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# Investigation of Reproductive Birds in Hara Biosphere Reserve, Threats and Management Strategies

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## 1. Introduction

Mangroves usually occur in the intertidal zone (Naidoo, 2009) within tropical and subtropical coastal rivers, estuaries and bays of the world (Zhou et al., 2010), where they may receive organic materials from estuarine or oceanic ecosystems (Ellison & Farnsworth, 2000). In addition, mangroves have been defined by Hamilton and Snedaker (1984) as salt tolerant ecosystems of the intertidal regions along coastlines. Mangroves generally grow in loose, wet soils, saltwater and are periodically submerged by tidal flows along sheltered coastal, estuarine and riverine areas in tropical and subtropical latitudes (Kasawani et al., 2007). In order to fulfill their important socio-economic and environmental services, issues concerning mangrove functions and their biodiversity have grown in importance in conservation biology all over the world (Badola & Hussain, 2005; Jennerjohn & Ittekkot, 2002; Radhika, 2006; Simard et al., 2006). Furthermore, mangrove roots become habitat for terrestrial species as well as marine plants, algae, invertebrates and vertebrates. Mangroves provide a habitat for a wide variety of species with high populations. Mangroves are also important to humans for a variety of reasons, but especially in aquaculture, agriculture, forestry and protection against shoreline erosion, and as a source of firewood, building material, and other local subsistence use (Walters et al., 2008).

Mangrove forests were first recorded in the Persian Gulf and Oman Sea by Eratosthenes (194 to 276 BC), a geographer from Alexandria (Safiari, 2002). Nowadays, mangroves are found along the Iranian coasts of the Persian Gulf and Oman Sea, as well as around Bahrain, Qatar, Saudi Arabia and the United Arab Emirates (Daneshkar, 1996). Iran has the largest acreage of natural mangrove forests and its area ranks 43rd in the world and 10th in Asia (FAO, 2007). Mangrove forests on the southern coast of Iran, are given the common title "The Hara forests", and they cover several locations between the 25°11' and 27°52' parallels longitude (Safiari, 2002). Mangrove growth in Iran consists of only two species of trees *Avicennia marina* and *Rhizophora mucronata*, with *Avicennia marina* scrub being the most prolific, covering over 90% of the Oman Sea and Persian Gulf mangrove habitats. *Rhizophora mucronata* growth is limited and is usually restricted to creeks of the Syric

region (included Gas and Hara River Delta). Other sites, however, are dominated by *Avicennia marina*, known locally as the “Hara”. Hara Biosphere Reserve is located on Tor’ehyeKhoran-e Bostanu strait between Khamir port and Qeshm island in the environs of Hormozgan Province within 40 km of Qeshm city as well as northwest wetland and swamp margin of Qeshm island between latitudes 26°40\_ to 37° N and longitudes 55°21\_ to 55°22\_ E.

