

Annex 3

ENVIRONMENT ANALYSIS

[FAA 118/119 Report for the USAID Interim Strategy for Assistance to the Republic of Yemen]

Executive Summary

Yemen has a unique and interesting biological and cultural heritage. Recent political events, including a joining of North and South Yemen and a subsequent civil war and reunification, have overshadowed important environmental problems. In addition, oil revenues, Yemen's main source of income, are set to decline in the near term, implying an increased reliance on non-oil sources of revenue for Yemen.

Increases in non-oil revenue are likely to come from the agriculture sector, increasing reliance on the natural environment for sustainable development. Projects in the agriculture and natural resource management sectors will need to address a set of fundamental environmental problems, including, declining water resources, land degradation, waste management, and habitat degradation (including biodiversity).

Yemen has a number of endemic species, some of which are threatened. A biodiversity assessment of vegetation, terrestrial fauna, mammals, birds (including seabirds, waterbirds, raptors, migrating and wintering) are included here. Major threats to biodiversity is also presented as well as threats to fauna and freshwater biodiversity.

Since Yemen is located at the conjunction of African, Asian and Palearctic ecological zones, the diversity of plants and animals is greater than in any other parts of the Arabian Peninsula. Indeed, the wide variety of environments within the country has resulted in some of the greatest biological diversity in the Middle East. Due to the range of environmental zones and relative isolation of the country, a number of endemic species are found. The valuable biological resources have an obvious scientific significance, but there are also major economic implications for sustainable productivity in the country. The genetic diversity of indigenous crops, most notably sorghum, and medicinal plants is of critical importance for pest management and the control of viral disease in the agriculture sector. Similarly, protection of critical habitats is necessary for sustainable fisheries and for reforestation of much of the country.

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Introduction

[Source: passages were summarized and extensively quoted verbatim from World Bank (2000) “The Republic of Yemen Comprehensive Development Review: Environment” Rural Development, Water and Environment Department, Middle East and North Africa Region, <http://worldbank.org> . A very similar discussion of environment can be found in Yemen: Human Development Report 1998. Ministry of Planning and Development, Republic of Yemen.]

The Republic of Yemen lies in the south-western part of the Arabian Peninsula between latitude 12 o 40' and 19 o 00' North, and 42 o 30' to 53 o 05' East longitude. The country covers an area of some 555,000 sq km excluding Rub-Al-Khali, with about 2000 km of coastline along the Red Sea and the Gulf of Aden. Its altitudinal range extends from sea level up to 3760m at Jabel Al- Nabi Shauib, the highest point in the Arabian Peninsula. Yemen is bordered by Saudi Arabia to the north, the Arabian Sea and the Gulf of Aden to the south, Oman in the east, and the Red Sea in the west. Lying in the South-west of the country is the Bab-Al-Mandab Strait which is divided by Mayoon Island into two parts that also controls the pass way to the strait. Socotra Island in the Arabian Sea is the largest Yemeni Island (3650 km²) and lies some 510 km from the mainland coast. Besides Socotra more than 112 Yemeni islands are scattered in the Red Sea, the largest of which are: Kamaran, Great Hunish, Little Hunish, Zakar, Al-Zobair, Al-Tair, and other smaller islands¹.

Yemen's climate is in the Sahel Belt and shares many features with African countries of the same latitude. However, rarely has famine been a part of Yemen history, partly due to the relatively large amount of arable land in Yemen. There are four distinct climatic regions in Yemen: the Tihama and Southern Coast, the Western Mountains, the Central Highlands, and the Outskirts of ar-Rubi' al-Khali. Variability in rainfall and altitude distinguish these regions. The Tihama and Southern Coast region is arid and hot. Monsoon rains come between July and September. The Western Mountains, rain is more plentiful and produces significant biological diversity, particularly in the southern and western slopes of the mountains (near the Province of Ibb). At higher elevations (above 1500 meters), crop cultivation is common. The Central Highlands (north) are arid and the summers are dry, although at higher elevations, sorghum and various vegetables are grown. The Outskirts of ar-Rubi' al-Khali (east and north) is generally arid, with various shrubs and grasses survive².

The 2001 population of Yemen was approximately 18 million, 98% of whom are of Arab descent. Islam is the predominant religion. The majority of males are educated (79.4%) while fewer than half of the women are (33.9%). Unlike other people of the Arabian Peninsula who have historically been nomads or semi-nomads, Yemenis are almost

¹ Socotra Islands will not be covered in this assessment since it is not part of the Mission's coverage area.

² Yemen, a Lonely Planet Survivor Kit. 3rd ed.. 1996 Pertti Mämäläilan. Australia:Lonely Planet Publishers.

entirely sedentary and live in small villages and towns scattered throughout the highlands and coastal regions.

Yemenis are divided into two principal Islamic religious groups: the Zaidi sect of the Shi'a, found in the north and northwest, and the Shafa'i school of Sunni Muslims, found in the south and southeast. Yemenis are mainly of Semitic origin, although African strains are present among inhabitants of the coastal region. Arabic is the official language, although English is increasingly understood in major cities. In the Mahra area (the extreme east), several non-Arabic languages are spoken. When the former states of north and south Yemen were established, most resident minority groups departed.

The Economy and Society of Yemen

Yemen, one of the poorest countries in the Arab world, reported strong growth in the mid-1990s with the onset of oil production, but has been harmed by periodic declines in oil prices. Yemen has embarked on an IMF-supported structural adjustment program designed to modernize and streamline the economy, which has led to substantial foreign debt relief and restructuring. Aided by higher oil prices in 1999-2000, Yemen worked to maintain tight control over spending and implement additional components of the IMF program. A high population growth rate and internal political dissension complicate the government's task.

Remittances from Yemenis working abroad and foreign aid paid for perennial trade deficits. Substantial Yemeni communities exist in many countries of the world, including Yemen's immediate neighbors on the Arabian Peninsula, Indonesia, India, East Africa, the United Kingdom, and the United States. Beginning in the mid-1950s, the Soviet Union and China provided large-scale assistance to the YAR. This aid included funding of substantial construction projects, scholarships, and considerable military assistance. North Yemen became independent of the Ottoman Empire in 1918. The British, who had set up a protectorate area around the southern port of Aden in the 19th century, withdrew in 1967 from what became South Yemen. Three years later, the southern government adopted a Marxist orientation. The massive exodus of hundreds of thousands of Yemenis from the south to the north contributed to two decades of hostility between the states. The two countries were formally unified as the Republic of Yemen in 1990. A southern secessionist movement in 1994 was quickly subdued. In 2000, Saudi Arabia and Yemen agreed to a delimitation of their border.

At unification Yemen was struggling economically. In the north, disruptions of civil war (1962-70) and frequent periods of drought had dealt severe blows to a previously prosperous agricultural sector. Coffee production, formerly the north's main export and principal form of foreign exchange, declined as the cultivation of qat increased. Low domestic industrial output and a lack of raw materials made the YAR dependent on a wide variety of imports.

