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## **Plant Communities in Wadi el-Gemal–Hamata**



*Balanites aegyptiaca* forest

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## **Acronyms and Abbreviations**

ARE	Arab Republic of Egypt
EEAA	Egyptian Environmental Affairs Agency
EEPP	Egyptian Environmental Policy Program
G.	Gebel (Arabic word for mountain)
GEF	Global Environmental Facility
GOE	Government Of Egypt
MSEA	Ministry of State for Environmental Affairs
PSU	Program Support Unit
USAID	United States Agency for International Development
US	United States

## **1. Introduction**

Within the framework of the Egyptian Environmental Policy Program (EEPP), the Program Support Unit (PSU) provides assistance to the Egyptian Environmental Affairs Agency (EEAA) in creating a management plan for the newly established protected area in the Wadi el-Gemal–Hamata region.

This consultant was asked to make a survey of flora in this area, which was declared a protected area according to a decree issued by the Prime Minister (decree number 143 of year 2003).

The report comprises an overall identification of the components of the various plant communities within and bordering the protected area. It focuses on the present conservation status of the flora and plant communities and provides opinion as to the major threats to the vegetation of the region. It also proposes recommendations for the conservation, promotion, and sustainable exploitation of the plants as well as the mitigation of diverse negative impacts of urban development, over-exploitation, and environmentally unsound practices.

The report aims to contribute to the overall identification of conservation management priorities as well as the establishment of an appropriate management plan, aimed at the mitigation of existing negative impacts on the environment.

### **1.1 Study Objectives**

The study's objectives are to:

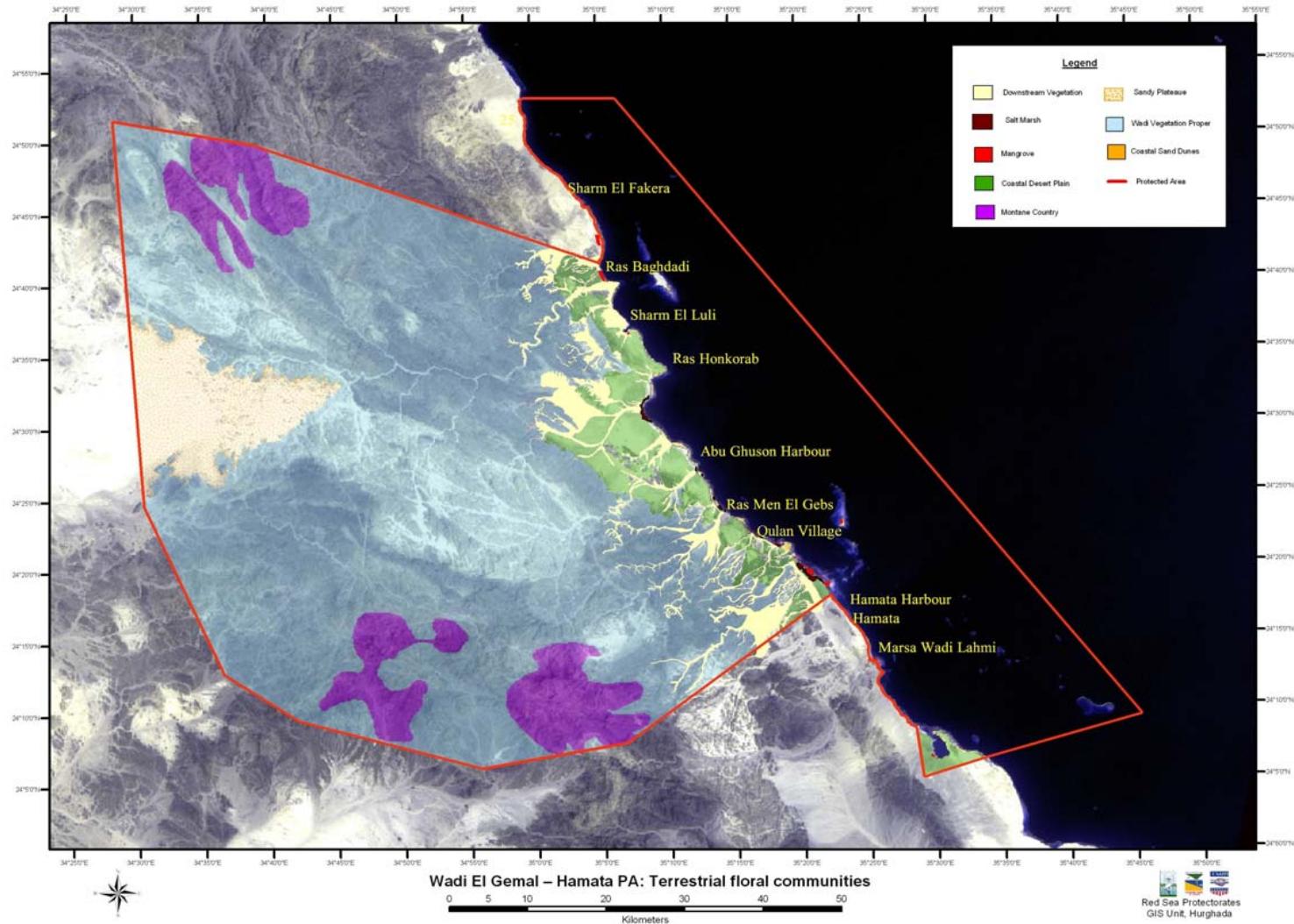
- Complete a survey of the flora and plant communities in the protected area
- Identify threats to vegetation and plant life
- Propose recommendations to mitigate negative effects, protect existing communities, and to prevent future destruction or negative impacts
- Propose recommendations concerning management issues for the protected area.

