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Effect of biodiversity conservation on arid ecosystem with a special emphasis on Bahrain

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Field observations of cases of biodiversity destruction and mankind's impact on desertification are discussed. Controversial cases of vegetation conservation and their effect on the reconstruction of ecosystems are also discussed. The importance of desert plants in the dry ecosystems of the Arab world are demonstrated, showing the importance of such indigenous genetical resources in stopping desertification and the necessity to support the sustainable use of natural resources. The study shows that in the Arab world's dry ecosystems, sufficient biodiversity and genetical resources exist to support natural vegetation, assure the stoppage of degradation and desertification and fix sands if sustainably used. Case studies from Bahrain are taken as examples.

Keywords: Bahrain; conservation; biodiversity; arid ecosystems; gene-banks

Introduction

Biodiversity and sustainable use are words associated with human beings and very much related to the welfare of mankind. Most aspects of living systems are based on the variability and complexity of organisms that constitute the biodiversity of a given geographical region and, thus, in the world as a whole. However, this biodiversity, which has proved through history, to be critical, to the continuous and sustainable life of all living communities, has been greatly subjected to unprecedented damage and destruction. In previous times, primitive societies cared very much about the continuous productivity of ecosystems, which in recent times is called 'sustainable use'. Nevertheless, due to the effect of the rapid industrial revolution, and the ever-increasing demand on food and raw materials as a natural result of human population increase, the damage to biodiversity has been very fast and rather complicated. Various references have dealt with the issue of biodiversity conservation from various aspects (Heywood, 1990, 1991, 1992; UNEP, 1992, 1995; WRI, IUCN, UNEP, 1992; UNEP/GCSS, 1992; Al-Eisawi & Hatough, 1987; Hatough *et al.*, 1986; Hatough & Al-Eisawi, 1988; Al-Eisawi & Oran, 1996; Oran *et al.*, 1995; Oran & Al-Eisawi, 1998; Posey, 1999).

During the past few months, two meetings were held in Saudi Arabia and Dubai dealing with similar issues of desertification, conservation and biodiversity in which detailed work has been introduced in this regard (Al-Eisawi, 1999, 2000). This paper will concentrate on the effect of conservation in the dry ecosystem of the Arab world, especially in the Arabian Gulf region, where the driest conditions prevail, with special emphasis on Bahrain.

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The State of Bahrain is an aggregate of a group of scattered islands forming an archipelago lying almost in the middle of the Arabian Gulf. The largest of these islands is Bahrain Island, on which the name of the State of Bahrain is based. The dimensions of Bahrain Island are 40×17 km (Corners & Corners, 1989).

The mean annual rainfall in Bahrain is 70 mm. The temperature ranges from 2·8 to 47·5°C with an average of 34·1°C (El-Oqlah & Abbas, 1994).

Vegetation classification was classified into three main groups: (1) coastal; (2) interior basin; (3) central plateau (El-Oqlah & Abbas, 1994). Corners & Corners (1989) classified the vegetation in Bahrain into five groups: (1) coastal region; (2) back slopes; (3) rim rocks; (4) central depression and (5) central plateau.

Many researchers have studied the flora of Bahrain. Some have preliminarily recorded less than 100 species (Zakis, 1978; Virgo, 1980), while others have recorded more than 200 species (Phillips, 1988; Corners & Corners, 1989). The most comprehensive study has recorded 307 species of vascular plants in Bahrain (El-Oqlah & Abbas, 1994).

Biodiversity assessment, species dynamics, ecosystems monitoring and environment impact assessment are rare and need to be continuous and more frequent. Abbas (1998) recently published a paper about the distribution and structure of *Zygophyllum qatarense* communities in Bahrain. Great effort is badly needed to find out the environmental impact of the speed of urbanization taking place in Bahrain at present.