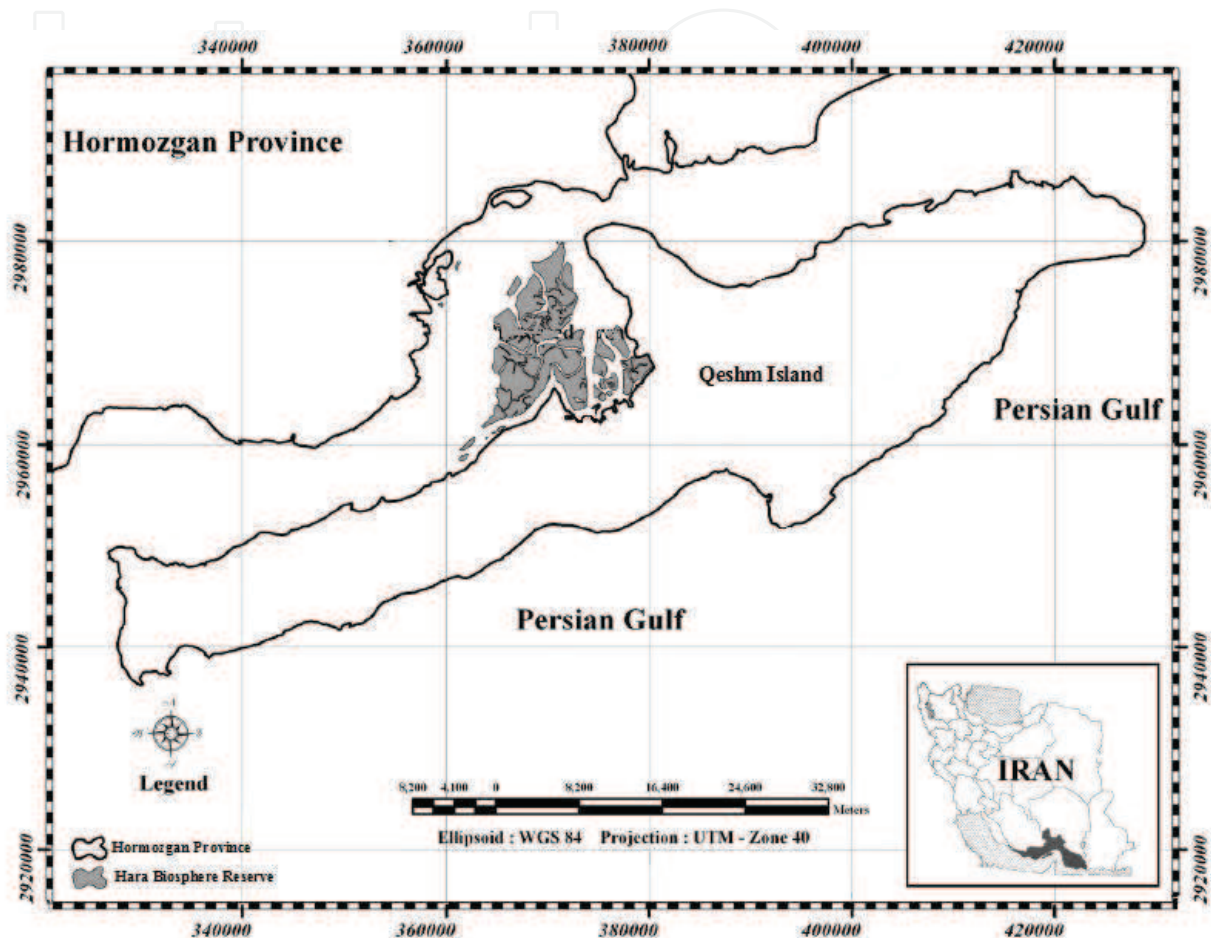


Fig. 1. Location of the study area in southern Iran, Persian gulf.

This area was recognized by the Man and the Biosphere program (MAB) of UNESCO in 1977. On the other hand, this region is one of the protected areas in Iran under the authority of the Department of Environment. The whole region was declared as a Wetland of international importance under the category: Wetlands of International Importance as the Habitat of Aquatic Birds under the Ramsar Convention. In addition, this region was introduced as one of the important bird areas By the Birdlife international.

The land cover of this area comprises two main life forms. The first includes the halophyte plant communities of coastal areas, extending up to the high tide zone. These plant communities are dominated by members of the Chenopodiaceae family which are at times accompanied by tamarisk bushes. The second growth form is the mangrove which constitutes relatively dense forests on tidal islands. In some parts of the region, no other plants accompany mangrove. More than 100 species of sea and shoreline birds, including nine classes and 35 families, have been recognized in the Hara Biosphere Reserve. Moreover,

two threatened species and 32 species of Persian Gulf and Oman Sea fishes have been recorded. In addition, 6 and 10 species of prawn and crabs, respectively, have been identified in this area. Furthermore, five species of sea snake, two species of sea turtle and only one kind of marine mammal have been reported in this region. In addition, *Echiscarinatus*, which lives on land, has been observed along the north cost of this area.

## 2. Diversity and distribution of reproductive birds in Hara biosphere reserve

Since the species of birds which inhabit and reproduce in the Hara Biosphere Reserve are considered wetland-dependent they occupy an important niche in the food chain and their status serves as an indicator for understanding biological changes, impacts of pollutions, and other human activities on Hara Biosphere Reserve. Investigation of the reproductive behaviours of birds is also important for management planning in order to maintain the health of the mangrove ecosystem and control factors threatening the sensitive biodiversity of area (Neinavaz et al, 2010).