### **1.2 Methodology**

First-hand information was acquired during a field trip to the protected area. Plant species encountered were identified and documented by photos, as were plant communities. Special attention was given to threats and destructive activities observed in the field. Terrestrial floral communities are shown in figure 1.

The consultant also reviewed publications dealing with the flora and vegetation of the Eastern Desert–Red Sea Coastal Zone. These are listed in appendix 1.

**Figure 1** Terrestrial Floral Communities



## 2. Results

### 2.1 Plant Communities/Terrestrial Ecosystems

Generally speaking, the Wadi el-Gemal–Hamata Protected Area lies within the hyper-arid desert ecosystem, which, due to climatic and geomorphologic conditions is characterized by low rainfall and high summer temperatures with strong diurnal–nocturnal as well as summer–winter variation in temperatures. The ecosystem could be further divided into:

#### 2.1.1. Coastal Ecosystem

The coastal salt marshes comprise areas bordering the sea coast. Their composition and distribution relate to edaphic and climatic factors. They could be further subdivided as shown below.

*Mangals or Mangrove Community*

**Figure 2 Mangrove Bay**



**Figure 3 Avicennia marina Population**



**Figure 4      Sedimentation around Mangroves**



Climatic conditions and shoreline morphology in the coastal part of the protected area allow the presence of a mangrove ecosystem, which is confined to small sheltered bays cut into the beach where *Avicennia marina* form monotypic bushy forests.

*A. marina* grows in the water, on the terrestrial side of the shoreline or sometimes (as in the Wadi el-Gemal delta) partly covered with sand hillocks due to silting or an artificial sedimentation/deposition process probably as a result of the ongoing coastal development.

*Avicennia marina* is one of 55 species of mangrove growing in tropical and subtropical coastal areas. Another species; *Rhizophora mucronata* grows on the Red Sea coast from Shalateen southwards. They are both important plants; they create an ecosystem in which many other creatures live, produce biomass energy, and protect the coast against erosion.

Due to their importance, mangrove areas have been taken under protection. Detailed maps of the distribution of both species have been prepared and efforts towards their conservation are currently taking place through delimitation and signage.

Protected mangrove areas are still subject to many hazards due to grazing by camels, pollution of the Red Sea, human interference, and urbanization. Mangrove populations are suffering, little regeneration is taking place, and the stands are diminishing. It is necessary at this stage to invest extra effort and money in order to protect and rehabilitate these valuable plants.

#### *Salt Marshes*

Distinct zonation is evident within the coastal plant communities corresponding to their tolerance for salinity. The salt marsh communities are often fringed by Mangroves on the coast and their inland extension depends on the raised land further

east. The plant cover is formed of stands of uniform growth of a single dominant species and a few associates, mainly *halophytes*. Thus a mosaic of the following species is often recorded and varies according to local topography and soil salinity:

- Arthrocnemon/Salicornia*
- Atriplex halimus*
- Atriplex farinosa*
- Zygophyllum album*.

**Figure 5 Signage for Protected Mangrove Areas**



**Figure 6 Salt Marsh Vegetation**



#### *Coastal Sand Dunes*

Further from the shoreline, distinctive vegetation could be observed growing on sand dunes, forming phytogenic mounds or hillocks. Tamarix mounds are perhaps the most

prominent among these but there several other species growing within this type of ecosystem such as:

- Aeluropus brevifolius*
- Limonium axillare*
- Stipagrostis sp.*
- Zygophyllum album*
- Zygophyllum coccineum*
- Tamarix aphylla*
- Tamarix nilotica*.

**Figure 7 Vegetation on Coastal Dunes**



The sedimentation/deposition process going on, probably as a result of the ongoing coastal development, has resulted in the tamarisk suffering from shoreline recession and standing with their roots in the sea, as shown in figure 8.

**Figure 8** *Tamarix aphylla* in the Wadi el-Gemal Delta



#### *Reed Swamps*

Reed swamps are present where there is seepage of brackish water onto to the coastal plain. This usually occurs at wadi mouths, where cracks in the sediments allow the underground water accumulated in wadis to mix with the sea water, forming wadi deltas.

These special conditions lead to the development of a very peculiar assemblage of flora, characterized by the presence of reeds but also some halophytes in addition to palms.

The swampy areas are dominated by the reeds *Phragmites communis*, *Cyperus spp* and *Scirpus sp.*

**Figure 9** Reeds Growing in the Wadi el-Gemal Delta Swamp



**Figure 10** Camel in the Wadi el-Gemal Delta Swamp



The large swamp at the mouth of Wadi el-Gemal—the Wadi el-Gemal Delta—also harbors other species, the most interesting of which are:

*Avicennia marina* (mangrove)

*Hyphaene thebaica* (Dom palm) and *Phoenix dactylifera* (Date palm), shown in figure 11

*Tamarix aphylla* and *Tamarix nilotica*, shown in figure 12

*Zygophyllum album*

*Zygophyllum coccineum*

*Limonium axillare*

**Figure 11** *Hyphaene thebaica* (Dom palm) and *Phoenix dactylifera* (Date palm)



**Figure 12** *Tamarix aphylla* and *Tamarix nilotica*



*Zygophyllum album*

*Zygophyllum coccineum*

*Limonium axillare*

**Figure 13** Foreground, *Zygophyllum album*, background *Tamarix aphylla* and Date palm (*Phoenix dactylifera*), Wadi el-Gemal Delta



An example for the ensemble of the above mentioned communities is given in Zahran & Willis, 1992, p. 123 for the area between Wadi Ireir and the delta of Wadi el-Gemal

### *2.1.2. Inland Ecosystem*

With its mountains, basement complexes, limestone plateaus, and wadis, the inland ecosystem of the protected area is rich and varied. It is usually divided into the Coastal Desert Plain and the Montane Country ecosystems.

