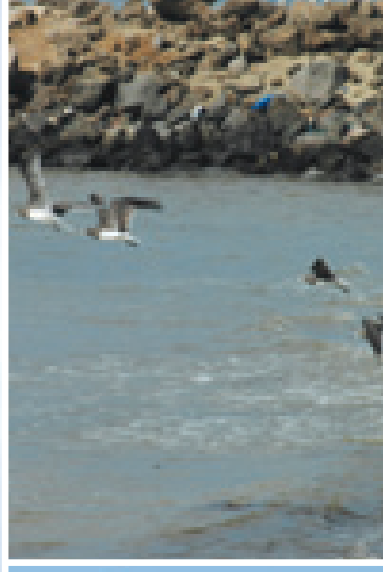
PRESIDENCY OF METEOROLOGY AND ENVIRONMENT
KINGDOM OF SAUDI ARABIA

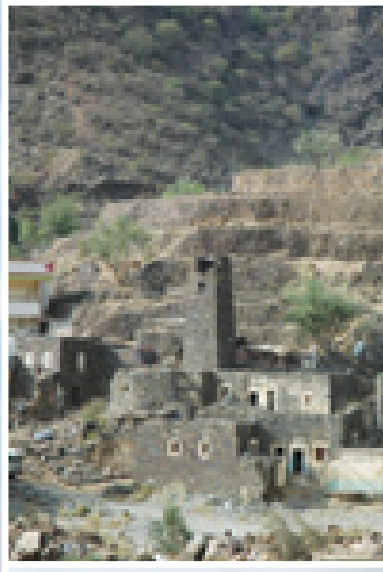
PME

UNEP

MILLENNIUM ECOSYSTEM ASSESSMENT

Sub-Global Arab Millennium Ecosystem Assessment





Saudi Arabian Millennium Ecosystem Assessment
For
Assir National Park
Main Report
June 2010

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KINGDOM OF SAUDI ARABIA

MILLENNIUM ECOSYSTEM ASSESSMENT

Sub-Global Arab Millennium Ecosystem Assessment

Saudi Arabian Millennium Ecosystem Assessment
For
Assir National Park
Main Report
June 2010

HRH Prince Turki Bin Nasser Bin Abdulaziz
President
Presidency of Meteorology and Environment (PME)
Ministry of Defense and Aviation
Kingdom of Saudi Arabia

Foreword

This report presents the assessment made for the Asir National Park (ANP) in Southwestern Saudi Arabia, the first to be established in the Kingdom. The park was opened for public in 1981 which represents a unique ecosystem in this part of the world in that there are at least four distinct ecosystems ranging from a mountainous area to a coastal plain in close proximity to each other. The study focuses on one of these ecosystems, the mountainous agro-forestry and assesses the relationship between ecosystem services and human well-being.

The Millennium Ecosystem Assessment (MA) was called by the United Nations Secretary-General in his report to the UN General Assembly in 2000. It was subsequently supported by Governments by establishing assessments through decisions made by three international conventions, namely:

- The Convention on Biodiversity
- The Convention to Combat Desertification and
- The Ramsar Convention on Wetlands

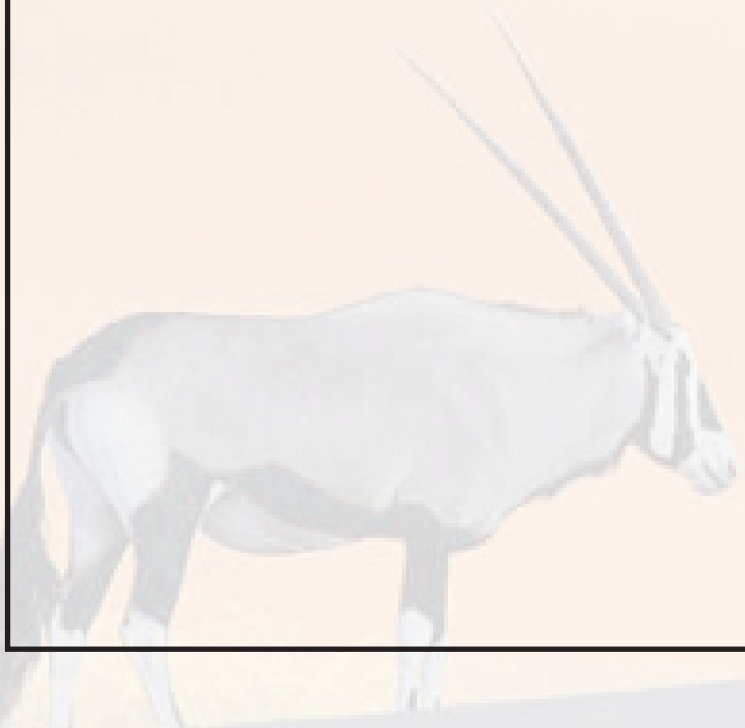
The objective of the MA was to assess the consequences of ecosystem change for human well-being, and to establish the scientific basis for actions needed to enhance the conservation and sustainable use of ecosystems and their contributions to human well-being. As reflected in this report, the MA includes the following assessments (Millennium Ecosystem Assessment, 2005)

- Current State and Trends
- Scenarios and
- Policy Responses

The MA provides a unique set of information concerning human dependence on ecosystems. Never before has such an assessment been conducted that addresses multiple environmental changes, drivers that force the changes and multiple linkages to human well-being and looking at ways in which societies have sought to manage these linkages.

Eighteen sub-global assessments by institutions or countries were approved as components of the MA. A country or institution was accepted to perform an MA if it agreed to use the MA conceptual framework, to involve the intended participants and to meet a set of procedure requirements related to peer review. The MA also relied on information from 16 additional sub-global assessments affiliated with the MA that met the above criteria or were at the early stages of development. Saudi Arabian Millennium ecosystem assessment for ANP is part of Sub-Global Arab millennium eco system asesment which also included sinai penensula, Egypt and Tafilalt Oasis, Morocco.

Turki Bin Nasser Bin Abdulaziz
Jeddah



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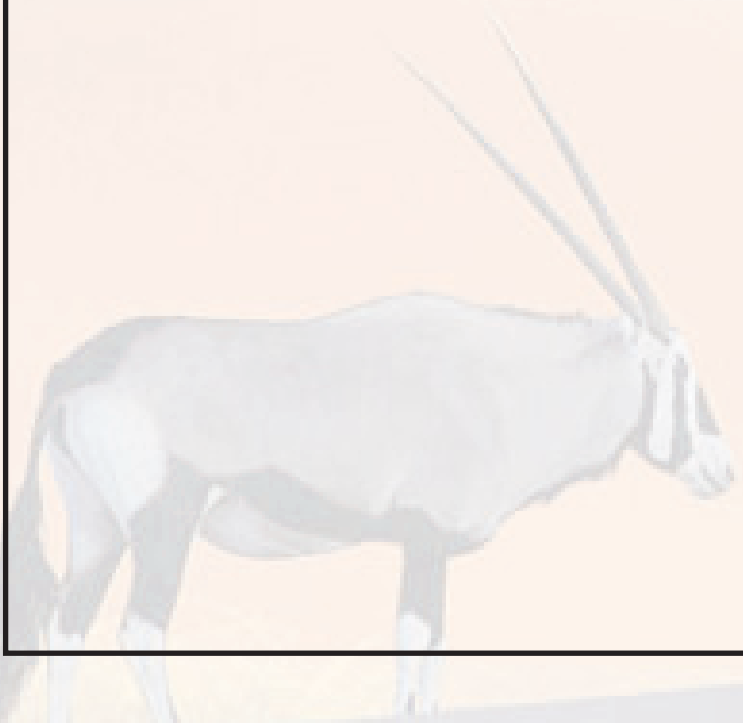

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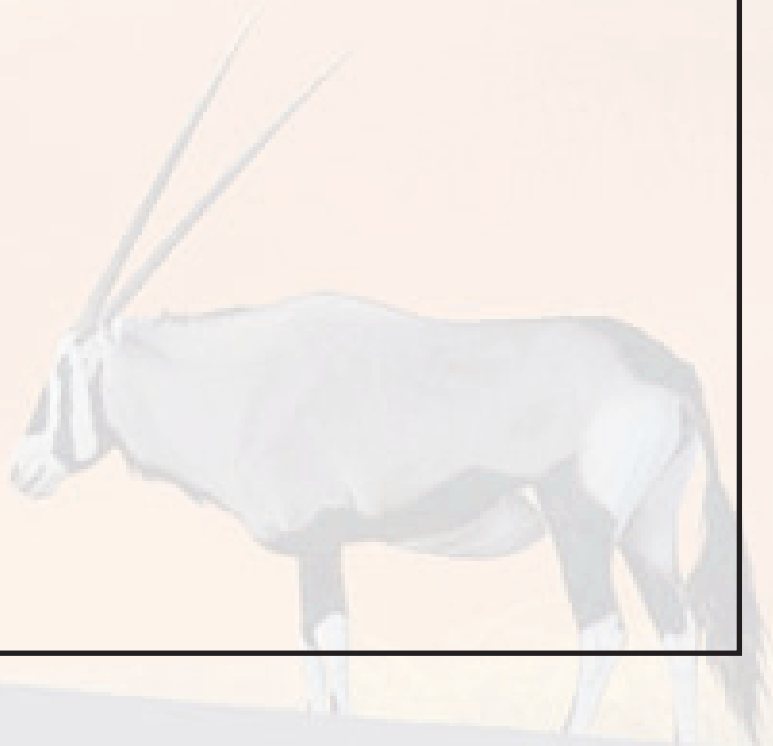
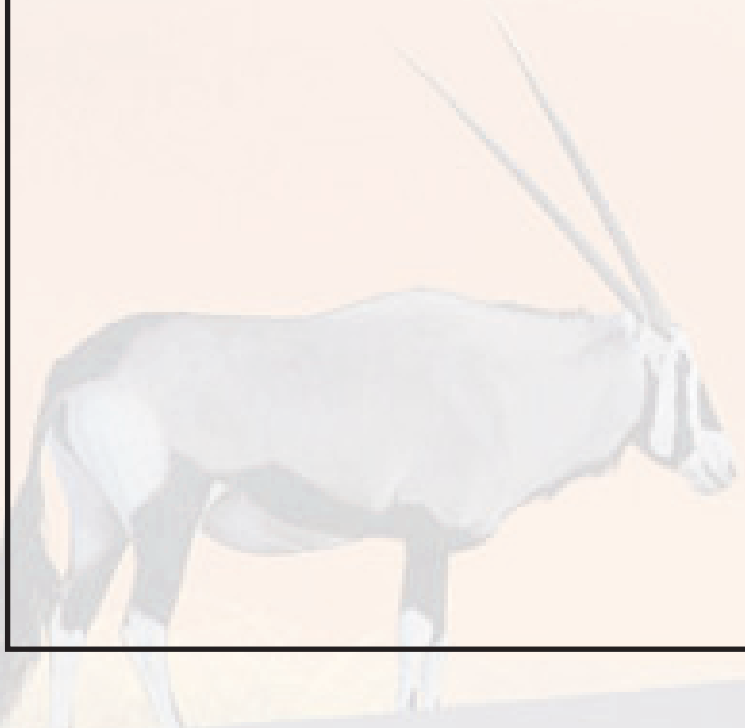
Note for Readers :
The official name of "National Commission for Wildlife Conservation and Development (NCWCD)" used in this report has been changed to "**Saudi Wildlife Commission**"

Acknowledgements





Acknowledgements

This study has been prepared by a team of experts and consultants from the Presidency of Meteorology and Environment (PME), Ministry of Agriculture, King Abdulaziz City for Science and Technology (KACST), National Commission for Wildlife Conservation and Development (NCWCD), King Abdulaziz University (KAU) and by external consultants from the University of Arizona, USA.

The study team is extremely grateful and thankful to HRH Prince Turki Bin Nasser Bin Abdulaziz, President, Presidency of Meteorology and Environment (PME) for his continued support and leadership throughout the study without which this study could not have been completed.

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- Adel Farid Abdel Kader, UNEP Coordinator of Arab Millennium Ecosystem Assessment and Regional Coordinator, Division of Early Warning and Assessment-West Asia, Bahrain.

- Marcus Lee, Former Deputy Director, Millennium Ecosystem Assessment, Currently with World Bank.
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- Salif Diop, Acting Chief, Scientific Assessment Branch, Division of Early warning and Assessment, Nairobi.

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- Dr. Herman Andres Blanco, Executive Director, RIDES, Chile
- Dr. Belinda Reyers, Natural Resources & Environment, CSIR, South Africa
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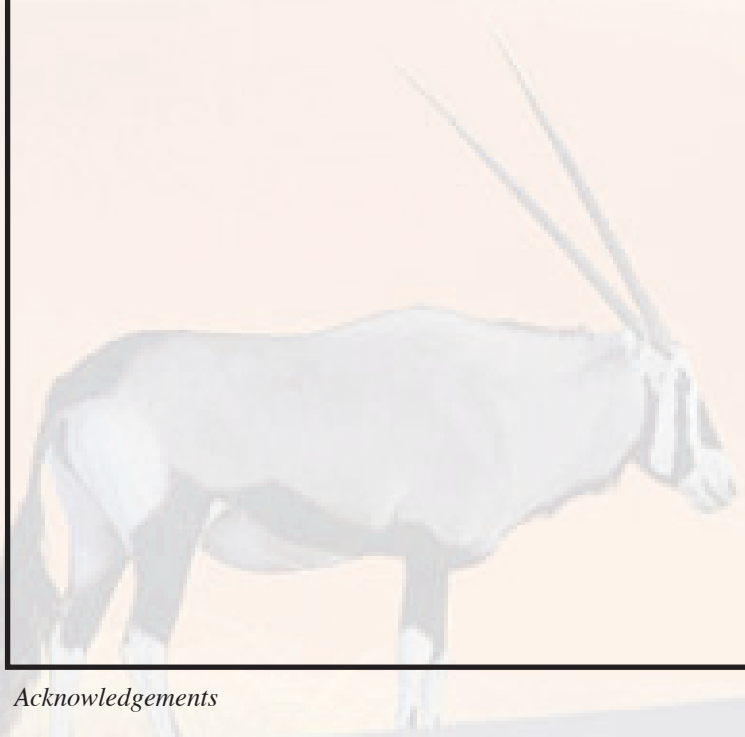
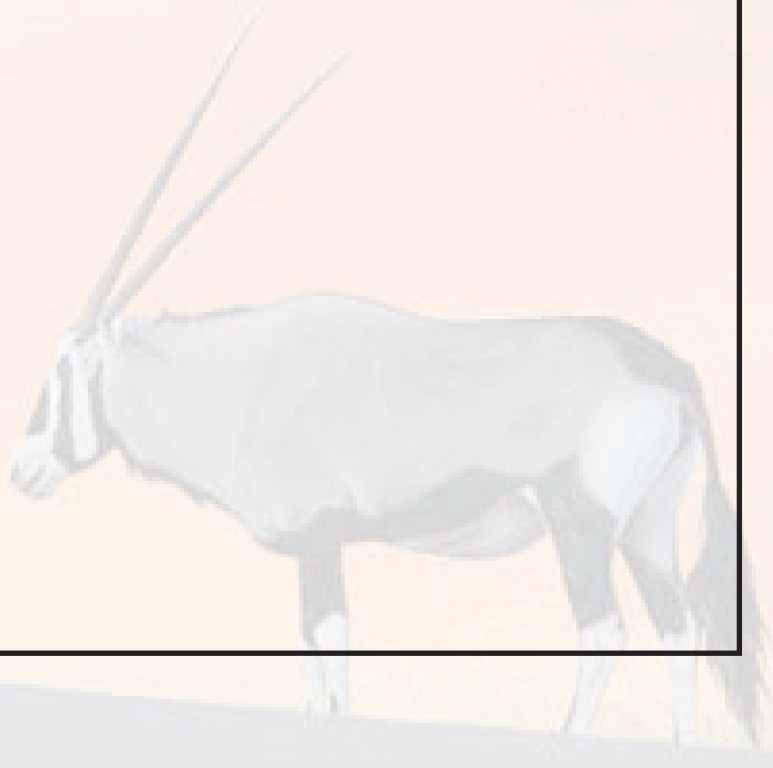
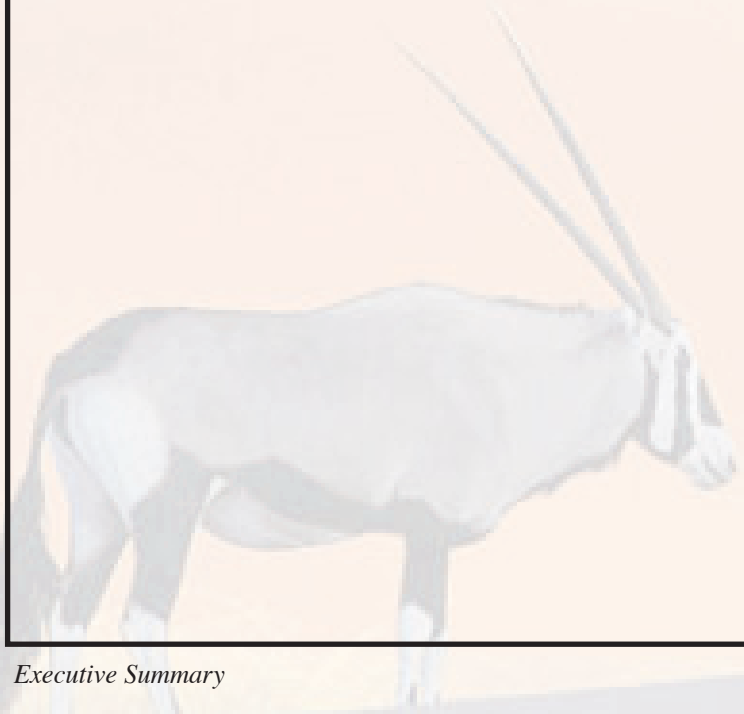


Executive Summary





Executive summary

Millennium Ecosystem Assessment and Sub-Global Assessments:

Millennium Ecosystem Assessment (MA) was a 4-year "multi-scale" integrated assessment, launched in 2001, that was designed to meet the needs of decision-makers for scientific information on the links between ecosystem change and human well-being.

The MA sub-global assessments were designed to meet needs of decision-makers at the scale at which they are undertaken, strengthen the global findings with on-the-ground reality, and strengthen the local findings with global perspectives, data, and models. The Asir National Park (ANP) assessment is one of fifteen assessments around the world and one of three of the sub-global Arab Millennium Ecosystem Assessments with an associated status. Asir National Park is spread over 45,000 ha, and is comprised of four ecosystems, including a mountain ecosystem having juniper forest, a terraced agricultural area, a grazing zone, and a coastal and marine ecosystem. This assessment focuses particularly on the forest ecosystem, because of its vital role in the protection of watersheds, soils and regulation of rainwater flow.

Human well-being is the central focus of the MA conceptual framework around which a dynamic interaction exists between people and other parts of ecosystems. Human well-being has multiple constituents, including basic material for a good life, freedom of choice and action, health, good social relations, and security. As humans are an integral part of ecosystems, the MA pays particular attention to the linkages between ecosystem services and human well-being.

For the purposes of MA, the mountainous ecosystem within the ANP can be subdivided into two main components: the forest/woodland zone, and terraced agricultural areas.

Methods of data collection and analysis

Different methodologies were used to assess and evaluate the status of ecosystems and human well-being in Asir National Park:

- Literature Review and Survey of Published Reports
- Observation visits to the ANP by Study Teams
- Survey of users and inhabitants of ANP by Questionnaires
- Interviews and Discussions with Local Inhabitants
- Analysis of Socio-economic Indicators
- Analysis of Remote Sensing and Satellite Imagery Data

Driving Forces

In laying the foundation for scenarios, it becomes necessary to identify drivers and select critical uncertainties which are as follows:

Direct driving forces

- Economic - land use change
- Science and technology - fuel
- Biological and Physical - climate variability and change
- Technological adaptation - water desalination
- Biological and Physical – nutrient loading

Indirect driving forces

- Economic – tourism
- Demographic - changing or growing Population
- Demographic - Urbanization
- Cultural – changes in land and resource management from traditional to more modern systems

Likely Scenarios

Scenarios are descriptions of possible futures. Scenario development allows us to explore a possible set of outcomes that might result if there is a change in the basic assumptions. MA scenarios assess the consequences of contrasting development paths for ecosystem services.

The three scenarios to be discussed herein refer to three different levels of interventions on how the mountainous region of Asir National Park will be managed in the future, and what the outcome will be with respect to their impact on human well-being and environment.

Scenario One: No intervention from government or from private sector where market forces dominate (Al-Na'amah)

This scenario looks at what the future may hold when no government or private sector interventions are planned, other than support for market driven economic development. Economic development will dominate the political agenda and will accelerate urbanization, decreasing dependence on agriculture development, and also increasing pressure on land and forest use. The forested area will continue to shrink as a result of new housing and road construction. Income generation from forest products will decrease for the local inhabitants. Access to clean drinking water from the forested areas will decrease due to the loss of forested areas. Storm run-off will continue to rise along the slopes, causing further soil erosion, nutrient depletion and downstream land degradation, destruction of habitats for wildlife, sediments and buildings as well as farming land for the local inhabitants.

Agriculture terraces will continue to deteriorate because there will be little or no support for improving agriculture development in ANP. Many of the terraces will be abandoned because of poor crop returns and farmers shifting to other income generating activities.

Scenario Two: Public Awareness, Capacity Building and Training programs Implemented (Al-Maha Al-Arabi)

In this scenario, limited interventions are implemented by the government through public awareness campaigns and education initiatives. In the next five years, without any strong policies in place to protect ecosystem services, their quality will slowly decline. Forested areas will continue to be cleared for more housing and road developments. Local inhabitants will receive less income from forested products and be forced to seek other income generating activities. More terraces will be abandoned and less agriculture production will result in fewer locally produced staples, increasing the local prices. Land clearing for development will create more storm run-off, leading to siltation.

Once services begin to adversely affect the local inhabitants, local community leaders, government and private sector stakeholders will lead an awareness-raising campaign to address some of these issues. Awareness raising campaigns will involve disseminating information on issues such as environmental protection, sustained use of resources (water, fuel, land, vegetation and forests), water reuse and recycling, and sustainable agriculture.

Scenario Three: Government Policies aimed at Sustainability of Forest and Terraced Agriculture (Al-Nimr Al-Arabi)

In this scenario the Saudi government supports policies around sustainable forest and terraced agriculture management practices. Although it is the most expensive, it is potentially the most desirable in regards to supporting ecosystem services and human well being. A more progressive approach, including the involvement of local inhabitants and public awareness will replace existing traditional cultural habits and attitudes. However, an understanding will be maintained of the value in certain customs for conservation such as the use of Al Hema.

Policies will include control measures to provide environmental protection to the forested area, repairing of damaged terraces and an increase in expenditure for socio-economic activities to improve the quality of life of the local inhabitants.

Implications of Scenarios

Based on the information collected during the assessment and the discussions documented during the scenarios process, the most plausible scenario would most likely be scenario 2, where interventions will occur, but not to the effect needed immediately. The Saudi government has already been working towards implementing and reinforcing new policies on sustainable forest and agriculture management yet the challenge will be to work with the local inhabitants to support these policies over time.

Assessment Results

ANP has a diverse range of highly specialized flora and fauna, but misuse of its natural ecosystems is a serious economic and social threat. Rainfall is limited in most parts of the country and is erratic both spatially and temporally. Soil erosion by water and wind, salinization of soils, deterioration of the natural vegetation of rangelands and forests and sand encroachment contribute to ecosystem degradation.

The natural vegetal cover of the Park is currently at risk of deterioration in some parts due to the adverse climatic factors and anthropogenic misuse. This risk is posed by unplanned tree removal, intensive unbalanced pasturing, fires, diseases, tree senescence and weak natural regeneration which will lead to continuation of the current deterioration of the natural resources such as soil, water and wildlife if appropriate actions are not taken at various levels.

Water

Water is probably the most critical resource in Asir region and is a key concern for national and regional security, as well as human well-being. In the foreseeable future, it is believed by locals that the use of terraces for agriculture will decline primarily due to the lack of terrace maintenance and non-availability of labour. Local inhabitants predict that land-use changes will continue to take place; for example, forest areas will be cleared for the production of agricultural crops, because of the economic advantage of crops over forest products. On the other hand, forests have an environmental advantage over cropland in that they protect the soil from erosion by transforming intense rainfall into a more gentle rainfall

Food

More than three-quarters of the farmers interviewed stated that agricultural systems had deteriorated during the past 25 years. The food habits of most of the ANP inhabitants have changed. People now rely primarily on rice instead of wheat, and on bread made with white flour instead of millet-flour. Terraces have been deteriorating for the last two to three decades. Maintenance

has not kept up due to lack of labor. With a forecast of agricultural water to decrease in the future, crop production will decline, and food imports to the area will increase. More than a third of the pastoralist respondents believe that livestock-keeping as a livelihood system is declining because of the degradation of rangelands.

Fuel

The trend in the near future is that the use of oil and gas will continue to replace wood and charcoal because of its ease and availability, according to the local inhabitants. Although, oil and gas is more expensive, its use will increase causing a decrease in wood cutting resulting in increase of vegetation cover in the area. This will have positive impacts on forest cover, biodiversity, and food availability for herding animals and humans.

Human wellbeing and cultural services

Majority of the questionnaire respondents believe that deterioration of natural resources such as soil erosion, use of ground water for commercial purposes, desertification, wood cutting for trade and over grazing are reducing the opportunities for inhabitants to work in the agriculture and livestock-herding sectors. These respondents believe that these changes are causing urban migration.

In discussions with local inhabitants, it was found that tourism is expected to increase, and while local communities may not completely understand eco–tourism, they believe that too will increase.

Biodiversity

Given the establishment of the Supreme Commission for Tourism, the efforts to promote the internal tourism especially the environmental tourism during the hot summer and the increasing number of national and foreign tourists, Asir National Park will not be able to cope with these numbers. It can be expected that biodiversity will be reduced as a result.

Another issue affecting biodiversity is the spread of invasive species, such as *Opuntia ficus-indica, and Argemone Mexicana*. While data on the extent to which these species are displacing indigenous tree varieties is not available, it is a worrying trend.

Responses

Responses are considered to be human actions such as policies and strategies for a given purpose. Responses may be technical, economic or institutional, and may operate at various levels of management. In Saudi Arabia, these responses generally emanate from the highest level of government. Establishment of Ministerial Committee on Environment in 1994 under the Chairmanship of HRH Prince Sultan Bin Abdulaziz, the Crown Prince and Minister of Defense and Aviation and Inspector General was to ensure effective coordination among relevant sector ministries and government institutions on environmental issues. At the local level, there are permanent committees at the governorate levels under the governor of the region to look into and deal with different local and regional environmental issues. Individual responses already implemented are as follows:

Regional training center in Al -Soda

Considering the importance of training and capacity building, the Presidency of Meteorology and Environment (PME) has established a “Regional Training Center” in Al-Soda to train Saudi Graduates in the field of meteorology and environment.

Ministry of Agriculture regional headquarters

The Ministry of Agriculture (previously Ministry of Agriculture and Water) required that Asir

National Park be established without changing or modifying the natural environment. For this reason, local raw materials were used for construction of infrastructure in the Park, which has given the magnificent design a complete and natural panorama. The Ministry insisted on giving the young citizens a chance to try themselves by operating and maintaining this park as the Saudis are part of and qualified for such things.

Raydah reserve

The Raydah escarpment was declared a Special Natural Reserve by NCWCD in 1989. Raydah provides one of the few intact examples of virtually pristine escarpment of juniper woodland, and habitat for a high density of the south-west Arabian endemic and near endemic bird species. Under the Reserve's designation as an SNR, all livestock should be excluded from the protected area. In practice however, grazing of the juniper under-storey does take place.

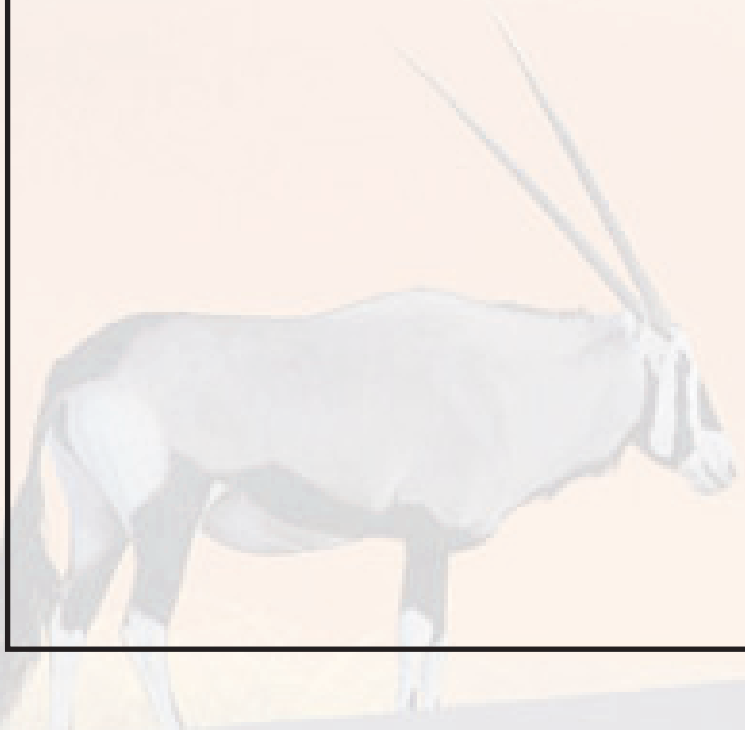
Afforestation efforts

The Government of the Kingdom of Saudi Arabia has paid great attention and concern towards forests conservation and development. This was reflected in the preparation of the National Forest Strategy (NFS) and National Forest Programme (NFP). More than 143 hectares have been reforested in Asir Province as a whole.

Conclusion

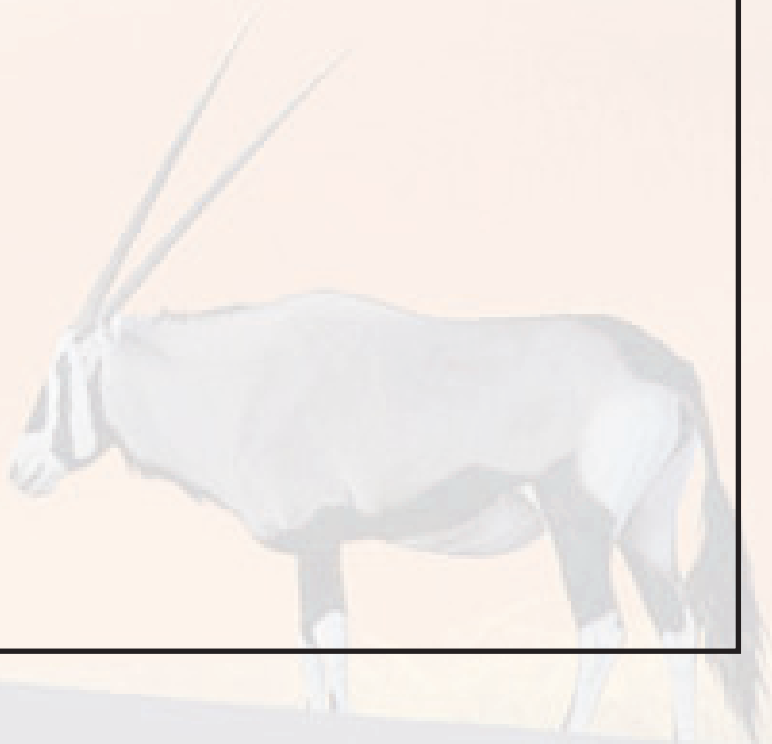
It is widely recognized that stakeholder participation in planning and decision–making is essential for any proposal to be successfully implemented. To ensure the involvement of stakeholders, public education and awareness is considered to be an effective tool. A number of stakeholder organizations and agencies such as Presidency of Meteorology and Environment (PME), National Commission for Wildlife Conservation and Development and Ministry of Agriculture have embarked upon ambitious programs of public education and awareness.

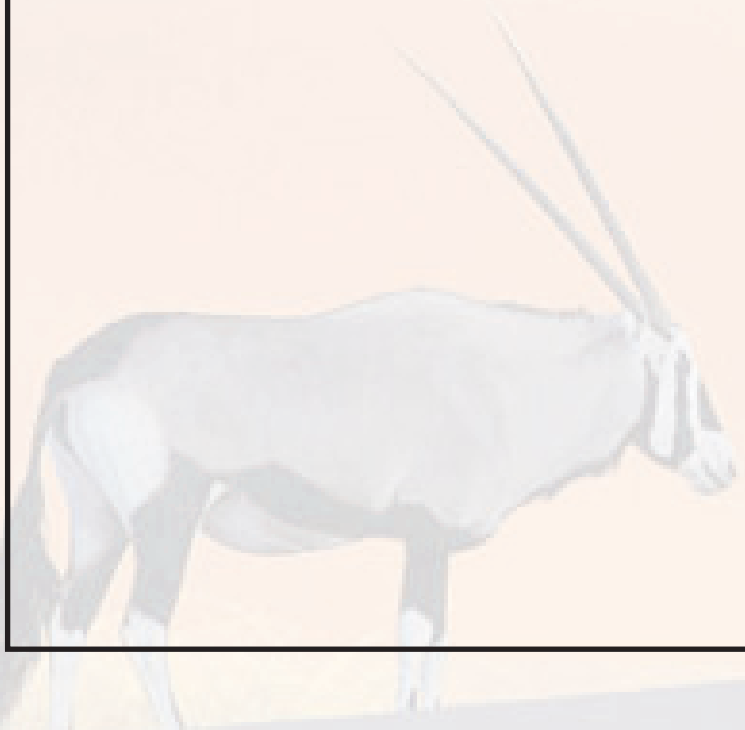
Effective action to address problems related to ecosystem services requires improved coordination across national and local levels of decision-making. Almost any action affecting an ecosystem has consequences including trade-offs. These trade-offs cannot be adequately addressed by either through traditional sector management approaches, or through action taken at a single scale. Thus, an effective ecosystem management involving effective coordination among government institutions directly or indirectly responsible for environmental issues, non-government organizations and private sector is needed to manage the forest areas in the Kingdom of Saudi Arabia.