In the recent years, studies revealed that only six species of birds have successfully bred the Hara Biosphere Reserve. They are four: the Great Egret (*Ardea alba*), Western-reef Heron (*Egretta gularis*), Indian Pond Heron (*Ardeola grayii*), Eurasian Spoonbill (*Platalea leucorodia*), Great Stone Plover (*Esacus recurvirostris*) and Kentish Plover (*Charadrius alexandrinus*). Reproduction of Great Egret, Western-reef Heron, Indian Pond Heron and Great Stone Plover had been reported in the 1970's. However, there are no reports dating back to the same decades regarding the reproduction of the Eurasian Spoonbill and the Kentish Plover.

Great Egret, Western-reef Heron, Indian Pond Heron and Eurasian Spoonbill build their nests on mangrove trees. On the other hand, the Kentish Plover and the Great Stone Plover build their nests on the ground (sandbar). Today, the Great Egret and the Western-reef Heron have the largest reproductive population in Hara Biosphere Reserve and the Kentish Plover and the Great Stone Plover have the (smallest) least one (Etezadifar et al, 2010; Scott 2007).

In the past years, the breeding range of the Great Egret was in southern provinces of Iran (Fars and Hormozgan); due to the recent multi-year drought, reduction of precipitation and habitat destruction, it appears that the breeding places of the Great Egret are now limited to the Hara Biosphere reserve in the Hormozgan Province. It is considered (Neinavaz et al, 2011) as the largest breeding colony of the Great Egret in the Persian Gulf. In addition, a recent study by Etezadifar (2010) shows that the biggest breeding population of the Western-reef Heron in Iran occurs in the Hara Biosphere Reserve too.

## 3. The threats

### 3.1 Natural threats

#### 3.1.1 Invasive species threats

One of the main factors which has a severe impact on breeding success of herons is the status of invasive species. Black Rat (*Rattus rattus*) is the only rodent species which exists in the mangrove forests of the Hara Biosphere Reserve. This has been reported as an invasive species with a significant impact on the reproduction of forest birds and breeding seabirds.

Field observations have revealed that Black Rats (*Rattus rattus*) feed on the eggs and chicks of the Western-reef Heron, Great Egret and the Indian Pond Heron in this region. For instance, Black Rat (*Rattus rattus*) was responsible for about 50% of nest failures of the Western-reef Heron in the Hara Biosphere Reserve (Etezadifar et al, 2010).

Considering the impact of the Black Rats on the breeding success of the Great Egret and the Western-reef Heron, nest site selection by the birds and food preferences of the Black Rat are important factors. In the Hara Biosphere Reserve, Black Rats build their nests on mangrove trees that are greater than the average height. Incidentally, herons use similar trees for nesting as well. Ghadirian (2007) has shown that Black Rats and the Great Egret both prefer the densest areas of the mangrove forest to build their nests. Such an overlap of niches of the rats and the herons has increased the rate of egg/chick predation of the herons by Black Rats.

On the other hand, abandoned cats by local people have a significant impact on the breeding success of the Kentish Plover and the Great Stone Plover which nest on the ground.

### 3.1.2 Climate change as a threat to mangroves

Climate change components that affect mangroves include changes in sea-level, high water events, storm surges, precipitation, temperature, atmospheric CO<sub>2</sub>, ocean circulation patterns, health of functionally linked neighboring ecosystems, as well as human responses to climate change. Of all the outcomes from changes in the atmosphere's composition and alterations to land surfaces, relative sea-level rise may be the greatest threat (Field, 1995; Lovelock and Ellison, 2007). Although to date it has been a smaller threat than anthropogenic activities such as conversion for aquaculture and filling (IUCN, 1989; Primavera, 1997; Valiela et al., 2001; Alongi, 2002; Duke et al., 2007) relative sea-level rise is a substantial cause of recent and predicted future reductions in the area and health of mangroves and other tidal wetlands (IUCN, 1989; Ellison and Stoddart, 1991; Nichols et al., 1999; Ellison, 2000; Cahoon and Hensel, 2006; McLeod and Salm, 2006; Gilman et al., 2006, 2007a,b). Mangroves perform valued regional and site-specific functions (e.g., Lewis, 1992; Ewel et al., 1998; Walters et al., 2008). Reduced mangrove area and health will increase the threat to human safety and consequently its species, particularly birds; shoreline development that can impact risks arising from coastal hazards such as erosion, flooding, storm waves and surges, and tsunamis, as most recently observed following the 2004 Indian Ocean tsunami (Danielsen et al., 2005; Kathiresan and Rajendran, 2005; Dahdouh-Guebas et al., 2005a,b, 2006) can also adversely impact mangrove integrity. Mangrove loss will also reduce coastal water quality, reduce biodiversity, eliminate fish and crustacean nursery habitats, adversely affect adjacent coastal habitats, and eliminate a major resource for human communities that rely on mangroves for numerous products and services (Ewel et al., 1998; Mumby et al., 2004; Nagelkerken et al., 2008; Walters et al., 2008). Mangrove destruction can also release large quantities of stored carbon and exacerbate global warming and other climate change impacts.