#### *Coastal Desert Plain*

This extends from the littoral area to the foot of the coastal mountains and is characterized by semi-halophytic *Tamarix aphylla*, *T. nilotica*, and shrubs of *Salvadora persica*, and the smaller herbaceous *Zilla spinosa* and *Pulicaria crispa*.

#### *Wadi Vegetation*

The protected area is characterized by a number of wadis that run eastward to flow into the Red Sea. Perhaps the most important is Wadi el-Gemal. The wadis offer large drainage systems and could be transformed into temporary water courses after rainfall.

Wadis have distinctive features and characteristic plant cover; they also have an important potential vegetation due to their large catchment area. Wadi vegetation could be divided into two main categories:

- **Down Stream Vegetation**—The littoral downstream of wadis supports a vegetation in the intermediate area between the coastal desert plain and main wadi vegetation and varies according to geomorphology and soil characteristics. The eastern part, closer to the coast and where the soil is sandy and salty, usually supports halophytic to xerophytic species with *Zygophyllum album*, *Z. coccineum*, *Z. berenicense*, *Tamarix aphylla*, *Tamarix nilotica*, and *Panicum turgidum*. As one moves westward, several other species are recorded including *Calotropis procera*, *Capparis spinosa*, *Leptadenia pyrotechnica* and *Pulicaria crispa*. As in Wadi el-Gemal, this zone ends with the growth of *Salvadora persica*, which forms huge stands on sandy soil and in association with *Tamarix aphylla*.
- **Wadi Proper Vegetation**—This includes the vegetation in the main wadi trunk as well that in runnels pouring into the main wadi.

The central part of the main wadi trunk is usually devoid of plants, which are present on the terraces, as shown in figure 14. This is due to the effect of erosion by torrents.

Wadis in arid regions are also characterized by a framework of perennial vegetation and an ephemeral vegetation that grows only if rain is received. During the survey, it was observed that the perennial plant cover reached 10–15 percent, but could reach up to 60 percent if some rain falls.

**Figure 14 Tamarix aphylla Gallery Forest on Wadi Halous Terrace**



Wadis can be further divided into upstream, middle, and downstream sections.

The main trunk of the wadi is dominated by *Acacia tortilis* and *Balanites aegyptiaca* (as in Wadi el-Gemal). Associates are *Acacia ehrenbergiana* (which sometimes replaces *A. tortilis* or *A. raddiana*), *Panicum turgidum*, *Leptadenia pyrotechnica*, *Lycium shawii*, *Aerva javanica*, *Solenostemma argel*, *Citrullus colocynthis*, and *Ochradenus baccatus*.

- **The *Balanites aegyptiaca* forests**—The density of the *Balanites aegyptiaca* trees in certain parts of Wadi el-Gemal in particular, but also in other neighboring wadis is striking. It is by far the dominant species and sometimes forms a forest, as shown in figure 15. The tree is valuable, its fruits are used medicinally in the control of diabetes and are collected by the local population and sold as a cash crop, the branches are palatable and grazed by camels, and the wood is collected for fuel. The presence of the *Balanites aegyptiaca* in the protected area is important and its sustainable exploitation is vital to the livelihood of the local population. The *Balanites aegyptiaca* currently suffers from negative impacts from vehicular use, overgrazing, over-cutting of fuel wood, and although it still maintains a dense population, if measures for its protection are not put forward, *Balanites aegyptiaca* will decrease in numbers, fail to regenerate, and the fruit yield will decrease.

**Figure 15   *Balanites aegyptiaca* forest, Wadi el-Gemal**



Due to scarcity of rainfall, only perennial vegetation (10–20 percent plant cover) was observed in the wadis but it is to be expected that a much larger plant cover (30–40 percent) would grow during rainy years.

**Figure 16 Acacia tortilis–Zilla spinosa Community, Wadi el-Gemal**



At the eastern end of the main stream of Wadi el-Gemal, and beginning approximately 5 km from the shoreline, large stands of *Salvadora persica* (the toothbrush tree) are present. The *Salvadora persica* is associated with *Tamarix nilotica*, *T. aphylla*, *Pulicaria crispa*, *Z. coccineum*, *Zilla spinosa*, *Aerva javanica* and small *Balanites aegyptiaca* trees.

This plant community is interesting, as the *Salvadora persica* branches are used as toothbrushes by the local community. The stands are huge and similar stands are present in the Wadi Allaqi and Nabq Protected Areas in South Sinai.

Smaller population of *Salvadora persica* were also encountered in other wadis, sometimes in association with *Acacia* trees, e.g: Wadi Halous, as shown in figure 19.