Section 1

Introduction





Section 1 - Introduction

1.1 Millennium Ecosystem Assessment:

The Millennium Ecosystem Assessment (MA) was a 4-year "multi-scale" integrated assessment, launched in 2001, that was designed to meet the needs of decision-makers for scientific information on the links between ecosystem change and human well-being. The overall assessment includes component assessments undertaken at several different geographic scales, ranging from individual villages to the globe, and the process has been designed so that the findings at any given scale are informed by the assessment components undertaken at other scales.

The Millennium Ecosystem Assessment (MA) was called-for by the United Nations Secretary-General, Kofi Annan in his Millennium Report to the UN General Assembly in 2000. The results of the assessments will be utilized in the implementation of three international conventions, namely:

- Convention on Biodiversity
- Convention to Combat Desertification and
- Ramsar Convention on Wetlands

This assessment is made for Asir National Park (ANP) in Southwestern Saudi Arabia, the first to be established in the Kingdom (Ministry of Agriculture, 1976). The park was opened for public in 1981. The Park represents a unique ecosystem in this part of the world in that there are at least four distinct ecosystems ranging from a mountainous area to a coastal plain in close proximity to each other. The study focuses on the mountainous forests and agro-forestry and assesses their relationship to human well-being.

The objective of MA is to assess the consequences of ecosystem change for human well-being, and to establish the scientific basis for actions needed to enhance the conservation and sustainable use of ecosystems and their contributions to human well-being. As reflected in this report, the MA includes the following assessments (Millenium Ecosystem Assessment, 2005)

- Current State and Trends
- Scenarios, and
- Policy Responses

The MA provides a unique basis of information concerning human dependence on ecosystems. Never before has such an assessment been conducted that addresses multiple environmental changes, drivers that force the changes and multiple linkages to human well-being. The MA also examines the ways in which societies have sought to manage these linkages.

The Millennium Ecosystem Assessment is designed to provide decision-makers with information to manage ecosystems in a more sustainable manner that will maintain both biodiversity and the ecosystem services that are essential to human well-being.

Five overarching questions, along with the detailed lists of user needs provided by convention secretariats and the private sector, guide the issues being assessed:

(i) What are the current conditions and trends of ecosystems and their associated human well-being?

(ii) What are the plausible future changes in ecosystems and in the supply of and demand for ecosystem services and the consequent changes in health, livelihood, security, and other constituents of well-being?

(iii) What can we do to enhance well-being and conserve

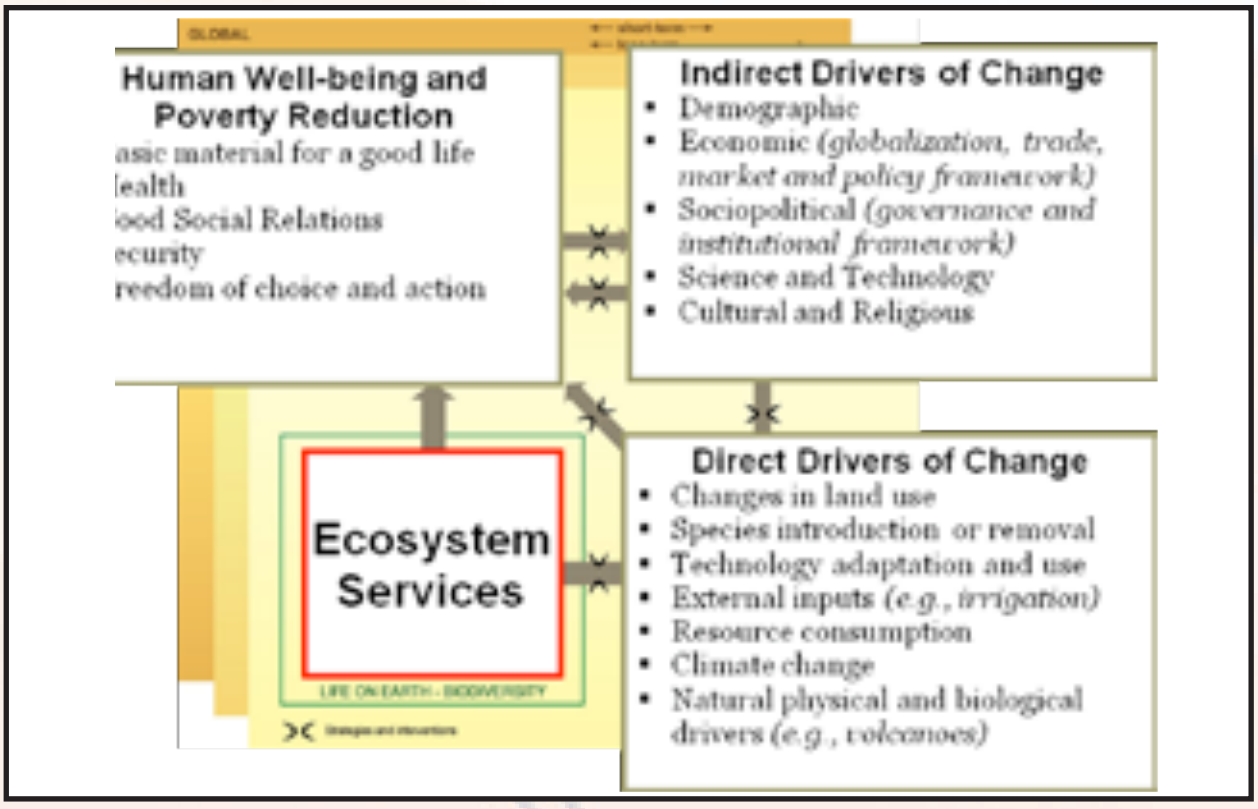
The objective of MA is to assess the consequences of ecosystem change for human well-being, and to establish the scientific basis for actions needed to enhance the conservation and sustainable use of ecosystems and their contributions to human well-being.

ecosystems? What are the strengths and weaknesses of response options, actions, and processes that can be considered to realize or avoid specific futures?

(iv) What are the most robust findings and key uncertainties that affect provision of ecosystem services (including the consequent changes in health, livelihood, and security) and other management decisions and policy formulations?

(v) What tools and methodologies developed and used in the Millennium Ecosystem Assessment can strengthen capacity to assess ecosystems, the services they provide, their impacts on human well-being, and the implications of response options?

The MA conceptual framework shows how changes in factors that indirectly affect ecosystems, such as population, technology, and lifestyle, can lead to changes in factors directly affecting ecosystems, such as the catch of fisheries or the application of fertilizers to increase food production. The resulting changes in the ecosystem cause the ecosystem services to change and thereby affect human well-being. These interactions can take place at more than one scale and can cross scales. For example, a global market may lead to regional loss of forest cover, which increases flood magnitude along a local stretch of a river. Similarly, the interactions can take place across different time scales. Actions can be taken either to respond to negative changes or to enhance positive changes at almost all points in this framework. (Millennium Ecosystem Assessment, 2003)



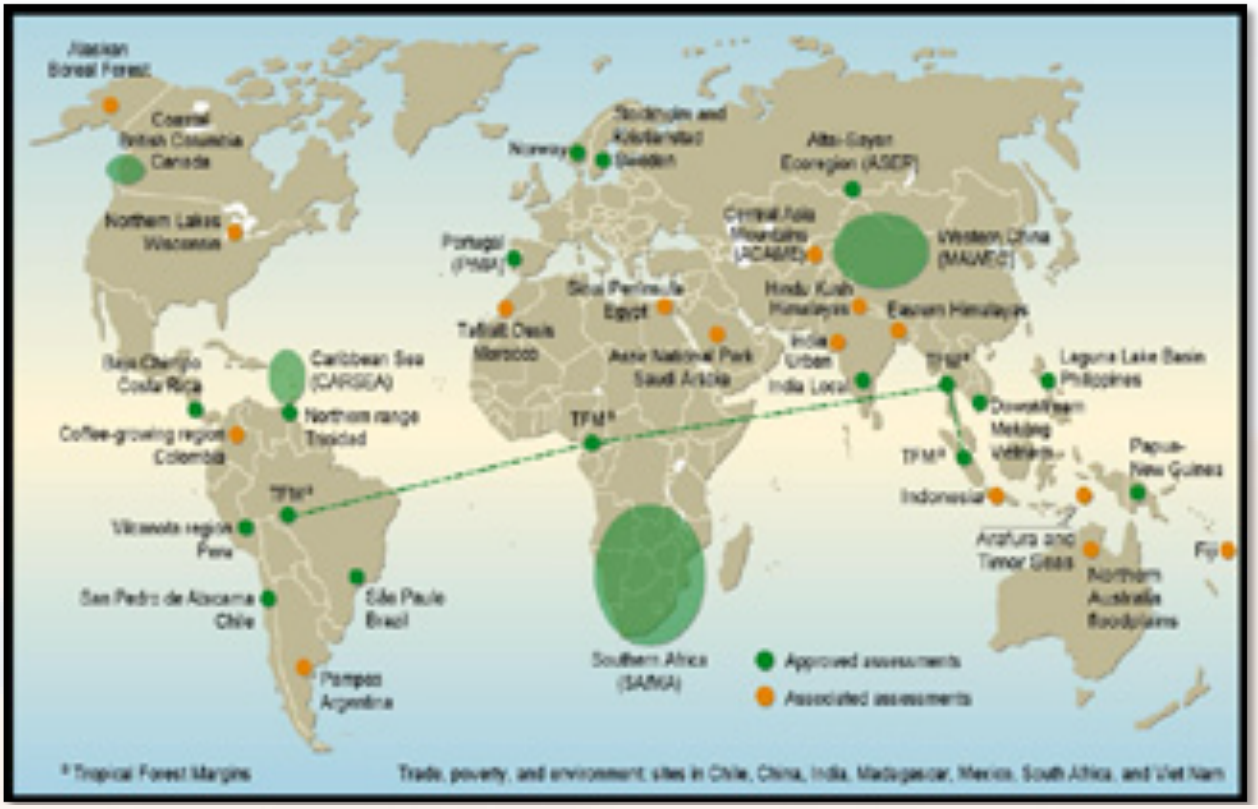
Source: Millennium Ecosystem Assessment

Figure 1.1 MA Conceptual Framework.

1.2 Arab Sub Global Assessment

The MA sub-global assessments were designed to meet needs of decision-makers at the scale at which they are undertaken, strengthen the global findings with on-the-ground reality, and strengthen the local findings with global perspectives, data, and models. There are 18 MA-approved sub-global assessments, and an additional fifteen with an associated status. Assessments at sub-global scales are needed because ecosystems are highly differentiated in space and time, and because

sound management requires careful local planning and action. Local assessments alone are insufficient, however, because some processes are global, and because local goods, services, matter, and energy are often transferred across regions. The sub-global assessments will directly meet the needs of decision-makers at the scale at which they are undertaken, strengthen the global findings with on-the-ground reality, and strengthen the local findings with global perspectives, data, and models.[1]



Source: Millennium Ecosystem Assessment

Figure 1.2 Location of Sub-global assessments

A country or institution was accepted to perform an MA if it agreed to use the MA conceptual framework, to involve the intended participants and to meet a set of procedure requirements related to peer review. MA processes with associate status have been carried out in three areas within the Arab sub-region:

- Assir National Park (ANP), Kingdom of Saudi Arabia; located in the Assir Mountains which contain one of the most important ecological hotspots in the Arab region. Encompasses three main habitat types: sandy desert, high altitude habitats, and Marine habitat of the red Sea.
- Sinai Peninsula, Egypt; one of the main heritage sites of Mankind, embracing a unique collection of sacred shrines and ecologically valuable landmarks. The ecosystems include desert, mountains, wetlands, coastal, agricultural and marine ecosystems.
- Tafilalt Oasis, Morocco; located in the Sahara SE Morocco, with an area of about 1,370 km^2. It contains date groves, palm trees and small trading settlements [2]

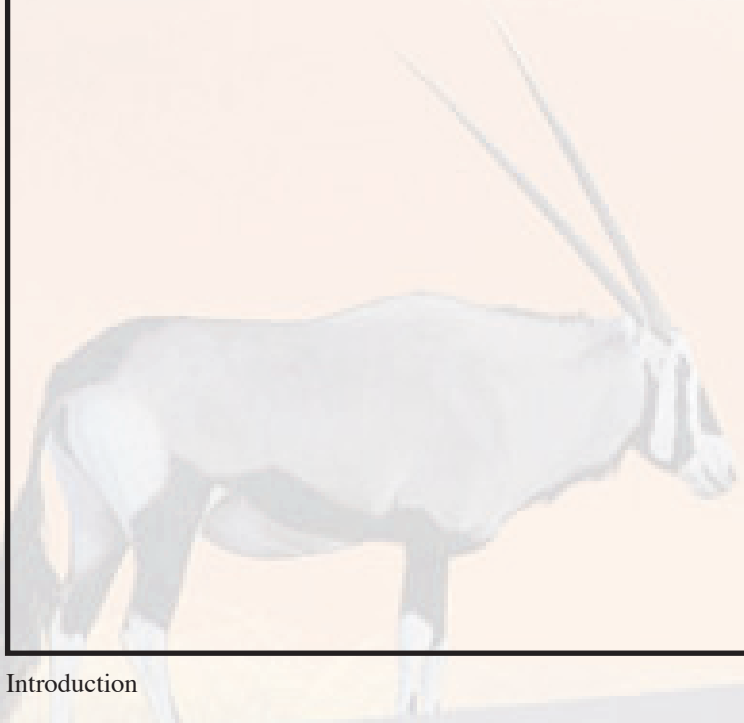
[1]See the Millennium Ecosystem Assessment website, http://www.millenniumassessment.org/en/Multiscale.aspx

[2]See the UNEP Regional office for West Asia website: http://www.unep.org.bh/Programmes/dewa/Assessments/arabmillass.asp

It has been well documented that ecosystems and human well being are inextricably linked together. Improved ecosystem productivity, and the services that the ecosystem provides such as water, food and fuel to the local population, services for the tourist industry and actions required to protect and conserve the natural resources of the Asir National Park will also improve.

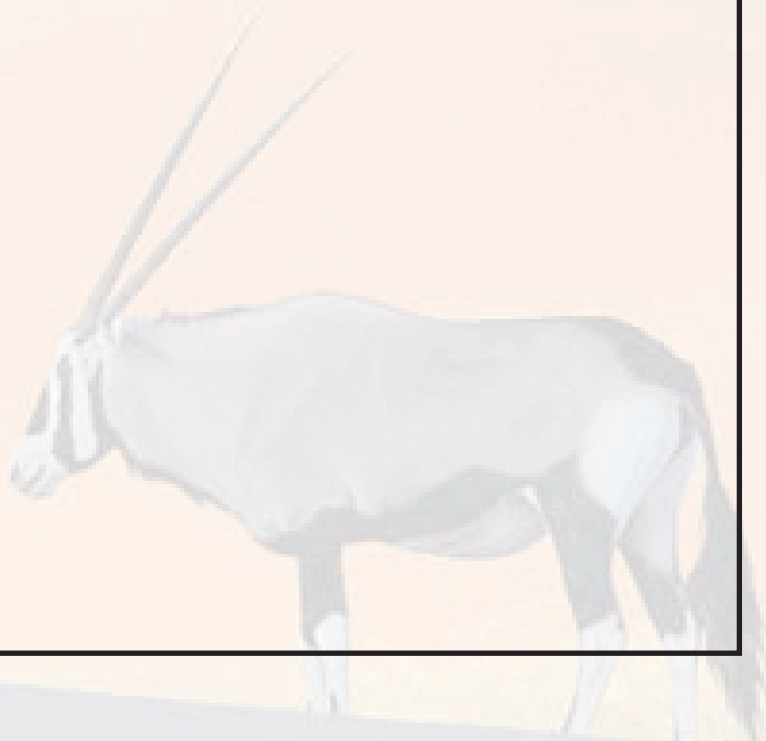
The MA for the ANP assesses the current condition and trends of ecosystems and the ways in which ecosystem changes affect human well-being. Another goal of the assessment is to establish the scientific basis for actions needed to provide for conservation and sustainable use of ecosystems.

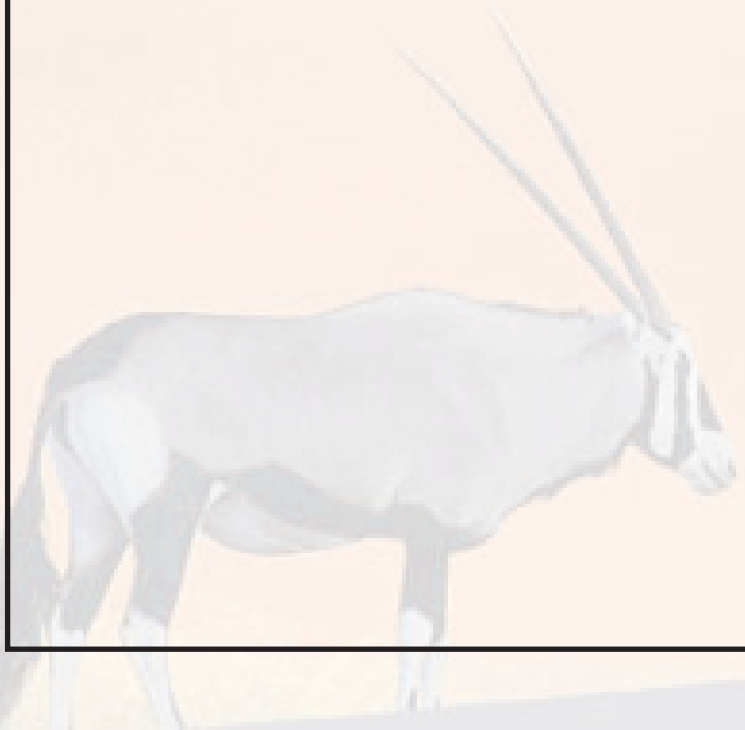
The ecosystem assessment is needed to determine its current state, past trends and those which may be experienced in the future, possible future changes to the ecosystem services, and their likely impacts on human well-being. The assessment will also examine the interventions will be required in the future to provide an improved quality of life for local populations. In addition, there is a need to determine key uncertainties that hinder effective decision-making concerning ecosystems.



Section 2

Objectives





Section 2 - Objectives

2.1 General Objectives:

The basic aims of the assessment are two–fold:

(i) To assess the impacts of park degradation on ecosystems and

(ii) To enhance community livelihood through improving the existing linkages between local authorities in the Asir region, researchers, NGOs and national development organizations. A framework has been developed by the Ministry of Agriculture (MA), the Presidency for Meteorology and Environment (PME), the National Commission for Wildlife Conservation and Development (NCWCD), Universities and other stakeholders for the assessment of ecosystems studied in this report. Particular attention is paid to forest ecosystem, as this ecosystem predominates in the ANP.

2.2 Specific Objectives:

The project focused on human well-being through such indicators as their access to health–care facilities, their economic situation and training and capacity-building opportunities. The assessment also identified factors affecting the Asir National Park ecosystem, and the application of successful measures to conserve the ecosystem in selected pilot areas in mountain and foothills ecosystems. Appropriate management of the ecosystem is a key element in the sustainable development of the Asir National Park. It is essential to combat land degradation and to conserve soils, vegetation cover and biodiversity and prevent soil erosion by wind and water, as well as to maintain the inherent productivity of the resource base for future generations. The specific objectives include:

i. To establish a reference baseline from which future changes to the various ecosystem components may be measured.

Objectives

General objectives:

i) To assess the impacts of park degradation on ecosystems

ii) To enhance community livelihood through improving the existing linkages between local authorities in the Asir region, researchers, NGOs and national development organizations.

Specific objectives:

(i) To establish a reference baseline from which future changes to the various ecosystem components may be measured.

(ii) To assess the level of sustainable management of National Park (SMNP) implementation or development in selected sites.

(iii) To demonstrate at selected sites that increased integration of park management can contribute to improved ecosystem protection management.

(iv) To increase information dissemination and to enhance expertise exchange within the national, regional and international institutions.

(v) To adopt and refine a model methodology for ecosystem assessment that can be applied to the Arab region.

(vi) To promote coordination between local communities, researchers, and NGOs in order to protect the park and its environment from degradation, and to conserve the biodiversity of ANP.

ii. To assess the level of Sustainable Management of National Park (SMNP) implementation or development in selected sites.
iii. To demonstrate at selected sites that increased integration of park management can contribute to improved ecosystem protection management.
iv. To increase information dissemination and to enhance expertise exchange within the national, regional and international institutions.
v. To adopt and refine a model methodology for ecosystem assessment that can be applied to the Arab region.
vi. To promote coordination between local communities, researchers, and NGOs in order to protect the park and its environment from degradation, and to conserve the biodiversity of ANP.

The assessment has adopted a multidisciplinary approach that addresses issues from biophysical, technical, socio-economic, cultural, institutional, and policy perspectives, and stimulates interactions among researchers, policy-makers, and community leaders. Such an integrated approach ensures that all resources are studied together within the system and that socio-economic and policy issues are considered throughout the process. The project has been implemented in a collaborative and participatory mode involving researchers, policy makers, and farmers, nomads and other community members. The study was designed to develop close interaction with the beneficiaries to ensure that the assessment and the responses developed are accepted by the target groups.

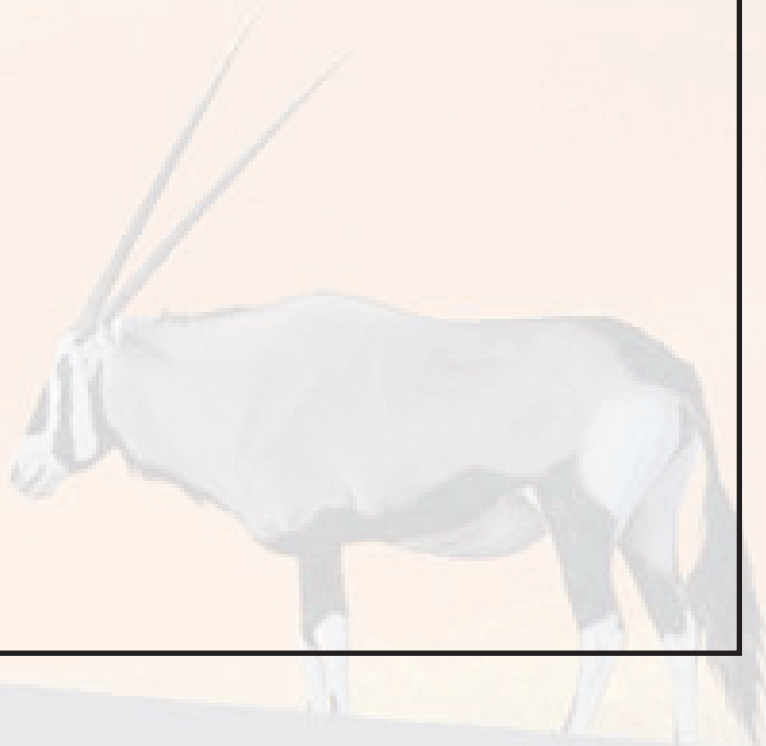
The ANP assessment has been conducted to provide the scientific information base to support decision-making and policy formulation to conserve, protect and promote sustainable use of the ecosystems in ANP.

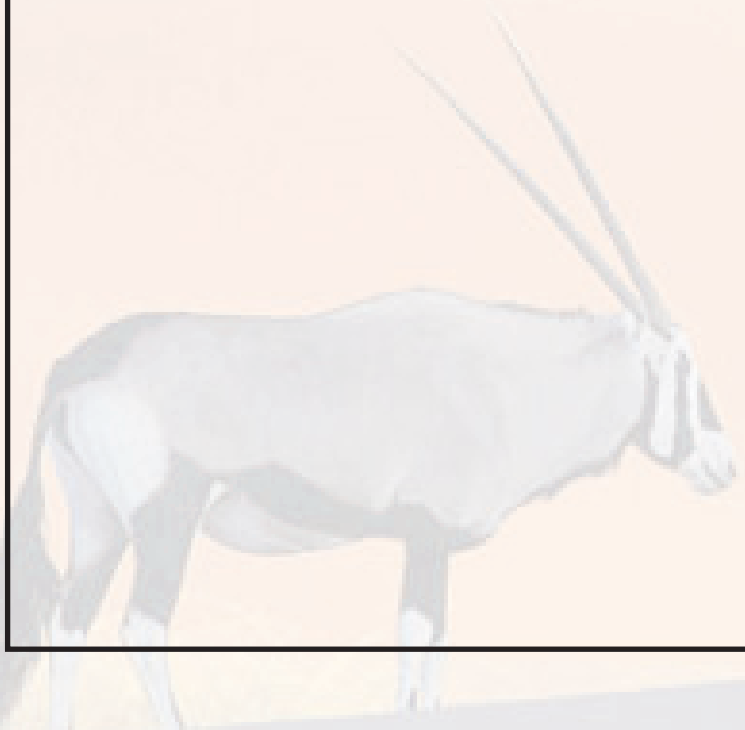
The assessment will be of particular interest to the following primary beneficiaries:

(i) Pastoralists whose animals graze in the park area
(ii) Farmers involved in agriculture in ANP
(iii) Tourists that visit the Asir National Park
(iv) Local agencies such as the Asir Governorate
(v) Ministry of Agriculture who produced the original report on the Asir National Park.
(vi) Presidency of Meteorology and Environment, the central environmental protection agency and lead agency in this study.
(vii) Municipalities and local communities
(viii) Universities such as King Saud University and King Abdulaziz University which have conducted agricultural and environmental research in maintaining Bedouin's culture and traditional way of life.
(ix) Other government agencies including King Abdulaziz City for Science and Technology (KACST), Ministry of Water & Electricity and National Commission of Wildlife Conservation and Development (NCWCD).

Section 3

Study Area





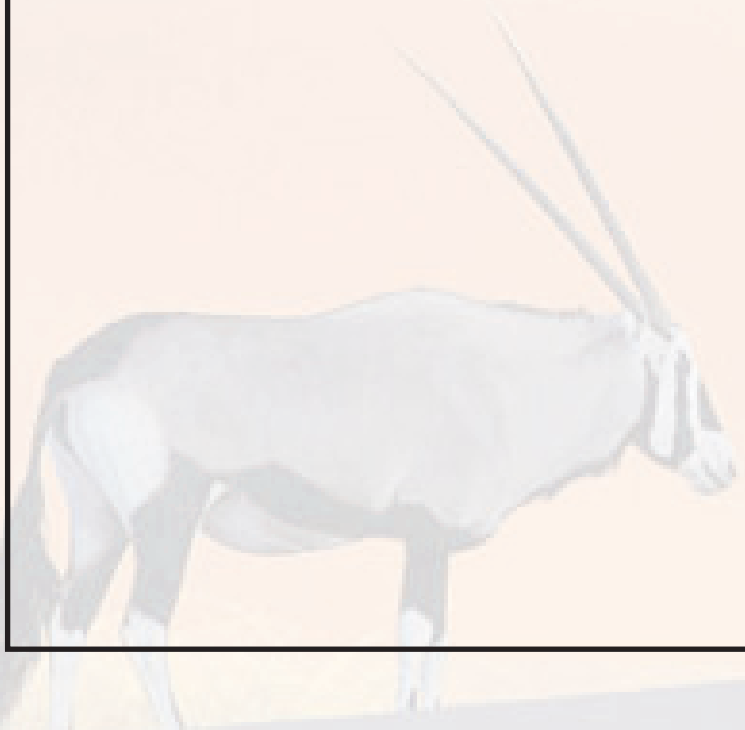
Section 3 - Study Area

3.1 Location in Saudi Arabia

The Kingdom of Saudi Arabia covers an area of more than two million square kilometers. It is located approximately between latitudes 18° and 19° N and longitudes 41° and 42° E, and is characterized by dry, harsh climatic conditions and limited natural resources of water, soil and vegetation. Levels of water scarcity in the country are among the highest in the world. Rainfall is limited and erratic both spatially and temporally and the country experiences frequent droughts. Most of the forest areas cover the Sarawat Mountains, which represent about 1.2 percent of the area of Saudi Arabia. Asir Mountainous areas occupy the south part of Sarawat Mountains, which are particularly important for agricultural production in the country. The complex landscape of the mountainous areas consists of steep slopes, terraced croplands, sloping rangelands, and scattered patches of shrubs and trees.

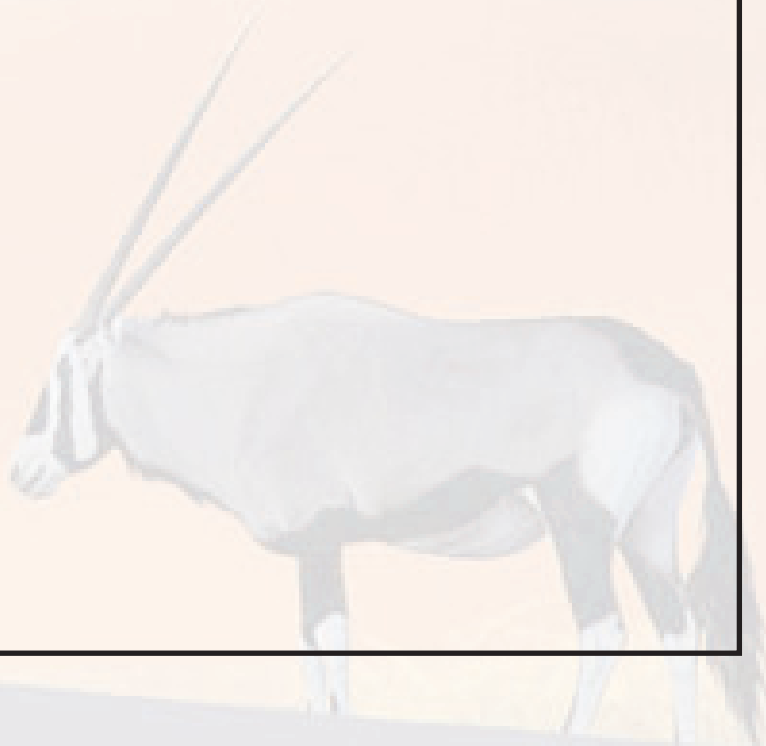
ANP is a huge area spread over 450 km^2. ANP includes a combination of four ecosystems including mountain ecosystem having forest and terrace agriculture, agricultural and grazing land, and coastal and marine ecosystems.

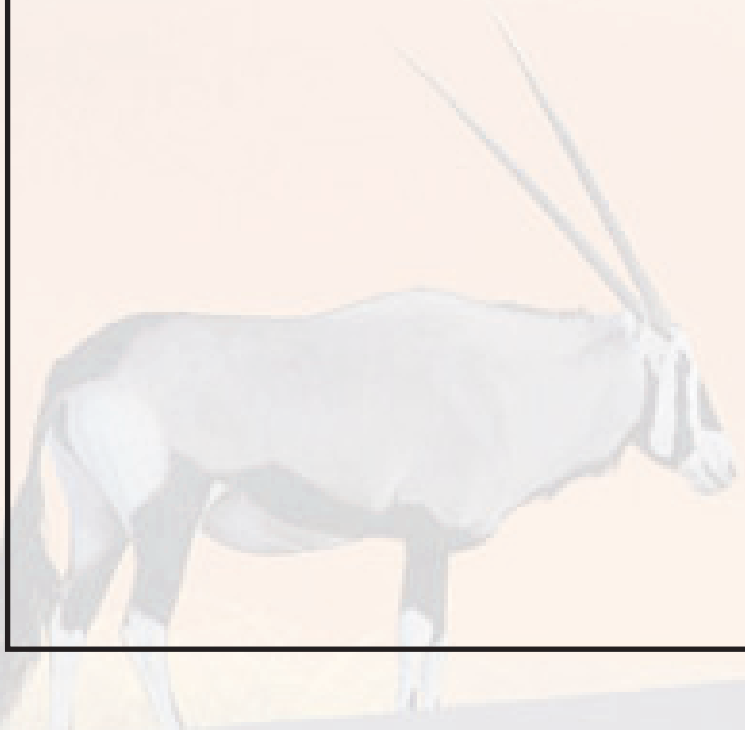
Map of Saudi Arabia showing the location of Asir Province



Section 4

Stakeholder Involvement





Section 4 - Stakeholder Involvement

Asir region of Saudi Arabia and ANP present a striking biodiversity. Its conservation is the direct concern of three national agencies (Ministerial Committee on Environment, 1994).

(i) Ministry of Agriculture (MoA).
(ii) Presidency of Meteorology and Environment (PME).
(iii) National Commission for Wildlife Conservation and Development (NCWCD).

The main users of the ANP include:

(i) Pastoralists whose animals graze in the park area.
(ii) Farmers who cultivate in ANP.
(iii) Tourists that visit the Asir National Park.

Other key stakeholders include:

(i) Local agencies such as Asir Governorate.
(ii) Ministry of Agriculture who produced the original report on the Asir National Park.
(iii) The Presidency of Meteorology and Environment who is the central environmental protection agency and lead agency in this study.
(iv) Municipalities and local communities
(v) Universities such as King Saud University and King Abdulaziz University which have conducted agricultural and environmental research on ways to maintain the Bedouin culture and traditional way of life.
(vi) Other government agencies including King Abdulaziz City for Science and Technology (KACST), Ministry of Water & Electricity and National Commission of Wildlife Conservation and Development (NCWCD).