In the south, pre-independence economic activity was overwhelmingly concentrated in the port city of Aden. The seaborne transit trade which the port relied upon collapsed with the closure of the Suez Canal and Britain's withdrawal from Aden in 1967. Only extensive Soviet aid, remittances from south Yemenis working abroad, and revenues from the Aden refinery (built in the 1950s) kept the PDRY's centrally planned Marxist economy afloat. With the dissolution of the Soviet Union and a cessation of Soviet aid, the south's economy basically collapsed.

Since unification, the government has worked to integrate two relatively disparate economic systems. However, severe shocks, including the return in 1990 of approximately 850,000 Yemenis from the Gulf states, a subsequent major reduction of aid flows, and internal political disputes culminating in the 1994 civil war hampered economic growth.

Since the conclusion of the war, the government entered into agreement with the International Monetary Fund (IMF) to institute an extremely successful structural adjustment program. Phase one of the IMF program included major financial and monetary reforms, including floating the currency, reducing the budget deficit, and cutting subsidies. Phase two will address structural issues such as civil service reform. The World Bank also is active in Yemen, providing an \$80-million loan in 1996. Yemen has received debt relief from the Paris Club. Some military equipment is still purchased from former East bloc states and China, but on a cash basis.

Following a minor discovery in 1982 in the south, an American company found an oil basin near Marib in 1984. A total of 170,000 barrels per day were produced there in 1995. A small oil refinery began operations near Marib in 1986. A Soviet discovery in the southern governorate of Shabwa has proven only marginally successful even when taken over by a different group. A Western consortium began exporting oil from Masila in the Hadramaut in 1993, and production there reached 420,000 barrels per day in 1999. More than a dozen other companies have been unsuccessful in finding commercial quantities of oil. There are new finds in the Jannah (formerly known as the Joint Oil Exploration Area) and east Shabwah blocks. Yemen's oil exports in 1995 earned about \$1 billion.

Marib oil contains associated natural gas. Proven reserves of 10-13 trillion cubic feet could sustain a liquid natural gas (LNG) export project. A long-term prospect for the petroleum industry in Yemen is a proposed liquefied natural gas project (Yemen LNG), which plans to process and export Yemen's 17 trillion cubic feet of proven associated and natural gas reserves. In September 1995, the Yemeni Government signed an agreement that designated Total of France to be the lead company for an LNG project, and, in January 1997, agreed to include Hunt Oil, Exxon, and Yukong of South Korea as partners in the project (YEPC). The project envisions a \$3.5 billion investment over 25 years, producing approximately 3.1 million tons of LNG annually. A Bechtel-Technip joint venture also conducted a preliminary engineering study for LNG production/development.

Environment in Yemen

The Republic of Yemen is located on the southern coast of the Arabian Peninsula. Its land boundaries are with Saudi Arabia in the north and Oman in the east. The coastline extends to more than 2,000 km. The country is characterized by five major land systems: (1) a hot and humid coastal Tihama plain, 30-60 km wide, along the Red Sea and the Gulf of Aden, (2) the Yemen Highlands, a volcanic region with elevations between 1,000 and 3,600 m. parallel to the Red Sea coast, and with temperate climate and monsoon rains, (3) the dissected region of the Yemen High Plateaux and the Hadramawt- Mahra Uplands, with altitudes up to 1,000 m, (4) the Al-Rub Al-Khali desert interior, with a hot and dry climate, and (5) the islands, including Socotra in the Arabian Sea and more than 112 islands in the Red Sea. Yemen's coastal and marine eco-system which include extensive mangroves, coral reefs, and seagrass areas, are of major economic importance for fisheries and tourism. Yemen covers a total land area of 55.5 million hectares. About 3 percent of the land can be used for agriculture, or about 1.6 million hectares, but only about 1.2 million hectares are actually cultivated. The main crops are cereals (0.7 million ha.), followed by fruits & vegetables (0.14 m ha.). Fodder and qat areas are smaller but significant at about 90,000 ha each. Mainly rangelands and some forest area cover 40 percent of the land area. Other land, mostly desert, constitutes the remaining 57 percent of the total land area. Renewable fresh water is very scarce. Fresh water available to the country of 2,100 million cubic meters (cu. m.) per year, and with a population of about 16 million (1997), the availability per capita is only 130 cu. m. per year. This compares with an average annual availability of 7,500 cu. m. for World and 1,250 cu. m for MENA. The resource is mainly ground water and its over exploitation is one of Yemen's major environmental problem. Fisheries resources are also important and the combined surface and deep water fish catch is about 80,000 metric tons per year. Oil and gas resources are also significant contributing about 85% to Yemen's export revenues . Environmental problem in Yemen are caused by three fundamental factors: (1) population growth, (2) poverty and (3) institutional weaknesses. These factors are discussed below.

Key Environmental Issues

Yemen's natural resources are the basis of the national economy. The depletion or degradation of these resources represents not only a loss of the country's national capital but undermines the sustainability of its economy. Although Yemen is experiencing numerous environmental problems, GOY's NEAP focuses on those issues that are of national importance and that pose immediate threats to health and sustainable economic and social development. The main issues are discussed below.

A. Water Depletion, Pollution, and Supply

Yemen is facing a water crisis, in terms of depletion of water resources, water pollution, and water supply. Although complete data on the nature and magnitude of the water crisis are limited, the basic trends are reason enough for concern. For instance, according to Yemen Government sources, Yemen's per capita share of water resources is 137 m³, compared to 1250 m³ in the Middle East and North Africa Region, and a world average of 7500 m³. Likewise, water resources imbalance, reached a deficit of 900 m³ in 2000. Furthermore, irrigation consumes 90% of water, and it is used at 40% efficiency.³

Failure to meet the country's potable water needs will intensify health and environmental problems. The synopsis of main problems and specific concerns with regard to Yemen's water resources. as given in Table 1 is presented in more detail below.

Table 1: Main Environmental Problems and Specific Concerns in Water Resources

MAIN PROBLEM	SPECIFIC CONCERN
WATER DEPLETION, POLLUTION, PLUS	1. OVER-EXTRACTION OF SUPPLY GROUNDWATER 2. LACK OF WATER ALLOCATION AND CONSERVATION SYSTEMS 3. WATER POLLUTION INADEQUATE WATER SUPPLY SERVICES

1. Over extraction of groundwater

Ground water is being mined in many areas. Countrywide, it is estimated that current withdrawals of water for all purposes are over 130 percent of renewable resources. In 1994, water use was estimated at about 2,800 million cubic meters per year; the annual recharge is only 2,100 million cubic meters. Since unification of the country, uncontrolled drilling has spread to the south, which resulted in lower water tables. The most obvious impact of this trend is the increased cost of drilling deeper wells and increased pumping costs in existing wells. In Sanaa the ground water level is dropping by more than 4 meters per year. This is clearly unsustainable and a threat to future prosperity of the country.

Critical aquifers are expected to reach the end of their useful life within twenty years. The depletion and degradation of Yemen's ground-water resources represents a disinvestment of the country's natural resource base. In the short-term, depletion adds to disposable incomes, contributes to rural employment, and postpones the need for more expensive alternatives such as desalinization. In the longer-term, however, these trends are unsustainable.

³ Summary of the Second Five-Year Plan for Economic and Social Development 2001-2005" (n.d.) Republic of Yemen Ministry of Planning and Development.