**Figure 17** *Balanites aegyptiaca* and *Salvadora persica*



**Figure 18** *Salvadora persica* stand , Wadi el-Gemal

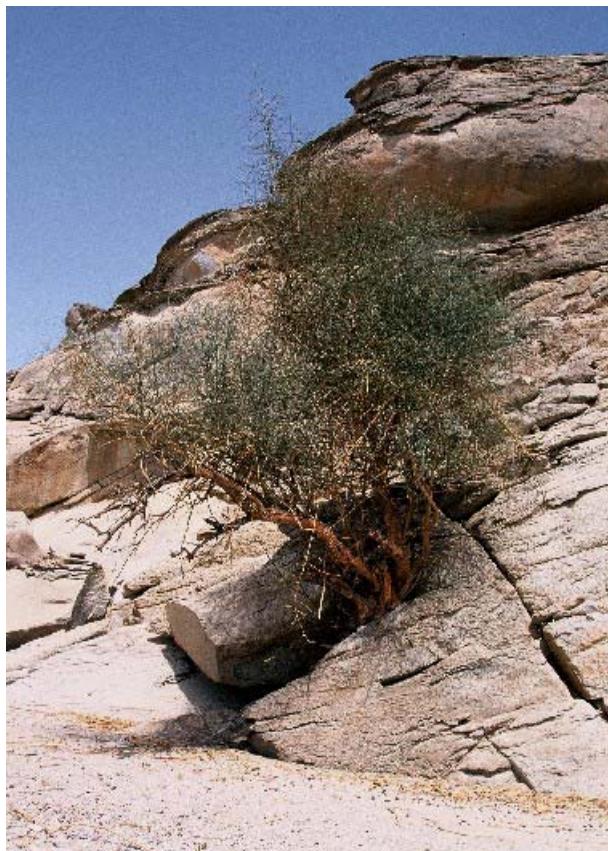


**Figure 19** *Acacia-Salvadora* stand, Wadi Halous



Chasmophytes such as *Capparis decidua* and *C. spinosa* grow in rock crevices along the wadi sides, and are also found in the upstream region of wadis as in Wadi Um Lassaf.

**Figure 20** *Capparis decidua*, Wadi Abu Eishoush



**Figure 21** *Capparis spinosa*, Wadi Um Lassaf



*Maerua crassifolia* tree was a rare find, associated with *Acacia ehrenbergiana*, *Panicum turgidum*, *Cleome droserifolia*, *Trichodesma Africana* var. *homotrichum* as in upstream of Wadi Halous.

This list includes the rest of the plants recorded in the main stream of various wadis within the protected area:

*Caylusea* sp.  
*Chrozophora oblique*  
*Citrullus colocynthis*  
*Cleome Africana*  
*Erodium* sp.  
*Fagonia* sp.  
*Heliotropium strigosum*  
*Launaea spinosa*  
*Linaria arabica*  
*Lindenbergia abyssinica*  
*Lotus deserti*  
*Pulicaria crispa*  
*Senna alexandrina*  
*Tephrosia cf. nubica*  
*Trichodesma africana* var. *homotrichum*  
*Zilla spinosa*  
*Zygophyllum berenicense*  
*Zygophyllum coccineum*

**Figure 22 Upstream Part of Wadi el-Gemal and Wadi Kab Marfouah**



Upstream vegetation depends on the surface area drained as well as on the slope. The runnels and tributaries do not have large catchment areas and the vegetation is usually dominated by herbaceous perennials such as *Zilla spinosa*, *Fagonia* spp., *Trichodesma Africana*, chasmophytes such as *Capparis* spp. (in the upstream regions of wadis such as Wadi Um Lassaf), and *Moringa peregrina*. As the runnels join into larger tributaries, the vegetation evolves to include plants of less xerophytic characters such as *Cleome droserifolia*, *Pulicaria crispa*, and *Panicum turgidum*. The main difference between vegetation in smaller wadis or runnels and that of the main wadis is that runnels usually lack the tree/shrub component.

### 2.2.3 Sandy Plateau

An extensive open landscape characterizes the sandy flat plateaus such as El-Latch Plateau, where numerous gazelle tracks were observed. The vegetation is dominated by the perennial palatable grass *Panicum turgidum*, in association with *Zilla spinosa* and *Pulicaria crispa*. Also present were:

*Stipagrostis* sp.  
*Erodium* sp.  
*Heliotropium cf. strigosum*  
*Senna alexandrina*  
*Cleome africana*  
*Ochradenus baccatus*

And a few *Acacia tortilis* trees

**Figure 23** *Panicum turgidum* Dominates the Plateau Vegetation



### 2.2.4 Montane Country

This includes mountains facing the Red Sea within the protected area, and comprise the Gebel Nugrus group and part of the Gebel Samiuki group. The Gebel Nuqrus group includes G. Hafafit (857m), G. Migif (1198m), G. Zabara (1360m) and G. Mugargag (1086m)

Although not recorded on this field trip, it is reported that the bases of the mountains are characterized by the growth of *Moringa peregrine*.

The wadis cutting through these mountains harbor a vegetation dominated by *Acacia tortilis*, *A. ehrenbergiana*, *Balanite aegyptiaca*, *Leptadenia pyrotechnica*, *aerva persica* and *Salvadora persica*. Associates include *Ochradenus baccatus*, *Lycium shawii*, *Maerua crassifolia*, *Capparis decidua* and *Ficus palmata*. The herbaceous plants include *Cleome droserifolia*, *Pulicaria crispa*, *Zilla spinosa*, *Fagonia spp.*, *Solenostemma argel* and *farsetia longisiliqua*. In shady spots where humidity is higher, *Lindenbergia abyssinica* and *Kickxia nubica* grow.