Stakeholders

Main Users of the ANP:

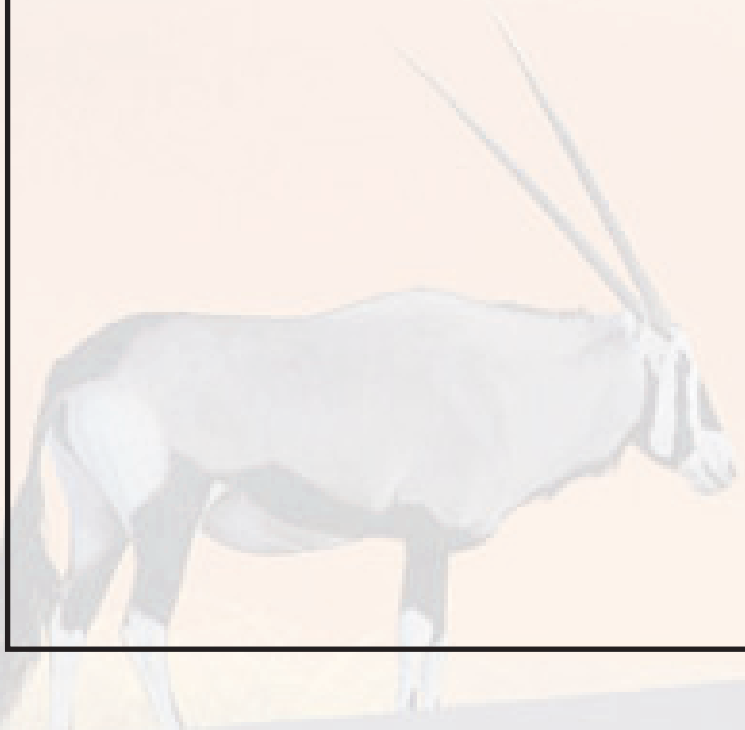
- Pastoralists whose animals graze the park area.
- Farmers involved in agriculture in ANP.
- Tourists that visit the Asir National Park.

ANP conservation is the direct concern of three national agencies:

1. PME, the central environmental protection agency and lead agency in this study.
2. NCWCD.
3. MoA

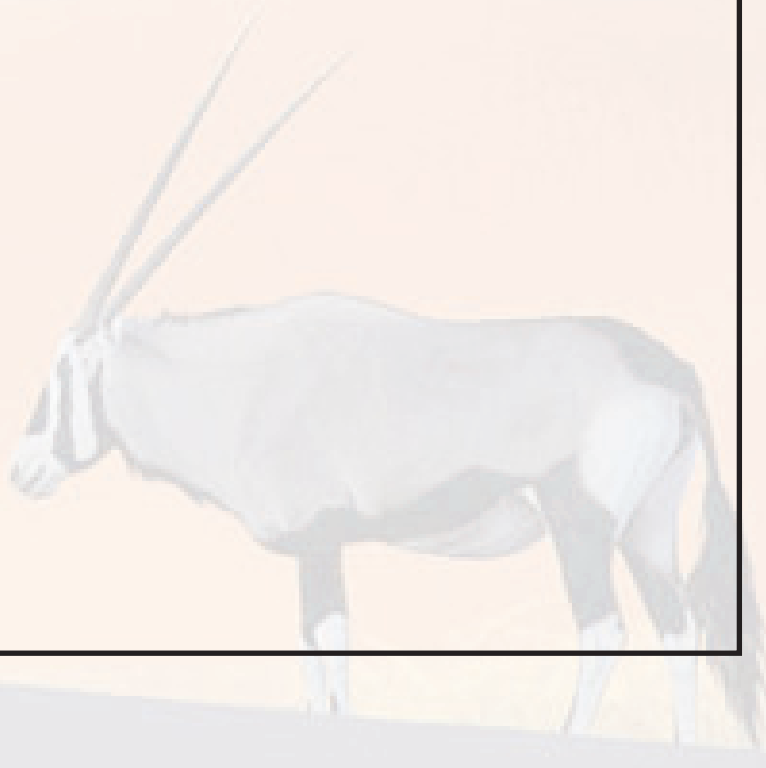
Other key stakeholders :

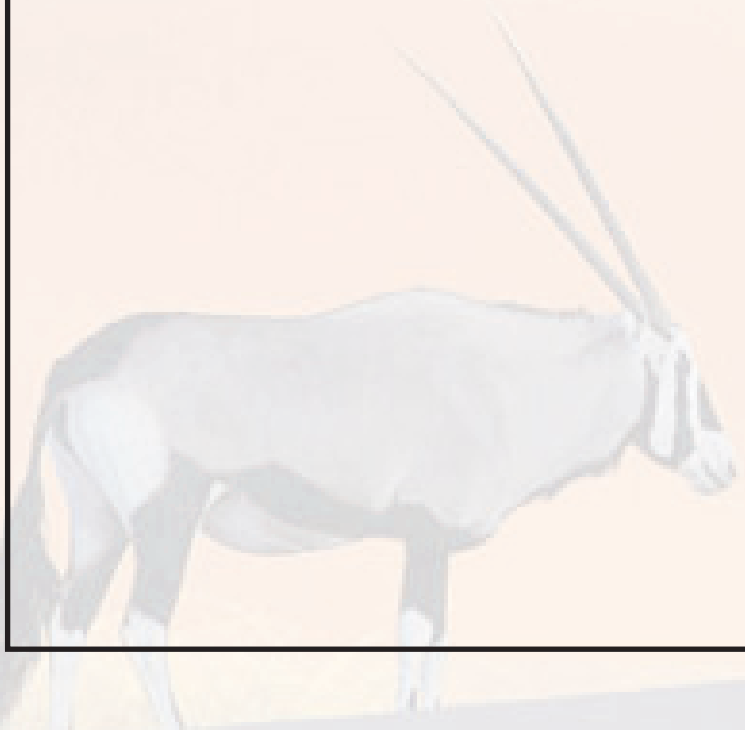
1. Local agencies such as the Asir Governorate.
2. Municipalities and local communities.
3. Universities.
4. Other agencies like KACST and Ministry of Water & Electricity.



Section 5

Assessment Methodology





Section 5 - Assessment Methodology

5.1 MA conceptual framework

Human well-being is the central focus of MA conceptual framework around which a dynamic interaction exists between people and other parts of ecosystems. As humans are an integral part of ecosystems, the MA pays particular attention to the linkages between ecosystem services and human well-being.

MA conceptual framework consists of several components such as ecosystems and their services. For example, products people obtain from ecosystems include fresh water, food, fuel and fiber, which are categorized as provisioning services. Another service is regulatory, which are the benefits people receive from regulation of human diseases, water purification, erosion control, air quality maintenance and climate regulation. There are other services such as culture which includes the benefits people receive from ecosystems through spiritual enrichment, reflection, recreation and aesthetic pleasure. Also, supporting services are those that are needed for the production of all other ecosystem services.

Human well-being and poverty reduction is another component of the MA conceptual framework. Ecosystem changes can affect human well-being in a number of ways. A change in security can affect supplies of food and other goods. Security can be affected by changes in services which could influence the frequency and magnitude of floods, droughts and other catastrophies. Changes in culture services can contribute to the weakening of social services in a community, which in turn, may affect material well-being, health, freedom and choice and good social relations . Another component of MA conceptual framework is the understanding of factors that cause changes in ecosystems and ecosystem services.

Finally, the last component of MA conceptual framework consists of temporal and spatial interactions and assessment of ecosystems and human well-being. Assessments done at smaller scales can help identify the dynamics of the system that might otherwise be overlooked. Time scale is also important in conducting assessments. Assessments that cover a shorter time period than the characteristic temporal scale may not adequately capture variability associated with long-term cycles.

5.2 Ecosystem services assessed

Forest ecosystem and Terrace agriculture and agroforestry on mountains and slopes in the ANP area are very important ecosystems in ANP area. The most important ecosystem services provided by the forested areas of ANP include water, soil, food, fuel, medicine and cultural resources (opportunities for education, recreation and eco–tourism), more details are in section 7.

Ecosystem Component	Indicator	Methodological Tool
Mountain: Forest/ Woodland	Forested area by species, Change in forested area, Condition of forest areas.	Historic satellite imagery with GIS and ground level verification
Mountain: Terrace Agriculture	Terraced area, Condition of terraces, Crop production	Satellite imagery with ground level verification, Local interviews

Table 5.1 Indicators and tools for assessing ecosystem components

5.3 Indicators used

The MA uses both biophysical and socio-economic indicators as tools for assessing the relationships between ecosystems and human well-being. In addition, models may be used to show the interactions between systems and drivers. For example, models can be used to determine the impact of change in land cover on river flow and land erosion. Models can also be used to predict the effects of environmental change on communities: for example, the human system model looks at the changes in ecosystems on production, consumption and the investment made by households.

Models can also be used to overcome data deficiencies by using probabilistic estimates in those cases where observations are not available. In Saudi Arabia, there may be situations where a lack of documented data may mean that the use of models will not produce reliable results.

For the purposes of MA, the mountainous ecosystem within the ANP can be subdivided into two main components: the forest/woodland zone, and terraced agricultural areas. Table 5.1 presents the indicators and the methodological tools used in assessing the ecosystem components (Ministry of Agriculture, 2007).

As noted above the MA pays particular attention to the linkages between ecosystem services and human well-being. Human well-being has multiple constituents, including basic material for a good life, freedom of choice and action, health, good social relations, and security. Well-being is at the opposite end of a continuum from poverty, which has been defined as a "pronounced deprivation in well-being" The constituents of well-being, as experienced and perceived by people, are situation-dependent, reflecting local geography, culture, and ecological circumstances. (Millennium Ecosystem Assessment, 2003), Table 5.2 below lists the key constituents of well-being for the inhabitants and users of the ANP and the indicators used to evaluate these factors (MoA, 2007).

Key Factor	Indicator
Finances	Employment opportunities, Land ownership
Health	Access to clean water, access to health care, access to nutritious food, sanitation.
Education/ Training	Education, awareness, availability of training programs
Infrastructure	Roads leading to market areas Access to utilities (electricity, gas, water & Sanitary facilities)
Social relations	Availability of cultural and religious services

Table 5.2 Key factors and their indicators for assessing human well -being

5.4 Methods of data collection and analysis

Six different methodologies were used to assess and evaluate the status of ecosystems and human well-being in the Asir National Park.

1. Literature Review and Survey of Published Reports.
2. Observation visits to the ANP by Study Teams.
3. Survey of users and inhabitants of ANP by Questionnaires.
4. Interviews and Discussions with Local Inhabitants.
5. Analysis of Socio-economic Indicators.

6. Analysis of Remote Sensing and Satellite Imagery Data.

It is widely recognized that stakeholder participation in planning and decision–making is essential for any proposal to be successfully implemented. While stakeholder participation often results in a slower and more costly process of implementation, it has the advantage that such involvement creates ownership in the policy being developed, acceptance of the policy by the participants and commitment to a successful implementation of the policy. To ensure the involvement of stakeholders, public education and awareness is considered to be the most effective tool.

Stakeholder involvement during the study was ensured by

(i) closely coordinating with the office of Abha's Governor.

(ii) involving all concerned government ministries and agencies such as Ministries of Agriculture, Water, Presidency of Meteorology and Environment (PME), National Commission for Wildlife Conservation and Development (NCWCD), Educational Institututions/Universities.

(iii) contacting members of the farming community and nomads and explaining to them the objectives of the study. The results of the study were discussed in a workshop and conveyed to the decision makers in a meeting.

Methods of Data Collection

1. Literature Review and Survey of Published Reports.
2. Observation visits to the ANP by Study Team.
3. Survey of users and inhabitants of ANP by Questionnaires.
4. Interviews and Discussions with Local Inhabitants.
5. Analysis of Socio-economic Indicators.
6. Analysis of Remote Sensing and Satellite Imagery Data.

Methods of Analysis

This project utilized the LANDSAT Thematic Mapper (TM) data to cover the study area of Asir National Park and analyzed the degradation of vegetation cover in the study area.

- **Literature Review and Survey of Published Reports:**

Data was collected from all reports published by various ministries and government departments regarding Asir province, developmental activities, agricultural development and biodiversity in the ANP including published reports of the Ministry of Agriculture, Ministry of Water and Electricity, National Commission for Wildlife Conservation and Development (NCWCD), Five Year Development Plans, Ministry of Finance Statistical Department Annual reports, and literature published in scientific journals and reports (see References section).

- **Study Team Visits to ANP:**

The study team members made three visits to the ANP as a team to collect information about the environmental status of the study area as well as to interact with various stakeholder groups and various sections of the society. The team met with the administrative and government officials responsible for the developmental and administrative work in the study area.

In addition, the team selected sites for verification and collected information about the soil, vegetation and biodiversity in these locations.

- **Survey by Questionnaires:**

Four types of questionnaires, related to i) the marine environment, ii) the forest and mountain ecosystem, iii) terraced agricultural areas, and iv) livestock herding areas, were prepared. The questionnaires were distributed to thirty individuals in different parts of the park between September and November 2006. Questionnaires on marine ecosystem were distributed to inhabitants (fishermen) in one of the coastal towns located on the red sea. Questionnaires related to livestock-keeping were distributed among the shepherds and herders, agricultural questionnaires were distributed among the farmers while questionnaires on the forest and mountain ecosystem were distributed to inhabitants living in mountainous areas (hilltops and slopes). Analysis of the questionnaire results enriched and confirmed the results of the surveys and visits conducted by the study team to the Asir National Park. The results of questionnaire analyses are discussed in the section entitled "Results and Discussion". A copy of the questionnaires is attached as Appendix 1.

- **Interviews and Discussions with Local Inhabitants**

A number of local residents of different age groups, such as elders, youths, and students belonging to various social groups were interviewed to get their perceived views about the current status of affairs in the study area (ANP).

- **Analysis of Socio-economic Indicators**

Data on socio-economic indicators such as population, health aspects, education, infrastructure development, availability of drinking water, waste management and wastewater management, availability of labour, rain, and floods was obtained using annual statistical reports of different ministries for Asir region, as listed in the references section of the report.

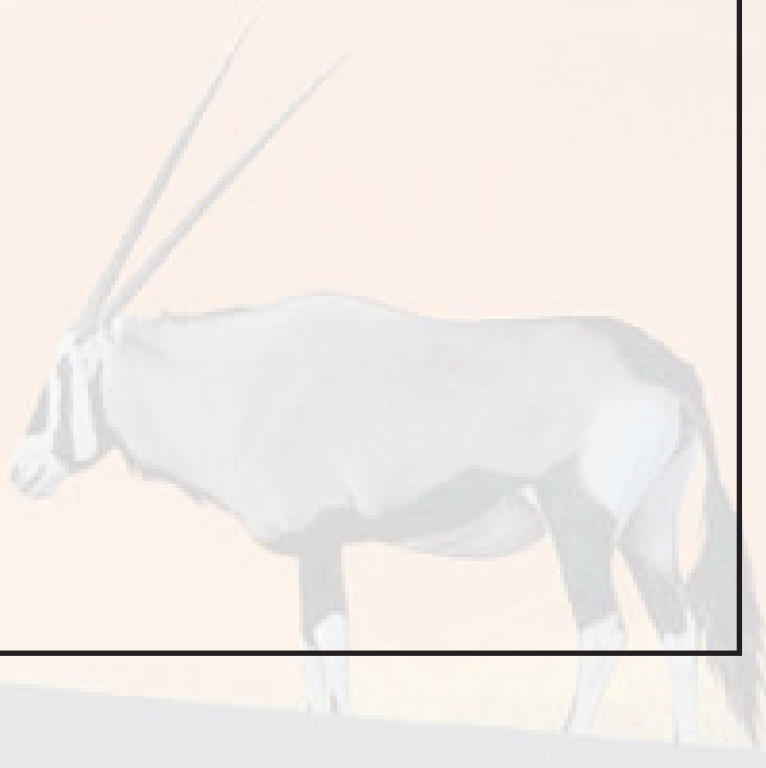
- **Analysis of Remote Sensing and Satellite Imagery Data**

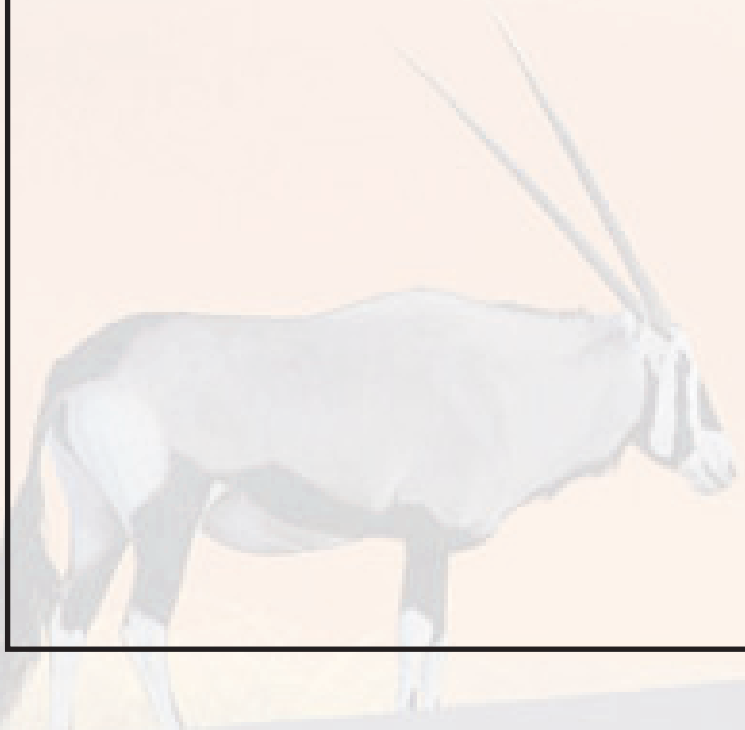
This project utilized the LANDSAT Thematic Mapper (TM) data to cover the study area of Asir National Park and analyzed the degradation of vegetation cover in the study area.

The LANDSAT Thematic Mapper (TM) satellite image analysis was performed at the GIS and Remote Sensing Unit of PME, Jeddah for preparing change detection maps of the temperature, and chlorophyll of the study area in ANP. The general approach involved the acquisition of two sets of LANDSAT TM data for two different dates (Aug. 1990 and June 2000) provided by UNEP-ROWA, Bahrain followed by extraction of digital numbers (DNs) from TM Bands, development and verification of correlation of selected vegetation variables to the spectral data, application of the models to the entire intensive study area, and the production of color coded resultant images showing difference in temperature and vegetation. Two TM scenes - Path/Row 167/047 acquired on 29-08-1990 and Path/Row 163/042 acquired on 21-06-2000, were utilized for the analysis. The details of this analysis and results obtained are discussed in section 8.

Section 6

Socio-economic Dynamics and Drivers of Change





Section 6 - Socio-economic Dynamics and Drivers of Change

6.1 Socio Economic Indicators

In the past, before the unification of the Kingdom of Saudi Arabia, the population of the mountainous forest areas, as was the case in most of the rest of Arabian Peninsula, was comprised of nomads and tribes. The life of the population in the forest areas was based on trade, farming and grazing. A century ago inhabitants of the mountainous areas were highly dependent on the natural forests which provided timber for making their own houses, wood for fuel and heating, fodder for their animals, and wildlife for hunting.

The forests in the past were protected by the inhabitants through a customary system called *Al Hema*. Under this system, every tribe or a clan controlled its own part of the forest, and no one was allowed to access the forested areas without the permission of the local clan or tribal leaders. The Arabic word '*Hema*' literally means 'a protected place or protected area'. In Islamic law it signifies a natural area that is set aside permanently or seasonally for the public good, which may not be privately owned. For more than fourteen hundred years, *Hemas* have helped conserve natural resources and biodiversity in the Arabian Penninsula and adjacent areas. They have secured sustainable use of renewable natural resources by and for people living adjacent to them. Thus the *Hema* has been one of the most successful institutions integrating nature conservation with human well-being.

In 1960s, it was estimated that there were about 3,000 *Hemas* in Saudi Arabia. Nearly every village in the south western mountains of the country, where the ANP is located, was associated with one or more *Hemas*. Other *Hemas* were in the northern and central regions. The areas under the *Hema* system varied in size from 0.10 sq. km. to well over 10 sq. Kms. Traditional *Hemas* made up a vast area of land under conservation and sustainable use and became the best-managed rangelands in the Arabian Penninsula (Llewellyn, 2003; Lutfallah 2006)

In the last few decades, life in the ANP area has changed and the traditional *Hema* system has deteriorated.

- **Population:**

The general census of 2004 conducted by the central statistics department revealed that the population of Saudi Arabia was 22.68 million. The Saudi citizens were 72.9 percent of the total population i.e. 16.53 million; while non-Saudis were 27.1percent. Just over half of the Saudi citizens were males (50.1percent) while 49.9percent were female. For the non-Saudi population, 69.4 percent were males while 30.6 percent were female. The average population growth in the Kingdom between the censuses of 1992 and 2004 was recorded to be 2.4 percent (Central Statistics Department, 2006).

Abha governorate is part of ANP with Abha city as its capital. The total population of Abha governorate was 317,159 and population living in cities was 222,398 while the population of the Abha governorate's villages was 94,766. The population of different cities and villages in Abha governorate are shown in table 6.1 below

Name of City/Village	Total Population	City Population	Village Population
Abha Governorate	317,159	222,398	94,766
Al-Soda	7,245 (90)/44.7		
Tabab	9,478 (66)/58		
Maraba	8,336 (141)/4.7		
Rejal Alma Governorate	69,288	4,460	64,828
Haswah	5,684/23		
Hobail	13,067/28.5		
Gahmah	1,033/13.6		
Horaidah	8,895/12		
Mahayel Governorate	195,584	48,760	146,824

Notes: Number of villages in each governorate/cities is given in paranthesis. Population density/km^2 is given after the sign /.

Table 6.1 Population distribution in the governorates of ANP.

In addition to the permanent population, the ANP hosts millions of tourists every year. It has been estimated that 2-3 million visitors visit Asir National Park annually in summer.

- **Education:**

The government of the Kingdom of Saudi Arabia has embarked on an ambitious plan for elementary, intermediate and high schools, training institutes and universities in ANP area (as in other regions of the country) to encourage education among the region's inhabitants. These facilities are equally made available for the education of boys and girls (Table 6.2) and an expansion plan is under way. The government spends a considerable amount of the annual budget on education. The allocated budget for education on national level increased from 52.00 billion Saudi Riyals in 1422 H (2001) to 83.15 billion Saudi Riyals in 1427 H (2006), an increase of 60 percent (Statistical Yearbook, 2006).

- **Health:**

The government of the Kingdom of Saudi Arabia, like in other regions of the Kingdom, has established primary health-care centers at city and village levels in the ANP to ensure adequate health services for the citizens and residents. In addition, specialist hospitals with the latest equipment and technology, both in private and public sector, are available to the common public to provide specialist health care. The government is expanding the network of primary health-care centers and hospitals to cover each and every city and village irrespective of the size of population. The government accords priority to health services which is evident from the budget allocation for Ministry of Health in the last five years i.e. 1422H-1427H (2001-2006). The budget allocated was 13.29, 13.99, 14.15, 15.09 and 20.19 billion Saudi Riyals for 1422 (2001), 1423 (2002), 1424 (2003), 1425 (2004), 1426 (2005) and 1427 H (2006) respectively, an increase of approximately 52 percent. The total number of health care centers in Asir region has also increased from 213 to 251 between 1422 (2001) and 1426 (2005) respectively, an increase of 38 health care centers, representing an 18 percent increase. (Statistical Yearbook, 2006)

	Rejal Al-Ma Governorate	Mahayel Governorate	Abha Governorate
University	None	None	King Khalid University
University Students	None	None	10,180
Number of Colleges	None	None	10
Male Schools			
Elementary	18	NA	72
Intermediate	17	NA	58
High School	09	NA	25
Training Schools/Technical Institutes	NA	NA	04 (2,293 students)
Female Schools			
Elementary	05	NA	43
Intermediate	09	NA	30
High School	05	NA	24
Training Schools/Technical Institutes	01	NA	02 (169 students)
Students (Male)			
Elementary	3,224	21,064	
Intermediate	1,942	5,386	9,234
High School	1,519	2,628	7,237
Students (Female)			
Elementary	NA	10,455	15,710
Intermediate	NA	4,166	6,728
High School	NA	3,151	6,009

NA: Data Not Available

Table 6.2 Number of male and female educational institutions and students in ANP

6.2 Drivers of Change:

It has been shown in the preceding sections that the ecosystems within the ANP have undergone changes in previous decades. It is important to identify the factors which are primarily responsible for causing ecosystem changes. These are known within the MA conceptual framework as 'drivers of change'. Drivers can be categorized as either direct or indirect, depending on the mechanisms through which it impacts the natural environment. A direct driver unequivocally influences ecosystem processes and can therefore be identified and measured to differing de-

grees of accuracy. An indirect driver operates more diffusely, often by altering one or more direct drivers, and its influence is established by understanding its effect on a direct driver. Both indirect and direct drivers often operate synergistically. Changes in land cover, for example, can increase the likelihood of introduction of alien invasive species. Similarly, technological advances can increase rates of economic growth (Millennium Ecosystem Assessment, 2003).

The last three decades have seen socio-economic, educational, technical, environmental, political and institutional changes in and around the ANP; these changes have their own direct and indirect negative impacts on forests. These are likely to increase in future as a result of the following driving forces.

- Increase in population and migration of population towards urban centres and nearby forests. This will cause urban expansion and increase in environmental tourism.
- Most of the urban centers in Asir National Park are located within the forest areas. So the forests are going to be affected by urban, agricultural and roads expansion within forests.
- Environmental issues will get worsened because of pollution, scarcity of water, desertification, sand dune movements, increased demands for water, grazing lands, timber and wood for fuel.
- Lack of private sector interest in the forests management and development.
- As a result of the government policy to protect water resources, people have started using forest areas for agriculture because of higher rate of rainfall in these areas. This will lead to decreased forest area.
- Population is becoming less dependent on forest materials and goods as other sources of income are available. This will lead to low care and destruction of forests.
- Increased environmental tourism will cause more pressure on forests because of favourable weather conditions.

- **Road construction:**

Construction of roads while is one of the important infrastructure development activity which provides means of transportation and facilities for the citizen, farmers and traders to transport their goods from one place to another, however, construction of roads is also considered to be responsible for an alteration in the natural set-up of the land resources and causes change in the ground water movement patterns.

Table 6.3 below shows the trend in the development of roads and budget allocated for this activity starting from first five year development plan (1975-1980) to the seventh five year development plan (2000-2005). The table shows that a considerable budget has been allocated to construct

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Five Year Development Plan Number	1975-1979	1980-1984	1985-1989	1990-1994	1995-1999	2000-2004	2004-2009
Length of Constructed Roads (Km)	1096	350	1395	711	54	258	714
Cost of Constructed Roads (Million Saudi Riyal)	2002	1280	2746	643	138	216	920

Reference: Ministry of transportation-Roads in Asir Province, Five year Development Plans

Table 6.3 Five year development plan allocation for road network development

roads in Asir region and a total of 4,578 km of roads were constructed during the seven five year development plans in Asir region.

Constructed road in the study area

- **Development plans:**

Al Gahma fishing port is in Rejal Al-Ma governorate which will be developed to become a sea port. This port will serve to transport goods from ANP to other parts of the Kingdom. Al Horaidhah is a town in Rejal Alma governorate. There is a plan to build an airport in Al Horaidhah.

- **Population change:**

The population in the Kingdom of Saudi Arabia is increasing with a rate of approximately 2.5 percent annually including Asir region. Increase in population at such a high rate puts a lot of pressure on various services such as water, food, fuel, power and energy, educational institutions, health facilities etc.

The government of the Kingdom of Saudi Arabia and governorate of Asir region (where ANP falls) have adequate plans included in the country's five year development plans to address these issues amicably and take provisions to ensure adequate supply of these services to the inhabitants of Asir region and ANP. In previous sections, it has been discussed that how the government is allocating increased budgets to ensure adequate supply of these services to the inhabitants.

- **Land use change**

Land use change because of the expansion of urban centers as a result of migration of population towards urban centers is another pressure on the forest areas as the land for expansion comes from forests. This also leads to increased demand for agriculture products which results in the expansion of agriculture activities converting forest areas into agriculture land.

Drivers of change can be divided into those which have a direct and an indirect effect upon ecosystems:

- **Direct driving forces:**
  - o Economic - land use change
  - o Science and technology - fuel
  - o Biological and Physical - climate variability and change
  - o Technological adaptation - water desalination
  - o Biological and Physical – nutrient loading
- **Indirect driving forces**
  - o Economic – tourism
  - o Demographic - changing or growing Population
  - o Demographic - Urbanization
  - o Cultural – changes in land and resource management from traditional to more modern systems
- **Drivers of change and Water Resources:**

National public decision–makers will most likely have the greatest influence in solving Saudi Arabia's future water supply and use issues. Socio-economic and cultural factors will enter into the decision-making process as will stakeholder participation.

Drivers of change

Direct driving forces:

- Economic - land use change
- Science and technology - fuel
- Biological and Physical - climate variability and change
- Technological adaptation - water desalination
- Biological and Physical – nutrient loading

Indirect driving forces

- Economic – tourism
- Demographic - changing or growing Population
- Demographic - Urbanization
- Cultural – changes in land and resource management from traditional to more modern systems

A problem to be addressed in the Asir region is water pollution where the discharges from Abha and Al-Birk wastewater treatment plants and septic tanks flow down the wadi into the Red Sea contaiminating the wadi areas it passes through and adversely affecting the marine ecosystem.

Global climate change is predicted to play a major role in determining the availability of water for drinking, agriculture, and other purposes in the world. A strong consensus of scientists proposes that arid zone temperatures will increase resulting in decreased precipitation.

Among all the ecosystem resources, water has the greatest impact on people and the environment as neither can exist without its availability. Too much water in the form of floods can also be as problematic as not enough water. Not only the quantity is of concern to decision makers, but also quality. Water pollution can adversely affect practically all other ecosystem services. Examples of services negatively impacted include water itself, food, agriculture, land and the fish population. Excessive amounts of fertilizers and pesticides can seep into the ground, mix with shallow aquifers and ultimately render water unsuitable for drinking purposes. When such chemicals (persistant organic pollutants (POPs)) mix with run off water discharged into the sea, fish population suffers. In addition, floods can erode the topsoil removing essential nutrients for crop production.

- **Drivers of Change and Food:**

The driving force behind the changes in crop production and food habits have been to some extent economic, but individual preferences also play the major role in this change. Interviews with local people indicated that the influx of new people to the region and increased interaction and communication with the outside world, such as television, were responsible for the local people making changes in the crops being produced and the food being consumed.

As for the terraces, the labor shortage has been the result of younger generation that grew up on the

terrace farms leaving the area to seek better education and employment in the Kingdom's larger cities.

It is difficult to ascertain exactly what the impacts have been in the past and the extent of impact in future with the changes in land use and food habits. As previously mentioned, the study area's total food production is likely to decrease as shown in the agriculture statistics. This alongwith increase in population would lead to increased food imports resulting in negative impact on people because of likely scenario of higher prices of food items.

Even with a land–use change to more agricultural land, a decrease in rainfall will cause groundwater irrigation wells to be dried with net likely result of decrease in food production.

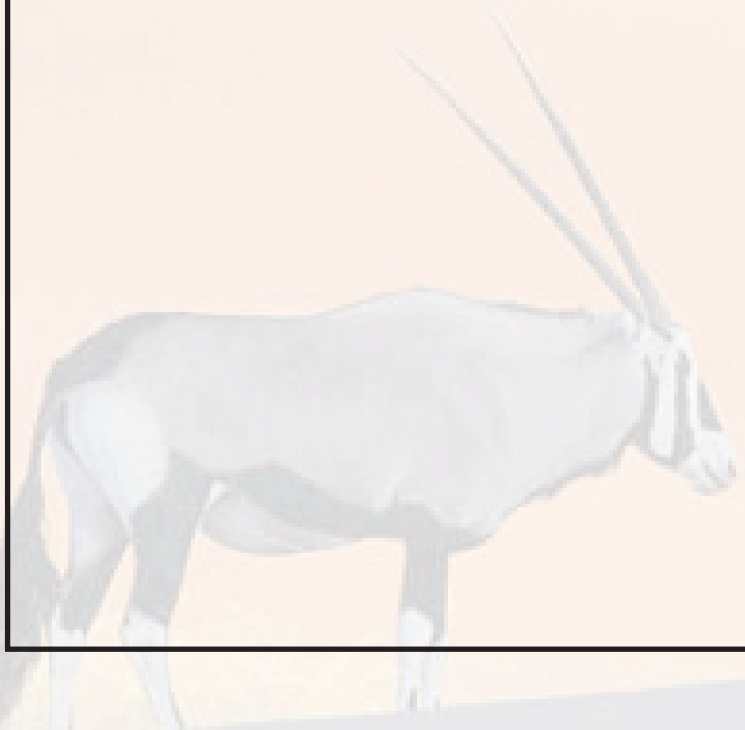
- **Drivers of Change and Fuel:**

Driver of change in the use of fuel, from wood and charcoal to oil and gas is mostly convenience and to some extent socio-economic conditions. The use of fuel wood and charcoal will still be practiced in the near future, especially in the smaller villages but at reduced rate. Thus, forests will continue to be denuded with resulting negative impacts despite the Saudi government forest regulations prohibiting this practice.

The negative impacts of the above mentioned drivers of change include loss of biodiversity, increased runoff causing soil erosion, loss of soil fertility, loss of forest foods for humans and animals and loss of economic opportunities in harvesting and selling forest products.

