Mahut island is very high with many types of mollusks, crustaceans and fishes living in the mangrove and adjacent seagrass beds. In fact, the diversity of crustaceans is among the highest in khawrs of Oman. Many birds also come to feed on these animals.

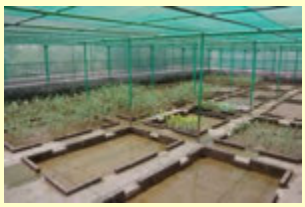
The villagers traditionally used to build their houses by using dead mangrove trees. They collect crabs and clams inside the mangrove forest and catch fish and shrimps around the coast for their living.



The drawing on the left shows a cross-section image of Mahut's coastal ecosystem. Mangroves and mud flats are distributed in the upper and middle intertidal zone. Seagrass then starts to appear in the lower intertidal zone, and extends further to relatively deeper waters. These ecosystems each play an important role in maintaining the rich biodiversity and abundance of marine resources in Mahut island.

Khawr Qurm

Khawr Qurm is located in the heart of Capital City Muscat and has been designated as Qurm Nature Reserve (QNR) since 1978. Although a part of the forest was washed away by the cyclone in 2007, the forest has quickly recovered since then. The site is frequently used for environmental education and training purposes, by using the boardwalk and shades constructed by MECA. There is also a nursery for producing mangrove seedlings. The area is also under the process of being registered as a Ramsar Site.



Nursery for seedling production with tidal irrigation system (constructed on 2001)

Boardwalk and shade house used for various activities (constructed on 2010)

Environmental education activities

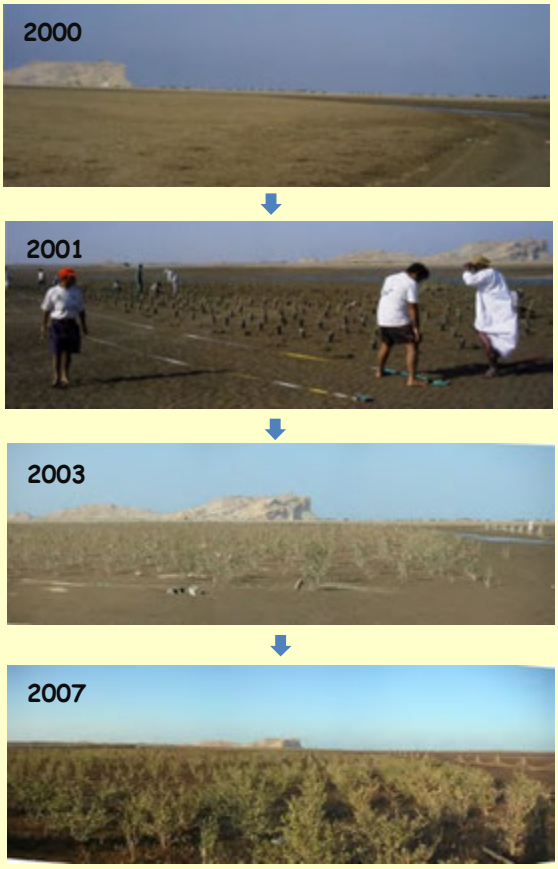
Environmental monitoring

Boundary of proposed Ramsar Site

Despite its urban location, QNR supports a wide diversity of fauna, including many juvenile species. Also due to its convenient location, it is an excellent place for introducing people the uniqueness and values of mangrove ecosystem and will be further promoted through the establishment of QEIC. However, due to its urban location, the mangrove ecosystem is under constant pressure from human activities such as construction works, wastewater discharge, illegal fishing and so on. The area will be managed and monitored through QEIC, and lessons learned through such activities will be utilized for the conservation of other mangrove sites in Oman.

Khawr Sawadi

Khawr Sawadi is located approximately 60 km west of Muscat. The area is a well-known beach resort and the offshore area is one of the most popular coral reef diving spots in Oman. Previously, there were no mangroves in this khawr but the wide mud flat was considered suitable for mangrove plantation and has been actively performed since 2001 by involving the local community. Now the area has developed into a thick mangrove forest, and is one of the most successful mangrove plantation sites in Oman.



Mangrove seedlings were continuously transplanted from 2001 to 2007. Approximately 100,000 seedlings were planted during this period.

The local schoolboys regularly participated in transplanting and maintenance activities. Such activities also provided good opportunities to learn about biodiversity as they could see first-hand many animals during their works.

Many trees are now reproducing, and consequently, the forest is now expanding through natural regeneration, especially in the upper stream of the khawr. As of 2012, the forest area has expanded to around 12 ha. It will be interesting to monitor how such artificial forest will evolve into a matured forest including changes in biodiversity.

Khawrs in Sur

In Sur, natural and planted mangrove forests are found in khawrs of Tina, Batah and Sukeikrar. Since these mangrove forests are located adjacent to the residential area, there are some issues regarding wastewater discharge and waste dumping. Also some locals are not happy with the way plantation was conducted. Such issues will be tackled by actively disseminating the values of mangrove ecosystem through environmental education activities. We have also learnt the importance of consulting the local community prior to conducting any plantation works to avoid future conflicts.

Mangrove forests of Batah and Sukeikra have expanded rapidly since the establishment of Royal Decree 114/2001, which prevents any cutting or damaging of trees in public forest.

There is a risk of eutrophication in the khawrs of Sur, due to wastewater discharge. Signs of such eutrophication can be seen by excessive algae growth. Mangroves can reduce such risks by absorbing excessive nutrients.

Wastes such as plastic bags, concrete debris and food waste are dumped in the mangrove forests. Food waste could attract unwanted animals such as rats. This is highly undesirable for tourism and recreation as well as for people living nearby.

Since the mangrove forests in Sur are located inside a semi-enclosed bay with limited water exchange, any unfavorable condition such as water pollution could affect all the forests simultaneously. Monitoring of the bay's water quality and implementation of strict pollution control measures will be necessary in order to keep the mangrove and the bay's ecosystem healthy.

Khawrs in Salalah

Mangrove forests in the Salalah region are unique, as they often grow in khawrs that are isolated from the sea by sandy beach. In such khawrs, water salinity is relatively low due to the inflow of fresh water and limited seawater exchange. Such low salinity condition seems to have not hindered mangrove growth as some trees have grown up to 10 m. However, mangroves are often damaged by animal grazing. Nine khwars are designated as protected area under Royal Decree 6/2003, which includes khwars with mangrove (e.g. Khawrs Kabir, Auqad and Balid).

Khawr Kabir

Khawr Auqad

Khawr Balid

The water level of some khawrs appears to be slowing rising as evidenced by abnormally long aerial roots. This may be stressful for the mangrove as they need to grow their aerial roots to meet with the rising water level.

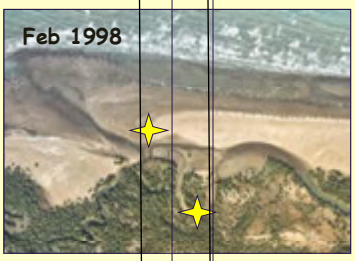
Algae growth is also extensive in some khwars, which may be due to excessive nutrient inflow. This may lead to hypoxic or anoxic conditions, through algae decomposition.

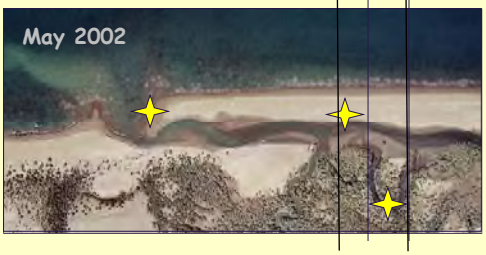
Nine khawrs (No.27 – No.35) in Dhofar region are declared as a protected area. It is mentioned that the conservation objectives are (i) sustainable use of the resources, (ii) protection of the khawrs ecosystems and (iii) promotion of ecotourism. In order to accomplish these objectives, the khawrs should be managed through regular monitoring.