**Figure 24** *Solenostemma argel* in Wadi Nugrus



The Gebel Samiuki group includes (Gebel Hamata 1977m). Gebel Hamata is reported to be much richer than G. Nugrus as in Zahran & Willis 1992, p. 176. In addition to the trees, shrubs and herbs recorded from G. Nugrus group, several other species are recorded, and these include: *Acacia mellifera*, *Rhus oxyacantha*, *Ficus salicifolia*. A fern: *Adiantum capillus-veneris* grows in moist spots around water wells. Although not very pronounced, humidity forms a quasi mist oasis on top of G. Hamata similar to that at G. Elba.

See appendix 2 for a comprehensive list of plants, including their Arabic names.

### **3. Threats to Flora and Vegetation**

#### **3.1 Charcoal Manufacture**

This is process by which the wood, mostly of *Acacia* is transformed into charcoal through anaerobic combustion. The charcoal produced this way is one of the very few cash crops available to inhabitants of the region.

**Figure 25 Tree Transformed into Charcoal through Anaerobic Combustion**



**Figure 26 Bagged Charcoal**



#### **3.2 Collecting Wood for Fuel**

Wood is collected as a source of fuel; dead wood is preferred but if it is not available, local people will break branches of the acacia tree and leave them to dry.

**Figure 27 Tree Branch Broken to Dry for Firewood**



### **3.3 Grazing and Breaking Branches to Provide Food for Animals**

Camels graze on everything that grows in wadis (except *Salvadora persica*). *Acacia tortilis* and *Balanites aegyptiaca* are among their favorites, but they would graze on *Zilla spinosa* a spiny shrub if there is nothing else.

**Figure 28 Camels Grazing on *Balanites aegyptiaca***



### **3.4 Desiccation Caused by Climate Change**

Wadis in the area have not received rainfall for the last 6 years and records from past years indicate there is a tendency towards aridity in the region. Although this is a natural phenomenon, its effects on the vegetation could be considerable.

### **3.5 Vehicles**

Whether for mining activities or safari trips, cars destroy the vegetation and prevent regeneration.

**Figure 29 Main Car Track in Wadi el-Gemal, Fringed by Plants**



### **3.6 Collecting Plants for Medicinal Uses**

*Balanites aegyptiaca* and *Salvadora persica* are two valuable medicinal plants. They are both traditionally used by the local community, the first as an anti-diabetic and the second as a toothbrush. The collection of *Balanites aegyptiaca* fruits and *Salvadora persica* branches is probably also a source of cash for the local population. The harvesting of these plants does not seem to have so far been very detrimental to their growth and regeneration. If uncontrolled, however, this activity could lead to the destruction of the plants and affect their regeneration.

### **3.7 Coastal Tourism Development**

Even in the areas where Mangroves are protected, coastal development comes so close that building materials, vehicles, and solid waste have greatly affected the plants' growth. There are spots where tourist development is taking place in the protected Mangrove area and investors have even attempted to change the ecosystem through digging ponds!