2. Lack of water allocation and conservation systems

National policy and regulatory process for water allocation, conservation, and drilling is weak. Surface water is regulated by customary practice, modified by the impact of Government projects.

Ground water, with few exceptions, is currently unregulated although state ownership of land and equipment gave the previous government of the south de facto control. Even where there are regulations, they are rarely enforced.

Qat, which requires large amounts of water to produce, is another constraint to water conservation. Qat production occupies some 25 percent of the irrigated area, provides employment for some 500,000 people, and generates important incomes. Although the official policy towards qat is to restrict cultivation to low potential areas and to levy a sales tax, these measures are not adequately enforced. Due to its profitability and widespread domestic consumption, nothing has been done to restrict production, whereas tax revenues are estimated to be less than ten percent of dues.

In Yemen, land rights are privately held and controlled and the owner of the land believes to have unlimited rights over tubewell water on his land. This has led to the construction of numerous tubewells, resulting in over-irrigation, wasteful energy use, and depletion of ground water. Moreover, the sensitive nature of water rights has posed substantial constraints on water conservation and the regulation of the drilling of new wells.

Numerous management activities in both the north and south have aimed to ensure efficient, equitable, and sustainable use of water resources. Nonetheless, an ineffective institutional framework has undermined these actions. Most agencies have followed their own objectives to expand irrigated areas, meet potable water standards, and satisfy industrial needs. Individuals also have pursued their own self interest without regard to the surrounding community. Further, the responsibilities for planning, management, regulation, and development are fragmented among several agencies and the private sector. To compound these problems, the government has been unable to secure sufficient technical and enforcement capacity, particularly at the local level, to address the complexities of water resource management which requires management responses tailored to each hydrological system. Not only does this require a greatly improved understanding of specific aquifers and patterns of recharge, but it also calls for measures that discriminate between different areas that are inherently difficult to administer.

3. Water Pollution

Water quality is deteriorating. Shallow aquifers, especially in urban areas, are becoming polluted and coastal aquifers are subject to saline intrusion. The capacity to plan and implement appropriate responses to water resources problems is undermined by insufficient data. Data on water quality and saltwater intrusion are particularly weak.

there are no national water quality standards, although WHO guidelines are generally applied to urban water supply monitoring for a restricted range of constituents.

Ground-water contamination is pervasive and poses a serious health threat for those dependent on water from private tankers and neighborhood wells in urban areas. Water resources are contaminated primarily by industrial and residential waste, seepage of wastewater, and low pressure, back siphonage, and cross connections. Consequently, many wells, especially those drawing water from shallow aquifers, are contaminated with viruses and bacteria, leaving large segments of the population vulnerable to waterborne diseases. In addition, ground water used in public water supplies is not filtered. In the poor neighborhoods, inadequate environmental conditions have led to outbreaks of diseases such as cholera, bacterial dysentery, infectious hepatitis, salmonellosis, and typhoid. It is estimated that about 70 percent of infant mortality (or 107 deaths per 1,000 life-births) is due to waterborne diseases.

Surface water is fully exploited and essentially distributed in the upstream parts of watersheds, and only limited flows reach the sea. The immediate impacts include: decline in water quality from diminished dilution of pollutants, seasonal or continuous shortfall in supply of downstream users, and increases in salinity in estuaries and other coastal areas.

4. Inadequate water supply services

Although water requirements for domestic and industrial purposes are estimated at less than 10 percent of total water consumption, competition among these water users is increasing due to population growth and increasing urbanization. In a situation where connections to the water network remain unchanged, water availability per capita is decreasing and the percent of the population that has access to piped water supply is decreasing as well. The problem in urban basins is compounded by growing water demand for agriculture and unclear water rights.

Currently, only 50 percent of the estimated 3.5 million urban population have access to public water supply systems. However, supplies are not always available, especially in the north. Sana'a, Taiz, and Mukalla are already running out of water for their existing populations and there are periodic shortages. The National Water and Sanitation Authority (NWASA) is officially responsible for the provision of water supply and sanitation services in urban centers with populations over 10,000 people. This agency, however, has not been able to fulfill its mandate. NWASA provides piped water to serve about 33 percent of the population of Sana'a, 39 percent of the population of Taiz, 25 percent of the population of Ibb, and 78 percent of the population of Dhamar. Pricing policies and incentives have not been used to increase the efficiency of urban services. In urban water supply, prices do not reflect the resource constraint; the prices charged do not even cover the cost for operating and maintaining the system, water is thus provided at a subsidy. Urban residents with no access to public drinking water 5 Comprehensive Development Review – Environment (often the urban poor) must obtain water from

private networks, private water tank trucks, or their own wells. Bottled water is available too. The cost of all non-public supplied water is high.

Currently, about 40 percent of the estimated 11 million rural population receives piped supply. Here, expansion of public water supply is even more difficult given the high capital cost of new systems due to scattered or remote locations of settlements. At the same time, much of this population is concentrated in the highlands and alternative water supply from seawater desalination is not an economically feasible option.

B. Land Degradation

Yemen covers a total land area of 55.5 million hectares. About 3 percent of the land can be used for agriculture, or about 1.6 million hectares. Rangelands together with forest and woodlands comprise almost 40 percent of the land area. The land is grazed by about 3.5 million sheep, 3.2 million goats, and 1.1 million cattle. Other land, mostly desert with limited use potential, constitutes almost 60 percent of the total land area.

Approximately 3,000 years ago, Yemeni farmers started clearing the hillsides and steep mountain slopes to increase the area of arable land. Terraces were constructed to conserve soil and water, to improve water use efficiency, and to increase crop production. The hillside terraces in Yemen constitute a national heritage and a monument to environmental sustainability and food security in years past. The terrace systems have developed in response to rainfall patterns and rainfall uncertainties and provide optimal soil and water management in dry, mountainous terrain. The farming systems schemes so designed were sustained until recently. Similarly, range management occurred in well-balanced operations. During the last 30 years, social and economic changes have resulted in changing farming and grazing practices and in rapidly expanding urban areas. This in turn, leads to widespread soil erosion and sand encroachment, deforestation, agricultural and range land deterioration, and loss of farm land due to urban encroachment. An overview of these land degradation concerns is presented in the Table below.

Table: Main Environmental Problems and Specific Concerns in Land Resources

MAIN PROBLEM	SPECIFIC CONCERN
LAND DEGRADATION	1. SOIL EROSION 2. DEFORESTATION 3. AGRICULTURAL AND RANGE LAND DETERIORATION 4. LOSS OF FARM LAND DUE TO URBAN ENCROACHMENT

1. Erosion

Although soil erosion occurs naturally and has been a major problem in Yemen since the dawn of civilization, the rate of erosion is increasing as a result of the removal of vegetation and unsustainable land-use and farming practices, particularly the development of large-scale irrigation schemes and deterioration of terraces due to

inadequate maintenance. Sedimentation also is affecting reservoirs and diversion channels downstream. The areas most seriously affected by soil erosion are Anas, Bani Matter, Wadi Serbah, Hamman Ali, Wadi Afk, Raymah, Wadi Shiras, Wesab, and Wadi Bani.