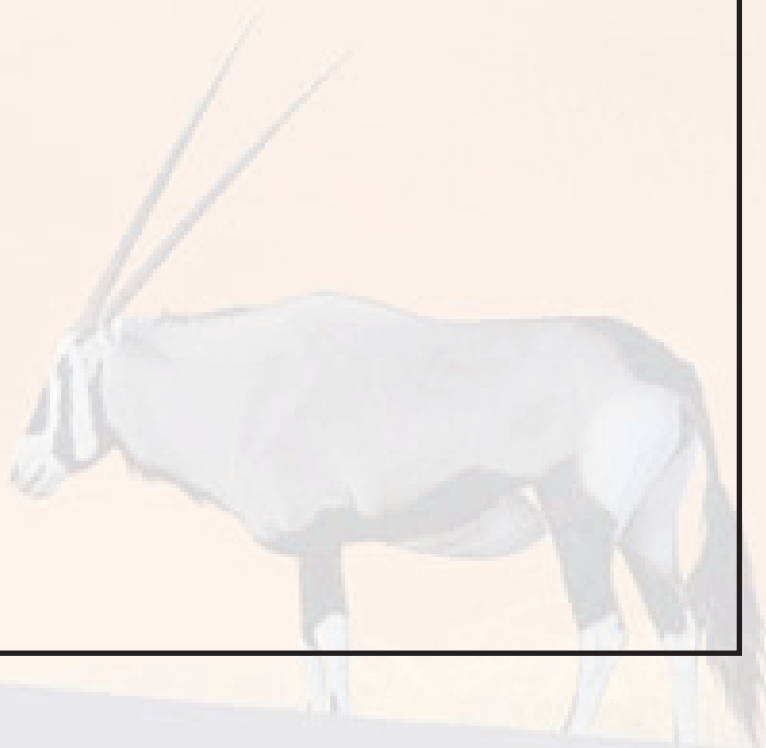
- **Drivers of Change and Cultural issues (Education, Recreation and Eco-Tourism):**

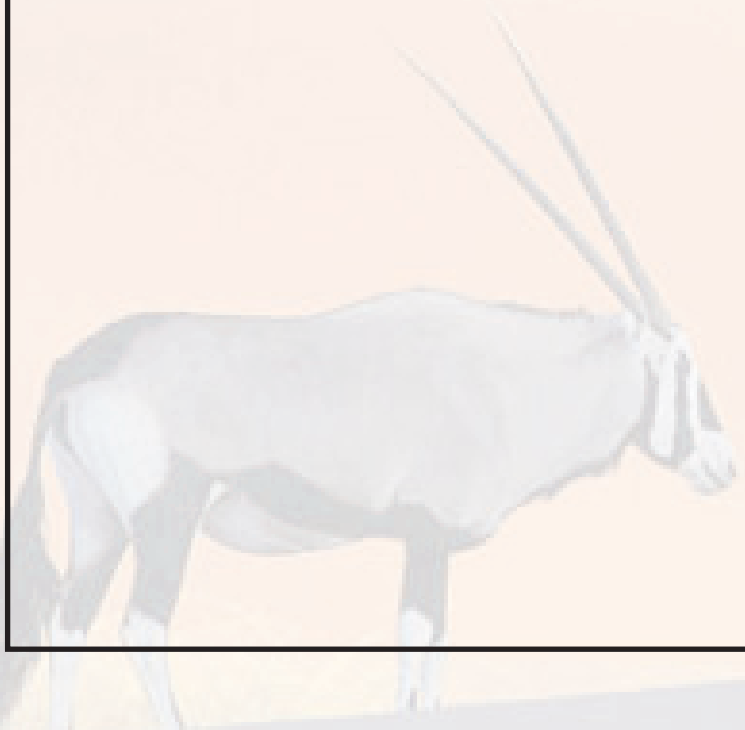
Where forested areas are lost, this is often associated with a loss of cultural values. These drivers such as health-care facilities, education and eco–tourism will be the policies of the government that will influence capacity building and training programs. The inhabitants in the study area indicate that their nonmaterial benefits are very important to them. In fact, they believe that tourism can turn into a material benefit with providing of lodging and food for the tourists (questionnaire Survey 2007).



Section 7

Ecosystem Services and Trends





Section 7 - Ecosystem Services and Trends

The concept of an ecosystem provides a valuable framework for analyzing and acting on the linkages between people and the environment. For that reason, the MA uses an "ecosystem approach" which has been endorsed by the Convention on Biological Diversity (CBD). The CBD states that the ecosystem approach is a strategy for the integrated management of land, water, and living resources that promotes conservation and sustainable use in an equitable way. This approach recognizes that humans, with their cultural diversity, are an integral component of many ecosystems. (Millennium Ecosystem Assessment, 2003)

7.1 Ecosystem Composition:

From a topographic perspective, the ANP is comprised of highlands, plateaus and coastal plains.

- **Western Highlands:**

The western highlands comprise the Sarawat mountains series separating the narrow coastal plains bordering the Red Sea and the rest of the Kingdom, which is considered relatively flat with many plateaus. Their height increases southwards to reach a peak of 3,353 meters at the Al-Soda mountains located in the study area of Asir National park. This is the most rainy and verdant spot in the Kingdom.


Sheep grazing on forest vegetation cover

- **Plateaus:**

The western highlands slope gradually eastwards to change into plateaus which are penetrated by long valleys like Al-Hijaz and Asir Plateus in the study area and Najran on Yemen border.


Camels grazing on range vegetation cover

- **Coastal Plains:**

The study area comprises of Tihama coastal plains along the Red Sea coast. Sand formations include three deserts among which the largest is the Rub Al-Khali which covers an area of 640,000 Km^2 and extends from the eastern borders of the western highlands in the Kingdom of Saudi Arabia and Yemen to the Oman highlands in the east through the Najd plateau in the north to the border lands of Oman and Yemen. It possesses complex longitudinal and crescent shaped sand dunes. In the north, the Nafud desert is found. It is less barren than the Rub Al-Khali desert.

- **Soils:**

Most soils in the Kingdom are recently formed. Soil profiles lack any development or amelioration factors. In fact, this is due to low humidity and continuous superficial regeneration through erosion and precipitation factors. Moreover, windblown salts, gypsum and calcium carbonate deposit rates within a given profile are higher than those of waste.

Severe soil erosion in the study area

- **Rainfall:**

Rainfall is the most important climatic factor affecting human activities since it is the main source of water in Asir region. It is directly utilized as surface water or recharge ground water. Rainfall is erratic both spatially and temporally (Table 7.1). The shortage of water is compensated for by the utilization of groundwater and desalinized water.

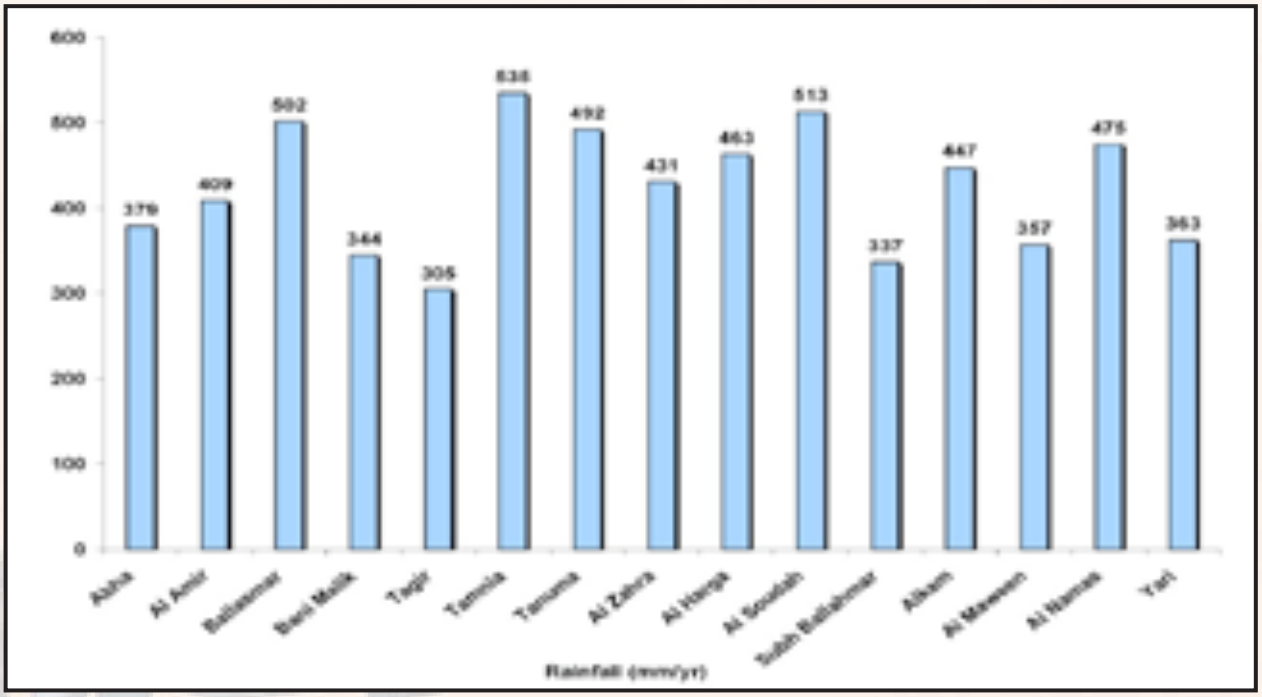


Figure 7.1 Average annual rainfall for some stations in Asir region (1970-1997)

- **Mountains (including forest)**

The mountain ecosystem is found in the Asir Mountains at elevations starting from 2000m to more than 3000m. The kind and composition of trees in these forests change with elevation. On the crests of ridges above 2000m, there are almost pure stands of Juniper trees (Juniperus procera) accompanied by Asparagus asiaticus, Lavandula dentate, Euryopus arabicus, Rosa abyssinica, Calutea spp., Helichrysum spp., Lactuca spp., Euphorbia schemperiana and others.

Within the boundaries of Asir upland watersheds, a number of land practices occur in separate areas, including protection and/or production forestry, agricultural cropping and grazing by domestic livestock. As such, these multiple–use watersheds define an agro-forestry system of land use.

- **Forest Vegetation:**

The Asir National Park is located in the region that consists of the only prominent forest in the Kingdom, situated in the Sarawat Highlands, extending from Al Taif in the north to Najran in the south.

The medium altitude mountains (1500-2000m a.s.l.) support evergreen forests, mainly consisting of Olea Africana accompanied by some members of *Juniperus* spp., *Euryopus Arabica, Rumex visicaria, Acacia asak, A.flava, Jasmenium* spp., *Hypoestes forsklei, Campanula edulis, Triconacthus comphratus, Russ* spp.

The less elevated mountains (1000m – 1500m a.s.l.) support Acacia – Commiphora scrub mainly consisting of *Acacia asak, A. humulosa, A. etbaica,* as well as *Commiphora* spp. e.g. *C. schempari and C. myrrha, Dodonia viscose, Ficus spp., Psiadia* Arabica, Ziziphus spp., *Lavandula denta, Maerua crassifolia, Otostegia fruiticosa* and many of the grazable grasses e.g. *Aristida spp., Pennisetum spp., Andropogon spp., Cenchrus spp., Chrysopogon spp., Eragrostos spp., and Tetrapog spp.*

- **Agro–Forest Ecosystem - Terrace Agriculture:**

The topography of the ecosystem in ANP is characterized by moderate to steep slopes. Soils are shallow and exposed to a continuous process of erosion, mainly by rainwater. In the past, terraces were constructed as means to conserve the soil, and to enhance water infiltration into the soil. Crops were cultivated on these terraces. Due to the discovery of oil in the country and the improvement of the economic situation, these terraces were not maintained, and have consequently been gradually damaged. As a result of this deterioration, Juniper forests in Asir National Park have suffered severe soil erosion and drought stress. Despite the general deterioration of terracing, some new terraces exist in privately owned households. These are well maintained and are used for cereal production.

Abandoned and damaged Terraces

- **Foothills**

This ecosystem generally ranges from 1000 to 2000m. At the medium altitude (1500 to 2000m), this area support evergreen forests consisting mainly of Olea Africana. Much of this ecosystem has been settled and patches of forest exist between farms and settlement buildings.


Effects of housing, power distribution and road network on the agriculture system

- **Coastal and Marine Ecosystem:**

This ecosystem interfaces between the Red Sea and a narrow coastal plain which includes many wadis draining into the Sea. The vegetation cover is dominated by Commiphora mirrah, Capparis decidua, Silvador, persica leptadinia pyrochnia, calotopis procera, zilla spinosa, Hyphene the baika and Panicum turgidum. Many Bedoiuns inhabit this area, with many range animals which are often responsible for overgrazing, and ultimately causing desertification.

Directions of marine limits of ANP

According to the field work observation, the coastal and marine ecosystems can be divided into three areas, based on the use of natural resources:

- **Mangrove Communities**
- **Fisheries, and**
- **Coastline**

Mangrove Communities:

Mangrove ecosystems serve as a link between the land and the marine ecosystems. These ecosystems are very important for the marine life in the study areas. They are considered potential fish production sites providing breeding areas for fauna and flora. In addition, they have the innate potential to bind toxic chemicals and pollutants which would otherwise run from the coastal areas into the marine ecosystem.

Since the mangroves are dynamic and fragile ecosystems, climate variables such as air temperature, rainfall, wind, and solar radiation play a major role in the natural growth and spatial distribution of the mangroves. Seawater temperature, coastal sedimentation and development are also important determinants of the viability of the mangrove ecosystems.

Based on our survey, large numbers of mangrove ecosystems exist along the coastline. Approximately 90 percent of these mangrove ecosystems are in good shape, the rest have deteriorated due to local expansion projects. The mangrove plants have traditionally been used for a variety of purposes by local people. For example, they provide charcoal, firewood, and stakes for fishing; local people believe that the green leaves of these plants are a good source for regular grazing for camels. Local communities are not aware of the wider ecological importance of mangrove ecosystems.

Mangrove communities along the coastal area of ANP

Dredging and filling activities along the coast and marine birds

The dominant mangrove species in the study area are Rhizophora mucronata and Avicinia marina. Based on the observation of the mangrove areas, other types found in the Kingdom coastal areas such as Rhizophora stylosa, R. mangle, Lumnitzera racemosa and Bruguiera gymnorrhiza do not seem to be found here, however they may exist. Large numbers of mangrove ecosystems are located at the mouth of the major wadis along the coastline. They also grow mostly at the end of the fresh water streams, where the silt and organic material are carried over by the water run off from the local wadis to the shore of the Red Sea. Some of the mangrove plants stand nearly 6m high from the ground level. These plants are used as resting areas by the local birds.

Fisheries:

The areas along the coast consist of mainly small towns and villages. These areas are characterized by dry, sandy soil, and water scarcity. These areas are not therefore suitable for cultivation or live-stock production. Most of the people living in these towns and villages are fishermen. They have inherited the profession from their forefathers. In Asir province, there are six major boat harbors; *Al-Birk, Al-Qahmah, Omog, Al-Moajez, Al-Nohod, and Dhahban*. These harbors have a total of 565 small boats; 341 are used for fishing and the rest are used for entertainment.

Fishing boats in ANP

Coastline:

The coast line is bordered by a high elevation area (25-150m) which runs for a distance of 5,000m towards the east away from the coast line. The coastal zone area is a narrow strip with different topographic features. The shore line is a flat plane covered with sand dunes, while most of the high elevation areas are covered by volcanic rock.

Off the coast line, north of Al-Birk town, the water depth is more than 20m; while shallower areas exist from Dhahban until Al-Huraydah town at the southern tip of Asir National Park coastline. The assessment area includes a big variety of coral reefs. Along the coast line zone, there are several small natural bays, small shallow semi-enclosed lakes, broad areas of *Sabakha* (salt marsh), huge numbers of mangrove communities and a number of sand spits. This area is home to many different types of marine creatures such as blue crab, sea turtle, sea birds, etc...

During the assessment of the marine and coastal ecosystems, the coast line particularly was divided into two sectors; moving south from Al-Birk town towards Al-Qahmah town was one sector, and from Al-Qahmah town towards Al-Huraydah town at the southern tip of the coast line was the second sector. Each sector has a total length of about 40,000m and unique characteristics when distinguished.

7.2 Biodiversity:

Biodiversity and ecosystems are closely related concepts (Millenium Ecosystem Assessment 2005). Biodiversity is the variability among living organisms from all sources. Diversity is a structural feature of ecosystems, and the variability among ecosystems is an element of biodiversity. Products of biodiversity include many of the services produced by ecosystems such as food and genetic resources. Changes in biodiversity can influence all the other services ecosystems provide.

Biological diversity includes all plants, animals, microorganisms, the ecosystem of which they are part, and the diversity within species, between species, and the ecosystems. Biodiversity is determined by the interaction of many factors that differ spatially and temporally.

In Asir region little research has been conducted on genetic diversity, but some research has been conducted on forest diversity. The mountain heights of Asir are divided into natural zones according to height as follows:

- **Very High Altitude Zone Above 2000m asl:**

  Juniperus procera is dominant in addition to some plant species like *Euryopus Arabica, Acacia origena, Nuxia oppostifolia, Cetis Africana, Psiadia panctulata, Asparagus Africana, Andropogon distachys, Hyperrhenia herta*. Also there are some members of *Tarconanthus comperatus, Russ pp., Pistacia falcate*.

- **High Altitude Zone Between 1500–2000m asl:**

  A mixture of *Juniperus procera* and *Olea europea* together with *Techlia nubilis, Tarconanthus compretus, Rumex visicaria, Dodonia viscose, Euryopus arabicus, Hypoestes forskali, Capandula edulis, Ficus sycomorus, Ficus fasta, Rumex nervous, Crassula pentadra, Psiadia punctual, Carrissa edulis*.

- **Middle Altitude Zone Between 1000–1500m asl:**

  Here evergreen *Olea europea* is dominant together with *Tarconanthus compratus, Russ spp., Telcea nubilis, Ficus vasta, Carrissa edulis, Eucleu kellau, Cadia varia, Jasminim gratissima*. Also *Acacia etbaica, A. asak, A. flava*, and *Euphorbia ammak*. Lower the zone Commiphora scrub, mainly deciduous bush of Acacia- Commiphora – formation where *Acacia asak and A. etbaica A. flava A. Senegal* are dominant accompanied by *Commiphora chemperi, C. myrrha, Ficuscycomorus, Ficus licifolus, Terminalia spp., Compretum spp*.

- **Low Mountain Zone Between 500–1000m asl:**

  The previous Acacia- Commiphora bush formation extends to this zone where Acacia nubicam and *Commiphora opobalsamum* replace the above- mentioned spp.

- **Lower Small Hills and Plains Between Sea Level and 500m asl:**

  Acacia–aerua bush orchards is dominant here comprising of *Acacia tortlis, A. ehrenbergiana, Maerua crassifolia, Capparis spp., Lycium shawii, Cadaba spp., Anisotes trisulcus, Salsola spp., Pannicum turgidum, Indigofera spp., cleome spp*.

Biodiversity of Algae, Fungi, and Lichens and Plant Species:

The list of key plant species is based on existing information available from the National Commission for Wildlife Conservation and Development (NCWCD). However, more research needs to be done as new species are still being discovered, and many of these new species are endemic. Already, some 246 endemic species and many of these are rare, vulnerable, or threatened, such as a number of succulent asclepiads and aloes, or the endemic genus *Dolichorhynchus*.

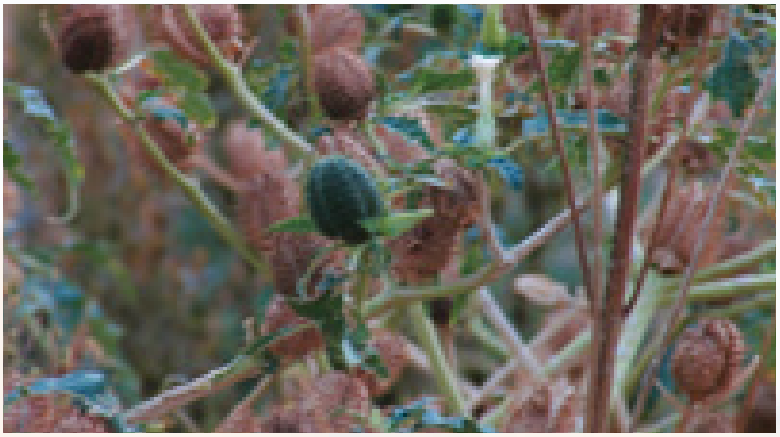
Different types of vegetation in ANP

Species of special ecological importance include the brown algae, seagrasses, mangroves, and *Juniper,* which constitute the habitats of exceptionally large numbers of other species. Species of actual or potential economic importance such as the truffles, some of the aloes, Maerua crassifolia, *Artemisia judaica,* the wild olive, and feral date palms may be endangered by overharvesting, but at the same time represent opportunities for conservation through sustainable use. Some of these are extensively used in traditional medicine, such as the two native lemongrasses *Cymbopogon schoenanthus and C. commutatus,* the wormwood Artemisia judaica, or wild crop strains of potential agricultural importance, such as the wild barleys *Hordeum murinum and H. spontaneum* and wild oat *Avena barbata*.

Invertebrates:

The invertebrate fauna are particularly difficult to define because there are so many gaps in the available information. A great many species remain to be discovered, while the ecology and conservation status of most species is unknown. Much research obviously remains to be done in compiling future lists of key taxa, groups such as the spiders, solifugids and other arachnids should be considered.





Different types of vegetation in ANP

In the present report, a number of corals, mollusks, echinoderms, crustaceans, and insects that clearly need to be conserved have been listed. Among the endangered, vulnerable, or rare taxa are the mushroom corals, several of which are relicts or endemics. Other endemics include the two Stylophora corals listed (both endemic to the Red Sea) and several species of crab.

The distribution of earthworms is severely restricted by the arid climate. They have been included as a key taxon in view of their valuable contribution to soil formation. Honeybees play a vital ecological role in pollination and an important economic role through the provision of wild honey. Other species of economic importance include the black corals, commercial shrimps, lobsters, crabs and cuttlefish, and edible oysters and clams, all of which are vulnerable to overharvesting. Shells that are vulnerable to unrestricted collecting include the conches, cowries, tritons, and cone shells, as well as the top shell, a source of mother-of-pearl. The pearl oyster is at present no longer exploited but remains a potential economic resource, as well as an indicator species by virtue of its sensitivity to pollution.

Reptiles:

All of the marine and freshwater turtles have been included in the list in view of their various degrees of vulnerability and endangered status. The two main species of marine turtle are the green turtle and the hawksbill, both of which are threatened globally. Although records of the loggerhead, olive ridley, and leatherback turtles in Saudi Arabian waters are extremely rare, the fact that these globally threatened species have occurred at all here is significant, and suitable habitats should be protected. The Caspian pond turtle, a Palearctic relict, and the side-necked turtle, an Afro-tropical relict, both have very limited distribution in freshwater wetland habitats.

Information about the distribution and populations of lizards is incomplete; however, the *chamaeleons and the skink Eumeces taeniolatus* appear to be relatively rare. Two of the stellios, one of dhabbs, *Uromastyx ornatus philbyi, and the skink Chalcides levitoni* are endemic; two of the dhabbs

Flagship species

Several plant species, such as native lemongrasses, the wormwood *Artemisia Judaica*, mangroves and wild crop strains of potential agricultural importance, could serve as flagship species. So could spectacular species such as the dragon tree *Dracaena serrulata*, the ban tree *Moringa peregrina, and Mimusops laurifolia,* One of Saudi Arabia's largest trees. A good example of a flagship tree species is *Ziziphus spina-Christi*, with its many uses in Arabian culture from shade to fruit and forage, soap, timber, and honey production. All of these exist in Asir region. The list is provided in section 14.

and one other agamid *Trapelus blandfordi fieldi*, are near endemics, while *Stellio stellio brachydactyla* is a Palearctic relict with limited distribution. As a predator and scavenger high on the food chain the desert monitor plays distinctive ecological role, as does the newly discovered Yemen monitor, a spectacular rare endemic species. The small-scaled dhabb is of economic importance for its highly esteemed flesh, for which it is under considerable pressure from hunting. The various dhabbs could also serve as flagship species. Wiegmann's skink Scincus hemprichii is believed to be vulnerable, and this may be true of other skinks as well, in view of their use in traditional medicine.

The large predatory snakes such as the Arabian cobra, moila snake, diadem snake, and glossy-bellied racer play important ecological roles; the later three species are important predators of rodents. The venomous borrowing asp, cobras, carpet vipers, and puff adder are all relentlessly persecuted, and are likely to come under increasing pressure from collection for their venom, which fetches a high price in the pharmaceutical market. The thread snakes Ramphotyphlops braminus and Leptotyphlops spp may be vulnerable, and play an ecological role akin to that of earthworms.

Birds:

The ferruginous duck and white-eyed gull are both endangered globally, while the houbara, Arabian bustard, lammergeier, lanner, brown noddy, and pink-beaked pelican are rare or threatened within Saudi Arabia; the sandgrouses are rare and appear to be vulnerable, and the population of griffon vultures appears to be declining.

Birds endemic to the Arabian Peninsula include the Socotra cormorant, Philby's partridge, Arabian red-legged partridge, Arabian woodpecker, South Arabian wheatear, Yemen thrush, Yemen warbler, Arabian waxbill, Arabian serin, Yemen serin, Yemen linnet, and the endemic subspecies of the magpie. Near-endemics and other species with critically important populations in Saudi Arabia include the sooty falcon, crab plover, white-eyed gull, lesser crested tern, white-cheeked tern, Barbary falcon, Hume's owl, Arabian golden sparrow, and golden-winged grossbeak. Migrants for which Saudi Arabia represents an important range include the demoiselle crane and houbara.

Cormorants, pelicans, vultures, and raptors occupy vital and vulnerable positions at the top of the food chain. The ostrich is a bird of high economic value; other birds of actual or potential economic importance include the hunting falcons, and gamebirds such as the partridges, guineafowl, and bustards. The ostrich, houbara and Arabian bustard, demoiselle crane, and larger falcons also serve as flagship species.

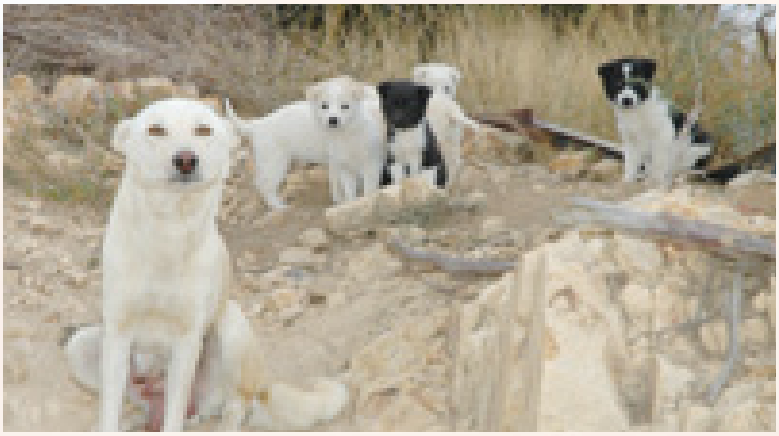


Marine birds in ANP

Terrestrial birds in ANP

Mammals:

Among the rare and endangered mammals listed are the idmi and reem gazelles, oryx, and ibex, the dugong, Arabian leopard, caracal and other carnivores which are ruthlessly persecuted. Endemics to the Arabian Peninsula include the idmi[3] and reem gazelle, Arabian oryx, Arabian leopard, and Arabian wolf, among others. The 'afri gazelle' which appears to be extinct, not only in the wild but in captivity as well, is also listed. Saudi Arabia also has some of the most important populations of the dugong and hamadryas baboon. The carnivores play an important role as predators at the top of the food chain. Game species are of potential economic value. The ungulates, dolphins and whales, and to some extent the larger carnivores can serve as flagship species.



Different types of Mammals in ANP

Forests:

Forest cover is estimated to be around 2.7 million hectares in the Kingdom of Saudi Arabia. They are concentrated in the mountainous region situated in the southwest of the Kingdom. Asir region alone has an estimated forest area of over one million hectares (Tables 7.1 and 7.2), Juniper trees mostly cover the highest altitudes. At lower levels come the wild olive trees. Acacias are found in piedmonts, valleys and other lowlands throughout the Kingdom including ANP. Forests play a protective role preserving soil, water resources, biodiversity and environmental components. Studies show that some of the forests in Asir regions are subject to remarkable deterioration due to unplanned urban expansion, pests and disease control and recurrence of drought spells. As a result, many phenomena such as dieback, total and partial mortality are found across large areas of Juniper forest. Furthermore, natural regeneration is scarce or even absent in many regions due to

3 Genetic analysis has revealed that the Farasan Islands population of idmi gazelle, which had been considered by some taxonomists to be an endemic subspecies or even an endemic species, is the nominal form of idmi Gazella gazella with evidence of hybridization.

the infestation of Juniper seeds by seed borer parasites and extensive and premature free grazing practiced over the years in the forests. Poor institutional structure and the lack of professional foresters are among the main reasons for deterioration of the forest, because they are responsible for the poor implementation of forest management and associated cultural operations, regeneration, expansion and protection of forest resources.

The forest outlook study carried out for Saudi Arabia in 2004 stated that "If the current forest status persists, many of the southwestern forest regions of the Kingdom, including Asir region particularly will witness serious environmental problems due to loss in green cover which may lead to long lasting environmental, and socio-economic problems in the region" (Ministry of Agriculture, 2004).

Region	Extent (ha)
Riyadh	290,000
Al Gasim	41,000
Makah Al Mukaramah	158,000
Asir	1,009,000
Tabuk	239,000
Al Madinah Al Munawarah	123,000
The Northern Boundaries	6,000
Najran	300
Gizan	30,000
Al Baha	830,000
The Eastern	841
Total	**2,727,141**

Table 7.1 Extent of Forest areas and their distribution in the Kingdom

Extent of forest and other wooded land			
FRA 2005 Categories	**Area (1000 hectares)**		
	1990	**2000**	**2005**
Forest	2,728	2,728	2,728
Other wooded land	34,155	34,155	34,155
Forest and other wooded land	**36,883**	**36,883**	**36,883**
Other land	178,086	178,086	178,086
…of which with tree cover	0	0	0
Total land area of the Kingdom	**214,969**	**214,969**	**214,969**
Inland water bodies	0	0	0
Total area of country	**214,969**	**214,969**	**214,969**

Data source: FAO, Global Forest Resources Assessment 2005

Table 7.2 Extent of forests and Other Wooded Land in Saudi Arabia.

7.3 Ecosystem services:

History shows that human well-being, and indeed the persistence of civilizations, is strongly linked to the capacity of their environments to continue to deliver ecosystem services at the local to regional scale. The linkage works in both directions:

- Human well-being depends, to a large measure, on many services provided by nature; and
- The state of the environment is affected by the size and consumption patterns of human populations in ways that reduce or increase (at least temporarily) the supply of ecosystem services. (Millennium Ecosystem Assessment, 2005)

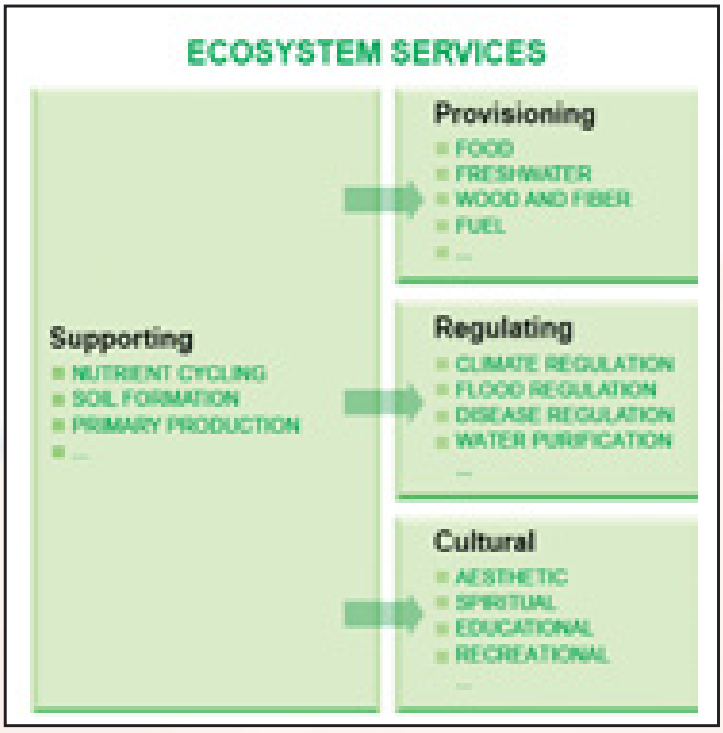


Figure 7.2 Ecosystem services (Source: Millennium Ecosystem Assessment)

The most important ecosystem services provided by the forested areas of ANP include water, soil, food, fuel, medicine, and cultural resources (opportunities for education, recreation and eco–tourism).

- **Water**

Water resources in ANP are comprised of Wadis (valleys) and Wadi Basins, groundwater aquifers and desalinated water used for potable purposes.

The Total area of wadis found in Asir region is 14,163 km^2 and the length of these wadis totals 450 km. The rainfall in the region ranges between 200-500 mm. There are four main Wadi Basins in the Asir region namely Wadi Hala, Wadi Atood, Wadi Baba and Wadi Beesh. These Wadi basins are used for irrigation, contribute to groundwater recharge, and provide potable water along with water for desalination. Around 76.4 percent of water from these basins remains within Asir region while the rest (23.6 percent) end up outside Asir region.

Wadis found in Asir region are very steep towards Red sea. On the hilltop, they look like deep and narrow tunnels while in the bottom, they are wide and surrounded by villages and agriculture lands.

Table 7.3 below shows details about the areas, lengths and annual discharges of these wadi basins in ANP.

Wadi basin	Area of Basin Km^2	Length of Wadi, km	Annual Discharge (million m^3)
Hala	4,783	145	1,610
Atood	1,551	55	320
Baba	2,665	105	1,180
Beesh	5,164	145	2,350
Total	**14,163**	**450**	**5,460**

Table 7.3 Data about the four main wadi basins in ANP

Hala Wadi Basin is one of the biggest in the region. It runs from Rejal Al-Ma in the south till Tehama Bani Shahr in the north. Water flow in this wadi basin is approximately 800 l/sec for holding layer depth of 160 m and the surface flow is 300 l/sec. Some 15 percent of the wadi's surface water is used for drinking purposes.

Atood Wadi Basin consists of Wadi Dala'a and Wadi Maraba branches. It has been considered a major source of irrigation water for agriculture in the lower parts of the valley. Recharge of groundwater from Wadi Atood is estimated to be 0.9 million m^3 annually. This wadi supplies more water for agriculture in these areas than the groundwater.

Baba Wadi Basin is 2,665 km^2 in area and 105 km in length. Rainfall in the wadi area is >300 mm and annual discharge is 1180 million m^3. However, only a fraction of this discharge is utilized because of low water holding capacity and the steep slope of the wadi.