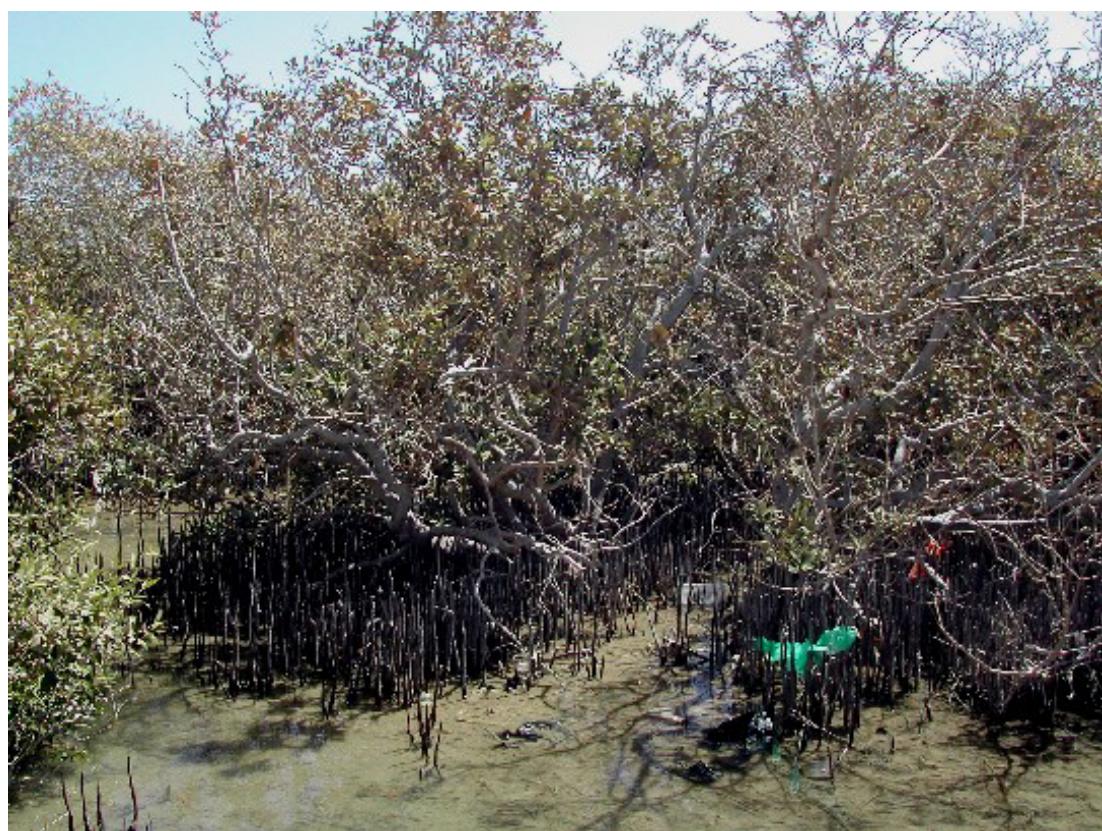
### **3.8 Pollution and Solid Waste**

Solid waste is already a serious problem in the coastal part of the protected area and around the protected Mangroves. The trash is partly from tourist development nearby and partly from the marine traffic waste disposal. Solid waste affects coastal vegetation and greatly diminishes the extent of Mangrove areas.

**Figure 30 Tourist Development at Lahmi Bay**



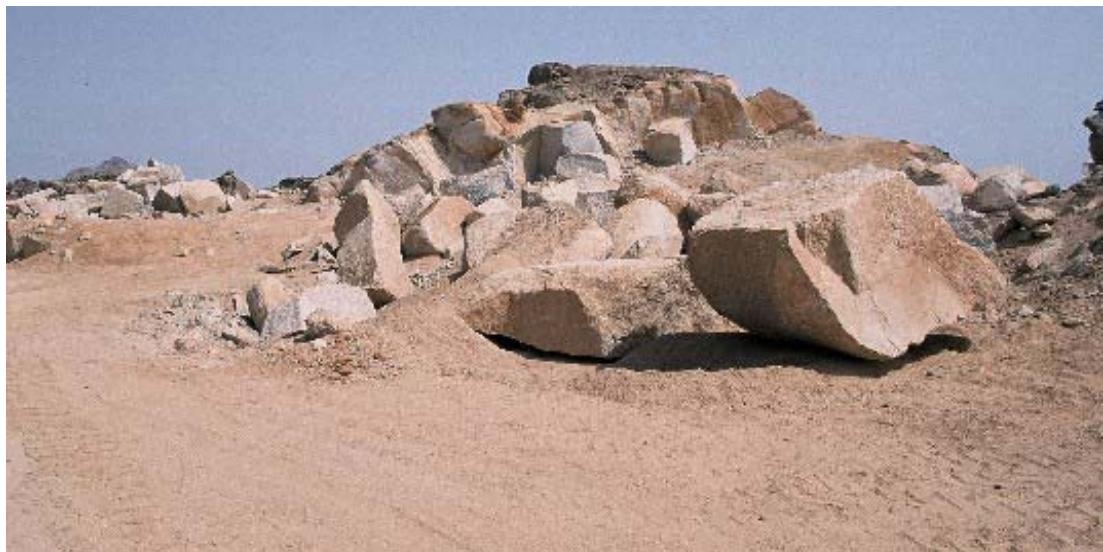
**Figure 31 Mangroves Standing in Solid Waste**



### **3.9 Quarrying and Mining**

Destructive quarrying is a serious problem, in this mineral-rich region.

**Figure 32 Quarrying Destroys Plant Life**



## 4. Conclusions and Recommendations

Several recommendations are put forward and could be included under the following categories:

### 4.1 Conservation

- **Buffer Zones around Protected Mangroves**—In certain spots, a sedimentation deposition process is going on, probably as a result of the ongoing coastal development, resulting in silting up around the Mangroves. In other areas, tourist developments are being built near to protected ecosystems or encroaching on them with buildings, building debris, and tourist waste. It is therefore highly recommended to have a buffer zone surrounding already protected Mangrove areas in order to further spare the ecosystem degradation as the result of tourist development, fishing activities, mooring yachts, and camel grazing.
- **A Strict Nature Reserve at the Delta of Wadi el-Gemal**—It is highly recommended that the Wadi el-Gemal delta and upstream from the wadi mouth for at least 15 km inland be considered a strict nature reserve, minimizing access to the wadi through the eastern side. This could be the core area of the protected area. It is a unique and well-developed ecosystem and is already suffering from excessive vehicular use at the entrance to the wadi; pollution is already affecting the beauty of the delta, and grazing is destroying the vegetation.
- **Protect High Value Plants**—Wadi el-Gemal harbors several plants of medicinal value such as *Balanites aegyptiaca* and *Salvadora persica*. At 24.33.54 N 34.51.23 E; there are precious huge populations of the Arak (*Salvadora persica*), the toothbrush plant, which is used by the local population and is collected as a cash crop. These stands are unique and need utmost protection. They should be included in the core area.

The *Balanites aegyptiaca* forests in the main trunk of Wadi el-Gemal are also unique. They seem to be thriving and regeneration has been recorded in several spots. The trees are bearing fruit. These are collected by the local population and sold for their medicinal value. It is recommended that through public awareness outreach, locals would be advised to seek a balance where the fruits are sustainably collected, grazing is regulated, and fuel wood collection limited to dead branches.

- **Protection of Coastal Zone**—Some coastal areas are high priority areas for wild life, such as the green turtle nesting area on the road to Mersa Alam.
- **Extension of the Protected Area**—Wadi Ghadeer, visited during the field trip, had received some rain earlier in the year. A relatively dense and varied plant cover was observed that included two very rare species (*Lindenbergia abyssinica* and *Kickxia nubica*). All along the wadi there were traces of other creatures (Hyrax middens with dense accumulation of excrements) of conservation value as well as great importance as a source of information for paleoclimatic reconstructions.