The erosion of arable land undermines agricultural production and therefore leads to substantial economic losses. Although there are no quantitative data on the magnitude of soil erosion and the possible increase in erosion as a result of unsustainable land use practices, terrace erosion has emerged as a priority resource management issue in Yemen. Without the proper maintenance of the terraces, and related farming systems and water management practices, productive land reverts to a barren landscape of upper catchments with no soils and a gravel-strewn wadi-beds with no water flow. The collapse of the terrace system also forces rural population off the land and into the cities, which are already suffering from overcrowding.

Generally, efforts aimed at halting erosion are sporadic, inconsistent and have been undertaken by various actors with little or no coordination. There is limited awareness among development addition to the random physical expansion of urban areas, damage to lands occurs as a result of indiscriminate construction of roads and other infrastructure and disposal of waste.

Another aspect of uncontrolled urban growth is the occupation of hazard-prone areas by Yemen's urban population, particularly the urban poor. In several cities (e.g., Sana'a, Aden), unauthorized settlements are spreading rapidly on wadi beds and unstable slopes where periodic floods and landslides are often caused by urban infrastructure and result in the loss of lives and extensive damage to buildings and infrastructure. Flooding causes widespread property damage, traffic disruption, and erosion which often leaves underground water, sewerage, power and telephone lines exposed. Apart from the loss of valuable land, those most affected are the households living below the poverty threshold. Based on a survey of 5,134 households and small businesses in one area in Taiz, the annual direct loss from floods is about YR 29.24 million (or US \$2.7 million, using the official exchange rate) mostly in property damage and missing stock from households and shops. In the city of Sana'a and peri-urban areas, low-income groups also occupy abandoned quarries and land adjacent to municipal landfills.

Inadequate regulation is a key factor accounting for the occupation of hazard-prone areas. In some cases, there are no clear rules governing the settlement of urban areas or guiding urban expansion away from areas poorly suited to urban development. In some southern governorates hazard-prone areas were actually designated for residential development. In other situations, excessive regulation artificially reduced the supply of land and raised the price by requiring large lot sizes or excessive amount of land for traffic or recreation. By reducing the amount of land in the formal land market, excessive land restrictions have increased costs and thus constrained access by low-income populations to safe lands in suitable locations.

C. Waste Management

Table: Main Environmental Problems and Specific Concerns in Waste Management

MAIN PROBLEM	SPECIFIC CONCERN
WASTE MANAGEMENT	<ul style="list-style-type: none"> • WASTE WATER MANAGEMENT • SOIID WASTE MANAGEMENT • HAZARDOUS WASTE MANAGEMENT • PESTICIDE. MANAGEMENT

In principle, several options are available to better organize waste management - through a department of municipal government, local or regional sanitary district, or a private operating company or companies under contract to the government. To the extent possible, the institutions need to be empowered to generate revenues adequate to cover costs. Permitting and inspection of installations and enforcing standards should be Government functions but could be delegated to local authorities. Actual implementation tasks can best be carried out by the private sector under contract to or licensed by the Government.

1. Waste water management

Access to sewerage services is provided only to a limited percentage of the urban population. NWASA's waste water collection system only serves about 8 percent of Sana'a, 25 percent of Taiz, 25 percent of Hodeidah, 15 percent of Ibb, and 15 percent Dhamar. The infrastructure which was build in the seventies is no longer capable of handling the demand. Most residences and businesses dispose of wastewater in on-site septic tanks, leaching pits, or through clandestine connections to sewerage systems. Over 90 percent of the urban population depend on individual septic tanks, some of which are emptied by trucks owned by the municipality or private companies. In wet years, shallow groundwater rises and waste water and storm drainage flows in the open.

The most common type of wastewater treatment in Yemen is stabilization ponds, found in Taiz, Hodeidah, Dhamar, and Aden. Stabilization ponds are under construction in Rada' and are planned for ten secondary towns. In Sana'a, sewage has been receiving partial treatment in temporary stabilization Comprehensive Development Review - Environment 10 ponds since 1988, but no acceptable site for a long-term stabilization pond has yet been identified. In 1991, a new site was chosen to construct an extended aeration treatment plant. The only other activated sludge extended aeration treatment plant is in Ibb. Although the major cities have wastewater treatment facilities, a portion of the wastewater collected by trucks is disposed of untreated in nearby wadis, which eventually seep into aquifers or the sea.

Some wastewater is reused in irrigation on an ad hoc basis and without quality controls. In Sana'a, 2.5 times more sewage is discharged into groundwater recharge areas and into

freshwater aquifers than into the sewerage system. Private providers of municipal disposal of wastewater are not subject to insufficient regulation.

One of the most visible and serious impacts of inadequate waste water disposal is on historic inner-city buildings where dampness is rising to unprecedented levels. Yemen is one of the oldest civilizations in the world. Its architectural resources are perhaps the most spectacular and best known aspect of the country's heritage and tourism potential. The deterioration and loss of these resources in Yemen's cities, such as Sana'a and Shibam, is due in large part to insufficient maintenance of both buildings and infrastructure. In Shibam, for example, inadequate drainage systems and leaking water pipes have brought increasing amounts of sewage, and other pollutants straight into the ground around some of the highest mud buildings in the world. This has produced structural problems as evidenced by large cracks appearing on the buildings and eventual collapse. Islamic monuments such as the city wall of Shibam and the mosque at Bor are not receiving the care and maintenance that their antiquity demands.

Although the conservation of cultural properties is not viewed as a priority problem in light of other pressing pollution and resource management issues, the destruction of Yemen's cultural patrimony is irreversible. When important historic sites are degraded or destroyed, their value and the information they contain is lost forever. For many, the destruction of Yemen's cultural resources represents a loss of national identity and spiritual values. In some cases, the integrity of internationally significant resources is threatened.

2. Solid waste management

Inadequate municipal solid waste management is a serious problem in the cities as well as in small towns and villages.

Waste collection is especially poor in the low-income neighborhoods, where most of the waste is dumped into wadis, streets, and open dumps. In many cases, accumulated refuse and the stagnant water resulting from the clogging of drainage systems, serve as breeding grounds for rats and insects, contributing to both disease and nuisance. the influx of migrants to the cities has compounded the problem.

Municipal solid waste disposal is a major concern, in particular in Sana'a. The capacity of the existing landfill has long been exceeded; waste presently reaches an elevation of five to ten meters above design level. Spontaneous combustion results in constant fires, widespread smoke, and odors. Moreover, the top of the landfill is dangerously close to high voltage power lines. The fence also has been destroyed allowing access to the landfill by scavengers and animals. The critical conditions of the landfill provoked residents living nearby to block access of disposal trucks to the field. Refuse is now disposed of on public land that had been previously zoned for recreational use.

The regulatory framework leaves many gaps. For example, there are no provisions for national or local regulation of solid waste collection and disposal. In some cases, municipalities have established informal arrangements to enforce appropriate refuse disposal. In the case of the municipality of Taiz, for example, NWASA can interrupt water supply to those residents that do not comply with minimum 11 Comprehensive Development Review – Environment requirements for safe disposal. The effectiveness of this mechanism, however, is limited to the extent that NWASA only supplies water for domestic purposes and to a very small portion of the urban population.