Beesh Wadi Basin Wadi Beesh is one of the major Wadis of Gizan region. It starts from the hilltop of southern Asir region, passes through Gizan to Yemen. About 66 percent of its water goes to the Red sea and rest is used for agriculture and the recharge of groundwater aquifers.

Groundwater in Asir Region:

There are no deep groundwater aquifers in Asir region because of the geological formations of igneous rocks. Most of the groundwater wells are shallow, ranging between 5 and 10 meters, and the water depth in these wells ranges from 2 to 5 meters. There are 31 water wells in wadi Baba and 100 wells in wadi Hala. Well water quality is sufficiently good to allow drinking. Salinity increases gradually towards the sea (the discharge point). Total dissolved solids (TDS) range between 350-1,080 ppm in wadi Atood and 400-800 ppm in wadi Baba. The salinity of soil in these wadis also increases towards the sea.

Desalinated Water:

The current production capacity of Al-Shuqaiq desalination plant is 120,000 m^3 per day and 128 MW of electricity. The second phase of Al-Shuqaiq desalination plant will produce 212,000 m^3/day additional desalinated water and 850 MW electricity to cope with increasing demand from ANP. (Saline Water Conversion Corporation, Annual Report, 2007).

Water Abstraction and Recharge:

In Asir region, groundwater is abstracted by pumps. Traditional techniques were abandoned some 25 years ago. Water loss is high due to evaporation. Groundwater abstracted from upper parts of Baba wadi is estimated to be 5.5 million m^3, while groundwater extraction from upper parts of Hala wadi is estimated at 11 million m^3 annually. Downstream near the shore, water abstraction from Baba and Hala valleys is estimated to be 47 million m^3 annually which is used in agriculture to grow fruits, vegetables and other crops and for human and animal consumption.

Ecosystem Services

The most important ecosystem services provided by the forested areas of ANP include the following:

Water, soil, food, fuel, medicine, and cultural resources (opportunities for education, recreation and eco–tourism).

Potable water consumption in the governerates of Abha, Mahayel and Rejal Al-Ma is 103 million m^3, 33 million m^3 and 3.1 million m^3 annually respectively, from sources such as ground water wells, desalination plant and dams. The consumption rate per person is 250 liters in Abha city while in other small cities it is slightly lower at 200 liters per day. In rural villages, each inhabitant consumes 100 liters per day on average.

The government of the Kingdom of Saudi Arabia has constructed a number of dams in ANP to collect and store rain water. The new dam capacity of Abha is 2,130 million m^3. The dam water is used generally for irrigation purposes while Al-Shuqaiq desalination plant production is used as potable water.

Expansion of water collection and storage will include building Atood, maraba, Heli and Yeba Dams and expanding Abha Dam capacity to reach 2,450 million m^3 as well as increasing abstraction of well water to reach 2.7 million m^3 a year (Ministry of Water, 2004).

Many scientists are predicting that much of the world's arid regions will suffer increasing temperatures, reduced rainfall and a greater frequency of damage–producing floods. Saudi Arabia's Initial National Communication (2005) submitted to UNFCCC has analyzed various climate scenarios with temperature increase of 1-5^0 C and its effects on agriculture, biodiversity and sea level rise (SLR).

Reduced rainfall can dry up shallow wells as recharge is reduced causing water tables to drop while more severe storms will produce greater damages as a result of inundation and erosion.

Water is probably the most critical resource in the Asir region and is a key concern for national and regional security, as well as human well-being. The degradation of watersheds and its consequences on the water supply, including irrigation, have been widely reported. While soil erosion and watershed degradation are recognized as important problems, it is necessary to assess the potential role of forests in providing a solution, especially in the context of several factors that influence the hydrology in the region. The problem mainly stems from land-use changes, especially when woodlands are cleared for crops without adequate soil and water conservation measures. Increased grazing, far beyond the carrying capacity of the land, causes soil compaction and is another factor that reduces infiltration and enhances run-off. Increased urban build up and infrastructure development (especially roads) have reduced the proportion of water that seeps into the soil, resulting in increased peak flows and reducing the duration of stream flow. Grazing and fuelwood collection (especially production of charcoal) is important causes of land degradation, undermining the ecosystem services provided by watersheds (Ministry of Agriculture, 2007).

In the foreseeable future, it is believed by locals that the use of terraces for agriculture will decline primarily due to the lack of terrace maintenance and non-availability of labour. Local inhabitants

predict that land-use changes will continue to take place; for example, forest areas will be cleared for the production of agricultural crops, because of the economic advantage of crops over forest products. On the other hand, forests have an environmental advantage over cropland in that they protect the soil from erosion by transforming intense rainfall into a more gentle rainfall.

Another observed trend is the introduction of intensive agriculture at the higher altitude where rainfall averages 400-500mm per year. Dams installed across wadis are used to divert water for irrigation.

- **Food**

More than three-quarters of the farmers interviewed stated that agricultural systems had deteriorated during the past 25 years. Some 66.6 percent of respondents said that declining profits from agriculture were one of the reasons for this. 58 percent of farmers interviewed in the study stated that they grew only wheat, maize and barley, while 42 percent added millet and 17 percent said they grew vegetables and fruits in addition (questionnaire survey 2007). The aforementioned study revealed that the food habits of most of the ANP inhabitants have changed. People now rely primarily on rice instead of wheat, and on bread made with white flour instead of millet-flour.

Terraces have been deteriorating for the last two to three decades. Maintenance has not kept up due to lack of labor. With a forecast of agricultural water to decrease in the future, crop production will decline, and food imports to the area will increase.

More than a third (36.6 percent) of the pastoralist respondents believe that livestock-keeping as a livelihood system is deteriorating because of the degradation of rangelands. The majority blame a lack of labor and low profit margins for changes in the pastoralist lifestyle. All the pastoralists depend mainly on tree fodder to feed their animals. Trees provide shade for livestock, important to their health and productivity in hot, dry areas. Grazing is a normal practice in Asir National Park thus milk and meat are produced indirectly from the ecosystem.

The mangroves in Asir National Park provides habitats for many fish species, especially shrimps. The fish catch enriches protein-deficient diets and generates household income.

- **Fuel**

The trend in the near future is that the use of oil and gas will continue to replace wood and charcoal because of its ease and availability, according to the local inhabitants. Although, oil and gas is more expensive, its use will increase causing a decrease in wood cutting resulting in increase of vegetation cover in the area. This will have positive impacts on forest cover, biodiversity, and food availability for herding animals and humans.

Cutting and burning of plants and transportation of wood in ANP

- **Waste**

The Water and Sewerage department owns and operates a 20,000 cubic meter capacity aerobic biological secondary level wastewater treatment plant connected to the sewerage system in Abha city. The treatment plant is operating within the design capacity and the treated wastewater is land disposed into the valleys, in compliance with the specified standards. However, the wastewater treat-

ment plant serves a limited population and the rest of the population in Abha city and other cities and villages of Asir governorate discharge the sewage to underground septic tanks which are periodically hauled by tankers to the designated valley areas. Al-Birk in Asir region also operates an additional wastewater treatment plant. Its treated wastewater is also discharged into the nearby valley. Ministry of water and Electricity has embarked upon a 30 year plan to cover all inhabitants with sewerage network and reuse/recycle the treated wastewater for irrigation and other purposes.

For some years now, an effective solid waste management system has been in place whereby the domestic solid waste is collected in different cities by municipalities and disposed off in landfills. In some areas, solid waste is disposed of on land, or sometimes burned in the open air. However, these practices are limited to villages where the municipal administration lacks capacity.

Abha, Rejal Al-Ma and Al-Birk each have their own landfill. In addition, there are branch (small) landfills in other towns in the ANP. These landfills supply enough space for the proper disposal municipal solid waste in Asir region and the ANP.

- **Forest products**

Many people in Asir region supplement their income through the processing, consumption and marketing of non–wood forest products. The main non–wood forest products in Saudi Arabia include medicinal and aromatic plants, herbs and spices, gums, resins, tannins, mushrooms, honey, fruits and nuts. In some cases, fodder is also considered a non–wood forest product as a large number of livestock depend on it from forests and woodlands. In fact non–wood forest products are more valuable than wood products in Saudi Arabia.

In the past, fuel wood and charcoal production were carried out according to traditional way. Trees were cut, dried and sold in fuel wood markets without any consideration of the associated damage of forestry resources. In 1977, the Forest & Rangelands Act was issued by the government of Saudi Arabia. The Act established the principles and regulations concerning the exploitation methods of any of the public or village forests. Violations and penalties were clearly explained. The executive regulations for the Forest & Rangelands Act were issued. They explained the methods for forest exploitation and transportation of products according to specific models of licensing relative to fuel wood collection, fuel wood transportation, charcoal making activities and charcoal transportation.

In the year 2000, a Royal Decree was issued banning issuance of any licenses for wood collection or charcoal making for five years The Decree also allowed the import of firewood and charcoal from abroad.

Rural villages and resettlement areas' population are most affected by the condition of the forest as they rely on many of its benefits such as fuel wood, animal grazing, byproducts including fruits, seeds, medicines, honey, environment conservation, improvement of soil and water systems and the associated increase in productivity of other agricultural crops. Forests also ensure economic benefits by providing job opportunities in educational operations and guard duties.

Trees were and still are very important in nutrition, essentially providing fodder for wild and domestic animals that in turn transform this vegetal material into meat and milk for human consumption. Trees also provide an environment for grazing, plant growth and shelter and shade for wild animals. Forests are also considered direct sources of food, providing various fruits for human consumption such as Sidr *Ziziphus spp*., pistachio *Pistachia spp*., olive *Olea spp*. and others.

Forests play a key role in the development of tourism in the area as they represent the natural resources upon which environmental tourism depends. In fact environmental tourism is one of the fastest growing sectors of this decade. Through tourism, the awareness of nationals is raised regarding the role of forests, the importance of its conservation and the potential of generation of job opportunities for locals in forest region.

The indirect benefits of forests are particularly important as they are fundamental to the conservation of the natural environment through the following:

- Conservation of the plant cover that helps in soil fixation by the roots and the improved aeration.
- Decreasing of velocity of rainwater flow, soil surface and the mountain slopes which prevents the soil sliding and erosion.
- Decreasing wind speed and the sand creeping process.
- Decreasing the temperature and the water loss through evapo-transpiration.
- Providing organic materials that build the soil and increase its fertility.
- Providing fodder for domestic and wild animals.
- Improvement of the local climate and increase in the crops productivity.
- Providing parks and interior tourism sites.
- Decreasing environmental pollution through the absorption of harmful gases including the carbon dioxide and reducing sound pollution.
- Clearing of the weather that contributes in the condensation of clouds and increases the chances of rainfall especially in high altitude regions.
- Conservation of the wild life by providing suitable shield and safe refuges for animals during their normal migration.
- Production of honey, medicinal substances and tanning material.

- **Fisheries**

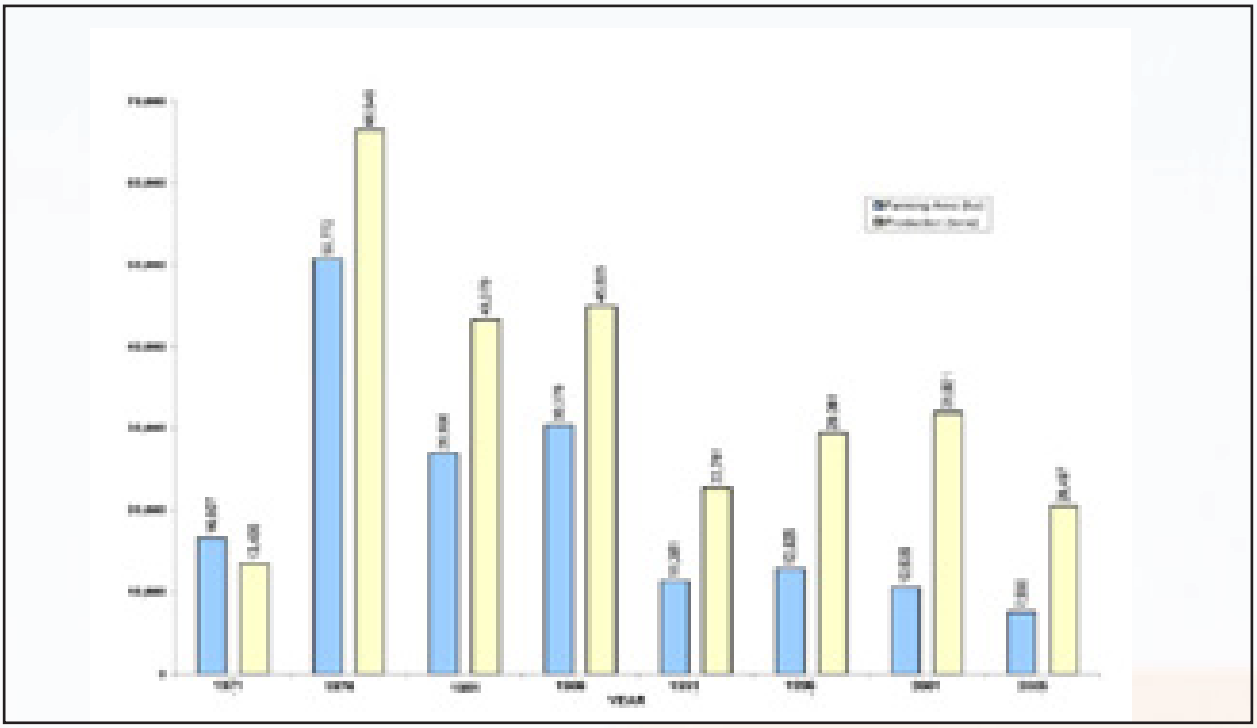
The inhabitants who were involved in fishing profession in these areas used to sell their catch in the local fish markets of their own town and villages. However, in the last ten years they sell their catch in other fish markets of the province. The attitude of new generation of fishermen towards fishing profession also varied; about quarter of them (26.6 percent) were not interested to adopt this profession, 20 percent were found willing to continue, and the rest (53.4 percent) were found confused having no firm opinion.

- **Agriculture**

Terrace agriculture on mountains and slopes in the ANP area is very common. Agriculture is also practiced in the plains towards the Red Sea.

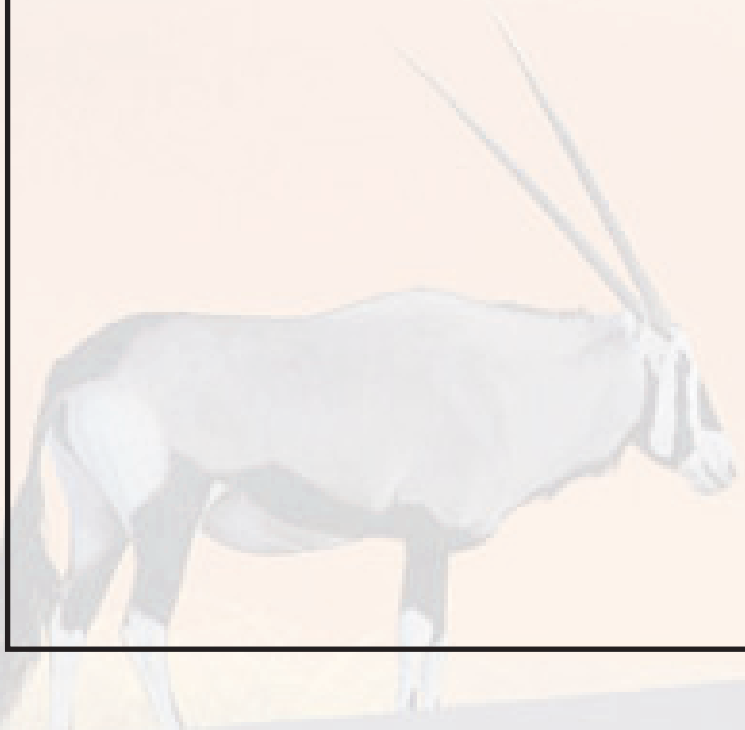
Most of the farms in the higher altitude areas are terraced. They depend on the rain as well as irrigation from some groundwater wells. In the Al sodah area, at the highest elevation of the ANP's mountains, farms are very small in size and are highly terraced because of the steep slopes. The size of the farm depends on customary tenure systems (ownership of clan and individual family fields near houses), soil fertility, availability of water sources and the topography of the area. Conventional methods of farming were used in the past, but these have been replaced by latest technologies. However, in some areas heavy farm equipment can't be used because of the small size of the farms and the steepness of the mountainous slopes. The climate in high terrain is cold in winter and moderate in summer and rate of rainfall is quite high. The farmers depend on rain and grow wheat, barley, millet and alfalfa. Due to the migration of inhabitants from rural areas to urban zones in order to gain access to jobs, education and for better opportunities, large areas of the farms are left fallow or are rented to others. Generally, the farms grow two crops in a year.

The total area and production of cereal crops in Asir region between 1971 and 2005 is given in figure 7.3. The farming area and crop production have fluctuated over the years. They increased from 1971 to 1979, then decreased till 1996, increased again in 1997 and 1998 and then decreased continuously till 2005. The cereals produced were principally wheat, millet, sorghum, barley, whilst some maize and sesame were also grown.



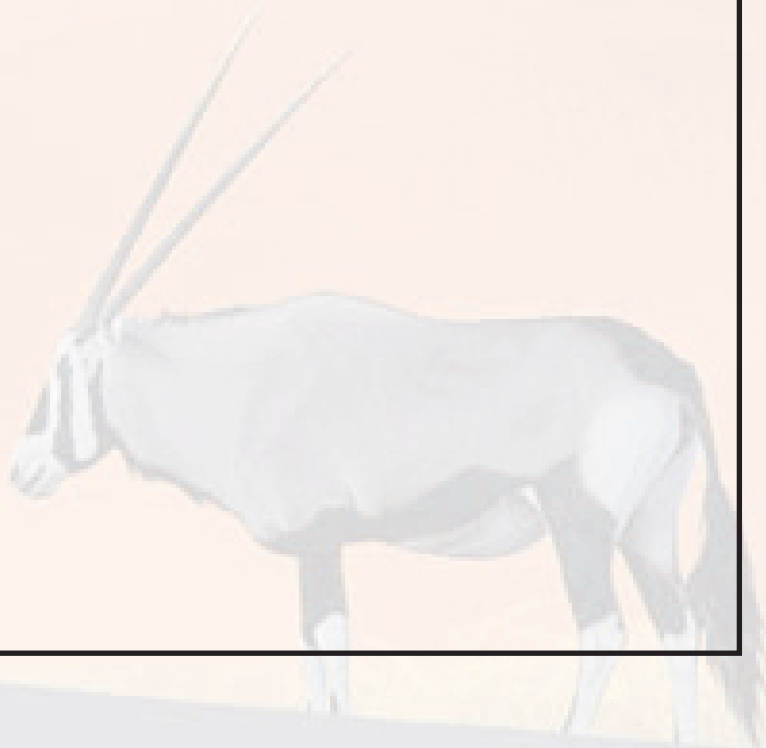
Ref.: Time series of agricultural statistics in Saudi Arabia during three decades, Ministry of Agriculture, Agriculture research development affairs, Department of planning studies and statistics, 2007.

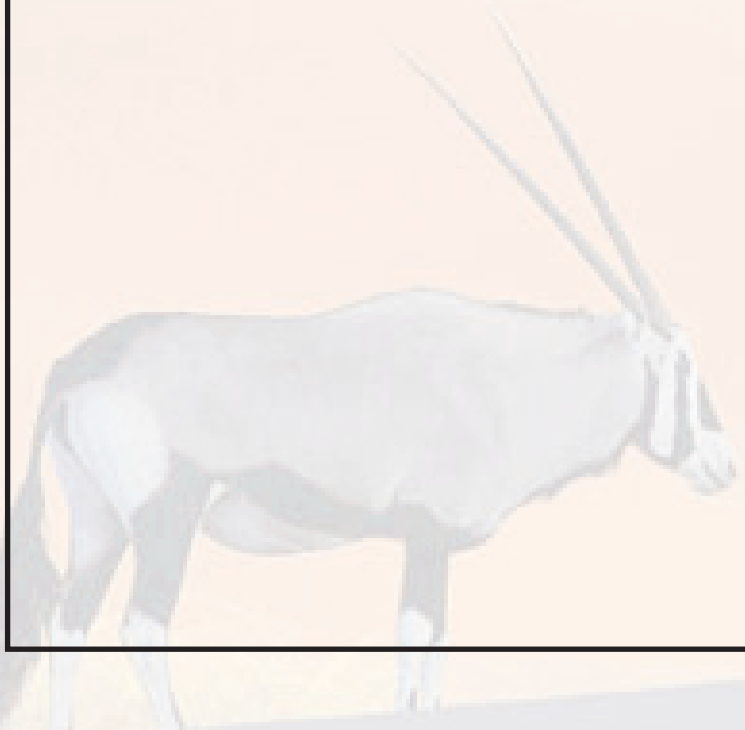
Figure 7.3 Farming area and Agriculture Production (cereals) in Asir Region



Section 8

Current state and trends





Section 8 - Current state and trends

ANP has a diverse range of highly specialized flora and fauna, but misuse of its natural ecosystems is a serious economic and social threat. Rainfall is limited in most parts of the country and is erratic both spatially and temporally. Soil erosion by water and wind, salinization of soils, deterioration of the natural vegetation of rangelands and forests and sand encroachment contribute to ecosystem degradation.

The natural vegetal cover of the park is currently at risk of deterioration in some parts due to the adverse climatic factors and anthropogenic misuse. This risk is posed by unplanned tree removal, intensive unbalanced pasturing, fires, diseases, tree senescence and weak natural regeneration which will lead to continuation of the current deterioration of the natural resources such as soil, water and wildlife if appropriate actions are not taken at various levels.Temperature distribution map :

Temperature distribution Maps:

The trends in forest cover are shown in the analysis of the remote sensing data Monitoring of surface temperature is one of the most common applications of satellite remote sensing. The temperature distribution was performed by utilizing appropriate TM information. Temperature is an important parameter which reflects on the evapo-transpiration and humidity in the area under study. A color rank for the temperature distribution were created for individual images showing higher temperature in Magenta and lower temperature in green[4]. Figure 8.1 illustrates the thermal distribution coverage for the study area in the years 1990 and 2000.

The temperature distribution in August 1990 shows patches of lower temperatures in Al-Soda area extending towards lower lands in the western part of the study area. In June 2000 the temperature distribution shows higher temperature in low lands and lower temperature in Al-Soda extending towards the east (Figure 8.1)

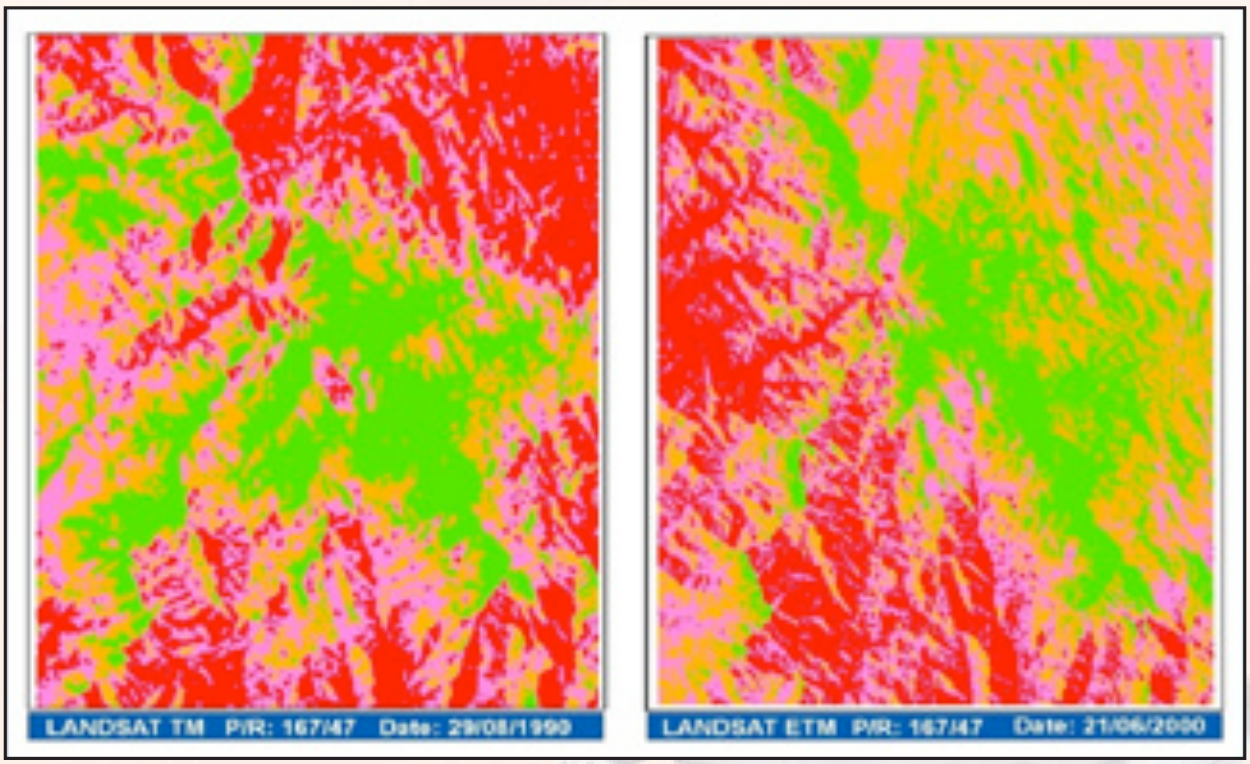


Figure 8.1 Change in temperature distribution on 29/8/1990 and 21/6/2000

[4] Surface temperature distribution was carried out by utilizing TM Band 6 (wavelength 10.4 to 12.5 micrometer, thermal infrared region) for the study area. Band 6 was a subset of the TM's 7 bands and image slicing was performed for each image. The Digital Numbers (DNs) of Band 6 are related to the thermal radiation.

Chlorophyll distribution map:

The data shows the distribution of chlorophyll, which indicates vegetation cover (Figure 8.2)[5]

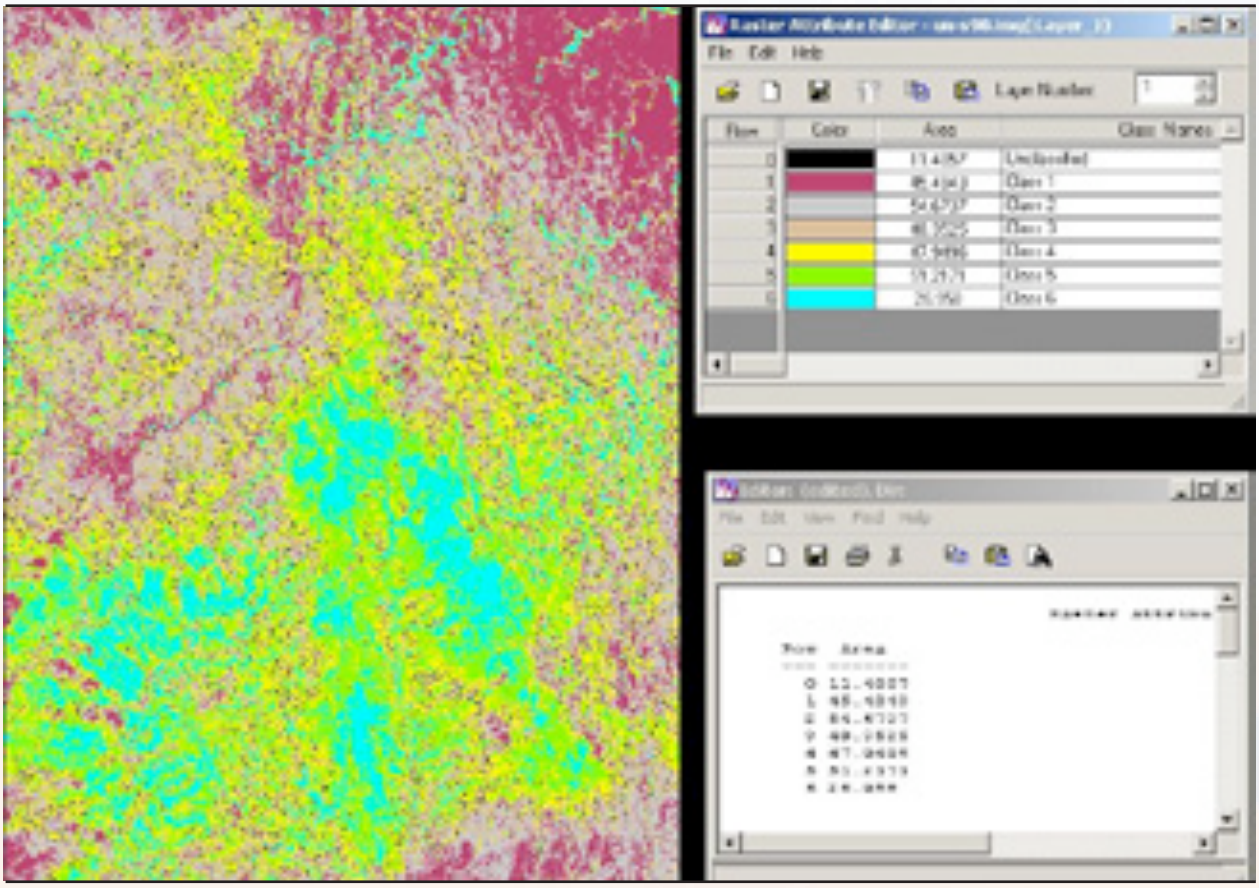


Figure 8.2 Chlorophyll distribution in study area

The color distribution of each image was categorized into five levels respectively (Figure 8.3). The red cyan indicates the highest and dark magenta the least distribution level (cyan>green>yell ow>brown>gray>magenta). The chlorophyll distribution in 1990 was observed to be concentrated in the lower lands while in 2000 the distribution observed to be concentrated in high lands. Comparing the two different set of images (August 1990 and June 2000), a variation of chlorophyll distribution change can be noticed in both sets of images. The total area colored in magenta, green and yellow (showing higher concentration of chlorophyll) was about 202.54 square kms in 1990 while in the 2000 the total area of high concentration of chlorophyll was about 194.77 Square kms. (Figure 8.3), a difference of 7.77 square kms.

[5] The TM Band 4 (0.76 to 0.90 µm range, near infrared region) was image sliced and distribution values were determined, vegetation reflectance show high values for highly concentrated chlorophyll existence. The TM 4 data have been level sliced into multiple levels for determining the chlorophyll distribution for each images and finally five categories were established and chlorophyll distribution map for each set of images in different years were prepared

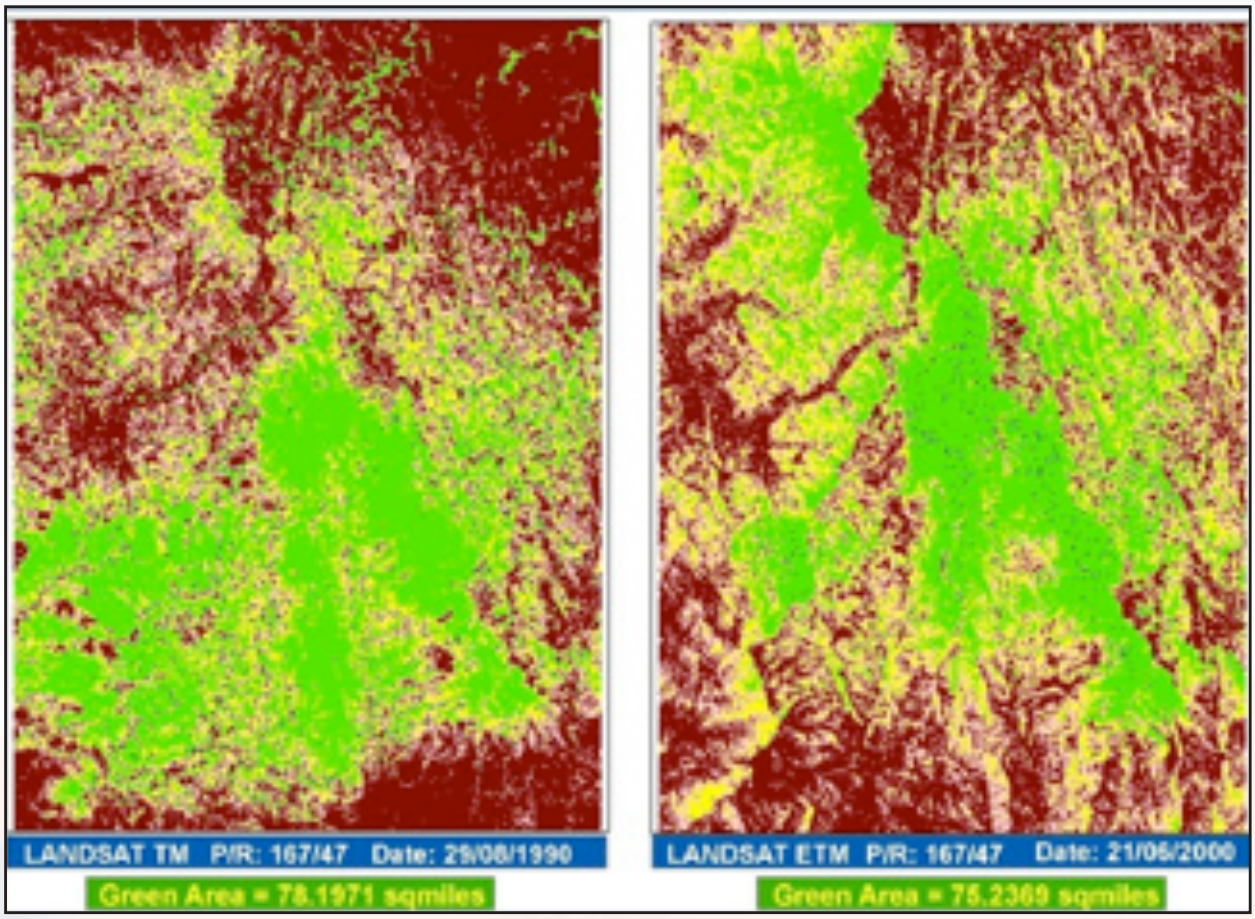


Figure 8.3 Chlorophyll distribution in study area (chlorophyll was used to reflect vegetation cover) on 29/8/1990 and 21/6/2000

Overall, TM data analysis appears to be a very effective means of assessing vegetation change detection, which provide a valuable source of information for this study.