This is an area worth protecting for its exceptionally beautiful and pristine scenery. It is worth considering enlarging the protected area to include Wadi Ghadeer and its tributaries.

- **Detailed Floristic and Ethnobotanical Studies**—A detailed survey of the flora of the protected area has to be carried out through several trips to cover the whole area. Locations that have received some rain should be visited several times at different time intervals (4–6 weeks, 3 months, and 6 months) in order to be able to record the ephemeral vegetation in all its stages. It would also be useful to study in detail the use of plants by the local community, harvesting of wild plants, and the effect of such activity on the vegetation. This would help in developing environmentally sound and adequate management measures.

## 4.2 Promotion and Sustainable Exploitation of Natural Resources

- **Regeneration of Vegetation**—Although the regeneration of the natural vegetation within protected areas is a subject under discussion, it seems plausible to propose a Mangrove rehabilitation project at certain spots that represent potential rehabilitation areas for *Avicennia marina* (only), such as at the mouth of Wadi Ramarum–Road El-Eshab and the delta of Wadi el-Gemal.

Within this context, it is important to have strict regulations regarding the introduction of exotic plant species, particularly in gardens of hotels and other tourist development projects. It is clearly stated in the Prime Minister's Decree, the introduction of exotic species would lead to many problems including the invasion of foreign weeds, destruction of the natural flora, and the introduction of various diseases.

- **Sustainable Grazing**—Grazing by camels and goats usually represents a threat to the vegetation and caring for such animals is a major activity in the local community in the protected area. It not only feeds the animals, but also is a social activity that plays an important role in the lives of the local people.

Bedouin people have developed measures that ensure the sustainability of this activity. Such practices have to be studied in detail before activities in the protected area could direct the local population towards different ways to sustainably exploit such resources. Some measures could surely be developed, such as identifying certain areas that could serve as grazing enclosures. These could change from year to year (or seasonally) according to rainfall. Grazing would only be allowed within these zones.

- **Promote Eco-tours and Scenic Spots**—Eco-tours organized within the protected area could include herbal tours, where information about the various components of the vegetation would be shown, and their interest, rarity, and importance explained. Activities around plant themes might include photography, herbal tours, and a visit to the unique delta of Wadi el-Gemal.

There are several scenic spots and descents (such as that to Wadi Raadi) close to old mining activities. Areas that possess beautiful scenery should be sought and (if possible) facilities installed near them in order to attract visitors to the protected area and make use of existing mining buildings as potential protected area headquarters.

- **Control Solid Waste and Marine Pollution**—Several spots on the coast, including several Mangrove areas, are currently suffering from solid waste, marine pollution and debris. Sharm Louly and other coastal areas could use cleaning up to make a scenic beach bay. Clean up must be carried out in a way

that does not damage the area, and it will have to be carried out periodically, as waste accumulates quickly.

- **Destruction of Trees**—Tree destruction for fuel wood or to make charcoal is usually a serious threat to the vegetation; however, it is also an important source of income for the local population. Controlling charcoal manufacture has to be preceded by a study to assess objectively the extent of damage done to the vegetation in the area. If banning is the solution, then it would have to be accompanied with a community development project in order to offer an alternative source of cash for the locals. Public awareness efforts should also be considered.

It is highly recommended that woodcutting by tourists be banned, as this would be highly destructive especially with ongoing tourist development along the coast and inland safari trips. Tourists should take along in their own fuel, preferably not wood, but gas-fueled cookers and lights.

- **Mitigation of Negative Impacts**—Quarrying and mining activities are highly destructive the way they have been carried out up till now. Areas around quarries are devoid of vegetation due to destruction of the landscape, solid waste has been piled up, vehicular use has decimated some areas, and firewood collection has damaged or killed trees. There are many areas within the protected area where all the vegetation has been destroyed.

It is highly recommended that quarrying activities be limited to off road areas, that debris and waste be recycled, and the effects of previous quarrying be mitigated whenever possible. In the future, strict rules should be applied to a limited number of quarrying companies.

- **Traditional Knowledge**—There is a lot of information to be obtained through studying the local community, their concepts of conservation, and the use of plants in their environment. Studies assessing the sustainability of their activities could greatly add to our knowledge and management skills.

Another objective could also be for the protected area management to identify and help promote local products that could be offered for sale to tourists, generating income for the local community.

## Appendix 1. References

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## Appendix 2. Survey of Flora in the Wadi el-Gemal–Hamata Protected Area