Khawr Harmul

Khawr Harmul is located at Liwa in North Batinah Region. This khawr has been affected by severe beach erosion and accretion along the coastline which may be related to the Sohar Port development. Many mangrove trees had been damaged at landward borders of northern channel. It is important to be aware that development activities, even at distant location, can be a threat to mangrove ecosystem.

The location of the khawr mouth had moved 200-300m from the original location before and after port construction. Such movement of the mouth had changed significantly the hydrology of the mangrove forest.





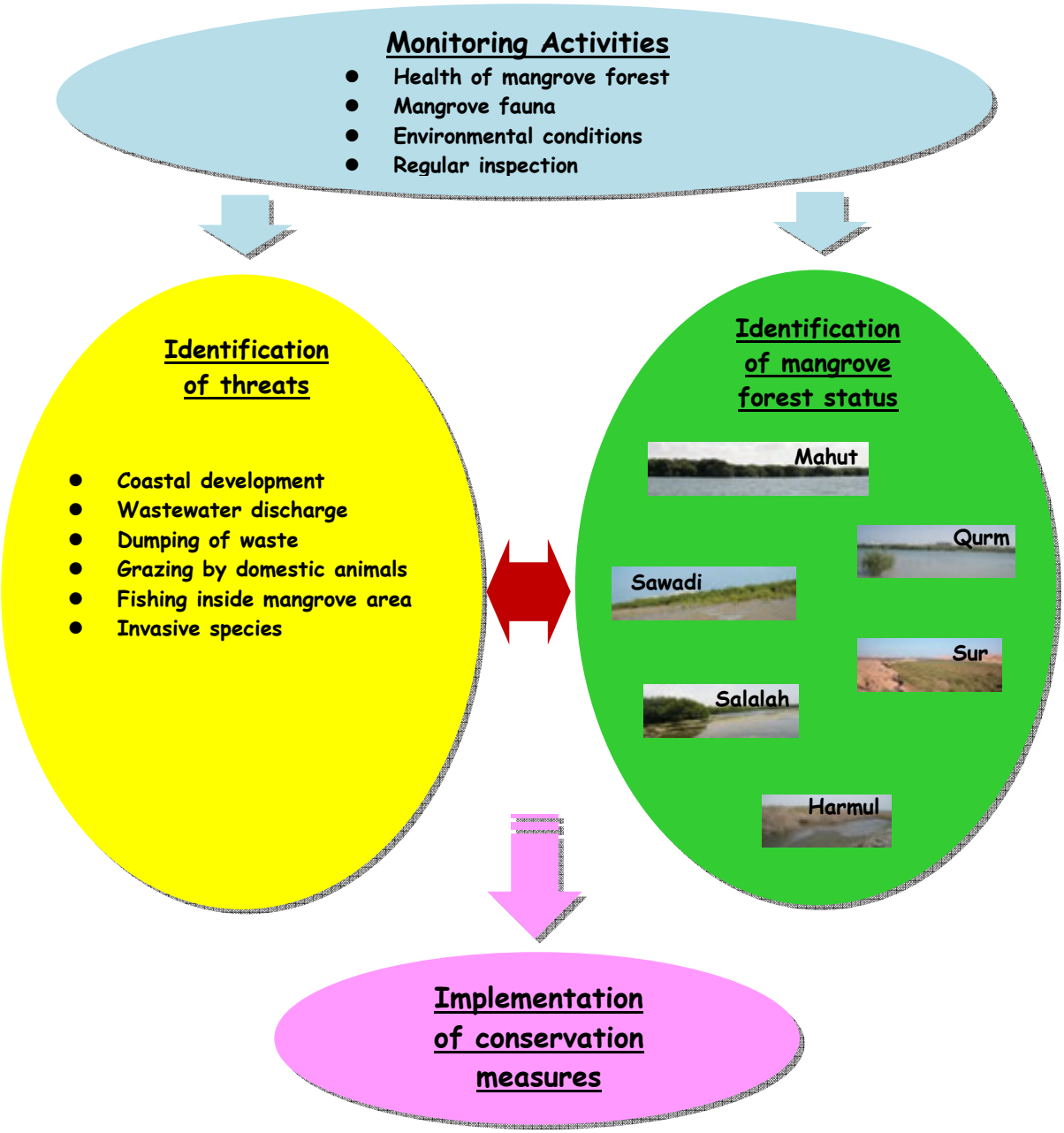
Damaged mangrove trees due to stagnant water, which was caused by sedimentation and soil compaction of the area at the end of the khawr.

Damaged mangrove trees due to sediment accretion and consequent water shortage. Some trees are also buried in sand.

Various coastal development activities such as port and road construction, may have adverse impacts on mangrove ecosystems. Alteration of the hydrology (both groundwater and surface water) and topography of the mangrove forest are one of the major impacts that may be caused by such development activities, as evidenced in the case with Khawr Harmul. However, since such impacts occur over a relatively long-term period, they can often be overlooked and realize the consequences only after it is too late.

Management of mangrove forests

Different types of mangrove forests are distributed along the coastline of Oman as shown in the previous pages. These forests are vulnerable to environmental changes and pressures from human activities. To protect these forests, QEIC will conduct regular monitoring activities, and from it, identify the status and threats to the mangrove forests, and take proactive measures, if any signs of degradation are identified. Following shows the framework of QEIC's mangrove forest management scheme.



Introduction of mangrove ecosystem

Qurm Environmental Information Center (QEIC)

■What are mangroves?

Mangroves are subtropical/tropical trees that grow in sheltered coastal areas along the intertidal zone, where it is often muddy and regularly inundated by seawater. While most trees cannot survive in such environment due to high salinity and low-oxygen soil conditions, mangroves have developed various ways to grow in such stressful environment. Worldwide, there are over 50 species of mangrove, but only one species grow naturally in Oman, which is *Avicennia marina*.

★Adaptations to low-oxygen soil conditions

Trees require oxygen to survive and grow, including the underground roots. While roots normally take-in oxygen from the soil, this is often difficult for mangroves as the soil is usually low in oxygen due to regular seawater inundation. To adapt to such conditions, mangroves develop "aerial roots", which are root structures specialized in supplying above-ground oxygen to the underground roots. Oxygen is taken-in from the air through small pores (lenticels) on the surface of the aerial root, which is then transported to the underground roots via air channels (aerenchyma) inside the aerial root.

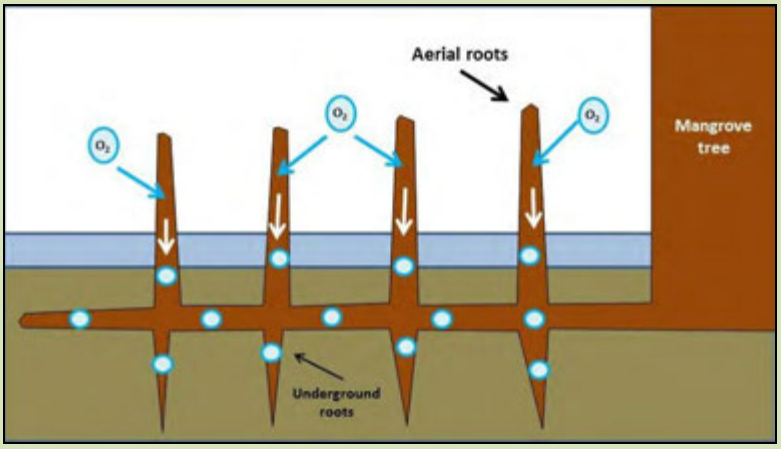


Image of oxygen supply mechanism of aerial roots

★Adaptations to high salinity conditions

Trees require water to grow, which is mostly taken-up through the soil via the underground roots. However, since mangroves grow in high salinity soil conditions, they must somehow remove the excessive salts contained in the water they consume, as too much salt is harmful to the tree. Mangroves have evolved various methods to cope with this problem.