To date, relative sea-level rise has perhaps been a smaller threat to mangroves than non-climate related anthropogenic stressors, which have mostly accounted for the global average annual rate of mangrove loss, estimated to be 1-2%, with losses during the last quarter century ranging between 35 and 86% (Valiela et al., 2001; FAO, 2003; Duke et al., 2007).



However, relative sea-level rise may constitute a substantial proportion of predicted future losses: Studies of mangrove vulnerability to change in relative sea-level, primarily from the western Pacific and Wider Caribbean regions, have been documented and the results indicate that the majority of mangrove sites have not been keeping pace with current rates of relative sea-level rise (Cahoon et al., 2006; Cahoon and Hensel, 2006; Gilman et al., 2007b; McKee et al., 2007). Based on this limited information, relative sea-level rise could be a substantial cause of future reductions in regional mangrove area, contributing about 10–20% of total estimated losses of mangroves. Rising sea-level will have the greatest impact on mangroves experiencing net lowering in sediment elevation, that are in a physiographic setting that provides limited area for landward migration due to obstacles or steep gradients. Direct climate change impacts on mangrove ecosystems are likely to be less significant than the effects of associated sea-level rise. Rise in temperature and the direct effects of increased CO<sub>2</sub> levels are likely to increase mangrove productivity, change the timing of flowering and fruiting, and expand the ranges of mangrove species into higher latitudes. Changes in precipitation and subsequent changes in aridity may affect the distribution of mangroves. The combined effect of just three stresses, climate change and other anthropogenic and natural stressors on the mangrove could result in an accelerated rate of rise in sea-level relative to the mangrove sediment surface; decreased mangrove productivity may compromise that ecosystem's resistance and resilience to stresses from climate change and other sources. (Gilman et al., 2007)

### **3.2 Anthropogenic threats**

Anthropogenic pollution in many coastal regions due to rapid population growth, urbanization and industrialization has received considerable public concern, as it may reduce biodiversity and productivity of marine ecosystems, thus posing direct or indirect potential threats to marine species and human health . (Lin and Mendelssohn, 1996; Duke et al., 1997)

#### **3.2.1 Local people**

Lack of awareness about reproductive ecology and behaviour of birds in Hara biosphere reserve is the other problem among local communities. Therefore some risks and damages might be caused by them. For instance, in some cases, local people picked up the eggs of Great Egret, Western-reef Heron and Eurasian Spoonbill and used them.

#### **3.2.2 Industrial pollutants**

Worldwide, mangrove forests are under threat due to the accumulation of pollutants, which may be imported into mangrove ecosystems through the waters from rivers and streams. The distribution, behaviour, and accumulation of these imported chemicals in the ecosystem are largely defined by the hydrology of the mangroves, the geochemical properties of sediments, and the class of pollutants (e.g. heavy metals, organotins, organochlorine pesticides (OCPs), polychlorinated biphenyls (PCBs)). The properties of the mangrove sediments provide good binding opportunities for a number of these pollutants: hydrophobic organic pollutants adsorb to the extensive surfaces that are provided by the fine particulate sediments of estuaries and mangroves. Metals are trapped in mangrove sediments through the formation of complexes with sulphides (Lacerda et al., 1991),

particulate organic carbon, or iron oxyhydroxides (Chapman et al., 1998). As a consequence, anthropogenic pollutants are filtered from the water layer and accumulate in the sediments of estuaries and mangroves (Bayen et al., 2005; Bhattacharya et al., 2003; Tam and Wong, 1995; Tam and Yao, 2002). Depending on the speciation of chemicals, the pollutants can accumulate in the tissues of biota. Some examples of pollutants are heavy metals, considered as natural elements used in high concentrations in many industrial processes. PCBs are included as key representatives of industrial persistent organic pollutants (POPs). Hexachlorobenzene (HCB) was included since it is known to be a by-product of a wide variety of industrial processes and is also present in some pesticides (Bailey, 2001), while dichlorodiphenyl-trichloroethane (DDT) and hexachlorohexanes (HCHs) are representatives of agrochemical POPs.