3. Hazardous waste management

Although there are no definitive data, the total volume of hazardous waste produced in Yemen is estimated to be approximately 36,000 tons per year. Although this is a relatively small amount when compared to the amounts produced in industrialized countries, local impacts are considerable, particularly on ground water.

The types of hazardous wastes in Yemen include hospital waste, waste oil, industrial waste, pesticides, photographic waste, and pharmaceutical waste. The main sources of hazardous waste are textiles, food processing, cement, plastics, chemicals and petrochemicals, paper and printing industries, and tanneries. Among these, the cement industry, energy sector (refinery and power plants), textile industry, and the plastic industry are producing 85 percent of the hazardous wastes, most of which is oil or oily sludge. Due to expanding oil, chemical, pharmaceutical, plastic, and paint industries, the amounts of hazardous waste is expected to increase in the near future.

Some industries incinerate their solid hazardous waste in open pits. Other hazardous waste is dumped on open dump sites, or on private and municipal landfills, where supervision is inadequate. It is difficult to monitor dumping and ensure that disposal workers are protected or to control the hazards that toxic waste poses to the environment, in particular to fresh water.

Liquid hazardous waste is disposed of into the sewerage system or, as is the case in some industries, disposed of with the wastewater which is discharged into the surroundings without any treatment. There is no regular separation of medical, toxic, and domestic waste. Often, chemical from laboratories, blood banks, and x-ray departments as well as used oil and oily sludge are discharged directly into sewerage systems or disposed locally in the soil.

Hazardous waste is a growing environmental threat due to inadequate disposal of industrial discharges and the lack of separate collection and disposal arrangements in municipal waste management. The responsibility for managing hazardous and toxic waste is not clearly delineated and falls under eight ministries. The resulting duplication and inconsistencies lead to chaotic waste management.

4. Pesticide Management

A special hazardous waste issue is the existing stock of outdated pesticides (about 300 tons) requiring safe disposal. Obsolete pesticide stocks are stored at the Desert Locust Center in Hodeidah and at Lahej in the south. These stocks consists of chlorinated hydrocarbon insecticides used in locust control, which are no longer approved for application, and so can not simply be used up. They can pose serious environmental problem and require immediate appropriate disposal.

D. Habitat Degradation

Located at the cross-roads of the African, Asian, and Palearctic ecological zones, and with a wide range of terrestrial, coastal, and marine landforms, Yemen is characterized by a rich variety of natural habitats, species and genetic diversity, including many endemic species. These resources are of major economic importance because of their potential for tourism, and the wildlife and fisheries they support. Also, numerous plants are used in traditional medicine, in local industries, and for grazing and fuelwood. However, in recent decennia human activity has transformed the landscape and overexploited available biological resources, which resulted in the deterioration of many habitats, in major reduction in plant and animal species.

Table: Main Environmental Problems and Specific Concerns in Habitat Degradation

MAIN PROBLEM	SPECIFIC CONCERN
HABITAT DEGRADATION	<ul style="list-style-type: none"> • DEGRADATION OF NATURAL HABITATS (FORESTS, WETLANDS, COASTAL HABITATS) • LOSS OF BIODIVERSITY (EXTINCTION OF ENDEMIC, RARE AND ENDANGERED SPECIES) • LACK OF MANAGEMENT OF ECOTOURISM

1. Degradation of Natural Habitats

Many factors contribute to the degradation of critical habitats such as forests, wetlands, and coastal areas. Among these are inadequate management of municipal and industrial waste, haphazard urban land development, tourism, fuel wood collection, overgrazing, overfishing, and intensive agriculture. For example, the conversion of traditional agricultural systems to large-scale farming with greater dependency on fossil fuels, fertilizer, and pesticides is proceeding rapidly in the Tihama lowlands. Although this activity is largely isolated from the coast by the band of saline soil and halophytic shrubs, runoff and contamination by pesticides and sediments from soil loss in the upper watersheds have a negative effect on wadi's downstream. Similarly, the large-scale extraction of ground water by tubewells and the diversion of wadi runoff with barrages to support agriculture reduce the fresh water flows downstream. The effects of these

activities are likely to be reduction in nutrient input from flooding and changes in groundwater salinity that affect salt sensitive plant communities.

In the coastal areas the principal threats are as follows:

- urban development – critical habitats such as mangroves are being threatened by the disposal of raw sewage and untreated industrial;
- over-exploitation of coastal resources - continued fishing activity during the spawning season despite recommendations made by fishery experts; development of industrial scale fisheries has a potential for disrupting ecosystems upon which fish, shrimps, and another marine fauna depend.
- pollution from oil spills - oil spills occur frequently in the Gulf of Aden (ten spills were recorded in 1985); and
- physical destruction – bottom-trawling in shallow coastal waters destroys the egg deposits of the cuttlefish and damages seagrass vegetation which provides an important habitat for shrimp, extensive wood cutting destroys mangrove vegetation.

Effective management of natural habitats is hampered by (1) ineffective regulatory and economic policies, (2) a rudimentary information base - there is a lack of comprehensive surveys on the fauna and flora of Yemen, and (3) a lack of awareness regarding the importance of biological resources at the individual, communal, and national levels. Most important, however, are institutional weaknesses. The three main institutions that deal most directly with the county's habitat resources are the Environmental Protection Council (EPC), Ministry of Agriculture and Water Resources (MAWR), and Sana'a University. In addition, the Marine Science and Resources Research Center in Aden conducts research and training in various coastal and marine issues. All of these institutions, however, are unable to carry out or coordinate conservation initiatives without technical assistance and/or external funding. Shortcomings in the country's institutional capacity to address conservation problems are: a shortage of trained personnel, lack of coordination between ministries, and lack of enforcement capacity.

Effective management of coastal resources requires an understanding of the functioning of the marine and coastal system and their inter-relationships. Based on an analysis of available data on Yemen's coastal resources, however, many gaps can be identified. For example, little is known about changes in water quality and the composition and abundance of marine flora and fauna as a result of human activities. With respect to fisheries, data is needed on spatial and seasonal changes in the composition and size of the catches in relation to changes in the physical environment and the number and types of fishing units operating in the Red Sea and Gulf of Aden areas.

There is a need for coastal zone management (CZM). Coastal zone management is important to guide human development activities in the coastal zone, but is in particular vital to minimize or eliminate pressure imposed on the coastal ecosystems as a result of activities, such as urban development, port and industrial activities, fisheries, tourism, and road building. CZM should be based on information gathering and mapping of

current and potential critical habitats, reflecting the impact of environmental degradation on various coastal and marine living organisms and their habitats. The Yemeni coastal zone, because of its diverse habitats, has great significance in the life cycles of many marine animals such as sea turtles, sea cucumber, cuttlefish, shrimp, and larval and juvenile stages of many fishes. The marine and coastal habitats of Yemen are comprised of:

- sandy shores, important as nesting grounds for sea turtles
- rocky coasts
- saline mud flats, "Shabka"
- mangrove swamps, important as detritus producers for shrimp,
- palm groves, with doum palm (*Hyphaene thebaica*) and Phoenix *dactylifera*,
- coral reefs, important as feeding grounds for many fish and Hawksbill turtles (*Eretmochelys imbricata*), and
- seagrass beds, important nutrition for marine mammals, Dugongs (*Dugong dugon*), and green
- turtles (*Chelonia mydas*).