Method 1: Exclusion method

In the process of taking-up soil water, mangrove roots can somehow filter out some of the contained salts at its root surface. For *Avicennia* species, most of the salt (around 90%) contained in the water is excluded through this method (Hogarth 2007).

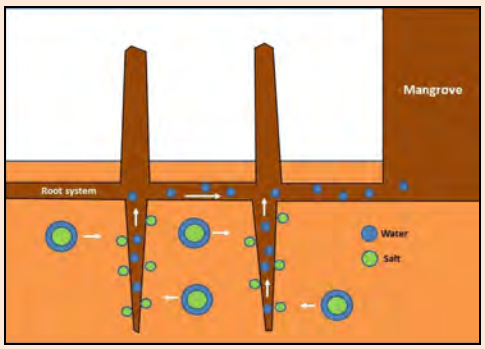


Image of salt exclusion at the root surface

Method 2: Secretion method

Some mangroves have salt glands on their leaves, and can secrete the excessive salt from these glands. If you carefully observe the backside of an *Avicennia* leaf, you may see the secreted salt crystals.

Method 3: Deposition method

Some mangroves can deposit excessive salt in the barks of their stems and roots. Some mangroves deposit salt in old leaves, which are then shed.

Avicennia species deploy all these methods, which may explain why they have high tolerance to high salinity conditions, compared to other mangroves.

■Reproduction methods of mangroves

★Pollination

Mangrove trees reproduce sexually by producing flowers, which are pollinated by wind or animals such as birds and insects. To attract animals, flowers produce nectar and emit a pleasant scent. Bees are the main pollinators of *Avicennia* species (Hogarth 2007). The main flowering season in QNR is April-May.

Flower of *Avicennia marina*

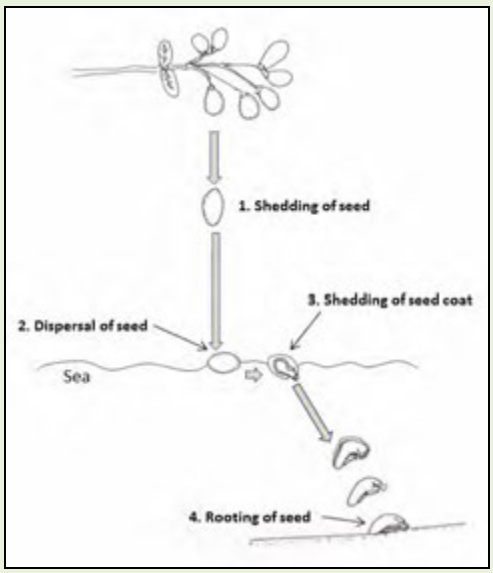
★Seed production

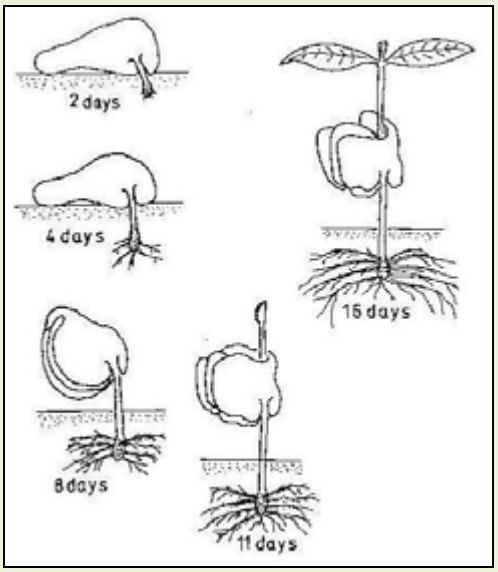
Once the flower is pollinated and successfully fertilized, the tree produces seeds. Unlike most trees, mangrove seeds are unique in that it germinates and continue to grow while still attached to the parent tree, which is called vivipary (seeds of orthodox trees germinate after detachment from parent tree and only when under favorable conditions such as after rain). The main seed-bearing season in QNR is June-July.

Seed of *Avicennia marina*

★Seed dispersal

Once the seeds grow to a certain size, they are shed from the parent tree and are dispersed by tidal currents, by being buoyant for a while. Seeds of *Avicennia* species remain buoyant for a few days until they shed their seed coat (pericarp). Once the pericarp is removed, the seed sinks to the seafloor and attaches itself to the soil with its hair-like root and rapidly grow from then on.



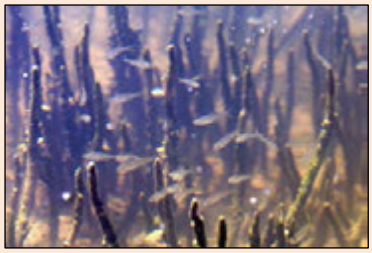


Dispersal and growth process of *A. marina* seed

■Animals in mangrove forest

Animals in mangrove forests are unique because they are adapted to live under constantly fluctuating water levels, by changing their behavior in accordance to the tide. The most conspicuous animals are fishes, crabs, snails and birds.

★Fishes



Many fish species come to mangrove forest when they are young, due to the calm waters, abundant food and many hiding places available (e.g. aerial roots of mangrove trees). Around 40 fish species have been recorded in QNR, which include commercially valuable species such as mullets and sea breams. Hence, mangrove forests are also important for the local fishing industry.

★Crabs

Crabs are found in many places, such as on mudflats, on mangrove trees and inside waterways. The most common crabs are grapsoid crabs, fiddler crabs and swimming crabs.

Grapsoid crabs

Grapsoid crabs typically have a squarish carapace and hook-like legs. They are often found in the upper intertidal zone, crawling on the mud-surface or climbing on mangrove trees during high tide. Some grapsoid species eat fallen mangrove leaves, which are important for the mangrove food chain, as they make the energy stored in the leaves more readily available to other organisms.

Grapsoid crab

Fiddler crabs

Fiddler crabs can be easily identified as one claw is much larger than the opposing one (female fiddler crabs have similar-sized claws). They also have long eye stalks, for all-round visibility. They make burrows in the intertidal zone, and come out during low tide to feed on organic matter on mud surface. Male crabs sometimes wave the oversized claw probably to attract female crabs or to defend their territory.

Fiddler crab

Swimming crabs

Swimming crabs are relatively large crabs that live mostly inside waterways. They have paddle-like legs and strong claws, making them fast swimmers and strong predators. They eat fish, crustaceans and can even eat snails by crushing their hard shell. Some swimming crabs are caught by humans as they are extremely delicious!