These pollutants have adverse effects on mangroves, in particular, their species which choose these ecosystems as their habitats. Birds are sensitive ones to industrial pollution like oil contamination, heavy metals, sewage and solid residues. Unfortunately these contaminants put the bird species of Iran mangrove under pressure. **Factors threatening or adversely impacting mangroves in Iran include:**

1. Overexploitation of mangrove leaves and branches as fodder for domestic animals by rural populations, especially in Qeshm Island and Khamir (Danehkar 1996; Khosravi 1992).
2. Severe waves and extreme tidal action can uproot mangroves, decreasing growth and development in some regions (Zahed 2002).
3. The alternation of rivers and delta directions to sea reduce mangrove forests area (Khosravi 1992).
4. Climatic change resulting in drying of land and retardation of inundation periods contribute to mangrove destruction (Zahed 2002).
5. Mangrove trees, resistant to most plant diseases, are susceptible to insects of the Cynipidae family, genus *Neuroterus* (specie unknown, possibly *Neuroterus lenticularis* or *Neuroterus lanuginosus*) these insects damage *A. marina* leaves in Khamir estuaries and Qeshm Island. Although, current damage is not extensive; it may increase in the future (Khosravi 1992).
6. Mammals, such as *Rattus rattus* and *Gerbillus nanus*, eat mangrove seeds, fruits and leaves, causing damage to these forests (Khosravi 1992).
7. Road construction within the Nayband forests created a seawater connection in the part of these regions, destroying part of the mangrove forests (Danehkar 1996).
8. The lack of forest conservation program as well as control and preservation plan in order to prevent destruction by villagers and other people (Mjnounian 1998; Khosravi 1992).
9. Even though some mangrove species show adaptability to salt stress (Yan and Guizhu 2007); freshwater extraction may cause excessively high salt level and reduced mangrove forests in Persian Gulf (Zahed 2002).
10. Urban and industrial wastewater and sewage discharge into forest areas generate microbial pollution. Marine Pollution, especially oil pollution in the Nayband Bay, as a result of development of the southern Pars oil field in Assaluyeh region (Zahed 2002) has caused damage.

Cutting seawater connections as a result of road construction and overexploitation as forage for domestic animals are the main threats for Iranian mangroves. Moreover, chronic oil

pollution in Persian Gulf exerts continual stress and pressure on these mangrove ecosystems.

### 3.2.2.1 Oil pollution and its impacts on birds

Oil pollution is a common pollution type that would cause a devastating impact on coastal marshes, including mangrove wetlands and salt marshes (Lin and Mendelssohn, 1996; Duke et al., 1997). They are of high ecological and conservation value, which serve as important nurseries for fish, crustaceans and birds; while on the other hand, this low-energy environment makes the mangrove habitat especially vulnerable to oil contamination (Jackson et al., 1989). The environmental impact of oil contamination in marine environments is potentially serious and increasing attention has been focused on the fate of oil in the environment and the weathering mechanisms (Garrett et al., 1998). Polycyclic aromatic hydrocarbons (PAHs), among the major components in crude oil, are defined as a group of organic compounds with two, or more than two fused benzene rings. PAHs have been targeted as priority pollutants by the United States Environmental Protection Agency (US EPA) for study in oil-contaminated sites due to their carcinogenic, mutagenic and toxic properties. Although contamination of PAHs can result from natural and anthropogenic processes, inputs of PAHs from human activities such as oil spill, offshore production, transportation and combustion are very significant and pose serious threats to coastal habitats such as mangroves (Corredor et al., 1990). Mangrove ecosystems are exposed to oil pollution by accidental or chronic oil spills (Getter et al., 1984). The unique features of mangrove systems such as high primary productivity, abundant detritus, rich organic carbon, anaerobic and reduced conditions favor the retention and accumulation of PAHs (Bernard et al., 1996). Oil spills that enter estuarine and marine intertidal systems can produce a number of deleterious effects. When spilled oil enters mangrove systems, oil soaks into sediments and/or coats exposed trunks, prop roots and pneumatophores sometimes causing extensive mortality of mangroves, declines in productivity or growth irregularities (Lewis 1983; Getter et al., 1985; Duke 1991; Devlin and Priffitt, in press). However the effects of oil go well beyond simple problems for survival and growth. Long-term chronic oiling or oil spills that result in elevated concentrations of polynuclear aromatic hydrocarbons in the sediment can produce chlorophyll-deficient mutations in *Rhizophora mangle* (Klekowski et al., 1994).