Materials and methods

Field trips were made to different parts of the country. Islands were also visited and photographs were taken in the field. Botanical notes and observations related to conservation and degradation were registered. Plant specimens were collected and taken to the laboratory for identification. Herbarium specimens were collected, pressed, numbered and deposited at the herbarium of the Desert and Arid Zones Programme in the College of Postgraduate Studies of the Arabian Gulf University in Manama, Bahrain (AGU). Extra information related to vegetation parameters was recorded using line-transect method. Details of the vegetation studies will be published in a separate work.

Results and discussion

Biodiversity Destruction and Human Impact on Desertification

Most causes of biodiversity destruction and, hence, causes of desertification, are human impact factors. Since loss of biodiversity is a major effect and results in the process of desertification, then it is justified to find out what the activities are that leading to the loss of biodiversity. In fact, more than 20 different causes can be listed, but since we are dealing with the dry ecosystem of the Arab world, in particular Bahrain in, the Arabian Peninsula, the seven discussed bellow are the most important.

Urbanization

Urbanization in the Arabian Peninsula, including all Gulf Cooperation Council (GCC) members has surpassed all expectations. Vast areas of the grazing lands have turned into concrete cities, factories and paved roads. This has destroyed some of all of the components of the area's biodiversity including plants, animal life and microorganisms. This is not all. Associated with the urbanization, is a whole series of other harmful consequences, such as pollution, overcrowding, overheating, increased CO2 emissions, increased on food demand and overuse of water and energy.

Agriculture

Although agriculture is rather limited in the study area, and the extent of the forests, which would have been affected most, is almost next to nothing, agricultural activities and practices have caused major biodiversity losses, water overpumping, and often soil salination and desertification. In even the best agriculture cases, damage has taken place as wild plants have been uprooted and replaced by obnoxious weeds. Pesticides and fertilizers have filtered into the soil and often the water table causing a very real hazard. Dangerous, resistant, pathogenic pests have replaced useful insects. Thus, the whole natural system of biodiversity has become unnatural.

Overgrazing

The increase in population and the increasing demand on meat and milk products, coupled with decreasing pastureland, or loss of rain have all worsened the situation. Unfortunately, the degradation has not made the inhabitants or the decision-makers thoroughly investigate nor manage this serious problem. Therefore, overgrazing has decreased the chance of plants growing, to flower and produce enough seeds to spread and germinate from year to year. Accordingly, species decline until they become rare or disappear totally, leading to imbalance in the species dominance and thus in the ecosystem.

Land ownership

Land ownership in many cases has led to irresponsible misuse of the land. Clearing the natural vegetation from the land with the intention of later on cultivating the land, but usually keeping the land unplanted leads to soil dryness and wind erosion of the soil. In some cases, useless weeds will replace long-adapted useful plants. In other cases grazing of such privately owned land has led to overgrazing, and thus the, destruction of biodiversity.

Over-pumping of water

Due the ever-increasing demand on water in the States of the Arabian Gulf, over-pumping of water is a common phenomenon. Such over-pumping has led to the lowering of the water table, causing, in some cases loss of all water ecosystems, and thus, loss of biodiversity. In other cases, the water becomes more saline, which in turn alters the nature of the ecosystems and reduces biodiversity. This problem is rather serious since certain species are not able to grow if fresh water is not available.

Ecotourism, camping and rallying

The term 'ecotourism', in this case, is erroneously used since it does not involve people interested in the ecological components of the area. In most cases, it involves the harmful use of four wheel-drive cars to a race for fun, or climbs sand dunes and drive in the desert. This has led to the smashing of plants, compaction of soil and loss of biodiversity, all very serious problems. Similarly, intense annual camping from November through March in specific places using cars for transport is a very dangerous problem. These camping activities can interfere with germination, plant flowering and seed production. This definitely reduces the number of species and enhances their disappearance over time, and results in, the loss of a very important component of biodiversity. Unfortunately, these two activities are not stopping, or even declining, but rather, they are increasing day after day.