2. Loss of Biodiversity

The "Biological Diversity Assessment of Yemen prepared by the International Council for Bird

Preservation summarized the main concerns in the conservation of biodiversity in Yemen as follows:

- Lack of adequate legislation to protect flora and fauna
- Lack of Institutional Capacities at EPC, MAWR, and Sana'a University
- Criteria for defining critical habitats or biotypes are missing
- Critical or endangered species of international or national interest occur, but insufficient information is currently available
- Genetic diversity is a major feature of a variety of species in Yemen, in particular for sorghum species.

Threats exist to an estimated 200 to 300 endemic bird species known in Yemen, including three globally threatened, an unknown number of endemic coral reef fish species, and wildlife such as ibex and gazelles. Threat occur as a result of indiscriminate hunting of birds and mammals. Collection of shells, corals, and coral reef fishes likewise leads to reduction in their number. There is a clear need for establishing protected areas.

Even with is a lack of precise information on the number of fauna and flora species present in Yemen, or on rare, threatened endemic species and their habitats, or inadequate legislation, proposals exist for the development of a network of protected areas. Specifically, the following high-priority sites have been identified: Socotra Island, Jebel Bura, Hugaria (Qubayta and Jebel Iraf), Mahra (Hawf), and the Tihama Mangroves.

3. Lack of Management of Eco-Tourism

There is considerable potential benefit for Yemeni nationals to develop eco-tourism in Yemen. However, as a national undertaking this sector is yet to be developed. Some international initiatives taken do not necessarily benefit local interest. National plans to organize the sector are needed as well as a modest unit in the Ministry of Tourism to guide sustained eco-tourism and to ensure that tourist developments are environmentally acceptable. Eco-tourism possibilities should be explored in conjunction with protected area establishment.

To focus initial NEAP activities on the most urgent national issues, the eleven problem areas were further narrowed down to four main problems. Consensus was reached that the four main environmental problems presented in Table 5 below constitute the current national priority issues.

Table: Main Environmental Problems and Specific Concerns in Yemen

MAIN PROBLEM	
WATER DEPLETION, POLLUTION AND SUPPLY	<ul style="list-style-type: none"> • OVER-EXTRACTION OF SUPPLY GROUNDWATER • LACK OF WATER ALLOCATION AND CONSERVATION SYSTEMS • WATER POLLUTION INADEQUATE WATER SUPPLY SERVICES
LAND DEGRADATION	<ul style="list-style-type: none"> • SOIL EROSION • DEFORESTATION • AGRICULTURAL AND RANGE LAND DETERIORATION • LOSS OF FARM LAND DUE TO URBAN ENCROACHMENT
WASTE MANAGEMENT	<ul style="list-style-type: none"> • WASTE WATER MANAGEMENT • SOIID WASTE MANAGEMENT • HAZARDOUS WASTE MANAGEMENT • PESTICIDE. MANAGEMENT
HABITAT DEGRADATION	<ul style="list-style-type: none"> • DEGRADATION OF NATURAL HABITATS (FORESTS, WETLANDS, COASTAL HABITATS) • LOSS OF BIODIVERSITY (EXTINCTION OF ENDEMIC, RATE AND ENDANGERED SPECIES) • LACK OF MANAGEMENT OF ECOTOURISM

BIODIVERSITY IN YEMEN

[Source: This section is based in part on, and quotes verbatim and summarizes, material gathered from “The Integration of Biodiversity into National Environmental Assessment Procedures: National Case Studies, Yemen” 2001. Produced for the Biodiversity Planning Support Programme UNDP/UNEP/GEF. In addition, these passages summarize and extensively quote verbatim from, “Biological Diversity of The Republic of Yemen.” 1992. By Daniel Varisco, James Ross, Anthony Milroy and edited by Michael Rands. International Council for Bird Preservation, supported by USAID, and US Fish and Wildlife Service]

Since Yemen is located at the conjunction of African, Asian and Palearctic ecological zones, the diversity of plants and animals is greater than in any other parts of the Arabian Peninsula. Indeed, the wide variety of environments within the country has resulted in some of the greatest biological diversity in the Middle East. Due to the range of environmental zones and relative isolation of the country, a number of endemic species are found. The valuable biological resources have an obvious scientific significance, but there are also major economic implications for sustainable productivity in the country. The genetic diversity of indigenous crops, most notably sorghum, and medicinal plants is of critical importance for pest management and the control of viral disease in the agriculture sector. Similarly, protection of critical habitats is necessary for sustainable fisheries and for reforestation of much of the country.

Vegetation

The flora of Yemen is especially rich, with an estimated 1,700 plant species in a wide variety of ecological habitats. About one-third of these belong to the Saharo-Arabian plant geographic region. The remaining two-thirds are of African orientation. There is a high degree of similarity of both plant and animal species with East Africa, although the areas have been isolated for at least 18,000 years. The variations in elevation and rainfall in the western escarpment have led to significant genetic variation. Much of the original forest cover has been denuded (as of 1991), especially in the last two decades, for fuelwood. The rangeland remains an important part of the agricultural ecosystem, although this has deteriorated with the collapse of numerous terrace systems. A wide range of plants have been used in traditional medicine and in local industries in Yemen's history. Some of these species (e.g. certain *Aloe*, *Juniperis*, and *Acacia*) are rare and important. There is a variety of marine plant communities, the most important economically being the mangrove forest on which the shrimp stock depends.

Species diversity is a result of considerable climatic changes in former periods, which enabled different species to survive in the different ecological habitats. Over 3000 plant species are possibly found in the mainland, and about 10% of them are endemic. One checklist comprised 467 plant species belonging to 244 genera from 71 families. Socotra Island is unique in its flora and like many oceanic islands, has a high level of endemism.

The latest study reported that Socotra contains approximately 850 plant species, 254 (about 30%) of which are endemic. Out of the eighteen plant genera endemic to the Arabian Peninsula, ten genera are restricted to the Socotra archipelago. The majority of endemic taxa in Yemen are associated with mountainous areas which provide a rich variety of ecological niches and offer a degree of environmental stability during periods of climatic changes. Endemism is generally very high among the succulent plants. The largest numbers of endemic species are found within the *Asclepediaceae* taking into account the *Stapeliad* genera (*Carraluma*, *Duvalia*, *Huernia* , and *Rhytidocaulon*). *Euphorbiaceae* and *Aloeceae* also have high percentage of endemism as they include the succulent *Euphorbia* and *Aloe* species respectively. Socotra Island contains about 30% of endemic species. Precise data on the status and number of rare and endangered plants are not available. Some eight species (seven of these from Socotra) are included in the IUCN Red Data Book as being endangered or rare, and an additional 19 species are considered to be endangered or rare at the national level in Yemen. The medicinal flora in Yemen is not yet well documented, as research on this subject is still limited. However, medicinal and aromatic plants are of great interest and use to Yemenis. There are accumulated experiences in using these plants as traditional remedies to cure diseases in different areas of the country while others are used as cosmetics, condiments, coloring matters and flavoring agents. A list of 224 medicinal and aromatic plants species along with their scientific names, families, vernacular names, distribution, active substances, medicinal use has been compiled. A similar study concentrated on the use of medicinal plants endemic to Yemen. Other uses include 19 species of common trees and shrubs used for fuel wood, seven species used as timber for construction, another 19 species for dune stabilization and a great number of plants (weeds, trees, shrubs, grasses and some succulents) are used by grazing ungulates.