Unfortunately, one of the main destruction factors of Iran mangroves which at the same time have fatal impact on birds' species is chronic oil pollution in the Persian Gulf. It exerts continual stress and pressure on these mangrove ecosystems and their species.

Some of the important health effects of oil pollution on mangrove birds are:

- Hypothermia in birds by reducing or destroying the insulation and waterproofing properties of their feathers;
- Birds become easy prey, as their feathers being matted by oil, making them less able to fly away;
- Birds sink or drown because oiled feathers weigh more and their sticky feathers cannot trap enough air between them to keep them buoyant;
- Birds lose body weight as their metabolism tries to combat low body temperature;
- Birds become dehydrated and can starve as they give up or reduce drinking, diving and swimming to look for food;



- Damage to internal anatomy; for example ulcers or bleeding in their stomachs if they ingest the oil by accident

Non-sticky oils such as refined petroleum products are not likely to stick to a bird, but they are much more poisonous than crude oil or bunker fuel. While some of the following effects on sea birds can be caused by crude oil or bunker fuel, they are more commonly caused by refined oil products. Oil in the environment or oil that is ingested can cause:

- poisoning of species which are higher up in the food chain if they eat large amounts of other organisms that have taken oil into their tissues;
- interference with breeding by making the bird too ill to breed, interfering with nesting behaviour, or by reducing the number of eggs a bird will lay;
- irritation or ulceration of skin, mouth or nasal cavities;
- damage to red blood cells;
- organ damage and failure;
- damage to a bird's adrenal tissue which interferes with a bird's ability to maintain blood pressure, and concentration of fluid in its body;
- decrease in the thickness of egg shells;
- stress;
- damage to estuaries, coral reefs, sea grass and mangrove habitats which are the breeding areas;

### 3.2.2.2 Impacts of Heavy metals on mangrove ecosystem

Heavy metals are common pollutants in urban aquatic ecosystems and in contrast to most pollutants, are not biodegradable and are thus persistent in the environment. Many metals, a number of which are non-essential to plant and animal metabolism, are often toxic in low concentrations (Baker, 1981). Metal inputs arise from industrial effluents and wastes, urban runoff, sewage treatment plants, boating activities, agricultural fungicide runoff, domestic garbage dumps and mining operations. The metals of greatest concern are copper (Cu), lead (Pb), and zinc (Zn), both because of potential threat they pose to aquatic organisms and to human consumption (Luoma, 1990; MacFarlane; 2000). Mangrove systems have the capacity to act as a sink or buffer and remove or immobilize heavy metals before they reach nearby aquatic ecosystems. Because mangrove sediments have a large, heavy proportion of fine particles, high organic content and low PH, they effectively trap metals, often by immobilizing them in the anaerobic sediments either by adsorption on ion exchange sites on the surface of sediment particles, or precipitation as insoluble sulfides (Hrbison, 1986).

### 3.2.2.3 Sewage and solid residues impacts on mangroves

Coastal areas of the developing world are often extensively populated and in many tropical regions peri-urban population concentrations also coincide with the existence of mangrove ecosystems. Consequently, many fringing urban communities depend heavily on mangroves for both subsistence and commercial harvesting of products (MA, 2005; Ro'nback et al., 2007). The biofiltering function of natural mangroves limits coastal sewage pollution to some extent. However, sewage effluents are also likely to affect other ecosystem services. Increased nutrients will enhance tree growth but pathogens and heavy metals are a potential health hazard for people exposed through use of mangrove resources or