Coastal management

In some countries, due to the need for land, or new harbors or jetties, a great deal of the coastal land has been buried, and thus, biodiversity and marine life have been destroyed. Accordingly, a group of consequence result such as the following:

(1) Mangrove plants and associated ecosystems are destroyed;
(2) Coral reefs are destroyed;
(3) Shallow marine life is destroyed or altered;
(4) The inter-tidal area is reduced, and thus marine life is destroyed or altered;
(5) Seagrass beds needed for shrimp and other organisms may disappear;
(6) Pollution spreads into new marine areas.

Conservation and Biodiversity

Field observations in many places in the Arab world have demonstrated the importance of natural conservation in arid environments. In this paper cases, of conserved land have been studied in the State of Bahrain and are given as an example of the prevailing biodiversity structure in a dry ecosystem. Such conditions are present in most Arab countries, and in particular, in the Arabian Peninsula including the Arabian Gulf countries.

Four divergent sites in Bahrain were selected in which to study biodiversity and the effect of:

(1) The University of Bahrain, Sakheir Campus;
(2) Privately owned land along the road to Pelage Al-Jazzier;
(3) The Island of Hawar;
(4) The Island of Sawad South.

The University of Bahrain's Sakhier Campus

A stone fence surrounds most of the university and a barbed wire-fence encloses the rest. The total area of the university is about 4 km^2. The academic and administration buildings occupy part of the university. The accommodations of both staff and students occupy another part. Both parts are surrounded by a ring road, the sides of which are planted with ornamental trees and shrubs, that use drip irrigation of pretreated sewage water coming from the university's sewage plant. The rest of the land is left as it is.

The site has been protected for at least the past 13 years from grazing or other destructive human activities. The soil in the studied area varies between clayey-sandy, hard and rough, to mostly sandy in softer areas.

The vegetation cover varies from 30 to 60% with an average of about 45%. This compares to the vegetation cover outside the fence of around 10% and not exceeding 15% in the best situations. This means that the vegetation cover was more than three times in protected areas than in the non-protected areas.

The vegetation height within the reserve was in general about 50–60 cm long with some shrubs reaching 2 m as in *Leptadenia pyrotechnia*, and 3–3·5 m in *Tamarix arabica*. In some cases a few trees, of *Prosopis juliflora* were observed with heights of more than 5 m. These trees either had been planted, or most probably, were natural since they were irregularly distributed. This plant is well adapted to local conditions and grows very fast.

The ecosystem looks stable, and steps of succession have begun to take place since seedlings of wild plants have been observed. In addition, richness in wild animal life is observed into the form of rabbits, butterflies, hedgehogs, reptiles, beetles, birds, rodents

and other types of animals, especially invertebrates. It is also clear that burrows and animal faces were abundant.

The vegetation is dominated by the succulent species *Zygophyllum qatarense*, followed by *Heliotropium kotschyi* and *Helianthemum lippii*. It is clear that the perennial bushes and shrubs dominate the vegetation. Annual plants will always be found where water run-off is present. More than two 20 species were recorded in a shallow ditch, where rainwater passes. The following are some of the species recorded:

Aeluropus lagopoides, Anastatica hierochuntica, Asphodelus fistulosus, Astragalus corrugatus, Brassica tournefortii, Cymbopogon commutatus, Emex spinosa, Gastrocotyle hispida, Heliotropium kotschyi, Helianthemum lippii, Leptadenia pyrotechnia, Malva parviflora, Medicago laciniata, Ochradenus baccatus, Panicum turgidum, Phragmites australis, Plantago coronopus, Salsola vermiculata, Senecio glaucus, Sporobolus arabicus, Sporobolus spicatus, Stipa capensis, Tamarix arabica, Tetrapogon villosus, Trigonella homosa, Trigonella stellata, Urospermum picroides, Ziziphus spina-christae and *Zygophyllum qatarense*.

Similar results are found in similar studies in other parts of the Arab world (Hatough *et al*., 1986; Al-Eisawi, 1999, 2000).