Swimming crab

Young swimming crab

★Snails

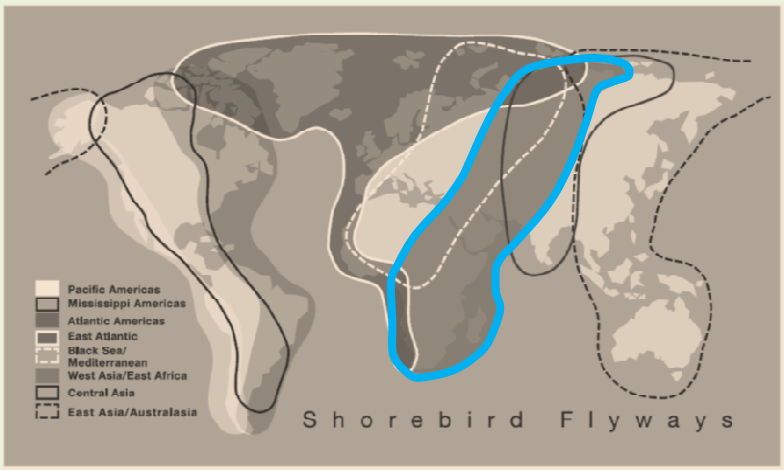
Snails are found crawling on the mud-surface or buried inside the mud. They feed mainly on detritus and algae. One of the most conspicuous snails is the mangrove whelk (*Terebralia palustris*). Like some crabs, they eat fallen mangrove leaves, playing a significant role in the mangrove food chain.

Mangrove whelk

★Birds

Many types of birds come to the mangrove forest and adjacent mudflat to feed on the abundant food available. The most conspicuous birds in QNR include herons, sandpipers and plovers. These birds are usually seen foraging at intertidal mudflat areas for small invertebrates (e.g. crabs, snails and worms) or in shallow waters for fish. Most of these birds are also migratory, so their abundances fluctuate with the season.

Bar-tailed Godwit

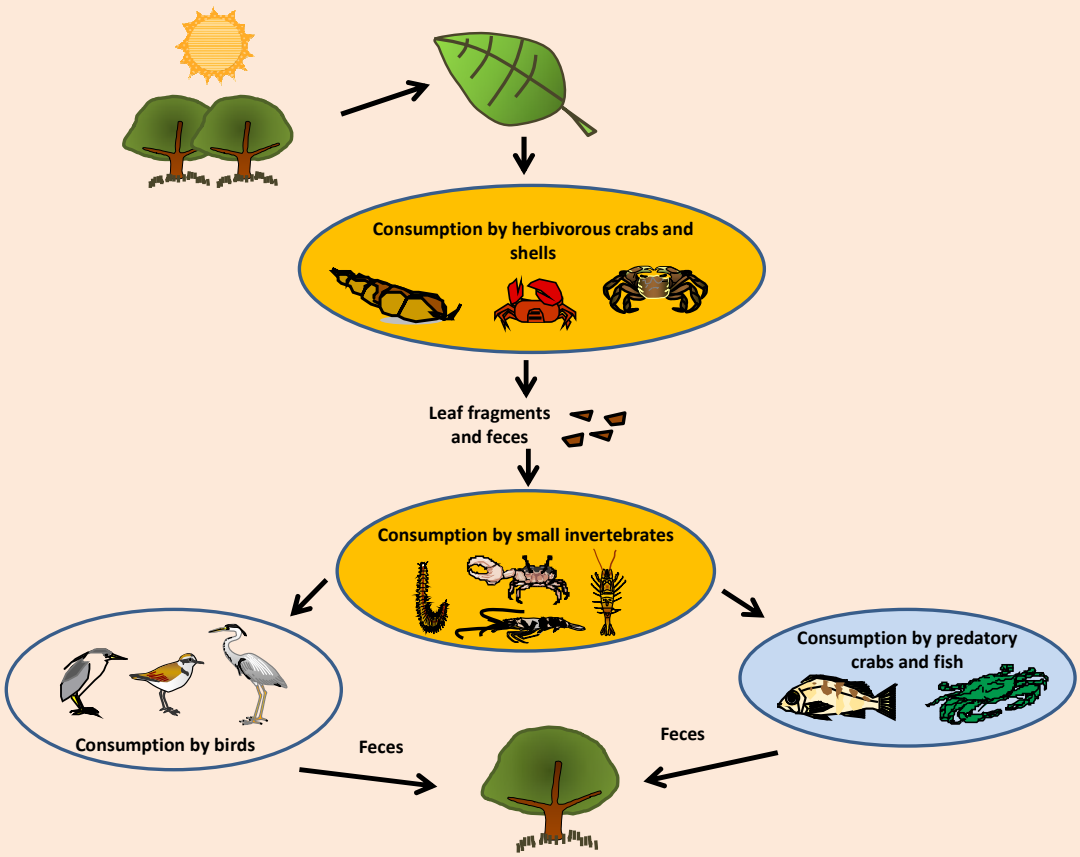


Source: International Wader Study Group

Main flyway of migratory birds that come to Oman (circled in blue)

■Food chain of mangrove ecosystem

Mangroves produce large amount of litter as they shed their old leaves. While these leaves may appear insignificant, they are one of the principal driving forces of the mangrove ecosystem. For example, fallen leaves are consumed by leaf-eating crabs and snails. The leaf fragments and wastes produced from these animals then become food for other organisms such as small invertebrates. These are then consumed by larger predators such as fish, crabs and birds. The wastes of these animals also become important sources of nutrients for mangrove trees. From this, we can see that nothing is wasted in a mangrove forest, and is sustained by the interaction of various animals large and small, each playing an important role in keeping the mangrove and ecosystem healthy.



Food chain of mangrove ecosystem based on fallen mangrove leaf

■Why conserve mangrove ecosystem?

Mangrove ecosystem has important ecological roles in the coastal ecosystem, as it serves as a nursery and spawning ground for various marine species, including commercial species. Migratory birds also feed on the crabs, worms and fishes that are abundant in and around mangrove areas. Therefore, any loss or damage to mangrove ecosystem may have significant impacts to the entire coastal ecosystem and then eventually to the human society.

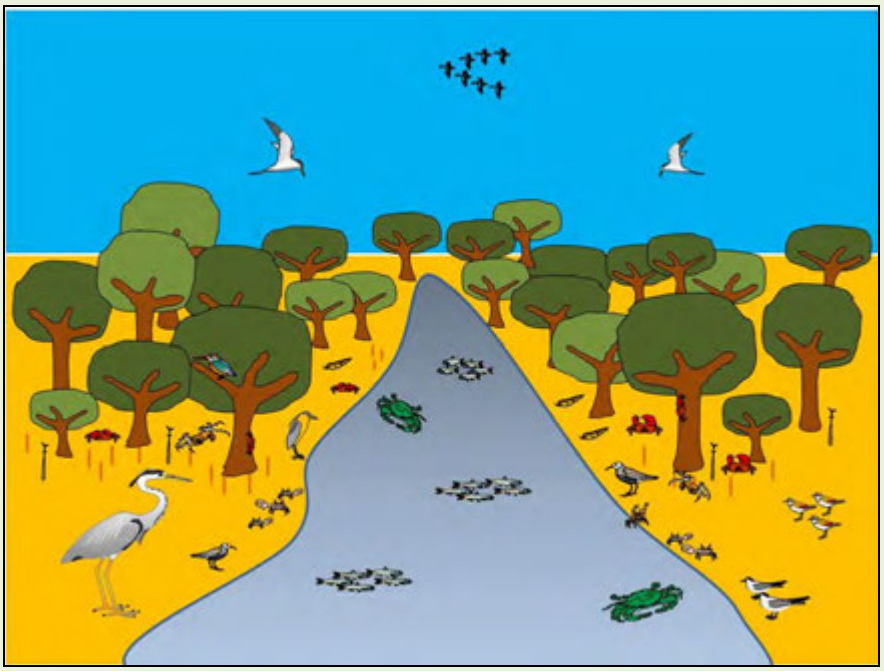


Image of mangrove ecosystem

In addition to its ecological importance, mangrove ecosystem also has numerous other benefits such as:

- Provides precious greenery without any need to supply freshwater, which is especially valuable in arid countries like Oman.
- Provides place for relaxation and recreation.
- Potential source of income for the local community (e.g. ecotourism, honey production).
- Protects land from high waves and flooding.
- Improves water quality by absorbing excessive nutrients and trapping suspended sediments.
- Reduction of atmospheric CO_2 levels by fixing carbon.