Terrestrial Fauna

The fauna of Yemen is also quite diverse, in large part because of the range of plant communities and habitats. New species are regularly being described as scientific research on the fauna continues. The long history of human settlement and transformation of the landscape into a terrace cultivation ecosystem have led to major reduction in the larger vertebrates, particularly mammals. The ibex and three species of gazelle, were once plentiful here, but are severely threatened today. Indications are that there has been a major decline in the number of most species of large mammal during the past three decades because of increased access to remote areas of the countryside and the use of rifles and automatic weapons. From a scientific point of view, certain species are of particular interest because of the long genetic isolation from African components (e.g. local race of baboon populations). Among the more important declining, rare and/or threatened and endemic vertebrate species in Yemen are: Leopard, Caracal, Queen of Sheba Gazelle, Ibex (possibly extinct), Ruppell's Sand Fox, Striped Hyaena, African Small-spotted Genet, Dugong, Green and Hawksbill Turtles, Bald Ibis, Arabian Bustard, Philby's Rock Partridge, Arabian Red-legged Partridge, Arabian Woodpecker, Arabian Accentor, Arabiamn Wheatear, Yemen Thrush, Yemen Warbler, Arabian Golden

Sparrow, Arabian Waxbill, Arabian Serin, Yemen Serin, Golden-winged Grosbeak, and Yemen Linnet.

Yemen has a rich and diverse terrestrial fauna primarily due to two factors: the wide range of habitats in the country that vary from the highest mountains, to the plains, dry sand-deserts, marshes, coastal habitats and volcanic ocean islands; and the country's position at the juncture of three major biogeographic regions, the Palearctic, Afrotropical and Oriental regions.

Mammals

Yemen has a population of 71 recorded land mammal species represented by eight orders including the bats . About one third of the mammals are relatively large-sized species some of which are rare in other parts of Arabia. Five species of gazelle have been recorded in Yemen (Al-Jumaily, 1998) the most common being the "Idmi" or Arabian Mountain Gazelle (*Gazella gazella*) which is typically found in Acacia and Savanna-like habitats, but close to barren rocky hills with wadis and depressions that support a scarce vegetation of mainly *Acacia tortoils* , *Leptadenia pyrotechnica* and *Panicum turgidum* . The remaining four species are rare, and are believed to be almost extinct in the country. The Rhim or the Goitered Gazelle (*Gazella subguturosa*) is the typical desert gazelle being larger and stouter than the other four species. It is possible that Rhim may still occur in the most remote areas close to the hot desert area of Al-Rub, Al-Kahli near the border with Oman. The Dorcas Gazelle (*Gazella saudiya*), the smaller and lighter species with relatively longer horns, formerly inhabited the plains of the interior but has not been reported in recent times, and is believed to be almost certainly extinct in the country. The Queen of Sheba's Gazelle (*Gazella arabica bilkisi*) is known only from Yemen. Four specimens collected in the past few years were believed to be held in a private collection in the State of Qatar (Stauart and Stauart, 1997). Two specimens from Ma'bar were currently held in the Field Museum of Natural History, Chicago.

The Ibex (*Capra ibex nubiana*) still occurs in the eastern part of Yemen, inhabiting the difficult rocky slopes in mountainous areas which have served to protect the animals from hunters in vehicles. The Arabian Oryx (*Oryx leucoryx*) is almost certainly extinct in the wild, and there is no evidence that it exists within the accessible terrain in the deserts of north-eastern part of Yemen. The Baboon (*Papio hamadryas*) is still found in hilly terrain, preferring rocky slopes usually in the vicinity of permanent water. There has been a serious decline in the Baboon population with the occupation of nearly all water sources and fertile wadis by man .

The Arabian Red Fox (*Vulpes vulpes arabicus*) and the Striped Hyaena (*Hyaena hyaena*) are probably the most abundant mammals in Yemen and inhabit adequately vegetated areas throughout different parts of the country. Although the Striped Hyaena is primarily known as a scavenger feeding on carcasses of dead animals, people in many parts of the country have complained about Hyaenas attacking their domestic animals and raiding watermelon crops in the field. Two other species of foxes found in Yemen are

Sand Fox (*Vulpus ruppelli*) a paler and smaller species with larger ears that inhabits the desert, and Blanford's Fox (*Vulpes cana*), similar to the Sand Fox in general appearance but inhabits rocky slopes. Its occurrence in Yemen is not certain. The Arabian Wolf (*Canis lupus arabs*) is found in many areas, especially in the eastern part of the country. The Jackal (*Canis aureus*) can be found near human settlements.

The Family Felidae has the largest number of members and is represented by 5 genera and 6 species, all of which are considered endangered or extinct. Among the most notable are the Arabian Leopard (*Panthera pardus nimr*), a very rare, if not an extinct mammal in Yemen which was known to inhabit the rocky slopes of mountainous and hilly terrain. Recent reports indicate that a leopard was captured near the area of Wadeah, and was sent to the United Arab Emirates for a captive breeding program. The Cheetah (*Acinonyx jubatus*) has not been observed in the wild in many years. The last individual was seen by Ducker in March 1963 in Wadi Mitan. However, there is some evidence that cheetah may still survive in remote areas of the southern part of the country. A stuffed skin of cheetah was seen hanging on a building in Ataq in 1985, and was said to have been killed in the area.

Birds

Yemen has a very rich bird fauna with more than 363 species thus far recorded representing 18 orders, 61 families and 177 genera. The main reasons for this richness are: 1) Presence of a wide array of habitats (mountains, Tihama plains, wetlands and marshes, coastal areas, Gulf of Aden and Red Sea, and agricultural landscapes of many varieties) largely the result of the broad range of elevations and climate; 2) Geographic isolation by the sea and deserts, resulting in 13 endemic or near-endemic species; 3) Yemen's position at the transition zone of three biogeographic regions: Afrotropical, Oriental and Palearctic, resulting in a mixture of species from all three; and 4) The country's strategic position at the foot of the Arabian Peninsula, thus acting as an important stop-over in the path of flyways for migrant birds, notably birds of prey and waders.

Globally Threatened Species

- Bald Ibis (*Geronticus eremite*): Yemen is probably a vital wintering area for a small population of this species and may possibly even be their breeding ground. The retention of grazing marshes, especially in the Taiz area is critically important.
- White-eyed Gull (*Larus leucophthalmus*): Occurs throughout the year on the coast and may well breed on Yemen's off-shore islands. The main threats are oil pollution and destruction of nesting colonies through man's activities.