Privately owned land along the road to Pelage Al-Jazzier

This land is not far away from the previously studied university campus. It is about 5 km to the west along the road leading to Pelage Al-Jazzier. It is about 100 ha in total area fenced in with barbed wire. The soil is sandy mixed with clay. Adjacent to it, another piece of land of similar size is fenced in by a low cement brick-wall.

A barbed-wire fence encloses the first piece, and the vegetation is natural, while the adjacent piece (enclosed by a cement-brick wall) is used for grazing. It is clear that it has been used quite often for grazing by camels, which has caused severe damage and exhausted the vegetation, resulting in no apparent growth or regeneration.

The vegetation cover was about 40% in the first piece of land, while it was less than 10% in the adjacent piece, where the vegetation has been totally grazed and is only represented by the bases of plants. The height of vegetation was about 50 cm in the first piece, while it was not more than 10 cm in the adjacent piece.

Species diversity in the first piece was normal showing the dominant bushy and shrubby species especially *Zygophyllum qatarense, Heliotropium kotschyi, Cyperus conglomeratus, Anabasis setifera, Aeluropus lagopoides, Suaeda vermiculata, Panicum turgidum* and *Tamarix arabica* among others. In the adjacent piece only the bases of such bushes are available. The carrying capacity biomass produced by natural vegetation is definitely much less than that demanded by large grazing animals such as camels.

The Hawar Island

This is the largest island in the vicinity of the mainland of Bahrain Island. It is located on the southeastern side of Bahrain Island. It is characterized by limestone rocks yielding calcareous, clayey, yellowish, shallow soil. The island is meant to be a nature reserve for wildlife, especially oryx. A herd of oryx roams freely on the island. The vegetation can be divided into two groups:

(1) Coastal vegetation: Dominated by halophytes with the leading species of *Limonium axillare, Arthrocnemum macrostachyum*, *Halocnemum strobilaceum, Halopeplis perfoliata* and *Suaeda vermiculata*.
(2) Inland vegetation (Central plateau). The vegetation is similar to that of Bahrain central vegetation. The shrubs *Salsola drummondii, Lycium shawii* and *Taverniera spartea* (equivalent to what is identified as *T. aegyptiaca*) were found in good patches with heights of about 1·5 m. *Lycium* shrubs are used in one of the sites as a shelter by

the oryx as a place to lie down and for the protection from excessive radiation. Other groups of plants were also observed, such as *Anabasis setifera, Zygophyllum qatarense, Aeluropus littoralis, Salsola vermiculata, Bienertia cycloptera, Limonium axillare, Suaeda vermiculata, Zygophyllum simplex, Salvia aegyptiaca, Sesuvium verrucosum* and *Hyparrhenia hirta*. Sporadic *Prosopis juliflora* trees were observed.

Part of the island is a closed area that cannot be investigated more thoroughly. Some activities can be observed on the island, such as the establishment of a new hotel and wheel tracks produced by vehicles. *Salsola drummondii* was recorded for the first time among the flora of Bahrain during this study.

The Island of Sawad South

This is a small island located on the southeastern side of Hawar Island. The whole island is almost with the maximum height that does not exceed 10 m. The island is made of limestone, with a yellowish to whitish surface and lots of snail deposits, that reveal its previous history of being covered by the sea. This small island's fame comes from the fact that it hosts the largest known population in the world of the black Socotra cormorant bird. A population of about a quarter of a million birds gathers to breed on this island.

The vegetation of this small island is clearly divided into two groups.

(1) Coastal vegetation: Next to the sea and often reached by high tides, halophytic, succulent plants live on sandy deposits. Some of them have salt deposits, especially *Limonium axillare*. The leading species are *Arthrocnemum macrostachyum, Halopeplis perfoliata*, *Limonium axillare* and *Suaeda vermiculata*.
(2) Inland vegetation (central plateau): A few meters from the shore the land becomes drier and whitish. The vegetation changes towards the center and then reversed towards the other side of the island. *Salsola drummondii* is the dominant in land species and is be mixed with *Anabasis setifera, Halocnemum strobilaceum* and *Zygophyllum qatarense*. Towards the drier center *Anabasis setifera, Salsola vermiculata* and *Atriplex leucoclada* are apparent.