8.1 Human well-being and cultural services:

MA conceptual framework defines cultural services as the non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development and recreation. These benefits include cultural diversity, a sense of place, tourism, educational value and aesthetic values. Cultural drivers include changes in lifestyles, such as from traditional to more–modern, values and norms with respect to the environment and knowledge, education and health-care.

Majority of questionnaire respondents (63.3 percent) believe that deterioration of natural resources such as soil erosion, use of ground water for commercial purposes, desertification, wood cutting for trade and over grazing are reducing the opportunities for inhabitants to work in agriculture and livestock-herding sectors. These respondents believe that these changes are causing migration to urban centres.

A smaller proportion of to urban centres. People surveyed (23.4 percent) believe that government policies are responsible for loss of interest in these traditional jobs. They think that government policies have accelerated the migration of younger generation to urban centers to work as teachers, clerks and soldiers instead of staying in their villages and towns and work as farmers, fishermen and herders.

In discussions with local inhabitants, it was found that tourism is expected to increase, and while local communities may not completely understand eco–tourism, they believe that too will increase. Those interviewed believe that the government will continue to improve educational

facilities, and thus, the benefits from education will spread amongst greater numbers. This is also clear from the government budgetary allocation for education at national and regional (ANP) level. An increase in the number of educational institutions and the number of teaching staff and students entering these institutions also confirms this trend.

8.2 Biodiversity

Given the establishment of the Supreme Commission for Tourism, the efforts to promote the internal tourism especially the environmental tourism during the hot summer and the increasing number of national and foreign tourists, Asir National Park will not be able to cope with these numbers. It can be expected that biodiversity will be reduced as a result.

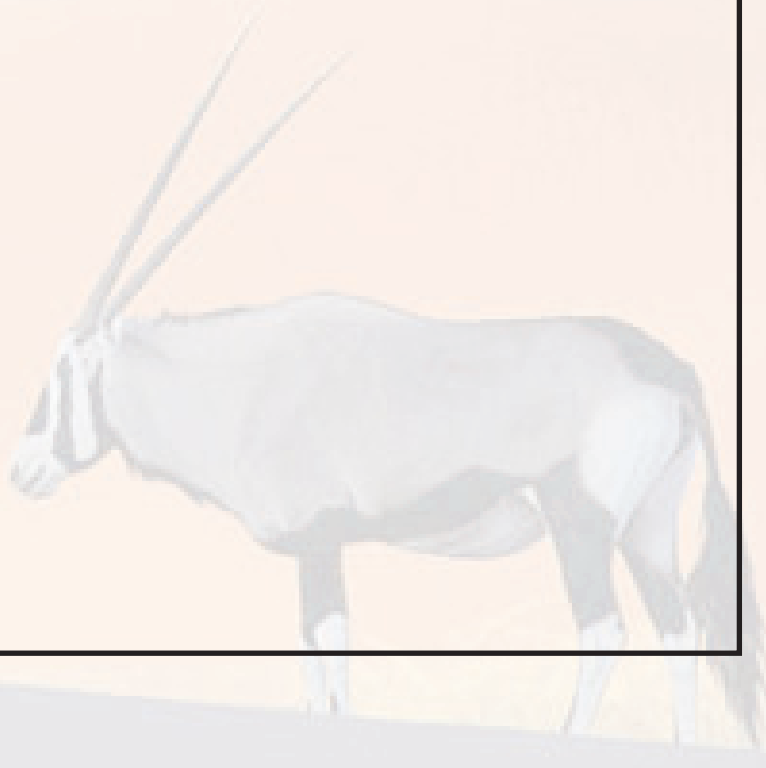
Develpment of ecotourism in ANP – Al-Sahab Restaurant

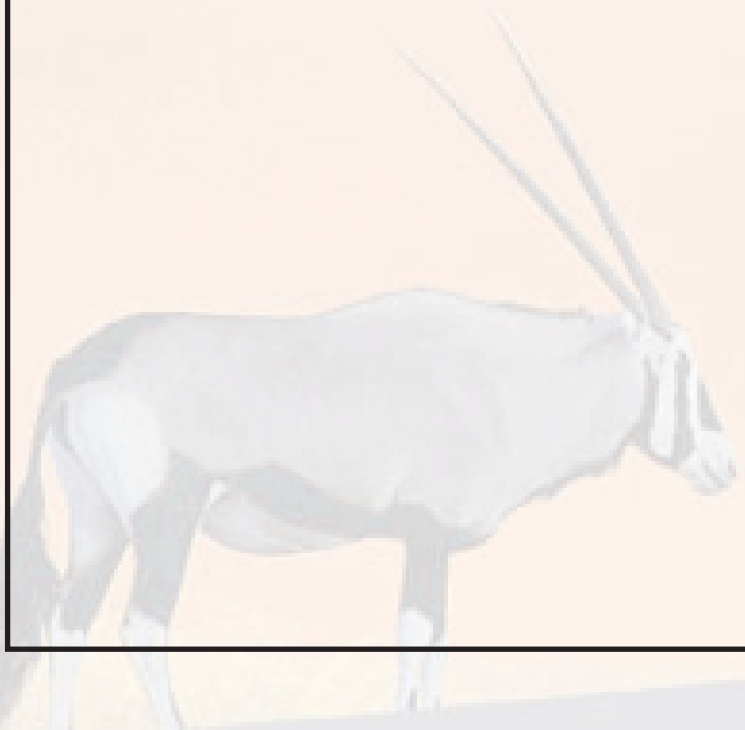
Develpment of ecotourism in ANP – Picnic Area

Another issue affecting biodiversity is the spread of invasive species, such as Opuntia ficus-indica, and Argemone Mexicana. While data on the extent to which these species are displacing indigenous tree varieties is not available, it is a worrying trend.

Section 9

Scenarios





Section 9 - Scenarios

9.1 Introducing scenario development

Scenarios are descriptions of possible futures. Scenario development allows us to explore a possible set of outcomes that might result if there is a change in the basic assumptions. Scenarios reflect different assumptions about how current trends will unfold, how critical uncertainties will play out and what new factors will come into play (UNEP 2002). Scenarios do not predict what the future will be. However if probabilities can be attached to a full range of uncertainties, this may be translated into a set of futures that has probability associated with each possible future. In this sense, it becomes possible to predict the probabilities of a given future occurring, much as hydrologists predict floods or meteorologists predict rainfall. The challenge here is to assign probabilities to the uncertainties.

Scenarios include an interpretation of the present, a vision of the future and the path that is taken from the present to various futures. Scenarios can include both qualitative and quantitative measures. Qualitative scenarios represent views and complexity of many different interests, often from many different stakeholders. On the other hand, quantitative scenarios are model based with numerical information which can identify underlying assumptions. The basic aim of scenarios is generally to provide better policy or decision support, and to stimulate discussion and creative thinking in the process of change at multiple scales.

Scenario Methodologies

Storylines were developed under the guidelines of UNEP for sub-global assessments. A wide range of stakeholders were consulted, including the ministries of Water and Electriciy, Municipal and Rural Affairs, Agriculture, Planning, NCWCD, PME, King Abdulaziz and King Saud Universities, farmers, pastoralists, fishermen, youth, society leaders, and other local inhabitants. Several communication tools were used, such as interviews, working meetings, discussions, visits, and questionnaires. The response was good from the local community. However, cooperation and coordination from the public sector was not as strong.

Scenarios serve a variety of purposes including the following:

- Help us understand the world better to make better decisions.
- Aid in recognition of weak signals of change.
- Raise awareness.
- Stimulate discussion and creative thinking.
- Create dialogue amongst different stakeholders accessing the same natural resources.

MA scenarios assess the consequences of contrasting development paths for ecosystem services. Ecosystems are dynamic and always changing. To complicate matters further, the pressures on ecosystems are increasing which can lead to reduced services provided by ecosystems or increased costs of maintaining services. As with all other components of MA conceptual framework, stakeholder participation in the development of scenarios is essential for a successful endeavor. In Saudi Arabia, the general population is not accustomed to participatory approaches. The Saudi Government should develop a sustainable education program to introduce the public to the need for them to participate in decision-making process. This was taken in to consideration when planning for the scenarios exercise.

9.2 Type of Scenarios used

Of the several different types of scenarios which can potentially be utilized, including qualitative

analysis, quantitative analysis and modeling, the ANP assessment applied a qualitative and exploratory scenario approach, where options for policy interventions are explored in each of the three different storylines. The approach was adapted from the Millennium Ecosystem Assessment scenario methodology and applied to the local context of ANP. Although four different types of ecosystems are discussed in the assessment, the scenario exercise focused on two: agriculture and forest ecosystems in the mountainous region of the Park.

9.3 Scenario Storylines

The three scenarios to be discussed herein refer to three different levels of interventions on how the mountainous region of Asir National Park will be managed in the future, and what the outcome will be with respect to their impact on human well-being and the environment. Examples of interventions include policy development and implementation to address climate variability and resources management; and investments in research and technology to support local management of ecosystems, water treatment and increased access to energy sources. Interventions can derive from either Government or the private sector, both of which have interests in the ANP. The three different scenarios presented as part of this assessment are:

- No intervention-market forces dominate.
- Public awareness, capacity building and training programs.
- Strong government policies and control measures geared up for sustainability.

Each scenario describes the state of both ecosystems (forests and agriculture), and the potential changes to the human well being of the local inhabitants. All the scenarios will be subject to the same uncertainties, such as the future climate, the impacts of international policies on local market forces, and environmental disasters.

9.4 Current state

Forest Ecosystem

Forested areas in ANP offer a number of different services to the local population and wildlife. In general, forests supply fodder for domestic animals, food, shelter and shade for wildlife, and food and medicines for humans. Examples of biological benefits include: conservation of plant cover that help in the soil fixation by the roots, improved aeration, prevention of soil erosion on slopes, and reduction of sand creeping due to high winds.

Juniper trees make up a large portion of the forested areas, especially along the slopes. When interviewed, the majority of local inhabitants (70 percent) said the Junipers are in good condition while the other 30 percent said the forests have deteriorated. They then stated that the major causes of forest destruction came from road and housing construction and from the expansion of urban centers. Fuelwood cutting still exists, with the most affected areas being on the mountain's lower slopes. The local community mentioned that the benefits they now receive from the forested areas include honey and medical substances, fodder for animals and picnic areas for themselves as well as for tourists.

Biodiversity in the region is closely linked to the health of the forest ecosystem. Although there is no data available to confirm the state of biodiversity with the forested areas, the assumption is that forest clearing for agriculture or deforestation directly and negatively affects the state of biodiversity in ANP. Forest ecosystems shelter a major part of terrestrial biological diversity, including an estimated 80% of all terrestrial species (see section 7.2 on biodiversity in ANP).

The natural vegetal cover of the Park is currently at risk of deterioration in some parts due to the adverse climatic factors and anthropogenic misuse. This risk is posed by unplanned tree removal, intensive unbalanced pasturing, fires, diseases, tree senescence (premature aging) and weak natural

regeneration which will lead to continuation of deterioration of the natural resources such as soil, water and wildlife if appropriate actions are not taken at various levels (see section 7.3, Ecosystem ervices).

Agriculture

The topography of the ecosystem is characterized by moderate to steep slopes. Soil is shallow and exposed to a continuous process of erosion mainly by rainfall. In the past terraces were constructed and maintained in the ecosystem as means for conserving soil and to increase water infiltration into the soil.

Traditionally, ANP agriculture systems consist of wheat, barley, maize, and some vegetables and fruits. Recently sorghum has also been introduced. Much of the agriculture production takes place on terraces. Due to the economic development in the country in the last few decades, the expansion of additional services and industries provide local inhabitants with alternative sources of income, reducing their dependence on agriculture production.

Consequently, some terraces were abandoned and gradually damaged. The abandoned and damaged terraces can no longer support soil and water conservation. As a result, soil erosion increased considerably to the extent that in some places, 20-80 cm of topsoil has been lost.

Erratic rainfall in the region poses a risk to the maintenance of terraces. High and intensive rains increase soil erosion by transporting soil particles from uphill to downhill where relatively deep soil sediments are found. Rainwater harvesting is generally on the decline.

9.5 Driving Forces and Uncertainties

In laying the foundation for the scenarios, it becomes necessary to identify drivers and select critical uncertainties. A list of possible driving forces, based on the results from the assessment, both direct and indirect is as follows:

Direct and Indirect Drivers

A direct driver unequivocally influences ecosystem processes and therefore can be identified and measured to differing degrees of accuracy. Indirect drivers operate more diffusely, from a distance, often by altering one or more direct drivers. An indirect driver can seldom be identified through direction observation of the ecosystem; its influence is established by understanding its effect on a direct driver.

(Millennium Ecosystem Assessment, 2003)

Direct driving forces

Economic - land use change –Changes in the way land is being used within the ANP for both the forest and agriculture ecosystems is one of the major drivers of change. Woodlands are cleared for crops without adequate soil and water conservation measures being put in place. Grazing and fuelwood collection (especially for the production of charcoal) are also important causes of land degradation, undermining watershed functions (Ministry of Agriculture, 2007). Further land is being cleared for development of housing and roads. While possibly improving the quality of life for the local inhabitants, in the absence of proper regulations, this could negatively affect the environmental stability of the area.

Science and technology - fuel -The construction of gas and power plants surrounding the ANP has greatly affected the local inhabitants' access to fuel sources. Previously, many inhabitants relied on fuelwood and charcoal. Though the practice still occurs, it is slowly on the decline as more communities are gaining access to the power produced by the new plants. An increased access to fuel sources will positively impact the quality of life of the local inhabitants, while also decreasing the dependency on the forested areas for fuelwood.

However, further research will be needed to assess the impact of fuel production on the surrounding environment.

Biological and Physical - climate variability and change – The agriculture ecosystem within ANP relies heavily on rainfall as water source and on the forest. High intensity rainfall causes high levels of run-off from highlands to the lower areas resulting in soil nutrient depletion and overall erosion of soil. Increased grazing, far beyond the carrying capacity of the land, causes soil compaction, reducing infiltration and enhances run–off. Unregulated tree-cutting also contributes to the soil erosion and loss of nutrients and water run-off. The impact of climate variability on the local inhabitants will depend on the adaptation and preparedness measures introduced through new government policies and through public awareness and education initiatives.

Technological adaptation - water desalination – Water shortages have been common in the past. Although they still occur, they are less frequent today due to the growing use of desalinated water. The use of this technology is changing the dependence on natural water sources (namely erratic rainfall) and has reduced the number of rain harvest systems present in the area. Desalinated water is mainly used for drinking and household use and not for agriculture purposes. This driver will continue to improve the health conditions for the local inhabitants.

Biological and Physical – nutrient loading – soil quality in the ANP is generally poor and no improvement or development factors are likely to occur in the foreseeable future. This is resulting from low humidity and continuous superficial regeneration through erosion and precipitation factors. An increasing use of inputs to compensate for poor soil quality will not sustain the agriculture activities in the future. There is a need to support soil fertility improvement initiatives such as agroforestry, intercropping and organic fertilizer use. Without proper soil quality, agriculture productivity will decrease inevitably, negatively impacting the local population, with a decline in locally produced staple foods and a loss of income.

Indirect driving forces

Economic – tourism – Domestic tourism in the park continues to generate income and employment for the local population. Visitors camp at the park and learn about different plant and animal species present. Growing population and economic development will increase the need for tourism in the area, which may negatively impact the forested areas in the long term. Some interventions regarding ecotourism have been implemented through public education, but an increased investment in this area will be needed to maintain the forests. Government policies will be needed to regulate and control the tourism in an environmentally sustainable way in general and for the forest in particular.

Demographic - changing or growing Population – The population in and around ANP is changing and increasing at a rate of 2.5 percent/year. Resources needed to support the growing population will also have to increase at a similar rate in the ANP. Management of both the forests and agriculture ecosystem will require additional resources and expertise.

Demographic - Urbanization Gradual development of roads, and the expansion of towns is affecting both forest and agriculture ecosystems. The clearing of forest and agriculture land for construction of roads, houses, and industry reduces forests' ability to absorb heavy rainfall, thus creating greater amounts of run-off. Changes to the agriculture production introduce additional services and means of income for the local population, thus reducing dependence on agriculture and increasing dependence of imported goods and services. With growing urbanization an increase in air pollution will begin to negatively impact agriculture (producing poor soil composition) and may possibly create health complications for the local population.

Cultural – changes to land and resource management (from traditional to more modern systems) As explained in section 6.2 the forests in the past were protected by the inhabitants through

the traditions and customs using a system called Al Hema. This traditional method of land management provided a means for the local population to enforce nature conservation.

In the last few decades, life in ANP area has changed and the traditional Hema system was neglected due to the introduction of a free open grazing system to all inhabitants. Living conditions have improved with the improvement of socio-economic aspects and as a result this traditional system

Type of driver	Driver	Indirect	Direct
Demographic	growing population	X	
Demographic	urbanization	X	
Economic	tourism	X	
Science and Technology	water desalination		X
Physical and Biological	climate variability		X
Physical and Biological	nutrient loading		X
Economic	land use		X
Cultural	land management	X	
Science and technology	fuel sources increasing		X

Table 9.1 Direct and Indirect Drivers

for land management or conservation has subsided to make way for more modern land policies and structures, accommodating the changing population

Uncertainties - A critical uncertainty is a driver that is very important in determining how the future evolves, but whose future development is highly unpredictable. In developing a scenario, the degree of uncertainty should be considered. Then, the relative impact or importance of each driver on the future should be considered. The critical uncertainties are selected from among those that have the highest importance or have the greatest impact on the future, together with the higher uncertainty.

Future climate - the potential changes in climatic patterns cannot be unknown, but based on global research on climate, it is expected to affect the health of ecosystems in the future. In ANP area, flooding had been a concern, which leads to an increasing rate of soil erosion in the forests along the slopes, amongst other issues.

International policies and local market forces – Growing concern for climate change, natural resources management, and fuel sources will influence future policy development at the global scale that may strongly encourage the direction of national policies towards ANP management.

Environmental disasters – the potential for environmental disasters, partially caused by extreme climatic variability is a potential uncertainty for the ANP. With flooding occurring in the past, the local population is susceptible to future flooding causing land degradation from land clearing and decreased forested areas. In 1988, an earthquake along the southern borders of Saudi Arabia affected the ANP region and subsequently lead to an increase in the baboon population which migrated from Yemen where the impact of the earthquake was very high.

9.6 Scenario Storylines

- **Scenario 1 (Al-Na'amah): No intervention from government or from private sector where market forces dominate**

This scenario looks at what the future may hold when no government or private sector interventions are planned, other than support for market driven economic development. The ANP area continues to develop at the same rate as present with little or no market regulation. There are no agriculture or forest policies in place for conservation or environmental services and local inhabitants, who previously relied on agriculture or forestry for their livelihood are forced to diversify their income generation to service provision for the incoming growing population. Economic development will dominate the political agenda and will accelerate urbanization, decreasing dependence on agriculture development, and also increasing pressure on land and forest use.

Housing construction and new roads will dominate the development activities in ANP. Although reduced fuelwood production will occur, the forested area will continue to shrink as a result of new housing and road construction. Income generation from forest products will decrease for the local inhabitants. Access to clean drinking water from the forested areas will decrease due to the loss of forested areas. However, additional desalination plants will be built in the area for water treatment and used to improve access to clean water. Storm run-off will continue to rise along the slopes resulting from gradual forest loss, causing further soil erosion, nutrient depletion and downstream land degradation, destruction of habitats for wildlife, sediments and buildings as well as farming land for the local inhabitants.

Agriculture terraces will continue to deteriorate because there will be little or no support for improving agriculture development in ANP. External economic and cultural influences will change the livelihoods of the local inhabitants, weakening their dependence on income generation from agriculture production. Rain water harvesting processes will be on the decline as more households gain access to water from new desalinization plants. However, the water from this source will not be used for agriculture production. Juniper vegetation along the slopes will be prone to drought due to reduced agricultural activity along the slopes. Many of the terraces will be abandoned because of poor crop returns and farmers shifting to other income generating activities.

Ecotourism

The number of tourists/visitors to the mountainous area of Asir National Park will increase at a rate at least equal to the population growth rate generally estimated to be in the vicinity of 2.5 percent. With no control, the increased number of visitors will result in an increase in the rate of environmental degradation of the Park. With growing unregulated and market driven tourism, the number of services and supports available to the tourism industry will also increase, creating more demand for land clearing for business development. With little or no investment, tourism will gradually erode the existing agriculture and forest systems.

Health, education and social conditions

With new development and a growing market economy within the ANP, the quality of health care will improve as will continued investment into education, however, the adverse effects of urbanization will create more and new health problems. Youth growing up in the area will be more interested in further studies overseas or in the urban areas rather than agriculture or forest industries.

Uncertainties

If the international markets and subsequent local markets decline, new services and business introduced into ANP in recent years will be negatively affected. An overall loss of income could potentially lead to a loss of basic needs of some local inhabitants, who may have previously relied on agriculture but shifted to alternative sources of living.

There has been flooding in the past, in 1984 and 1988 and although a new dam was constructed, there are still areas within the region susceptible to future flooding.

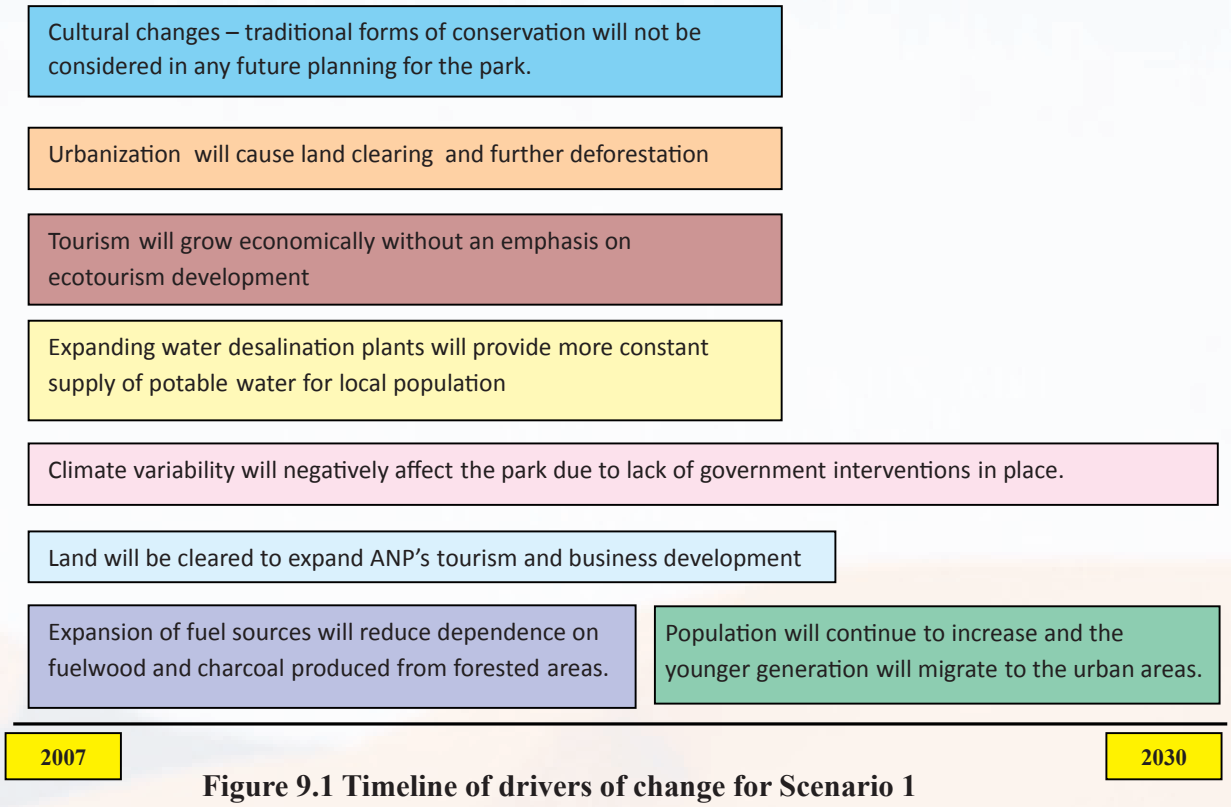


Figure 9.1 Timeline of drivers of change for Scenario 1

- **Scenario 2 (Al-MAHA Al-Arabi): Public Awareness, Capacity Building and Training programs Implemented**

In this scenario, limited interventions are implemented by the government through public awareness campaigns and education initiatives. In the next five years, without any strong policies in place to protect ecosystem services, their quality will slowly decline. Forested areas will continue to be cleared for more housing and road developments. Local inhabitants will receive less income from forested products and be forced to seek other income generating activities. More terraces will be abandoned and less agriculture production will result in fewer locally produced staples, increasing the local prices. Land clearing for development will create more storm run-off, leading to siltation.

Once services begin to adversely affect the local inhabitants, local community leaders, government and private sector stakeholders will lead an awareness-raising campaign to address some of these issues. Awareness raising campaigns will involve disseminating information on issues such as environmental protection, sustained use of resources (water, fuel, land, vegetation, forests), water reuse and recycling, and sustainable agriculture.

Forests

The forest ecosystem in ANP will initially be negatively affected by the expansion of urban centres, roads and land clearing for more agriculture production. The local population will be less dependent on forest materials and products for income because of a growing demand for new services in the urban centres which will lead to less investment in the maintenance and management of the forests. The younger generation will be less interested in forest related careers, which will

result in a lack of local forestry specialists in the future. Due to the relatively high level of rainfall in forested areas, much of the current forests will be converted to agriculture land. Since forests in ANP are home to most of the diverse plant and animal wildlife, biodiversity will be lost.

Agriculture

Overall, agriculture will continue to decline as per past trends. Alternative sources of income will reduce the dependence on agriculture for income. The high labour inputs into terraced agriculture will gradually decrease but will remain steady with new non-Saudi workers managing the land. Many terraces will continue to degrade. Decline in agriculture production will increase prices for staple foods and increase the dependence for imported food items for the ANP area. Soils will erode (because of declining forest cover as well as poorly maintained slopes). Storm run-off will deplete nutrient rich soils, thus increasing the demand for more external fertilizer and nutrient inputs.

Ecotourism

Tourism will be on the rise, bringing more people through the forested areas, but with decreasing support for maintenance and management. Tourism will accelerate the degradation of the forests. A population increase of 2.5 percent per year will result in an increase in the number of forest visitors of at least that rate. Thus, forest land degradation should occur in proportion to the number of visitors to the forest lands.

While no direct intervention will occur, local inhabitants will tend to police themselves and visitors as well, so that negative impacts will be reduced.

Gradual Changes due to increasing public awareness

Pressure from the public awareness campaigns will encourage national government interventions and policy enforcement around forest protection, development policies and land use restrictions to prevent road and housing projects encroaching protected forest and agriculture land.

The local population and those involved in forest preservation will begin to raise awareness of the degrading forests and start campaigning about the benefits, which include soil erosion prevention along slopes, the provision of fodder sources for domestic and wild animals and the production of products such as fruits, seeds, medicines, honey.

Local inhabitants affected by changing agriculture practices will begin to raise awareness of the decline in ANP which will encourage local leaders to negotiate with the government to reinforce effective policies.

Ecotourism activities will be implemented in an attempt to reverse forest degradation. Visitor limitations will be reinforced to reduce the number of people visiting the forest. Regulated replanting systems will be put in place by the local population. Shortly thereafter, public awareness and resulting pressures will be at a sufficiently significant level to force the government to take notice and inaugurate capacity building and training programs around sustainable forest management and reintegration of income generation from forest products.

Uncertainties

Changes to international and local markets and drops in commodity prices will most likely create the demand to shift government priorities. This would allow for more investment into forest and agriculture management, improving the quality of life for local inhabitants of the ANP. Climatic variability could adversely affect the region in the near future and accelerate a government response to policy development around maintaining the two ecosystems as well as ensuring the local inhabitants are not devastated by extreme weather changes.

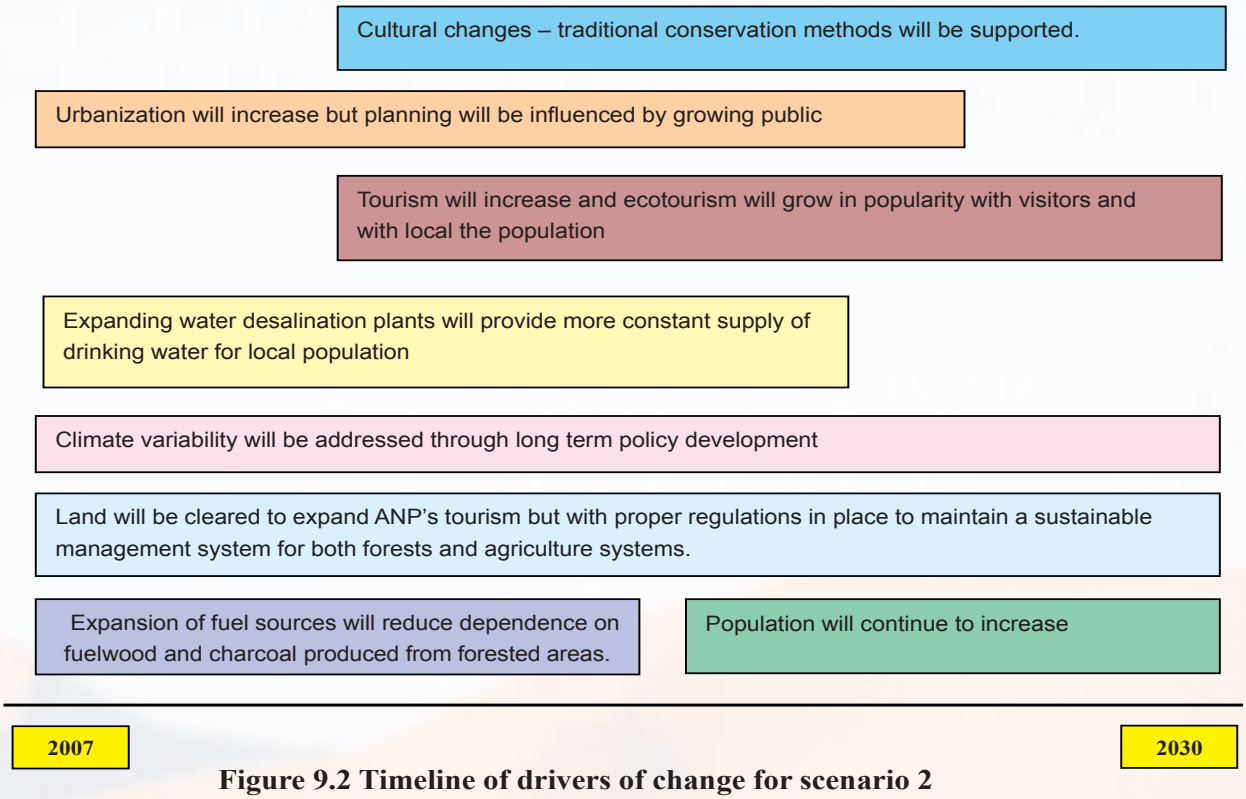


Figure 9.2 Timeline of drivers of change for scenario 2

- **Scenario 3 (Al-Nimr Al-Arabi): Government Policies aimed at Sustainability of Forest and Terraced Agriculture**

In this scenario, the Saudi government supports policies around sustainable forest and terraced agriculture management practices. Although it is the most expensive, it is potentially the most desirable in regards to supporting ecosystem services and human well being. A more progressive approach, including the involvement of local inhabitants and public awareness will replace existing traditional cultural habits and attitudes. However, an understanding will be maintained of the value in certain customs for conservation such as the use of Al Hema.

Policies will include control measures to provide environmental protection to the forested area, repairing of damaged terraces and an increase in expenditure for socio-economic activities to improve the quality of life of the local inhabitants.

Development, implementation and reinforcement of policies related to forest protection and management and sustainable agriculture will be the focus of near future planning. An integrated approach to investing in education and health would include training and awareness-raising initiatives to support human well-being relations to ecosystem services. Investment in research, science and technology will study the socio-economic potential of forested areas. Abandoned terraces will be supported in reconstruction, and existing terraces will be supported in maintenance needs. Tourism will be regulated by the Supreme Tourism Commission and ecotourism will be introduced as a main approach to tourism in the mountainous area of ANP. Additional support will be made available to coordinate different government agencies, non-government organizations and the private sector to work collaboratively on policies supporting sustainable ecosystem management and human well-being. Job opportunities for the local population will be ensured which would lead to fewer youth migrating to bigger cities and towns.

Forests and Agriculture

An ecosystem services approach to forest management will be developed and implemented for the ANP. Local inhabitants will be involved in the planning and design of these policies to ensure that the policies are relevant to their context and that the local community will lead the reinforcement and monitoring of such policies. Policies around tree cutting and fuelwood and charcoal will be reinforced. New regulations on land clearing will be developed and reinforced by the local gover-mant in collabration with local population to reduce the amount of forest loss due to development. Terraced agriculture production will be supported by new policies developed by the government. New labour policies for foreign workers assisting on private farms will encourage land owners to maintain their terraces and follow migrant worker guidelines.

Ecotourism

New tourism plans will focus on ecotourism as a means for educating local inhabitants and the general public on the importance of environmental protection. It will also involve regulating the number of visitors in the park to reduce the human impact on the ecosystems.

Uncertainties

Climatic changes such as decreased rainfall will be considered when developing and implementing new government policies on ecosystem services. Rainwater collection will be encouraged to offset potential damage from drought. Better preparation mechanisms will be in place to manage future environmental disasters through early warning systems.

Market fluctuations will harm initial agriculture production, however production will recover be-cause of the support received from the government.