■Threats to mangrove ecosystem

Mangrove ecosystems are sustained over a delicate balance between mangroves and the various animals that live in the area. However, threats to this precious ecosystem are ever-increasing mainly due to human pressures. Following are some of the main threats found in Oman:

- **Coastal development (e.g. ports, roads)** is one of the major threats to mangrove ecosystem. Mangroves can be affected even if development is conducted at a distant location by for example causing coastal erosion/accretion.

- **Wastewater discharge** into the mangrove area may pollute the waterway, and consequently affect mangroves and animals.
- **Dumping of waste** in mangrove areas is unfortunately quite common. Plastic bags are especially troublesome as it can entangle on aerial roots (hindering respiration) and stems of vulnerable young trees. Wastes dumped in the sea can also wash-up into the mangrove areas.

- **Grazing by domestic animals** (e.g. camels, goat, donkey) is a major threat, especially for small mangrove forests.
- **Fishing inside mangrove areas** will result in catching many juvenile species, which may have significant impacts on the coastal fish resources.
- **Others:** cutting of mangrove, tourism, intrusion of invasive species (e.g. *Prosopis juliflora*).

References: Hogarth, P.J. 2007. The Biology of Mangroves and Seagrass (2nd edition), Oxford University Press

The Ministry of Environment and Climate Affairs (MECA) is working to protect and conserve the mangrove ecosystem in Oman. Please contact us for any inquiries.

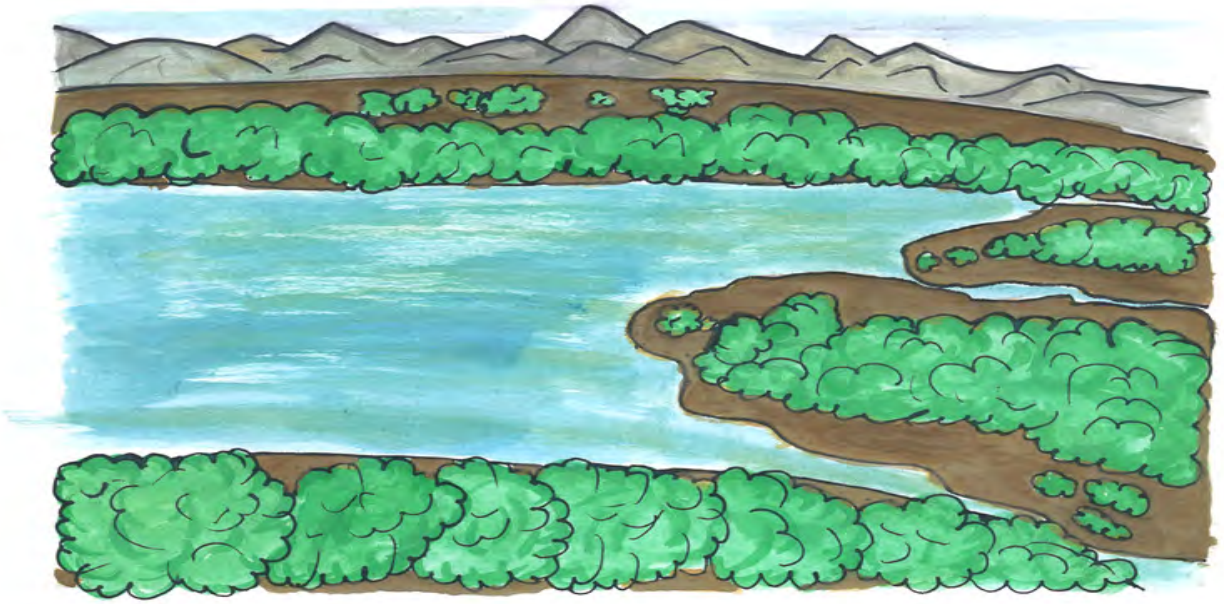
Directorate of Nature Conservation, Ministry of Environment and Climate Affairs
Contact Address: P.O.Box 323, Postal Code 100, Al-Khuwair, Muscat, Sultanate of Oman
Tel: 00968-24404756, Fax: 24602283

Do you know mangroves ?

~ Wonderful Mangroves of Oman ~

Qurm Environmental Information Center (QEIC)

Ministry of Environment and Climate Affairs (MECA)



Mangroves are subtropical/tropical plants that are growing coastal areas along the intertidal zone. Most of the plant cannot live in saline water, but mangroves can live even in seawater.
There are many different species of mangrove trees in the world.
We have only one species, Avicennia marina, in Oman.

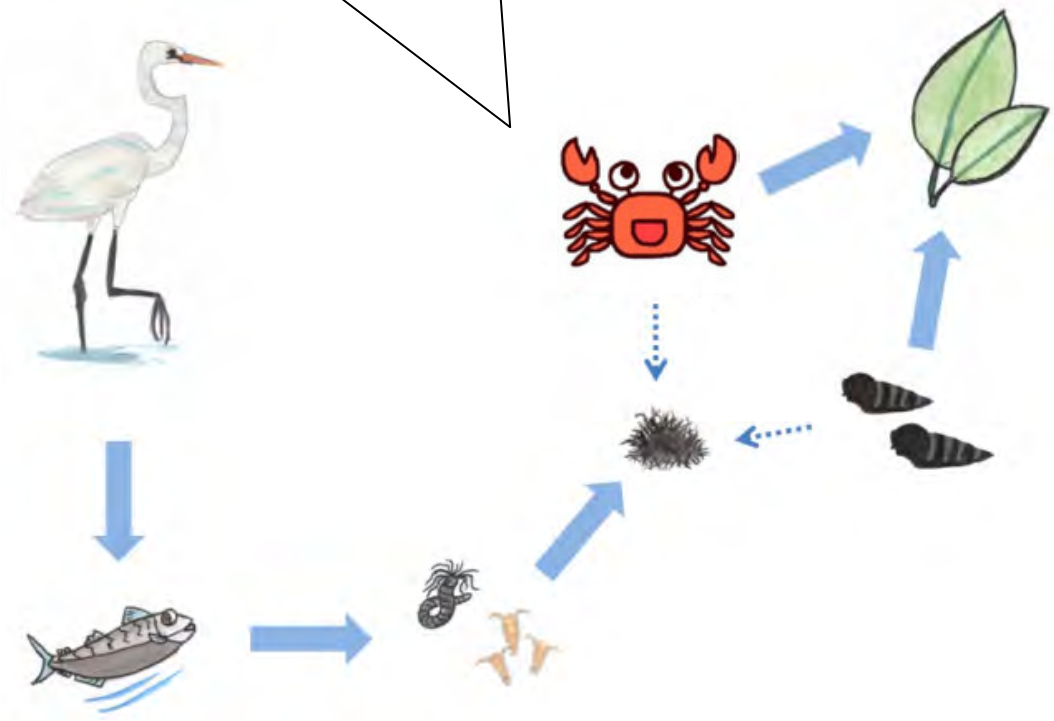
Do you know mangroves ?

Mangroves are trees living in the intertidal area !