The vegetation cover is about 50% close to the shore, becoming about 20% in the center due the presence, movement, and hatching sites of the birds. This island should be internationally protected as a nesting site for such species as the Socotra cormorant.

Importance of studying Conservation on Biodiversity

After examining the previous few cases of biodiversity conservation, the following have been determined to be necessary for biodiversity conservation to be effective.

(1) Determination of the approximate length of time needed for reconstruction of the ecosystem;
(2) Determination of what is the sequence of ecosystem succession;
(3) Determination of the biomass;
(4) Determination of the carrying capacity of the area;
(5) Determination of species diversity and the additions or losses of certain taxa;
(6) Understanding of how the ecosystem functions through monitoring;
(7) Assessment of the status of a given species as rare, endangered, endemic, etc.;
(8) Identification of the uses of species as medicines, food, ornaments, etc.;
(9) Determination a total inventory of taxa recorded in an area, country, region, etc.;
(10) Preparation of databases of biodiversity information;
(11) Linkage of the biodiversity databases to a geographical information system (GIS).

The importance of desert plants in dry ecosystems of the Arab world

Any plant, however small or big it is, and wherever it grows, it should have acquired a set of genetic characteristics through a long history of evolution over hundreds, thousands or millions of years. Therefore, it is no wonder that some plants such as *Ginkgo biloba* are called living fossils, since they are monotypic and have maintained almost the same characteristics though millions of years.

However, desert plants have also acquired their characteristics through adaptation to dry, harsh, hot condition over a long period of time. Such plants survive with minimum amounts of rainfall through long, dry seasons, where sandstorms strike swiftly. If human beings want to develop such characteristics in specific plants, how much time, manpower and funding is needed to produce a single plant, and how much for hundreds or thousands of such species. Accordingly, each species, or even variety, should be treated carefully because of its importance and because of its important uses whether known or yet to be discovered. In addition, each species is important to other plant or animal species especially in cases of parallel evolution; to the food web and food chain; or to soil fertility and soil fixation; for the production of oxygen and the consumption of carbon dioxide. Some plants are very important because of their medicinal value and have been used in herbal medicines for generations. Also of importance are pasture plants that are needed for grazing animals, and thus, for the survival of local communities. Lastly, plants are needed to stop desertification.

Some of the desert plants such as ephemeral have shifted their life cycles to adapt to the harsh condition. Others flower in the autumn to produce seeds to ensure that the seeds are able to germinate with the least amount of water available in the short rainy winter. Some plants germinate, and produce their maximum vegetative growth, flower and produce seeds during the hot, dry season, when no rain at all is available. Such plants have adapted through time to collect water from the atmosphere especially in the early hours of the morning. Examples of such plants belonging to the families Chenopodiaceae, Aisoaceae, Asclepidaceae, Tamaricaceae and Zygophyllaceae. Such plants are common in the dry lands of the Arab world. A special group of grasses can resist drought and are palatable. Hundreds of legume species are excellent forage plants and excellent nitrogen fixatives under dry conditions. Many legume trees that can grow under very dry conditions are palatable, produce palatable legume fruits, wood and very expensive gum and incense.

In the Arabian Peninsula at least 5000 wild plant species are available. At least 10% of these plants are medicinal. Another 10% are edible plants, while a further 10% are genetic resources for cultivated plants. Yet another 10% yield natural wood which is used to produce energy in the traditional methods used through the ages by our ancestors. A further 30–40% are pasture plants, normally used for grazing animals. Our ancestors took advantage of all of these characteristics and uses of plants in a most sustainable way. Therefore, we have to work hard to maintain these uses and to conserve these precious commodities of life.