consumption of mangrove associated marine products. The filtering service of mangroves have nonetheless been put forth as one sewage management option whereby mangroves are strategically reforested or conserved for biofiltration. It is well known that mangroves have a high capacity for filtering suspended and particulate matter (Hemminga et al., 1994) and that mangrove sediments make efficient 'sinks' of nutrients (Alongi, 1990, 1991, 1996; Boto et al., 1989; Hemminga et al., 1994; Holmboe et al., 2001; Rivera-Monroy et al., 1995), but it is uncertain how this capacity will translate to efficiently filter sewage. In addition, understanding of the capacity of mangroves to filter pollutants and pathogens is based on very limited work which has been paid to domestic sewage (Clark, 1998). Effects of sewage and sewage related pathogens on human health has been looked at in terms of infectious disease spread (e.g. Louis et al., 2003; Olago et al., 2007; Rogers, 1996; Singh et al., 2004) as well as use of sewage sludge and water for irrigation of crops (e.g. Rogers, 1996; Singh et al., 2004), but to our knowledge societal and cultural impacts on communities affected by sewage effluent in mangroves have not been previously studied. The deep cultural roots of human interactions with mangroves can be observed in the rituals and cults of many civilizations as well as in the techniques used to extract their biological resources (Kathiresan and Bingham, 2001). The wide traditional use of mangroves includes its exploitation as a source of food (hunting, fishing and harvesting mollusks) and wood (fire wood, extraction of tannins, house construction, the manufacture of utilitarian items, etc.). With growing human occupation of mangrove areas, many of the economic activities centered on the use of estuary resources have grown at scales far superior to the carrying capacity of these environments, contributing to their degradation. The advance of urban areas towards the coast precipitates additional environmental problems derived from the inability of the government to control the occupation of these areas and to provide basic sanitary needs (Field, 1999; Rosso and Cirilo, 2002). Only part of the residues produced by human activities can be assimilated by the ecosystem, depending on the river volume, the tidal regime, the types and frequencies of the discharges, and the over-all productivity of the estuary (Alongi, 2002) but most of the time solid wastes are not degraded and accumulate in these natural areas. The presence of solid anthropogenic residues in natural areas has always been a problem, but they have become increasingly evident as coastal areas previously known for their scenic beauty become degraded by pollution – at larger scales near urban centers, but visible even in remote islands – creating problems of global dimensions that are accelerated by the rapid and uncontrolled growth of human populations. In addition to their visual impact, solid residues generate costs to the ecosystem and the economy, resulting in the direct mortality of animal species by strangulation or ingestion, habitat suppression, the avoidance by tourists of low quality beaches and damage to boats (Ribic et al., 1992; Ress and Pond, 1995; Frost and Cullen, 1997; Walker et al., 1997; Macauley et al., 1999; Klein et al., 2004; Araujo and Costa, 2006).

#### 4. Management strategies

Mangrove biodiversity and conservation of different species especially birds have received considerable attention in recent years since research has increased the understanding of the values of biodiversity and functions and attributes of mangrove ecosystems. At the same time, coastal habitats across the world are under heavy population and development pressures. The scale of human impact on mangroves has increased dramatically over the

past three decades or so, with many countries showing losses of 50-80% or more, compared to the mangrove forest cover that existed as recently as in the 1960s. Recognition of the environmental, social and economic impacts associated with the decline and degradation of mangroves are now being addressed through legislative, management, conservation and rehabilitation efforts aimed at mitigating the negative impacts of development on mangrove ecosystems. These include the introduction of new legislation and new governing bodies with clearer administrative or advisory roles on environmental issues; stronger conservation status for some mangrove areas of outstanding value (e.g. as World Heritage sites in Sunderbans of India and Bangladesh, respectively); and more emphasis is being given to raising public awareness and promoting education about mangrove biodiversity. An understanding of the many aspects of human population influences on biological diversity and their underlying driving forces is of crucial importance for setting priorities and directing conservation and sustainable use measures (UNEP, 1995).

The adaptations of mangrove birds to live in the intertidal environment needs conserving . Mangroves support a high diversity of fauna, micro- and macroscopic, terrestrial and aquatic (marine and freshwater), temporary and residential. In this case, the many bird species that have been recorded from mangrove forests may only spend part of their time in mangroves. They migrate seasonally, commute daily or at different states of the tide and may use it as a feeding, nesting or refuge area.