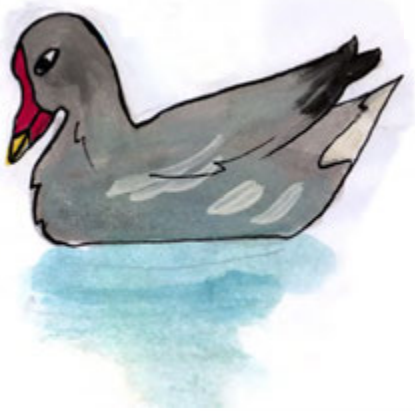
We can live in sea water !

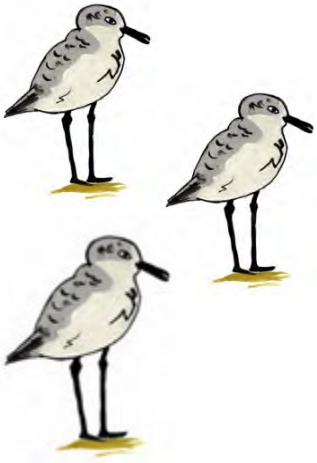
Mangrove forest is a nursery for crabs, shells, and fish.

There is a "food chain" in the mangrove ecosystem.

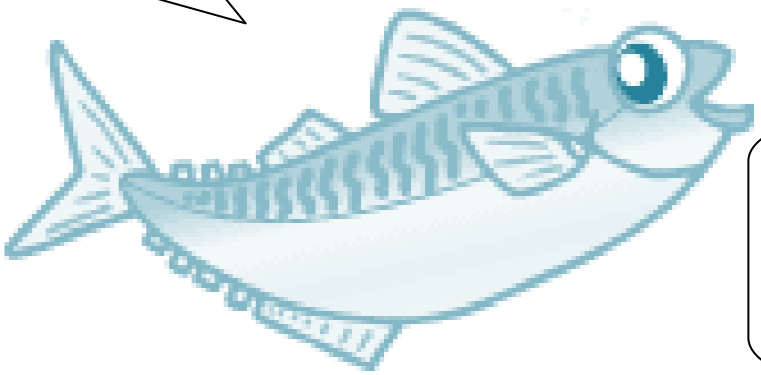


And you can find many birds in the mangrove forest.

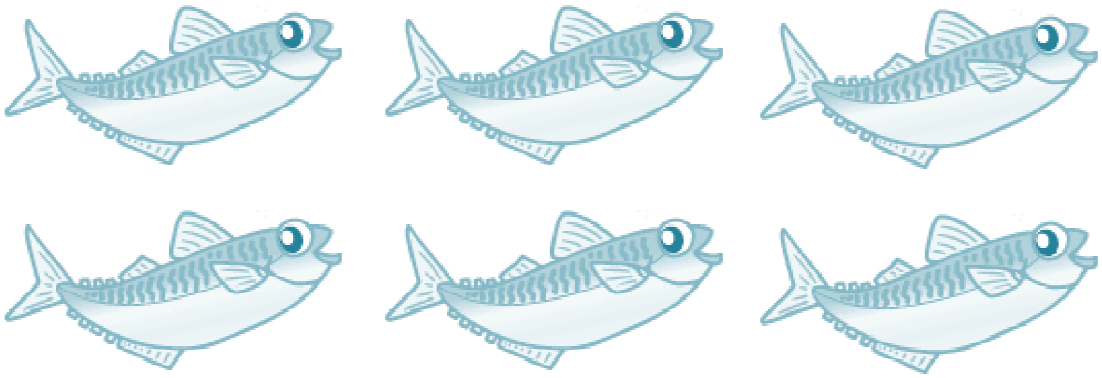




Mangrove forest provides various benefits to our life.



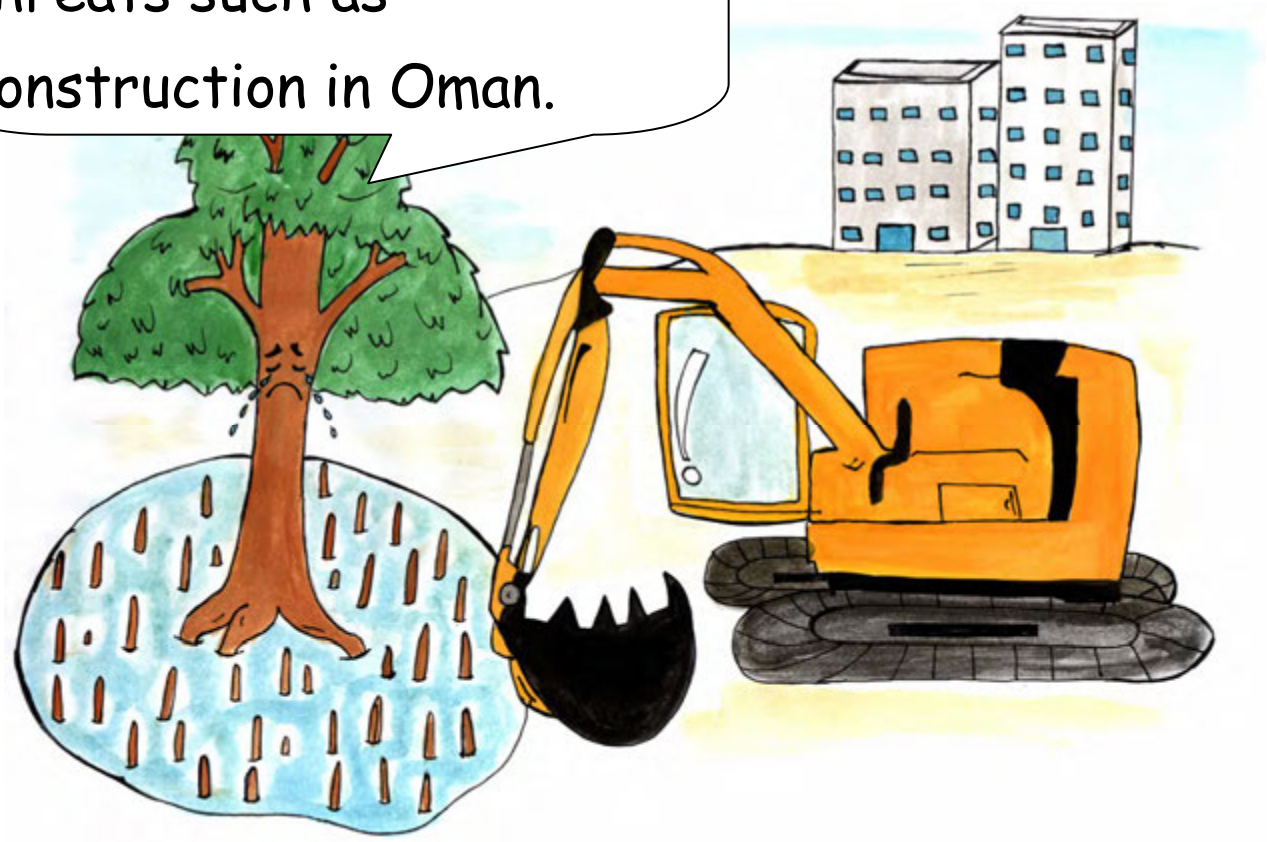
Mangrove forest enriches fishes !