Methods of Conservation

Methods of conservation have been listed by many researchers (IUCN, 1986; Groombrige, 1992; Al-Eisawi, 1996). Such conservation methods are general and do not deal with specific regions or specific issues. The dry ecosystem of the Arab world should be treated in a different way, taking into consideration the shortage of water, the high temperature, and the shortage of well trained manpower. Therefore, a practical program of *ex-situ* or *in-situ* conservation should be considered in each country.

Methods of conservation are subdivided into two main groups: e*x-situ* and *in-situ*.

Ex-situ conservation

These methods involve the conservation or propagation of a species variety, clone or genetic material. Classical methods of propagation include seeds, cuttings, rhizomes, tubers, corms etc. Other methods involve the use of biotechnological methods such as tissue culture, cell culture, culture of pollen mother cells, culture of anthers or culture of immature male or female tissues.

In the Arab world classical methods should be tried first, since they are direct and do not require sophisticated techniques, laboratory preparation or manpower. If the propagation is not successful, then other biotechnological methods should be sought.

One of the most valuable *ex-situ* methods is the use of seed banks or what are known now as gene-banks. It is no doubt, that such banks are valuable, but they are very expensive to run, and need continuous monitoring of the seeds before and after interring in the bank. Seed X-ray treatment is a must, as is seed dressing, in addition to other measurements. Also it is very important very important that seed germination tests are made routinely to determine the ratios of viability and germination. Many species can survive storage for hundreds of years, but at the same time, there are species that remain viable for only few years.

One of the major setbacks of seed banks (i.e. gene-banks) is that they only contain the genetic material present at the time of collection. A few years later the species, varieties, races or clones produced from the gene-banks are genetically different from what is present in nature, due to the continuous process of gene reshuffling, adaptation and evolution that takes place. Accordingly, genetic changes due to the environment or sudden changes will not be present in the gene-bank. This becomes more of hazard if a supply for a given species is collected from one place and not from other locales on the mistaken belief that the genetic material is already in the bank. Therefore, particularly in the Arab world gene-banks would not solve the problem. Continuous monitoring of species and ecosystems is the key to the solutions. Then it is necessary to try to find the correct solution for the imbalance in ecosystems or the absence of specific species.

Botanical gardens wherever they are, are great assets for humanity, since their role goes beyond conserving the genetic material of different species, to continually educating, young generations, especially school children. Therefore, every country should try to establish a botanical garden, and to include in it local plants in addition to ornamental, medicinal and other imported species.

In-situ conservation

This method of conservation is the most valuable method, since it is natural and relies upon the conservation of plants in their living forms, particularly in their natural condition and habitats. Such natural conservation is the most effective method of conserving biodiversity. This method conserves natural species growing under natural rainfall, temperature, humidity and soil conditions. The only factor required is the reserving a piece of land as a reserve, with the possible added requirement of fencing to assure proper protection of the area.

The dry ecosystems of the Arab world have proved through time to be highly diversified and productive. Species have adapted to be able to survive many years of drought. Seed banks for dry ecosystems have also proved to be very rich. Most species have a self-controlled mechanism to control their germination. Seeds usually will not germinate unless an adequate amount of humidity in the form of rainfall present for successful germination, flowering and, hence, seed production.

Expensive methods of conservation especially reseeding, fertilization and irrigation are not necessarily. The dry ecosystems have proved to be able to revive very quickly and start shedding more seeds, which will germinate and recruit other species of plants and animals. This in turn leads to natural succession. The final results will be towards the natural climax of the local ecosystem of the conserved area.

Recommendations and Conclusion

The following recommendations are made for successful biodiversity conservation in dry ecosystems:

- Reserves are vital for conserving biodiversity;
- Reserves are natural *in-situ* gene-banks;
- Small reserves can be effective, but more variation, and thus greater species richness, is expected in more variable habitat;
- Reserves provide a safe haven for rare, endemic and endangered species;
- Reserves have a very rich soil seed-bank;
- Reserves are the best solution to combating desertification.

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