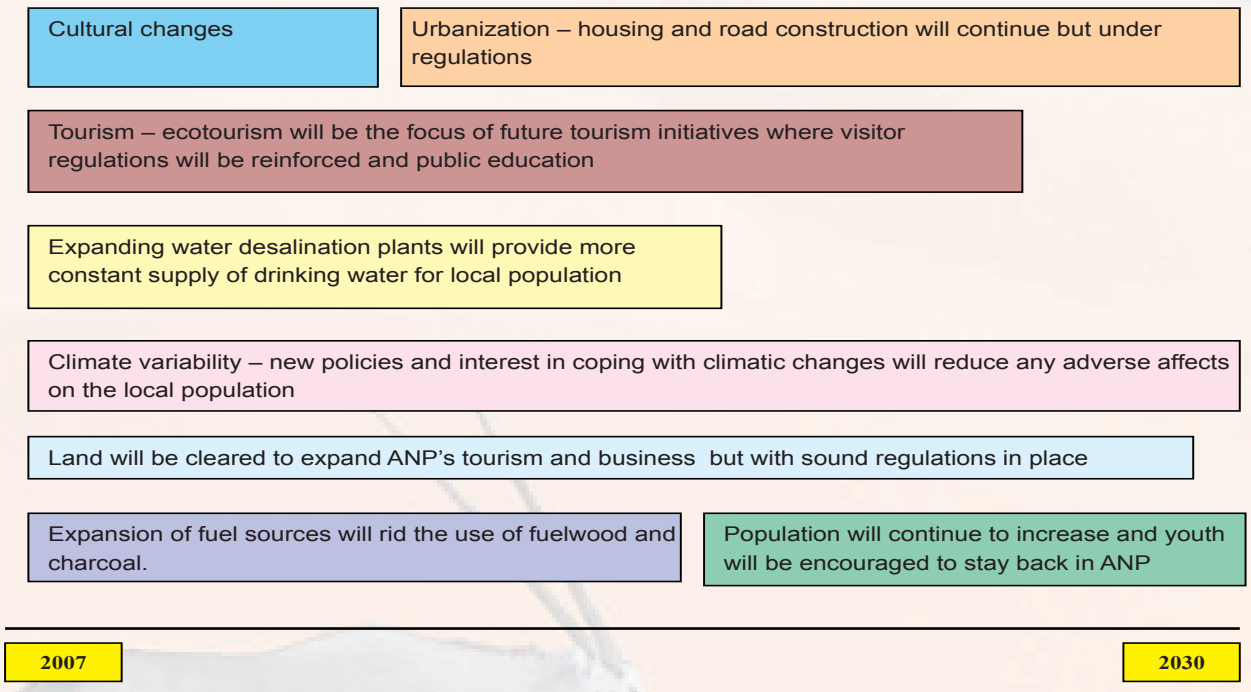


Figure 9.3 Timeline for Drivers of Change for Scenario 3

9.7 Implications of Scenarios

Based on the information collected during the assessment and the discussions documented during the scenarios process, the most plausible scenario would most likely be scenario 2, where interven-tions will occur, but not to the effect needed immediately. The Saudi government has already been

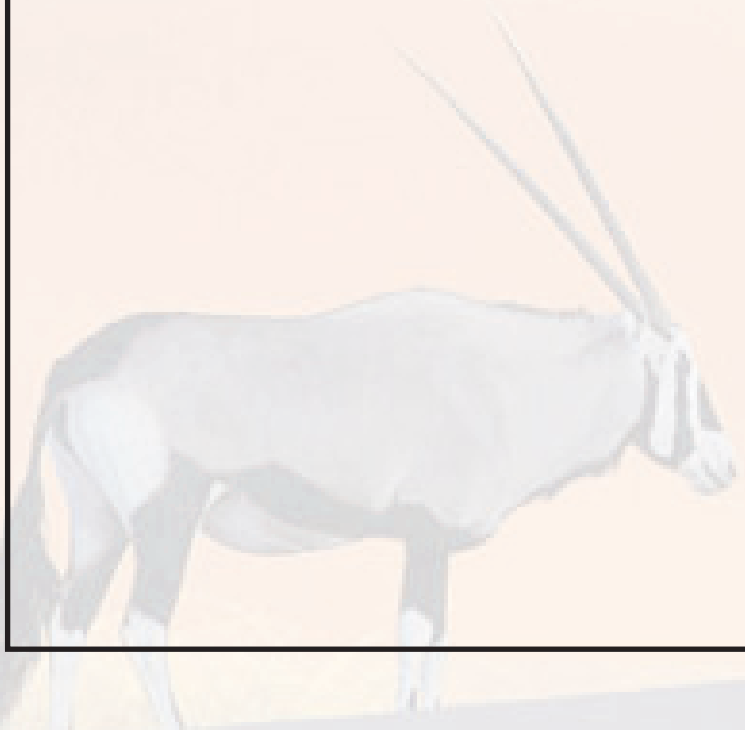
working towards implementing and reinforcing new policies on sustainable forest and agriculture management yet the challenge will be to work with the local inhabitants to support these policies over time. Public awareness and education initiatives will serve to inform the local population and the government on the importance of local policing and reinforcement of certain ecosystem management policies, which could potentially strengthen the effectiveness of future policy development initiatives. The more policies that are developed with the local population involved, the more effective and successful policies will be in meeting the needs of the local population and offsetting any negative impacts on the ecosystems in the ANP.

The most prominent drivers in all three scenarios are science and technology and climate variability. Since there is considerable investment in water desalination, and energy resources, the three scenarios describe different implications for each of these drivers. With little or no intervention in scenario one, development of science and technology will dominate over the preservation and management of the ecosystems. When there are policies in place to support both quality of life, and sustainable resource management, investment in science and technology will work to accommodate human well-being while maintaining sustainable management practices. Responses to climate variability will be directly influenced by the type of interventions developed. In scenario three for example, if there are interventions that are locally driven and nationally implemented, the necessary institutional and technological support will be in place to match the changing needs of climate variability.

It is important to deal with different aspects of uncertainties when developing and using scenarios and assessing responses. However, a limited understanding of ecological and human response processes can lead to caution in the use of scenarios. There are a number of reasons for this. First, individual scenarios represent conditional projections based on specific assumption. Thus, as the understanding and representation of the ecological and human systems is limited, specific scenarios are characterized by their own uncertainty. Second, there is uncertainty when translating the response derived from scenarios developed at one level to the assessment of responses at another level. The third reason to be cautious in the use of scenarios as environment scenarios tend to be more effective in the use of natural science modeling than social science modeling. The usefulness of the scenarios exercise is in the ability to generate discussions around potential changes in human – environment conditions based on historical accounts and current observations of the current state. Produced through a participatory process, it allows diverse stakeholders to identify linkages between certain drivers, environmental services and the impact on overall human well-being of communities dependant on the services in a particular area.

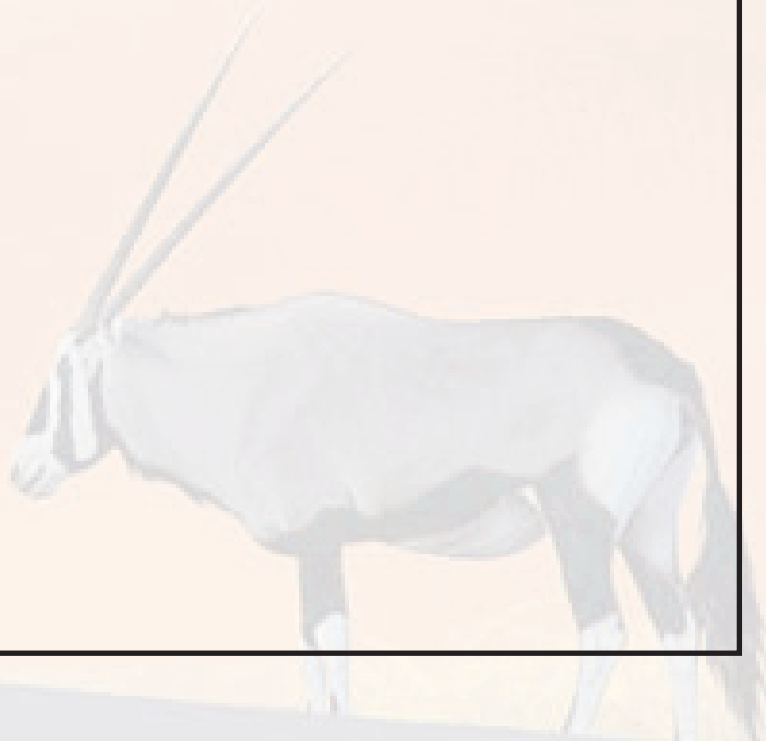
Drivers	Scenario 1	Scenario 2	Scenario 3
DIRECT			
Water	→ -	↗ +	↑ +
Climate variability	↓ -	→ +	→ +
Land use	↑ -	↘ -	→ +
INDIRECT			
Population increase	↑	↗	→+
Urbanization	↑ -	↗ -	↗ +
Land management	↑ -	↗ +	→
Land clearing	↗ -	↗ -	→+

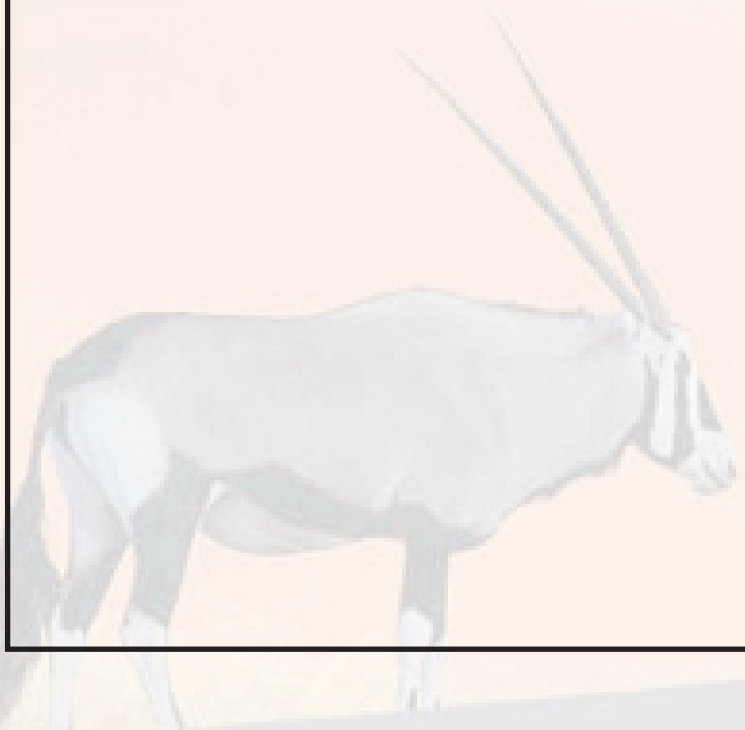
Table 9.2 Comparison of drivers in each scenario



Section 10

Responses





Section 10 - Responses

Responses are considered to be human actions such as policies and strategies for a given purpose. Responses may be technical, economic or institutional, and may operate at various levels of management. In Saudi Arabia, these responses generally emanate from the highest level of government. In relatively normal situations, responses to environmental problems tend to be more successful when:

- There is effective coordination among different levels of decision- making.
- Stakeholder participation is ensured, and
- There are trade-offs among ecosystems, ecosystem services and human well-being

Effective action to address problems related to ecosystem services requires improved coordination across international, regional, national and local levels of decision-making. Almost any action affecting an ecosystem has consequences including trade-offs. For example, by improving crop production through the use of fertilizers; such an action could affect, in a negative way, water quality, and fisheries production or flood control. These trade-offs cannot be adequately addressed by either through traditional sectoral management approaches, or through action taken at a single level. Thus, effective ecosystem management requires effective coordination among government institutions directly responsible for environment at all levels of governance, among relevant institutions and sectors.

Establishment of Ministerial Committee on Environment in 1994 under the Chairmanship of HRH Prince Sultan Bin Abdulaziz, the Crown Prince and Minister of Defense and Aviation and Inspector General was to ensure effective coordination among relevant sector ministries and government institutions on environmental issues. This is the highest environmental policy-making body in the country with PME as the General Secretariat of the Committee. Other ministries and agencies represented in the Committee are Ministries of Defense and Aviation, Interior, Petroleum and Mineral Resources, Agriculture, Water and Electricity, Trade and Commerce, Planning, Municipality and Rural Affairs, and KACST.

To meet the current environmental challenges posed by the development taking place in Saudi Arabia, Council of Ministers by Resolution No. 22 dated 29.01.1430 H (26 January 2009) established Environmental Council (EC) as a substitute for the Ministerial Committee on policies, regulations and national strategies on the environment in order to ensure that the developmental work undertaken by all government and private sectors take environmental protection, conservation of natural resources and principles of Sustainable Development into consideration through various stages of development. Into consideration through various stages of development. This will be achieved through the application of Environmental Regulations and its Implementation Procedures, and implementation of the local environmental legislations as well as the Regional and International Conventions, Treaties and Protocols ratified by the Kingdom. The Council is also having the role of coordination between those sectors to follow-up their environmental performance through specialized channels within the Council in order to be studied and developed for approval and implementation.

The Environmental Council is composed of sixteen members represented by a high ranking official from the following ministries and agencies; Presidency of Meteorology and Environment, Ministry of Foreign Affairs, Ministry of Municipal and Rural Affairs, Ministry of Petroleum and Mineral Resources, Ministry of Health , Ministry of Trade and Industry, Ministry of Water and Electricity, Ministry of Agriculture, Ministry of Transport, Ministry of Finance, Ministry of Economy and Planning, Ministry of Information, King Abdulaziz City for Science and Technology, Saudi Commission for Wildlife, the General Authority for Tourism and Antiquities.

At the local level, there are permanent committees at the governorate levels under the governor of the region to look into and deal with different local and regional environmental issues. These are expected to help the ANP, and other areas, develop local responses to the environmental challenges facing the region. The date of the Royal decree is (Jan 26, 2009)

10.1 Review of responses in ANP

PME Regional Training Center - Al-Soda:

Considering the importance of training and capacity building, the Presidency of Meteorology and Environment (PME) has established a "Regional Training Center" in Al-Soda to train Saudi Graduates in the field of meteorology and environment. The center is also planned to serve to the regional requirements of training and capacity building in the GCC and Arab League member states. The center has been equipped with the state of the art facilities like laboratories, computer networking, instrumentation etc.

Overview of PME's Training Center in Al-Soda

Ministry of Agriculture Regional Headquarters:

The Ministry of Agriculture (previously Ministry of Agriculture and Water) required that Asir National Park be established without changing or modifying the natural environment. For this reason, local raw materials were used for construction of infrastructure in the Park, which has given the magnificent design a complete and natural panorama. The Ministry insisted on giving the young

citizens a chance to try themselves by operating and maintaining this park as the Saudis are part of and qualified for such things.

Hoarding shows using part of ANP for sports activities

results of this experiment of Saudis running the park. The ANP administration takes care of guests who visit the national park and provides any required information. It also welcomes citizens from outside ANP area to use all the facilities. It takes care of the maintenance and operation of all park facilities. It goes further in its activities by preparing, training and demonstrating to visitors how to appreciate the park in their daily lives. It provides in-depth information, including through seminars which educate the public on nature preservation and heritage preservation both inside and outside the park.

Messages For Public Awareness, strengthning the concept of Environmental Protection in ANP

Specialized area for rehabilitation of Juniper species

Raydah Reserve:

The Raydah Reserve was created by an NCWCD policy to preserve a relatively pristine example of Asir juniper woodland habitats and their associated wildlife (NCWD 2007). The Raydah escarpment was declared a Special Natural Reserve by the NCWCD Board of Governors in 1989.

Raydah provides one of the few intact examples of virtually pristine escarpment juniper woodland, and habitat for a high density of the south-west Arabian endemic and near endemic bird species. The stakeholders are as follows:

- The inhabitants of Raydah village at the bottom of the escarpment, and As-Suqah settlement at the top;
- Members of the Rejal Al-Ma and Baalahmer tribes
- Ministry of Agriculture, Department of National Parks which administers Asir National Park.
- The local governorate and Abha municipality
- Joint owners of the football field and upper reaches of the reserve, including the land on which the current ranger station is sited.
- Owners of the two farms in the upper central part of the reserve
- Summer tourist visitors to the region.

The reserve is situated in Asir Emirate, approximately 15km from the city of Abha, accessed from the main road between Abha and Al-Soda. The reserve effectively lies on the southern edge of Jabal Al-Soda (Al-Soda mountain).

The reserve itself consists of 9km of steeply sloped escarpment, dropping from a maximum of 2,850 to 1,600m above sea level, just above Raydah village. The reserve encompasses pristine juniper woodland in the upper portion, giving way to open scrub and grassland in the lower reaches. Given the fall of 1,000m in 3km^2, the actual area of Raydah reserve has been estimated at 12km^2.

Under the Reserve's designation as an SNR, all livestock should be excluded from the protected area. In practice however, grazing of the juniper under-storey does take place.

Afforestation Efforts:

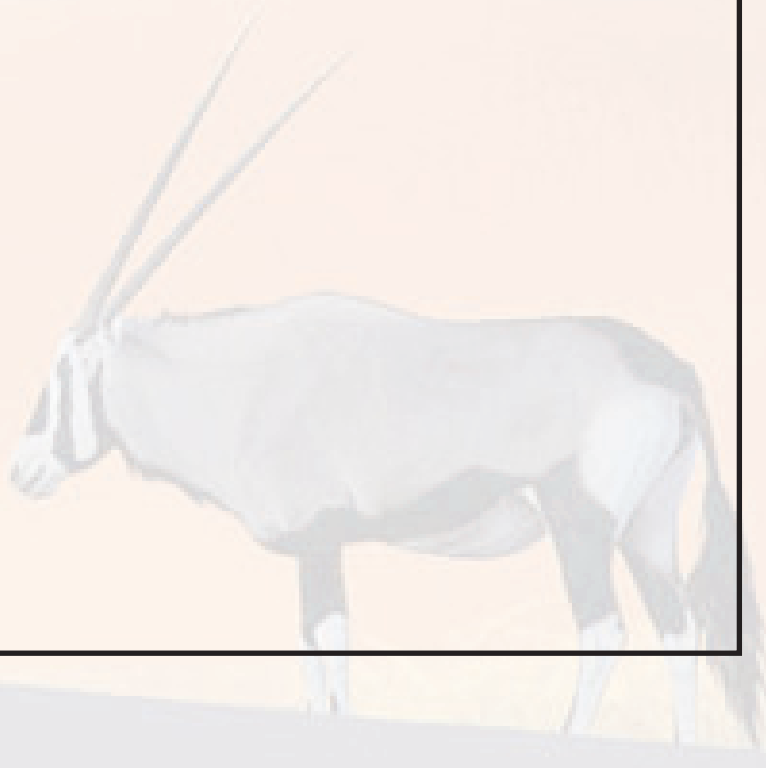
The Government of the Kingdom has paid great attention and concern towards forests conservation and development. This was reflected in the preparation of the National Forest Strategy (NFS) and National Forest Programme (NFP). Table 10.1 shows the afforestation efforts in the ANP area.

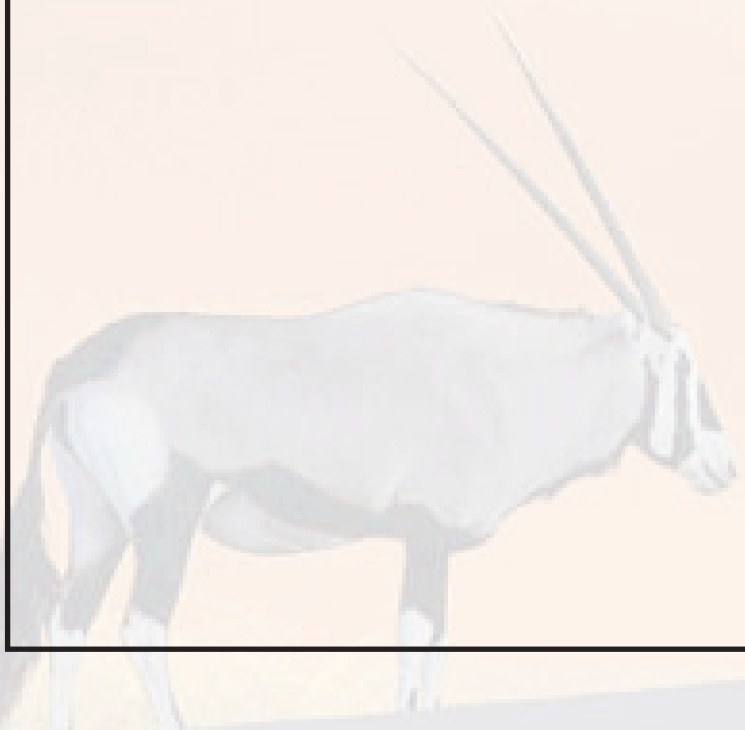
Region	Site Name	Area in ha.
Asir	Sir Lasan	4.0
Asir	Buhairat Al Sad	3.0
Asir	Muntazah Al Mistaf	15.0
Asir	Garb Abha	6.0
Asir	Abu Sidg	25.0
Asir	Sir Lasan	12.0
Asir	Dulgan	22.0
Asir	Shuab Al Khamira	5.0
Asir	Hawl Abha	10.0
Asir	Ballasmar	3.3
Asir	Al Namas	3.3
Asir	Al Batra	15.0
Asir	Kharif	20.0
Total in Asir		**143.6**

Table 10.1 Afforestation efforts in the ANP area

Section 11

Conclusions/Synthesis





Section 11 - Conclusions/Synthesis

The objective of the Millennium Ecosystem Assessment (MA) was to assess the consequences of ecosystem change for human well-being, and to establish the scientific basis for actions needed to enhance the conservation and sustainable use of ecosystems and their contributions to human well-being. As reflected in the study, the MA included the following assessments:

- Current State and Trends.
- Scenarios, and
- Policy Responses.

The study presented the assessment made for the Asir National Park (ANP) in Southwestern Saudi Arabia, the first to be established in the Kingdom. The Park represents at least four distinct ecosystems ranging from a mountainous area to a coastal plain in close proximity to each other. The study focused on one of these ecosystems, the mountainous agro-forestry and assessed their relationship to human well-being.

The mountainous agro-forestry ecosystem provides a variety of benefits to the local people, generally known as ecosystem services. Examples of such services are food, fuel, fresh water, regulation of human diseases, erosion control and water purification. The Juniper natural forests provide water, food, fuel, and opportunities for education, recreation and eco-tourism as well as the provision of other environmental services to the region. This is in addition to the conservation of natural resources such as soils, wildlife and biodiversity.

The current major threats to the forest ecosystem in ANP include settlements and associated road construction, as well as agricultural expansion. Moderate threats include overgrazing, deforestation, hunting, over fishing, pollution, dumping of refuse, littering associated with tourism and recreation, insecticides, landscaping with exotic plants, and invasive species, such as *Opuntia ficus-indica, and Argemone Mexicana*.

Owing to the current and past status review of the forest ecosystem in ANP, it was found that the ecosystem is deteriorating both in health and extent. Consequently the ecosystem services were also affected. The deterioration of ecosystem services is one of the causes of the immigration of young people to bigger towns within the Kingdom, as they look for better livelihood opportunities.

The last three decades have seen socio-economic, educational, technical, environmental, political and institutional changes; these changes have their own direct and indirect negative impacts on forests. These are likely to worsen in future as a result of the following driving forces.

- Increase in population and their immigration to urban centres and nearby forests. This will cause urban expansion and increase in environmental tourism.
- Most of the urban centers in Asir National Park are located within the forests areas. So the forests are going to be affected by urbanization and expansion of agriculture activities and roads expansion within the forests.
- Environmental issues will be worsened because of expansion of agriculture desertification, sands movements; increased demand for water, grazing lands and fuel.
- Lack of private sector interest in the forest management and development.
- As a result of the government policy to protect water resources; people have started using forests areas for agriculture as it receives higher rainfall resulting in decrease in the extent of the forests.

- Increased environmental tourism will cause more pressure on forests because of its favorable weather conditions which may lead to deterioration of forests.

These threats are clearly recognized by the government of Kingdom of Saudi Arabia. The development of cost-effective soil, water and biodiversity conservation practices are going on but not at the desirable pace since forest ecosystem degradation is taking place at faster pace than the technical remediation efforts. This is due to limited experience and lack of specialized personnel to promote sustainable management and to combat land degradation in mountainous areas, and to improve the quality of life of the local population.

The fundamental socio-economic problems related to the development of forestry sector are as follows:

(i) High costs of the reforestation and expansion of forests in forest sites.

(ii) Lack of forestry specialists.

(iii) Overpopulation and population increase.

(iv) Unorganized intensive tourism.

(v) Urban and agricultural expansion within forest sites.

(vi) Human activities.

(vii) Pests and Diseases.

The Kingdom of Saudi Arabia has established a policy to create and maintain a system of parks and related reserves. The purpose of this is to ensure that the scientific, natural, and cultural resources of the Kingdom will be identified and given protection for the benefit and enjoyment of present and future generations. But the lack of qualified personnel to manage the natural resources in an environmentally sound and sustainable manner is hindering this policy.

It is widely recognized that stakeholder participation in planning and decision–making is essential for any proposal to be successfully implemented. To ensure the involvement of stakeholders, public education and awareness is considered to be an effective tool. A number of stakeholder organizations and agencies such as Presidency of Meteorology and Environment (PME), National Commission for Wildlife Conservation and Development and Ministry of Agriculture have embarked upon ambitious programs of public education and awareness. However, in Saudi Arabia, the general population is not accustomed to participatory approaches. It is recommended therefore that the Saudi Government develops a sustainable education program to introduce the public to the need for them to participate in decision-making processes.

Three scenarios have been discussed referring to three different levels of interventions on how the mountains region of the Asir National Park will be managed in the future, and what the outcome will be with respect to their impact on human well-being and the environment. The three different scenarios were:

Scenario 1: No intervention-market forces dominate.

Scenario 2: Public awareness, capacity building and training programs.

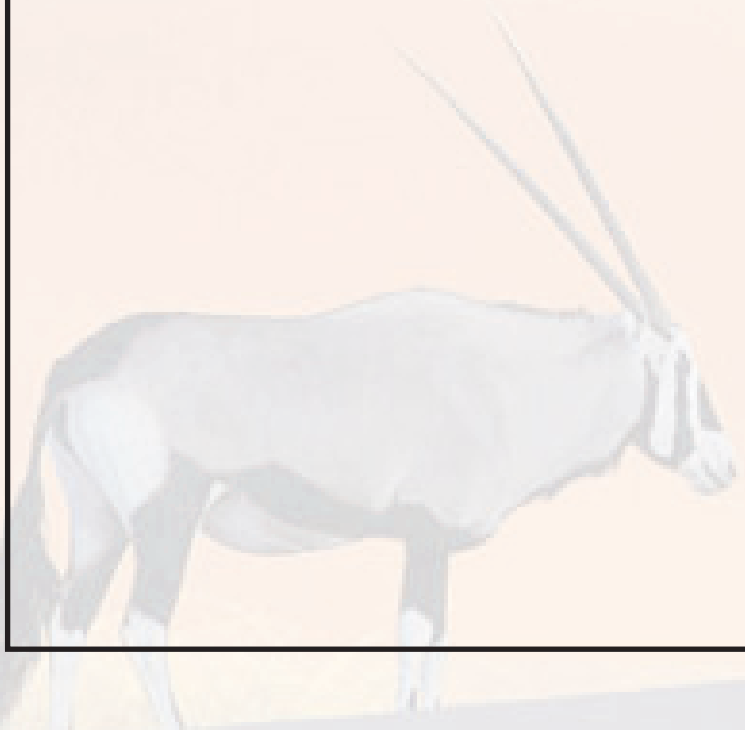
Scenario 3: Strong government policies and control measures geared up for sustainability.

Each scenario has two components, one for the forests and the other for agriculture both located within the mountainous region of the park. Each component will have the same current state for the three scenarios. Then, for the two components (forests and agriculture), the future impacts resulting from the three scenarios of interventions were presented. All the scenarios were subjected to the same uncertainties, such as with future climate, international policies and with local market forces.

Scenario 3 was found to be the most desirable and the most expensive. Not only does it include control measures to provide environmental protection to the forested area but it also includes expenditures for socio-economic factors to improve the quality of life of the local inhabitants. This will result in the following:

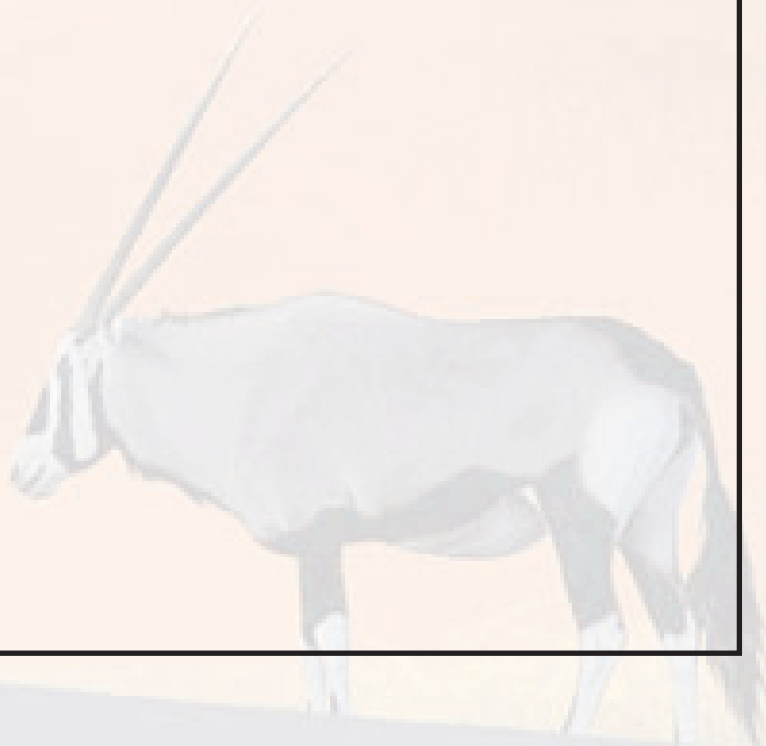
- Government policies that promote solutions with the goal of enhancing human well-being, protection of environment and conservation of natural resources.
- Heavy investment in education, capacity building and training programs.
- Health and environmental issues become a major concern of the government.
- Major funds for science and technology including research and development to address socio-economic impacts of forest areas.
- Make plans for economic development with minimal negative impacts on forest areas.
- Support Supreme Tourism Commission in adopting measures and policies for controlling and regulating tourism in forested areas.
- Promote eco-tourism as a means for educating local inhabitants and the general public on the importance of environmental protection and conservation of natural resources.
- Strengthen coordination and cooperation among government agencies, non-government organizations and the private sector in planning and development activities.
- The prime objective of the integrated approach for managing the forests and adjacent areas should be Human well-being and sustainable environment.
- A more progressive approach, including the involvement of local inhabitants and public awareness should replace existing traditional cultural habits and attitudes.
- Degraded portions of forest ecosystem will be rehabilitated.

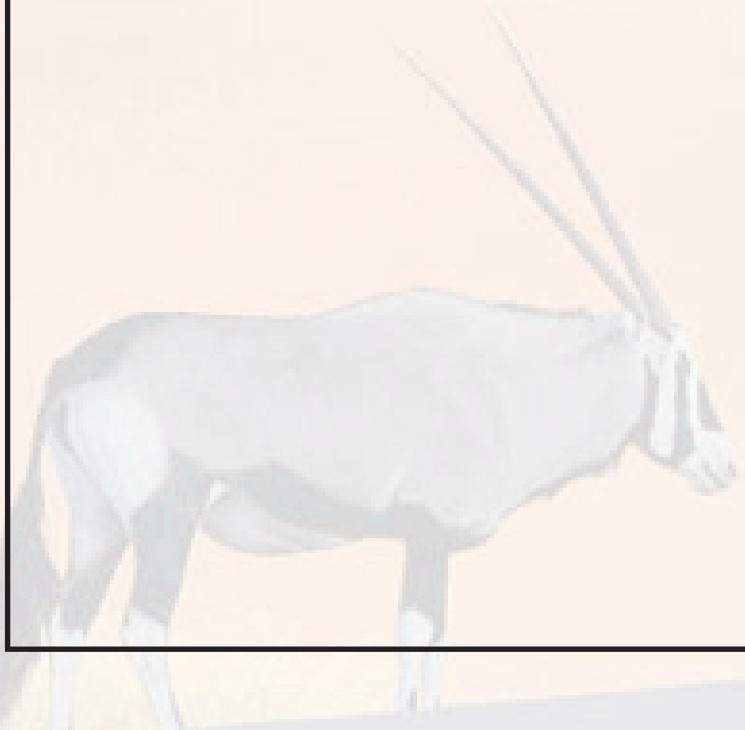
Effective action to address problems related to ecosystem services requires improved coordination across national and local levels of decision-making. Almost any action affecting an ecosystem has consequences including trade-offs. These trade-offs cannot be adequately addressed by either through traditional sector management approaches, or through action taken at a single scale. Thus, an effective ecosystem management involving effective coordination among government institutions directly or indirectly responsible for environmental issues, non-government organizations and private sector is needed to manage the forest areas in the Kingdom of Saudi Arabia.