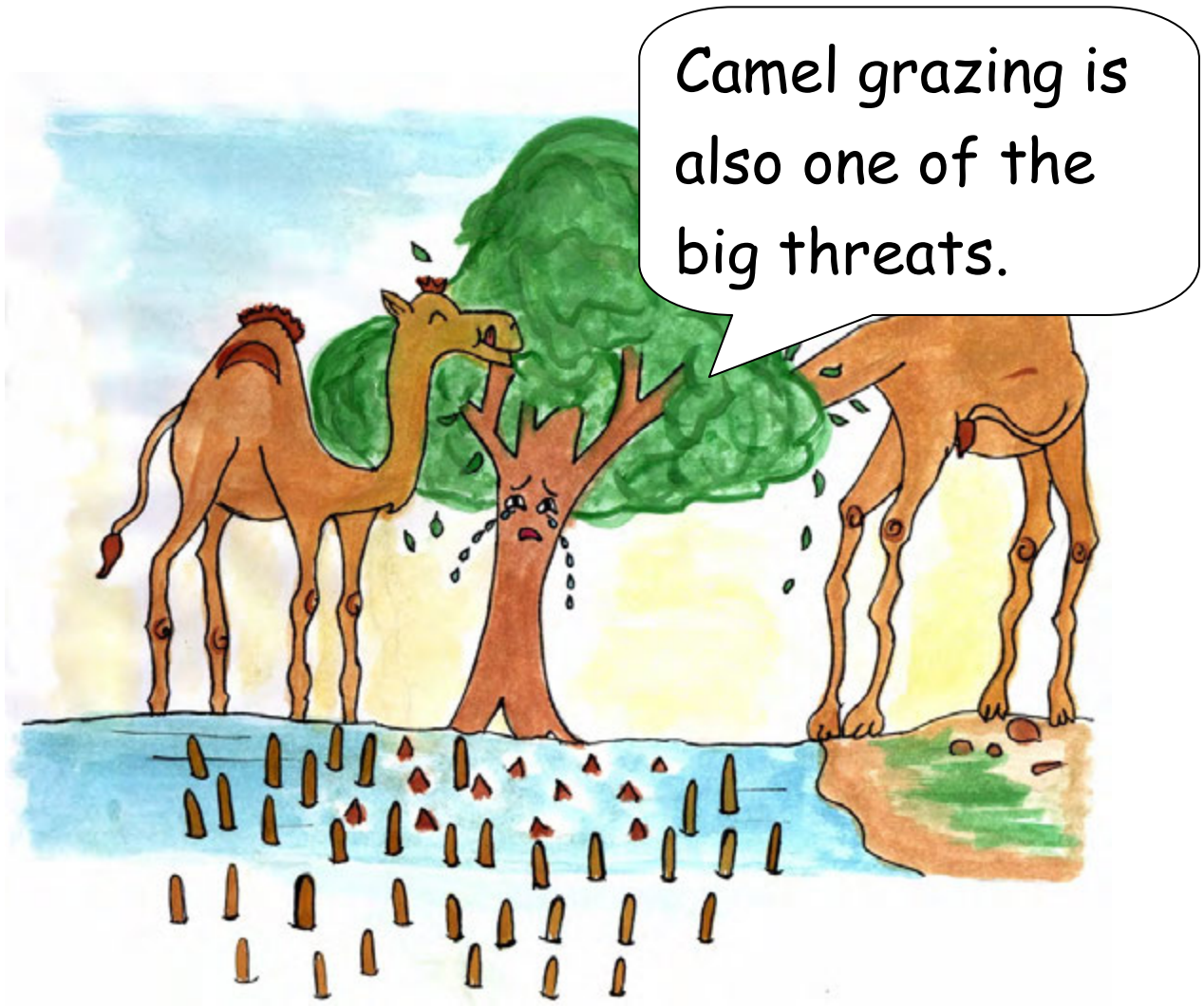
We provide honey from mangrove flowers !.

Mangrove forest provides place for relaxation.
We are useful to prevent disasters such as high waves.

We are facing various threats such as construction in Oman.



Dumping of waste in mangrove areas is a big problem.


Camel grazing is also one of the big threats.

Illegal fishing in mangrove areas damages fish resources.

Let's plant mangrove trees !

Let's conserve mangrove forests for the future !

Illustrated by Ms. Hanan Amor Al-Maamari

Qurm Environmental Information Center (QEIC), Ministry of Environment and Climate Affairs (MECA)

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Animals in mangrove forests of Oman

Qurm Environmental Information Center (QEIC)

Fishes

The waterways of mangrove forests are ideal for young fishes to grow, due to the calm waters, abundant food and many hiding places available (e.g. aerial roots). Over 40 species have been recorded at Qurm Nature Reserve (QNR), including many commercial species.

★Mullet

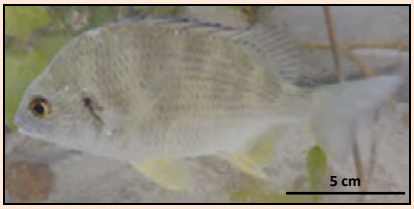
Mainly eat algae and detritus. High-valued commercial fish

Ellochelon vaigiensis

Moolgarda seheli

★Sea bream

Mainly eat small invertebrates. Commercial fish



Acanthopagrus latus

★Grunter

Mainly eat small invertebrates

Terapon jarbua

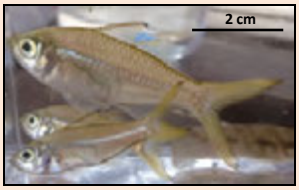
★Goby

Benthic fish. Mainly eat small invertebrates.

Oxyurichthys ophthalmonema

Favonigobius rechei

★Glassfish

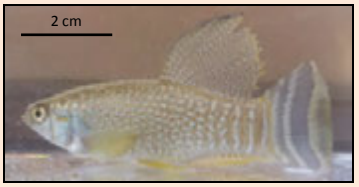


Ambassis gymnocephalus

★Silverbiddy

Gerres acinaces

★Killifish



Aphanius dispar

Crabs

Crabs are one of the most conspicuous animals in the mangrove forest, which can be found crawling on mudflats, around mangrove trees and inside waterways. The most common crabs are Grapsoid, Ocypodidae and Portunidae crabs.

★Grapsoid crabs

Typically have a squarish carapace with pointed and hook-like legs, making them good tree climbers. Often found in the upper intertidal zone including on mangrove trees. Some species eat fallen mangrove leaves, making the energy stored in the leaves more readily available to other organisms.

Metopograpsus sp

Episesarma sp.

Perisesarma sp.

★Ocypodidae crabs

Typically have long eyestalks and some have unequal sized claws (usually males). They make burrows in the intertidal zone, and come out during low tide to feed on organic matter on mud surface.

Macrophthalmus sp.

Uca sp.

Uca sp.

★Portunidae crabs

They have paddle-like legs and strong claws. These make them fast swimmers and strong predator (e.g. eat other crabs, fish, shells). Some species are consumed by humans.

Portunus sp.

Portunus segnis

Thalamita crenata

Birds

Many birds, including migratory birds, come to mangroves and adjacent mudflats to feed on the abundant food available. They are the top predators of the mangrove food chain. Some birds also nest inside the mangrove.

★Sandpipers and plovers

Often found in exposed mudflats next to mangrove forest during low tide. They mainly feed on small invertebrates such as crabs and worms. Most are migratory and travel extremely long distances (e.g. between Asia and Africa).

Common Redshank

Black-tailed Godwit

Eurasian Curlew

Plovers look similar to sandpipers but typically are smaller and have relatively short bills.

Lesser Sand Plover

Kentish Plover

Common-ringed Plover

★Herons

Herons are medium to large sized birds with long legs and necks. They often stand on the edge of shallow water, waiting until prey (e.g. fish) comes within range.

Western Great Egret

Grey Heron

Western Reef Heron

Purple Heron

Black-crowned Night Heron

★Spoonbills and ibises

Birds in this family have long bills. Spoonbills feed in the water by sweeping the spatula-like bill from side to side and shut's it the moment any small animals touches the inside of the bill.

Eurasian Spoonbill

Glossy Ibis

★Flamingos

Flamingos mainly feed on shrimp and blue-green algae. Their pink color is derived by eating these algae.