The importance of conserving bird species is now widely appreciated amongst the scientific community, international agencies, governments and NGOs. For this reason, one of the fastest growing sectors of international trade and a powerful tool for national development is ecotourism or nature-based tourism which reduces the negative social and environmental impacts of tourist visits to an area and the money which is gained from that can be used for the conservation of birds. But for best results the government should immediately institute an extensive program that develops awareness among the different sectors/stakeholders (in particular local decision makers) of the value of the mangrove ecosystem resources, functions and services. Also promote and encourage understanding and the importance of mangrove ecosystems through the media and education programs. In many countries the greatest strength of NGOs is public awareness. NGOs should review the information activities of others and prepare programs that fill important gaps. Work with schools and colleges, and with the general public through campaigns; media events are likely to be particularly effective, and will draw upon the unique qualities of many NGOs (Dugan, 1990). NGOs can generate public awareness on policy issues, and site-specific conservation problems and either support government action or press when it is lacking (Dugan, 1990). There are now several examples of successful partnerships (e.g. community-NGO, government- university, and researchers-public media) and stewardship schemes helping to achieve sustainable management of mangrove birds. A key aspect of their success lies in importing a sense of ownership over the mangroves to the local communities concerned.

Other useful strategies that may be considered for conserving birds in mangrove forests:

1. Preparation of environmental management plans for industries and factories located on fringes of the area
2. Environmental monitoring of human user units located along the circumference of the area

3. Preparation of mitigation plan with non-indigenous species (control, prevention, replacement and so on)
4. Preparation of training packages and public participation programs to support and protection of mangrove ecosystems and change people's behavior towards protected species like birds
5. Managing of solid waste disposal in the protected area in partnership with local groups to promote the culture of proper waste disposal.
6. Providing harvest program in the framework of production capacity, harvesting period, site selection and development of mangrove forests located outside the protected area
7. Environmental monitoring programs in partnership with local community
8. Infrastructure development plans related to healthcare and water in marginal habitats within protected area
9. Codification of participatory management plans using local communities as well as financial support from international organizations with the aims of the conservation and sustainable use of bio-regions
10. Use of a local environmental activist groups as a local guide in tourism projects
11. Surveillance on environmental privacy observations in the region for any future development activities (what does this mean?– not clear)

To support research projects in universities to further understanding of structure, process and performance of mangrove forests as well as wildlife protection and conservation in the broader region (Dilmaghani, 2011).

## 5. Conclusion

Mangrove forests on the southern coast of Iran, “The Hara forests”, are considered as one of the most important and unique ecosystems in the world, due to their potential to be an appropriate habitat for birds. Accordingly, this region has been introduced as one of the important bird areas By the Birdlife international. Subsequently, its conservation have become of greatest importance in terms of biodiversity in recent years. Unfortunately, these forests are susceptible to a few natural and anthropogenic threats such as invasive species, climate change, local use of biological resources, oil pollution, sewage and solid residues and heavy metals. These main threats have adverse effects on Hara birds, in particular, their productivity; the birds choose this region for feeding, nesting and resting during their seasonal migration. For comprehensive conservation, management strategies are necessary. In the first place, public awareness should be raised to protect these forests and their species from overexploitation; for example through the participation of local people in environmental management plans. Environmental management and monitoring plans should be prepared to reduce the negative impacts of sewage and waste disposal in marine ecosystems which put mangrove forests under pressure.

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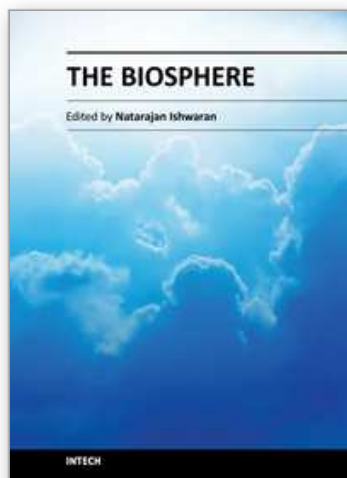
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## **The Biosphere**

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In this book entitled "The Biosphere", researchers from all regions of the world report on their findings to explore the origins, evolution, ecosystems and resource utilization patterns of the biosphere. Some describe the complexities and challenges that humanity faces in its efforts to experiment and establish a new partnership with nature in places designated as biosphere reserves by UNESCO under its Man and the Biosphere (MAB) Programme. At the dawn of the 21st century humanity is ever more aware and conscious of the adverse consequences that it has brought upon global climate change and biodiversity loss. We are at a critical moment of reflection and action to work out a new compact with the biosphere that sustains our own wellbeing and that of our planetary companions. This book is a modest attempt to enrich and enable that special moment and its march ahead in human history.

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