Species Endemic to Southwest Arabia

Yemen holds significant, and in most cases the major populations of 13 species unique to south-west Arabia. For a small country to be so richly endowed with endemic birds adds greatly to its international significance. With the exception of the Arabian Golden Sparrow (*Passer euchlorus*), all endemic species occur in the highlands. The Arabian Accentor (*Prunella fagani*) is known only from the highlands of Yemen mainland. The demise of the terracing systems could adversely affect several of the endemics as the resultant soil erosion will cause loss of trees. Acacias in the highlands, even isolated trees or clumps, are important for the Arabian Woodpecker (*Dendrocopos dorae*), Yemen Thrush (*Turdus menachensis*), Yemen Warbler (*Parisoma buryi*), Arabian Serin, (*Serinus rothschildi*), Golden-winged Grosbeak (*Rhynchostruthus socotranus*), and Yemen Linnet (*Carduelis yemenensis*).

Seabirds

The biological richness of the Red Sea and offshore islands of Yemen combine to make an ideal feeding and breeding area for seabirds, notably Red-billed Tropicbird (*Phaethon aethereus*), Masked Booby (*Sula dactylatra*), Brown Booby (*Sula leucogaster*), Sooty Gull (*Larus hemprichii*) and possibly White-cheeked Tern (*Sterna repressa*). The globally threatened White-eyed Gull (*Larus leucophthalmus*) may also breed there. All these species plus many others feed in the relatively shallow inshore waters along the coast of Yemen. Oil pollution, disturbance from military activities, port developments and planned tourist facilities may all have an adverse effect on the seabirds.

Waterbirds

Freshwater habitats are rare in Yemen. Concentrations of ducks and grebes occur in just two areas (both recently created sewage lagoons) but rarely exceed 1000 birds. These, together with the new dam at Ma'rib, may result in a notable increase in the numbers of waterbirds in winter; they have already led to some species breeding for the first time in Yemen.

For wading birds, coastal areas are important, particularly where wadis reach the sea. While comprehensive counts have not been undertaken it would appear that the biologically rich mudflats are particularly important for the following species: Carb Plover (*Dromas ardeola*), Greater Sand Plover (*Charadrius leschenaultii*), Lesser Sand Plover (*Charadrius mongolus*), Sanderling (*Calidris alba*), Little Stint (*Calidris minuta*), Curlew Sandpiper (*Calidris ferruginea*), Bar-tailed Godwit (*Limosa lapponica*), Grey Plover (*Pluvialis squatarola*), and Redshank (*Tringa totanus*). Storks, herons and egrets also occur on passage in small to moderate numbers but no important concentrations have been discovered. White Storks (*Ciconia ciconia*) winter in small numbers at freshwater sites and breeding species include Abdim's Stork (*Ciconia abdimii*) (on Tihama rooftops), Reef Heron (*Egretta gularis*) (coast), Cattle Egret (*Bubulcus ibis*) (trees on Tihama and foothills), Green-backed Heron (*Butorides*

striatus) (mangroves), and Pink-backed Pelican (*Pelicanus rufescens*) (mangroves); though none have been censused. Despite the close proximity of many breeding colonies to villages and human activities, there is no evidence of interference or persecution. The highest conservation priority concerning waterbirds is of course the Bald Ibis, mentioned under 'Globally Threatened Species'.

Raptors

Raptors frequently suffer more than other species in terms of both indirect (e.g. pesticide pollution) and direct persecution. However neither is common in Yemen. As a consequence there appears to be a healthy raptor population with some 17 resident species and a further 15 occurring regularly on passage or in winter. The limited information suggests that the country is in the path of an important flyway, at least in autumn, for migrant Steppe Eagles (*Aquila rapax*), Buzzards (*Botu spp.*) and Black Kites (*Milvus migrans*) passing from their Palearctic breeding grounds to their main wintering area in East Africa. Clearly there is an international responsibility to ensure that these birds are unmolested.

Migrant and Wintering Birds

Over 220 species have been recorded on migration in Yemen; mention has been made already of the waders, white storks and raptors. A number of passerines or near-passerines also occur on migration and/or in winter in what appear to be significant numbers. These are Golden Oriole (*Oriolus oriolus*), Bee-eaters (*Merops spp.*), Short-toed Lark (*Calandrella brachydactyla*), Swift (*Apus spp.*), Swallow (*Hirundo rustica*), Tawny Pipit (*Anthus campestris*), Yellow Wagtail (*Motacilla flava*), White Wagtail (*Motacilla alba*), White throated Robin (*Irania gutturalis*), Black Redstart (*Phoenicurus ochrurus*), Redstart (*Phoenicurus phoenicurus*), Stonechat (*Saxicola torquata*), Isabelline Wheater (*Oenanthe isabellina*), Pied Wheater (*Oenanthe pleschanka*), Olivaceous Warbler (*Hypolais pallida*), Menetries' Warbler (*Sylvia mystacea*), Desert Lesser Whitethroat (*Sylvia curruca minuta*), Chiffchaff (*Phylloscopus collybita*), Isabelline Shrike (*Lanius isabellinus*), and Great Gray Shrike (*Lanius excubitor*).

The Arabian Bustard (*Ardeotis arabs*)

Within the Arabian Peninsula, Yemen is probably now the only country with a self-sustaining population of Arabian Bustards. This may in fact be partly supplemented by migrants crossing the Red Sea. The species may be threatened from hunting on the Tihama, the only place where this bird occurs in the country.
Rangeland Resources

Crop Genetic Diversity

One of the unique aspects of Yemen's biological and indigenous agricultural species is the range of genetic diversity. This is especially evident in the documented diversity for the main subsistence (and prime cash crop for fodder) crop of sorghum (*dhura*). The USAID-sponsored National Sorghum and Millet Crop Improvement Program of the late 1970s collected 4,500 native sorghum varieties, of which 50 were tested at 18 locations over a two year period in Yemen. The technical conclusion of these tests and analysis was that locally adapted types from Yemen were more productive than available hybrid sorghum types developed for conditions outside of Yemen (University of Arizona, quoted in Variso et al.1992.). Given the importance of sorghum historically in Yemen and its continued production on the bulk of rainfed and a substantial portion of irrigated land. Preservation of this diversity is important both for Yemen and potentially for other regions where this crop is still of significance.

Although research is still in a preliminary stage, it is clear that in the range of environmental zones of the country there is great diversity of species and ongoing discoveries of new variants unique to Yemen, including two types of aloe (*Adenium abesum*). .

Major Threats to Biodiversity

Threats to Vegetation

The country's vegetation is being drastically reduced by rapid degradation of the environment, a direct result of desertification and droughts, among the oldest global environmental phenomena. These phenomena have increased drastically in Yemen and threaten about 90% of the land and can be attributed to the following:

- Cultivation and poor agricultural practices;
- Wood cutting for firewood, timber and charcoal;
- Over grazing;
- Soil Salinization;
- Wind erosion and Sand dune encroachment; and
- Construction expansion in cities and villages.

Threats to Terrestrial Fauna

Threats to terrestrial fauna in Yemen are common to many countries in the regions and are mainly:

- Destruction, degradation and loss of habitats;
- Over-hunting and proliferation of firearms; and
- Road construction opening up avenues into the hinterland.

Threats to Freshwater Biodiversity

Threats to freshwater biodiversity in ranking order of importance include:

- Overuse and depletion of water;
- Degradation of wetland ecosystems;
- Improper application of pesticides;
- Use of chemical fertilizers;
- Contamination of ecosystems with sewage; and
- Contamination by industrial waste.