<b>Perennial Plant Species</b>		
<b>Latin Name</b>	<b>الاسم العربي</b>	<b>Availability*</b>
<i>Acacia ehrnbergiana</i>	سلم	c
<i>Acacia mellifera</i>	خشب	rr
<i>Acacia raddiana</i>	طلح	c
<i>Achillea fragrantissima</i>	جيسوم	c
<i>Adiantum capillus-veneris</i>	كربة البير	rr
<i>Aeluropus lagopoides</i>	حنجنين	c
<i>Aerva javanica</i>	طرف	c
<i>Arthrocnemum macrostachyum</i>	خرizable	c
<i>Atriplex farinosa</i>	حوا / هندا	c
<i>Avicennia marina</i>	شورى / مانجروف	r
<i>Balanites aegyptiaca</i>	اللالوب / الهجليج	c
<i>Calligonum polygonoides</i>	أرطا	rr
<i>Calotropis procera</i>	عشار	c
<i>Capparis decidua</i>	تتدب	r
<i>Capparis spinosa</i>	لصف	c
<i>Caylusea hexagyna</i>	دينبان	c
<i>Chozophora tinctoria</i>	غبيرة	r
<i>Citrullus colocynthis</i>	حنظل	c
<i>Cleome amblyocarpa</i>	سمو	r
<i>Cleome droserifolia</i>	عفرين	c
<i>Convolvulus hystrix</i>	شيريم	rr
<i>Cotula cinerea</i>	أربيان	
<i>Crotalaria aegyptiaca</i>	نشش	r
<i>Cyperus conglomeratus</i>	سعد	c
<i>Erodium laciniatum</i>	أبو مصفي	c
<i>Euphorbia granulata</i>	البينة	r
<i>Fagonia sp.</i>	شوكة	cc
<i>Farsetia aegyptia</i>	جرابي	cc
<i>Farsetia longisiliqua</i>	دهيان	r
<i>Ficus palmata</i>	حماط	rr

\* Key to availability: cc = very common, c = common; r = rare; and rr = very rare

Perennial Plant Species		
Latin Name	الأسم العربي	Availability*
<i>Ficus salicifolia</i>	ام سيسى	rr
<i>Forsskaolea tenacissima</i>	لساك	r
<i>Heliotropium strigosum</i>	مكور	r
<i>Hyphaene thebaica</i>	نخيل الدوم	c
<i>Juncus rigidus</i>	سمر	c
<i>Kickxia nubica</i>	---	rr
<i>Launaea spinosa</i>	قداد	r
<i>Leptadenia pyrotechnica</i>	مرخ	r
<i>Limonium axillare</i>	شليل	c
<i>Lindenbergia abyssinica</i>	منهـه هـنـدي	rr
<i>Lontononis platycarpa</i>	حربيـت	r
<i>Lotus deserti</i>	---	r
<i>Lycium shawii</i>	عوجـز	c
<i>Maerua crassifolia</i>	سرـحـه	rr
<i>Moringa peregrina</i>	الـيـسـار	rr
<i>Neurada procumbens</i>	لـزـيق	r
<i>Nitraria retusa</i>	غرـدق	c
<i>Ochradenus baccatus</i>	قرصـيـتـبـان	c
<i>Panicum turgidum</i>	أـبـوـرـكـبة	c
<i>Pergularia tomentosa</i>	غلـق	r
<i>Phoenix dactylefra</i>	نـخـيلـالـبـاح	c
<i>Phragmites australis</i>	بوـصـ/ـغـابـ	c
<i>Pulicaria crispa</i>	قصـوم	c
<i>Pulicaria incisa</i>	رـبـل	r
<i>Rhus oxycantha</i>	زـعـورـ	rr
<i>Rumex cyprius</i>	حـضـنـ	r
<i>Salvadora persica</i>	الأـرـاـك	r
<i>Schismus barbatus</i>	بـهـمـه	c
<i>Senecio glaucus</i>	مرـارـ	r
<i>Senna alexandrina</i>	سنـمـكـي	c
<i>Solenostemma argel</i>	حرـجـلـ	r
<i>Stipagrostis ciliata</i>	حمـيرـة	r
<i>Stipagrostis plumosa</i>	حـشـيشـ	r
<i>Sueda monoica</i>	سوـيـدـةـ/ـعـسـلـ	r
<i>Tamarix aphylla</i>	أـتـلـ	cc

Perennial Plant Species		
Latin Name	الأسم العربي	Availability*
<i>Tamarix nilotica</i>	طرفة	cc
<i>Tephrosia purpurea</i>	نفل	r
<i>Trichodesma Africana var. homotrichum</i>	شوك الضب	r
<i>Zilla spinosa</i>	سيلا	cc
<i>Ziziphus spina-christi</i>	النبق / السدر	c
<i>Zygophyllum album</i>	رطيط	cc
<i>Zygophyllum berenicense</i>	---	rr
<i>Zygophyllum coccineum</i>	بطاط	cc
Ephemeral Plant Species		
Latin Name	الأسم العربي	Availability*
<i>Aizon canariense</i>	الدع	r
<i>Arnebia hispidissima</i>	فيبي	c
<i>Asphodelus fistulosus</i>	بصل ابليس	r
<i>Astragalus eremophilus</i>	مجد	r
<i>Astragalus vogeli</i>	قرن	c
<i>Filago spathulata</i>	---	r
<i>Ifloga spicata</i>	خريشه الجدي	r
<i>Malva parviflora</i>	خبيزه	cc
<i>Neurada procumbens</i>	لسيق	c
<i>Plantago ciliata</i>	حلوه البدن	c
<i>Schouwia thebaica</i>	مه	cc
<i>Senecio desfontainei</i>	قريص	cc
<i>Senecio flavus</i>	حدحيد	c
<i>Spergula fallax</i>	---	r
<i>Spergularia diandra</i>	قيقبيلة	c
<i>Spergularia marina</i>	---	c
<i>Trainthema crystallina</i>	اراريب	rr
<i>Tribulus longipetalus</i>	قتوب	c
<i>Tribulus orientalis</i>	درليس	r
<i>Tribulus pentandrus</i>	---	c
<i>Trichodesma crystalline</i>	---	r
<i>Zygophyllum simplex</i>	رطيط	c

\* Key to availability: cc = very common, c = common; r = rare; and rr = very rare