★Seabirds (birds that live and feed mainly in the open sea)

Black-headed Gull

Sooty Gull

Terns

★Other common birds

Moorhen

Grageny

Red-wattled Lapwing

Black-winged Stilt

Cormorant

Osprey

Kingfisher

Green bee-eater

White-eared Bulbul

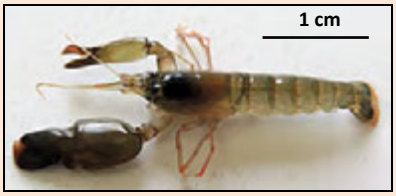
Other animals

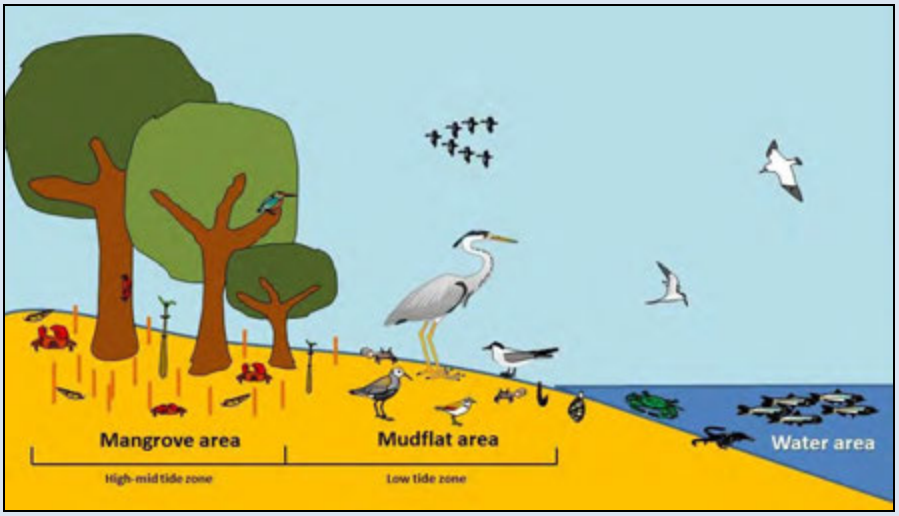
There are many other animals that are less conspicuous but just as important in the mangrove ecosystem.

★Snails (mainly eat algae and detritus)

★Bivalves (filter feeders)

★Shrimps (mainly eat detritus)





Animal distribution around mangrove forest (image during low tide)

Please contact us for any inquiries.

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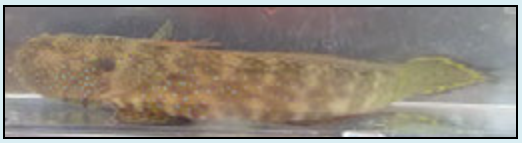
-Fishes-

★Mullet

★Grunter

★Glassfish

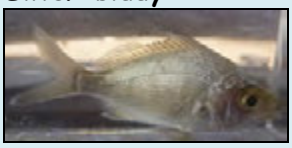
★Goby



★Killifish

★Sea bream

★Silver-biddy



-Crabs and other animals-

★Sesarmidae crabs

★Ocypodidae crabs

★Portunidae crabs

★Snails and clams

★Shrimps

-Birds-

ANIMALS OF MANGROVE FOREST IN OMAN
QURM ENVIRONMENTAL INFORMATION CENTER (QEIC) PROJECT
Ministry of Environment and Climate Affairs (MECA)
Japan International Cooperation Agency (JICA)

★Sandpipers

Common Redshank

Black-tailed Godwit

Eurasian Curlew

Common Greenshank

★Plovers

Kentish Plover

Common-ringed Plover

★Spoonbills and ibises

Eurasian Spoonbill

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★Herons

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Western Reef Heron

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★Gulls and terns

Black-headed Gull

Sooty Gull

Terns

★Flamingos

Greater Flamingo

★Other common birds

Moorhen

Grageny

Red-wattled Lapwing

Black-winged Stilt

Cormorant

Osprey

Green bee-eater

White-eared Bulbul

Basic Procedure of Mangrove Seedling Transplanting

الأساليب الأساسية في استزراع شتلات أشجار القرم

مشروع مركز القرم للمعلومات البيئية

The Qurm Environmental Information Center (QEIC) Project

Hold a pot by both hands tenderly.
احمل الشتلة بحذر إلى موقع الاستزراع

Cut a pot by knife gently.
اقطع الحافظة البلاستكية بحذر

Do not hold a seedling by stem.
حاذر.. لا تحمل الشتلة من الجذع

Do not plant a seedling without removing plastic pot.
تأكد من نزع الحافظة البلاستكية قبل زراعة الشتلة

Hold a seedling tenderly by both hands so as not to break root zone soil block.

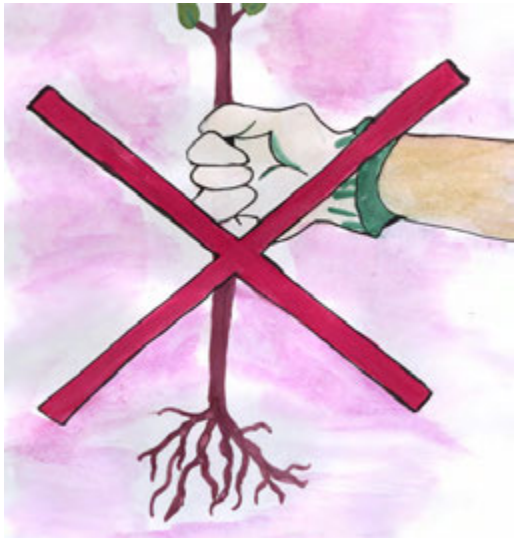
احمل الشتلة بكلتا اليدين حتى لا تتفتت التربة المحيطة بالجذور

Plant a seedling tenderly into a transplanting hole.

اغرس الشتلة بحذر

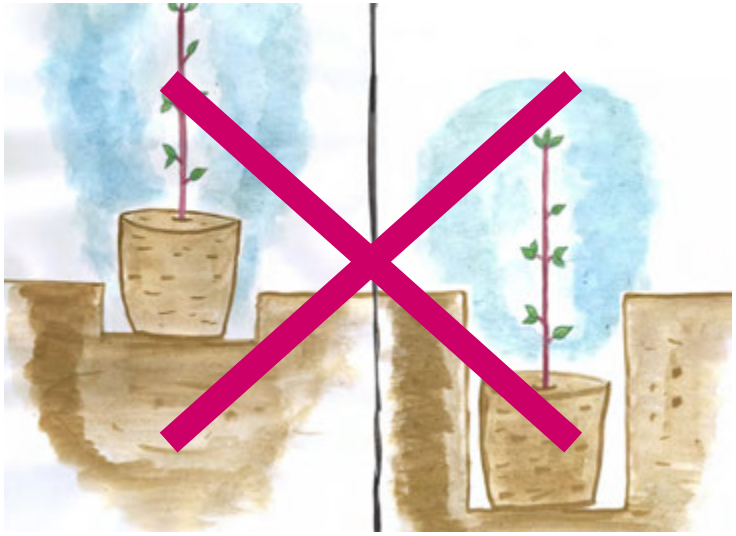
Firm the soil surface after transplanting the seedling.

قم بتسوية التربة وذلك بالضغط على مكان غرس الشتلة



Do not remove root zone soil from the seedling.

حاذر.. لا تقم بإزالة التربة المحيطة بالجذور



Do not transplant the seedling very shallowly or very deeply.

تأكد من غرس الشتلة على مستوى واحد

Responsible Organization:

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