Section 12

References





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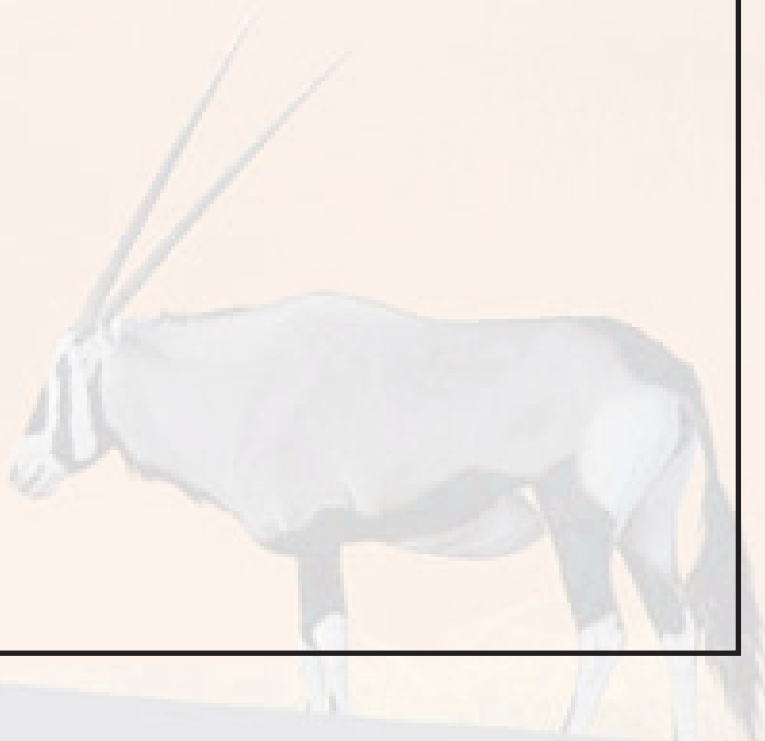
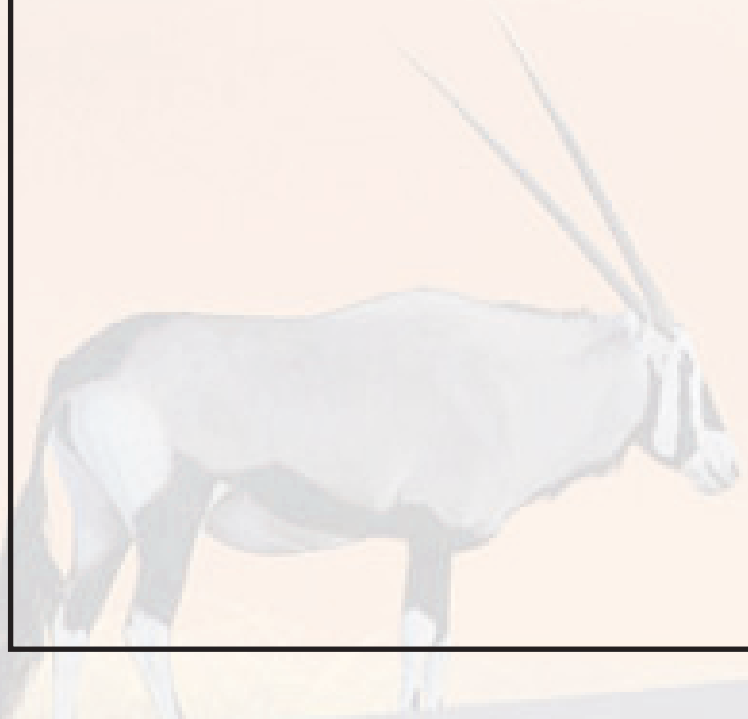
Section 13

List of Participants





Section 13 - List of Participants

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Mr. Adel M. Gusti, PME

Mr. Mohammed A. Bukhari, PME

Mr. Jamal M. Ismail, PME

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Mr. Ali Yaeenallah, NCWCD

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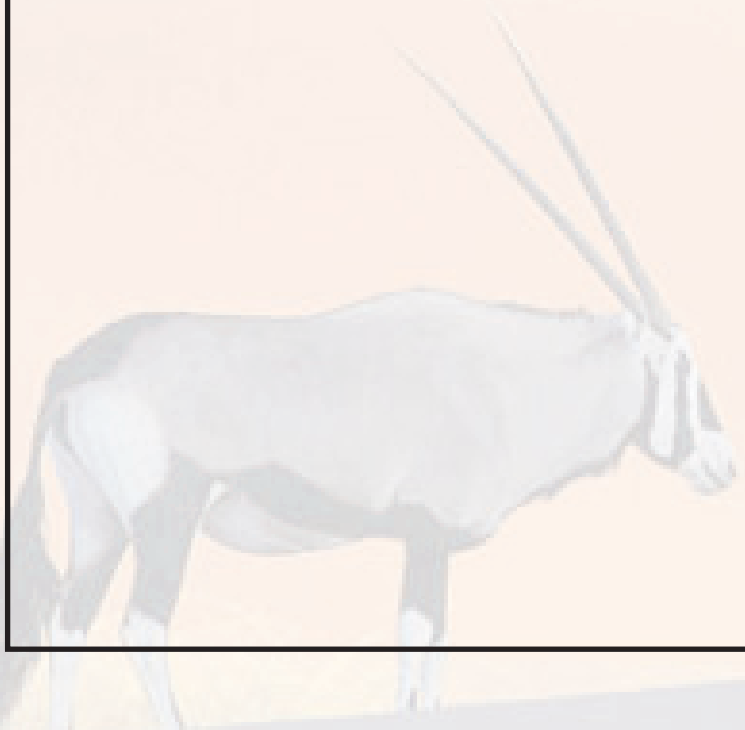
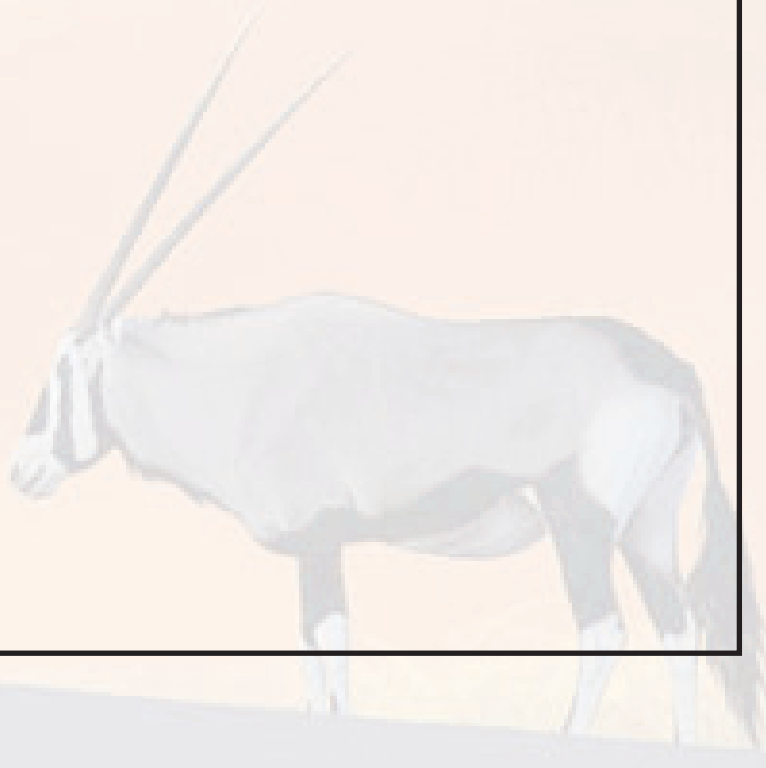
Mr. Abdulwahid Al-Almai, Environmental Specialist, Abha Regional Office, PME

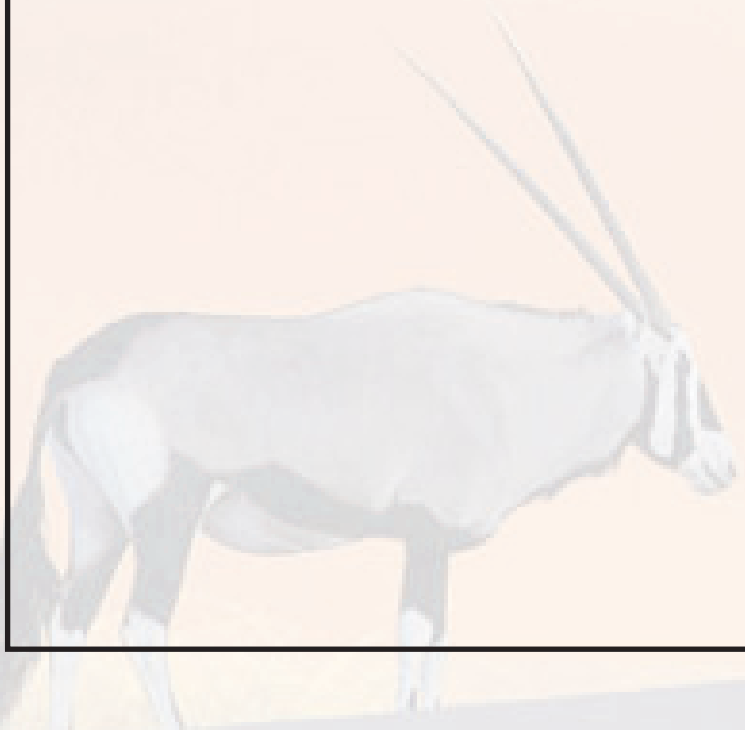
Mr. Faisal M. Al-Qahtani, Environmental Specialist, Abha Regional Office, PME



Section 14

List of Fauna and Flora in ANP





Section 14 - List of Fauna and Flora in ANP

Source: National Commission for Wildlife Conservation and Development (NCWCD)

List of Plants, Algae, Fungi, and Lichens in ANP

Taxon (Scientific name)	Criteria
Fungi	
Podaxis pistillaris	Ecn
Terfezia claveryi	Ecn
Tirmania nivea	Ecn
Lichens	
Usnea articulata (L.) Hoffm.	Rlc; Ind; Ecn
Usnea bornmuelleri J. Steiner	Rlc; Ind: Ecn
Algae	
Cystoseiraceae	Kst
Sargassaceae	Kst
Non-Vascular Plants / Bryophytes	
Hepaticopsida (liverworts):	Rlc; Ind
Bryopsida (mosses):	Rlc; Ind
Vascular Plants	
Pteridophytes	
ACTINIOPTERIDACEAE	
Actiniopteris radiata (Sw.) Link	Edg; Ind
ADIANTACEAE	
Adiantum capillus-veneris L.	Edg; Ind
PARKERIACEAE	
Ceratopteris cornuta (P. Beauv.) Le Prieur (nc)	EDG / Ext, Rlc; Ind
PSILOTACEAE	
Psilotum nudum (L.) Beauv.	Edg; Rlc
PTERIDACEAE	
Acrosticum aureum L.	Edg; Rlc
WOODSIACEAE	
Cystopteris fragilis (L.) Bernh.	Edg; Rlc; Ind
Gymnosperms	
CUPRESSACEAE	
Juniperus procera Hochst. ex Endl.= J. *excelsa*	EDG, Kst; Flg
Angiosperms	
ACANTHACEAE	
Barleria proxima Lindau	Edg; Ran, Rlc,
Echbolium gymnostachyum (Nees) Milne-Redh.	Edg
Ruellia grandiflora (Forssk.) Blatter = R. longiflora check	EDG, Edg, Edm, Ran,

ALLIACEAE	
Allium Asirense B. Mathew	EDG; Edm
ALOEACEAE	
Aloe x abhaica Lavr. & Collen. ined.	EDG; Edm
Aloe armatissima Lavr. & Collen. ined.	EDG; Edm
Aloe brunneodentata Lavr. & Collen. ined.	EDG; Edm
Aloe cephalophora Lavr. & Collen. ined.	EDG; Edm
Aloe edentata Lavr. & Collen. ined. = A. inermis	EDG; Edm
Aloe fleurentinorum Lavr. & Newton	EDG; Edm, Ran,
Aloe niebuhriana Lavr.	EDG; Edm
Aloe officinalis Forssk. = A. vera	Ecn
Aloe parvicapsula Lavr. & Collen. ined.	EDG; Edm
Aloe parvicoma Lavr. & Collen. ined. (= A. sp. aff. rivierei)	EDG; Edm
Aloe porphyrostachys Lavr. & Collen. ined.	EDG; Edm; Rlc; Ecn; Flg
Aloe pseudorubroviolacea Lavr. & Collen. ined.	EDG; Edm; Rlc; Ecn; Flg
Aloe x qaharensis Lavr. & Collen. ined.	EDG; Edm
Aloe rivierei Lavr. & Newton	EDG; Edm
Aloe rubroviolacea Schweinf.	EDG; Edm; Ecn; Flg
Aloe sabaea Schweinf.	EDG; Edm, Ran,
Aloe shadensis Lavr. & Collen. ined.	EDG; Edm
Aloe sheilae Lavr.	EDG; Edm
Aloe vulcanica Lavr. & Collen. ined.	EDG; Edm
Aloe yemenica J.R.I. Wood	EDG; Edm
AMARANTHACEAE	
Nothosaerva brachiata (L.) Wight.	Edg; Rlc
AMARYLLIDACEAE	
Crinum album (Forssk.) Herbert = *C. yemense*	EDG; Edm; Edg; Flg
Scadoxus multiflorus (Martyn)	Edg; Flg
ANACARDIACEAE	
Pistacia cf. khinjuk Stocks	EDG; Edm
APOCYNACEAE	
Adenium obesum (Forssk.) Roem. & Schult. = *A. arabicum*	Ecn; Flg
Angolluma (Caralluma) commutata (Berger) Plowes ssp. sheilae Plowes = Orbea sprengeri ssp. commutata	EDG; Edm
Angolluma (Caralluma) deflersiana (Lavr.) Plowes = Orbea deflersiana	EDG; Edm
Angolluma (Caralluma) eremastrum (Schwartz) Plowes = Orbea (Caralluma) wissmanii	EDG; Edm
Caudanthera (Caralluma) sinaica Plowes	EDG, Edm, or Edg, Ran,
Caudanthera (Caralluma) sinaica Plowes ssp. baradii (Lavr.) Plowes	EDG, Edm, or Edg, Ran,

Ceropegia arabica Huber	EDG; Edm
Ceropegia arabica Huber var. abbreviata Bruyns	EDG; Edm
Ceropegia aristolochioides Decne. ssp. deflersiana Bruyns	Edm
Ceropegia botrys K. Schum. (= C. mansouriana)	EDG, Edg
Ceropegia bulbosa Roxb.	Edg
Ceropegia rupicola Defl.	EDG; Edm
Ceropegia somalensis Chiov.	Edg
Ceropegia superba D.V. Field & Collen.	Edg
Ceropegia tihamana Chaudhary & Lavr.	EDG; Edm
Ceropegia variegata Decne.var. *adelaidae* Bally	Edg
Ceropegia variegata Decne.var. *variegata*	Edg
Ceropegia vignaldiana A. Rich.	Edg
Crenulluma (Caralluma) petraea (Lavr.) Plowes	EDG, Edg, Edm
Cylindrilluma (Caralluma) solenophora (Lavr.) Plowes	EDG; Edm
Cynanchum acutum L. ssp. sibiricum (Willd.) Rech. f.	Edg; Rlc
Diplostigma canescens K. Schum.	Edg
Duvalia sulcata N. E. Br.	Edg
Duvalia velutina Lavr.	EDG; Edm
Gymnema sylvestre (Retz.) Schult. = G. sylvestris	Edg; Ind; Rlc; Ecn
Huernia arabica N. E. Br.	EDG / Ext Edm
Huernia sp. nov. aff. *boleana* Gilb	EDG; Edm
Huernia laevis J. R. I. Wood	EDG; Edm
Huernia sp. aff. *lodarensis* Lavr.	EDG; Edm
Huernia saudi-arabica D. V. Field	EDG; Edm
Huernia sp. 5944	EDG; Edm
Nerium oleander L.	Ecn; Flg
Periploca visciformis (Vatke) K. Schum	Edg
Rhytidocaulon macrolobum Lavr.	Edg
Rhytidocaulon macrolobum Lavr. ssp. *minimum* Meve & Collen.	EDG / Ext, Edm
Rhytidocaulon sheilae D. V. Field	EDG; Edm
Sarcostemma arabica Bruyns & Forster = S. arabicum check	Edm
Sarcostemma forskaolianum Schult.	Edm
Sarcostemma vanlessenii Lavr.	Edg
Sarcostemma viminale (L.) R. Br. ssp. stipitaceum (Forssk.) Meve & Liede	Edm
Sulcolluma (Caralluma) shadhbana (Lavr.) Plowes	EDG, Edm
Sulcolluma (Caralluma) shadhbana (Lavr.) Plowes var. barhana (Lavr.) Plowes	EDG, Edm
ARACEAE	

Arisaema flavum (Forssk.) Shott.	Edg; Rlc
BURSERACEAE	
Commiphora erythraea (Ehrenb.) Engl.	Edg; Ran,
Commiphora gileadensis (L.) C. Christ.	Ecn; Ran,
Commiphora myrrha (Nees) Engl.	Ecn; Ran,
CAPPARACEAE	
Capparis spinosa L. var. (blue leaf)	Edg; Ran, Rlc; Ecn
Cleome austroarabica D.F. Chamb. & Lamond ssp. *muscatensis* D.F. Chamb. & Lamond	EDG; Edm
Cleome hanburyana Penzig	EDG; Edm
Maerua crassifolia Forssk.	Kst; Ecn
CARYOPHYLLACEAE	
Dianthus deserti Kotschy	EDG; Edm
Gypsophila umbricola(J.R.I.Wood) R.A. King	EDG; Edm
Petrorhagia cretica (L.) Ball & Heywood	Edg; Rlc
Silene asirensis D.F. Chamb. & Collen.	EDG, Edm
Silene corylina D.F. Chamb. & Collen.	EDG; Edm
Silene sp. aff. *peduncularis* Boiss	EDG; Edm
CELASTRACEAE	
Maytenus undata (Thunb.) Blakelock	Edg; Rlc; Ind
CHENOPODIACEAE	
Arthrocnemum macrostachyum (Moric.) K. Koch	Kst, Ecn,
Cornulaca arabica Botsch.	Edm; Kst
Haloxylon persicum Bung.	Kst; Ecn
Salicornia europaea L.	Kst; Ecn,
COMMELINACEAE	
Cyanotis nyctitropa Defl.	EDG, Edm; Rlc, Ind,
COMPOSITAE = ASTERACEAE	
Anthemis sheilae A. Ghafour	EDG; Edm
Anthemis zoharyana ssp. *brachyota* Eig	EDG Edg, Edm, Ran
Artemisia judaica L.	Ran, Rlc, Ecn
Centaurothamnus maximus Wagenitz & Dittr	EDG, Edm; Flg
Cichorium bottae Defl.	Edm; Rlc; Ind
Crepis sancta (L.) Bornm. ssp. *sancta*	Edg; Rlc
Echinops glaberrimus DC.	EDG, or Edg, Edm, or Ran, Rlc
Echinops sheilae Kit-Tan	EDG; Edm
Kleinia pendula (Forssk.) Sch. Bip.	Edg; Edm; Flg
Phagnalon viridifolium Decne.ex Boiss. var. *omanum* Qaiser & Lack *(omanense)*	EDG; Edm
Scorzonera intricata Boiss.	EDG; Edm
Senecio sumarae Defl.	EDG; Edm

Tanacetum sinaicum (Fresen.) Decne.ex Bremer & C.J. Humphries	EDG/Edg, Edm, Ran, Rlc; Ecn
CONVOLVULACEAE	
Convolvulus excelsus R. Mill	EDG; Edm
Convolvulus infantispinosus R. Mill	EDG; Edm
Convolvulus siculus L. ssp. *siculus*	Edg; Rlc
CRUCIFERAE = BRASSICACEAE	
Dolichorhynchus arabicus Hedge & Kit Tan	EDG; Edm
Erysimum hedgeanum Al-Shehbaz = *Arabidopsis erysimoides*	EDG; Edm
CYMODOCEACEAE	
Cymodocea rotundata (Hemprich & Ehrenb.) Aschers. & Schweinf	Kst
Cymodocea serrulata (R. Br.) Aschers. & Magnus	Kst
Halodule uninervis (Forssk.) Aschers.	Kst
Syringodium isoetifolium (Aschers.) Dandy	Kst
Thalassodendron ciliatum (Forssk.)	Kst
CYPERACEAE	
Cyperus alternifolius L. ssp. *flabelliformis* Rottb.	Edg; Rlc, Ind; Ecn
Eleocharis uniglumis (Link.) Schult.	Edg; Rlc; Ind
DIPSACACEAE	
Pterocephalus brevis Coult.	Edg; Rlc
Pterocephalus sp. nov. aff. *sanctus* Decne.	EDG; Edm
Pterocephalus sp. 7572	EDG; Edm
DRACAENACEAE	
Dracaena serrulata Bak.= *D. ombet* Ky & Peyr.	EDG; Edm; Ecn; Flg
Sansevieria ehrenbergii Schweinf. Ex Bak.	Edg; Ran
EBENACEAE	
Diospyros mespiliformis Hochst. ex. DC.	Edg; Ran, Rlc; Ind
ERICACEAE	
Erica arborea L.	Edg; Rlc; Ecn
EUPHORBIACEAE	
Euphorbia ammak Schweinf.	EDG; Edm, Ran, Flg
Euphorbia sp. aff. *ammak* Schweinf.	EDG; Edm; Flg
Euphorbia balsamifera Ait. ssp. *adenensis* (Defl.) Bally	Ran; Ecn
Euphorbia cactus Ehrenb. ex. Boiss.	Edg; Ecn
Euphorbia fractiflexa S. Carter & J.R.I. Wood	Edg; Ran, Ecn
Euphorbia sp. aff. *fractiflexa* S. Carter & J.R.I. Wood	Edg; Edm, Ran, Rlc, Flg
Euphorbia sp. aff. fruticosa Forssk. (E. fruticosa)	EDG; Edm
Euphorbia sp. aff. parciramulosa Schweinf. (E. parciramulosa)	EDG; Edm
Flueggea virosa (Roxb. ex. Willd.) Voight = Securinega virosa	Edg; Rlc

FLACOURTIACEAE	
Oncoba spinosa L.	Edg; Rlc; Ind; Flg
GENTIANACEAE	
Swertia polynectaria (Forssk.) Gilg.	EDG; Edm; Ran, Rlc,
Swertia woodii J. Shah	EDG; Edm, Ran, Rlc
GLOBULARIACEAE	
Globularia arabica Jaub. & Spach	EDG; Edm
GRAMINEAE = POACEAE	
Aristida pennei Chiov.	EDG, Edm
Avena barbata Pott ex Link	Rlc, Ecn
Cymbopogon commutatus (Steud.) Stapf	Ran, Ecn
Cymbopogon schoenanthus (L.) Spreng.	Ran, Ecn
Cynosurus elegans Desf.	Edg; Rlc
Enteropogon macrostachyus (Hochst. ex. A. Rich) Munro ex Benth.	Edg, Rlc
Hordeum murinum Huds. ssp. *glaucum* (Steud) Tzavelev	Rlc, Ecn
Hordeum spontaneum K. Koch.	Rlc, Ecn
Pogonatherum paniceum (Lamarck.) Hackel	Edg, Rlc; Flg
Sporobolus pellucidus Hochst	Edg; Rlc
Triseteria chaudharyana H. Scholz	EDG; Edm
Vulpia muralis (Kunth) Nees	Edg; Rlc
HYACINTHACEAE	
Albuca pendula B. Mathew & Collen.	EDG; Edm
Leopoldia tenuiflorum (Tausch) Heldr.	Edg; Rlc
HYPERICACEAE	
Hypericum collenettiae N. Robson (H. sp. aff. *sinaicum*)	EDG / Ext, Edm
HYDROCHARITACEAE	
Enhalus acoroides (Lf) Royle	Kst
Halophila ovalis (R.Br.) Hook. f.	Kst
Halophila ovata (R.Br.) Aschers.	Kst
Halophila stipulacea (Forssk.) Aschers.	Kst
Thalassia hemprichii (Ehrenb.) Aschers.	Kst
IRIDACEAE	
Gladiolus dalenii Van Geel	Edg; Rlc; Flg
Gladiolus italicus Miller	Edg; Rlc
Gynandiris sisyrinchium (L.) Parl.	Rlc; Flg
Iris albicans Lange	EDG Edg Edm Rlc Flg
Iris postii Mouterde	Edg; Rlc Flg
LABIATAE = LAMIACEAE	
Ajuga arabica P. Davis	EDG; Edm
Lallemantia royleana Benth.	Edg; Rlc
Lavandula citriodora A G Miller	Edg; Edm, Ran, Rlc

Lavandula dentata L.	Rlc; Ecn
Nepeta sheilae Hedge & King	EDG; Edm
Origanum syriacum L.	Edg, Rlc; Ecn
Phlomis brachyodon (Boiss.) Zohary	Edg; Rlc
Plectranthus arabicus E.A. Bruce	EDG / Ext, Edm
Stachys yemenense I.C. Hedge (S. yemenensis)	EDG, Edm
Teucrium hijazicum I.C. Hedge & R. A. King	EDG; Edm
Teucrium popovi R.A. King	EDG; Edm
Thymus decussatus Benth.	Edg; Rlc; Ecn
LEGUMINOSAE = FABACEAE	
Abrus bottae Defl.	Edm; Rlc
Abrus precatorius L.	Edg; Rlc
Acacia gerrardii Benth. var. *najdensis* Zohary = A. *pachyceras* var. *najdensis*	EDG; Edm; Kst
Acacia johnwoodii Boulos = A. *abyssinica*	Edm Ran Kst,
Acacia origena R. Br. Ex Hunde = A. *negrii*	EDG; Edm
Acacia seyal Del.	Edg; Rlc
Argyrolobium sp. aff. *crotalarioides* Jaub. & Spach	Edg; Rlc
Astracantha (Astragalus) echinus (DC.) Pall. ssp. *arabica* I.C. Hedge & D. Podl.	EDG; Edm
Astragalus collenettiae Hedge & D. Podl.	EDG; Edm
Delonix elata (L.) Gamble	Edg Ecn; Flg
Faidherbia albida (Delile) A. Chev.	Edg; Rlc; Kst Ecn
Prosopis koelziana Burkhart	Edg; Ecn
LILIACEAE	
Tulipa biflora Pallas	Edg; Rlc; Flg
LOGANIACEAE	
Nuxia oppositifolia Hochst.	Rlc; Ind
MALPIGHIACEAE	
Caucanthus edulis Forssk.	Edg; Rlc
MALVACEAE	
Alcea striata (DC) Alef	Edg; Rlc
MORACEAE	
Ficus palmata Forssk.	Rlc, Ecn
Ficus palmata Forssk.ssp. virgata (Roxb.)	Edg; Rlc; Ecn
Ficus populifolia Vahl	Edg; Rlc, Ecn
Ficus sycomorus L.	Edg, Rlc, Ecn
MORINGACEAE	
Moringa peregrina (Forssk.) Fiori	Ecn; Flg
MYRTACEAE	
Myrtus communis L.	Edg; Rlc

NYCTAGINACEAE	
Boerhavia elegans Choisy ssp. *elegans*	EDG; Edm
OCHNACEAE	
Ochna inermis (Forssk.) Schweinf.	Edg
OLEACEAE	
Olea europaea L.ssp. *africana* (Burm.f.) P.S. Green = O. e. ssp. *cuspidata* incl. forma *dulcis* P.S. Green	Kst, Ecn; Flg,
ORCHIDACEAE	
Bonatea steudneri (Rchb. f.) Th. Dur. & Sching	Edg; Rlc; Ind; Ecn
Epipactis veratrifolia Boiss. & Hohen.	Edg; Rlc; Ind; Ecn
Eulophia guineensis Lindl.	Edg; Rlc; Ind, Ecn
Eulophia petersii (Reichb.f.) Rchb. f.	Edg, Rlc; Ind, Ecn,
Eulophia speciosa (R. Br. ex. Lindl.) Bolus	Edg; Rlc; Ind, Ecn,
Holothrix arachnoidea Rchb. f.	Edg; Rlc; Ind, Ecn
PALMAE = ARECACEAE	
Hyphaene thebaica (L.) Mart.	Kst; Ecn; Flg
Phoenix dactylifera L.	Kst; Ecn; Flg
PITTOSPORACEAE	
Pittosporum viridiflorum Sims ssp. *arabicum* Chiov.	Edg; Ran; Rlc
PLUMBAGINACEAE	
Limonium cylindrifolium (Forssk.) Verdc.	EDG, Edm, Ran
POLYGONACEAE	
Atraphaxis spinosa L.	Edg; Rlc
Calligonum comosum L'Her	Kst; Ecn
Calligonum crinitum Boiss. ssp. *arabicum* (Sosk.) Sosk.	Edm; Kst; Ecn
Rheum palaestinum Feinbr.	EDG / Ext, Ran, Rlc
PORTULACACEAE	
Portulaca grandiflora Hook.	Edg; Rlc
Portulaca kermesina N.E. Br. agg.	Edg; Rlc
RANUNCULACEAE	
Delphinium sheilae Kit-Tan	EDG; Edm
RESEDACEAE	
Ochradenus arabicus Chaudhary, Hillcoat & A.G. Miller	Edm; Ecn
Reseda pentagyna Abdalla	EDG; Edm
RHAMNACEAE	
Sageretia sp. aff. *thea* (Osb.) M.C. Johnst.	Edg Edm Rlc
Ziziphus mucronata Willd.	Edg; Rlc
Ziziphus spina-christi (L.) Willd.	Kst; Ecn; Flg
RHIZOPHORACEAE	
Rhizophora mucronata Lam.	Edg; Kst; Ecn; Flg
ROSACEAE	

Crataegus sinaica Boiss.	EDG, Edm, Edg; Rlc
Prunus arabica (Oliv.) Meikle = *Amygdalus arabica*	Edg; Ran, Rlc,
Prunus korshinskyii Hand.-Mazz. = *Amygdalus korshinskyii*	Edg; Rlc
Rosa abyssinica Lindley	Rlc; Ecn, Flg
RUBIACEAE	
Breonadia salicina (Vahl) N. Hepper & J.R.I. Wood	Edg; Rlc
Crucianella arabica Schonb.-Tem. & Ehrend.	EDG; Edm
Tarenna graveolens (S. Moore) Bremek. ssp. *arabica* (Cuf.) Bridson	EDG' Edm
RUPPIACEAE	
Ruppia maritima L.	Kst
SALVADORACEAE	
Dobera glabra (Forssk.) Poir.	Rlc; Ecn
Salvadora persica L.	Ecn
SAPINDACEAE	
Allophylus rubifolius (Hochst.) Engl.	Edg; Rlc; Ind
SAPOTACEAE	
Mimusops laurifolia (Forssk.) Friis	Rlc; Ind; Ecn, Flg
SCROPHULARIACEAE	
Campylanthus pungens Swartz	Edm; Rlc; Ind
Halleria lucida L.	Edg, Rlc
Kickxia collenettiana D. Sutton	EDG / Ext Edm
Kickxia sp. aff. *scalarum* D. Sutton = K. *scalarum*	EDG; Edm
Verbascum decaisneanum O. Kuntze	Edg; Ran Rlc
Verbascum yemense Defl.	EDG Edm
SOLANACEAE	
Solanum cordatum Forssk.	EDG; Edm
STERCULIACEAE	
Glossostemon bruguieri DC.	Edg; Rlc
THYMELACEAE	
Daphne linearifolia Hart	Edg; Rlc; Ecn
Thymelaea mesopotamica (C. Jeffrey) Peterson	EDG, or Edg, Edm, or Ran, Rlc
ULMACEAE	
Celtis africana Burm. f.	Rlc; Ind
Celtis toka (Forssk.) Hepper & J.R.I. Wood	Edg; Rlc; Ind
Trema orientalis (L.) Blume	Edg; Rlc; Ind
UMBELLIFERAE = APIACEAE	
Oreoschimperella arabiae-felicis C.C. Towns var. laevis C.C. Towns	EDG; Edm
Peucedanum inaccessum C.C. Towns	EDG; Edm
URTICACEAE	
Parietaria umbricola A.G. Mill.	EDG; Edm

VALERIANACEAE	
Valerianella muricata (Stev.) Baxt.	Edg; Rlc
Valerianella cf. *sclerocarpa* Fisch. & C.A. Mey.	Edg; Edm, Rlc,
Valerianella cf. *szovitsiana* Fisch. & C. A. Mey.	Edg; Edm, Rlc
VELLOZIACEAE	
Xerophyta arabica (Bak.) N. Menezes	Edg
VERBENACEAE	
Avicennia marina (Forssk.) Vierh.	Kst; Ecn; Flg
ZYGOPHYLLACEAE	
Balanites aegyptiaca Del.	Rlc, Ecn
Tribulus arabicus (Hosni)	Edm; Ecn; Flg
Tribulus macropterus Boiss. var. *collenettiae* Hosni	Edm
Zygophyllum mandevillei Hadidi	Edm
Zygophyllum qatarense Hadidi	Edm, Ran

Note: **EDG**: globally endangered, **Edg**: nationally endangered, **Edm**: endemic, **Ran**: critical range, **Rlc**: relict, **Kst**: keystone, **Ind**: indicator, **Ecn**: economic, **Flg**: flagship

List of invertebrates in ANP

Taxon: Scientific Name	Common Name	Criteria	Notes
Corals (Phylum: Coelenterata)			
Antipathes dichotoma	bushy black coral	Edg, Ecn	Commercial black coral
Cirrhipathes anguina	wire coral	Edg, Ecn	Commercial black coral
Subergorgia hicksoni	Hickson's fan coral	Edg, Ecn; Kst, Flg	Keystone species
Subergorgia reticulata	fan coral	Edg, Ecn; Kst, Flg	
Subergorgia rubra	fan coral	Edg, Kst, Ecn; Flg	
Subergorgia suberosa	fan coral	Edg, Kst, Ecn; Flg	
Acabaria erythraea	knotted sea fan	Edg, Kst, Ecn; Flg	Keystone species
Acabaria sinaica	knotted sea fan	Edg, Kst, Ecn; Flg	Keystone species
Acabaria splendens	splendid knotted sea fan		Keystone species
Acabaria biserialis	knotted sea fan	Edg, Kst, Ecn; Flg	Keystone species
Rumphella aggregata	bushy sea fan	Edg, Kst, Ecn Flg	Keystone species
Junceella juncea	whip coral	Edg, Ecn Kst	Keystone species
Junceella sp.	whip coral	Edg, Ecn Kst	Keystone species; provides habitat for an exceptional diversity of species in the Gulf, with a level of biodiversity second only to coral reefs
Stylophora mamillata		Edm	Endemic; clear deep water 30 – 40 m depth
Stylophora wellsi		Ran, Ind	Near-endemic; indicator (Community B/2,9: reef crests and upper reef slopes exposed to strong wave action) very shallow water exposed fringing & barrier reefs
Acropora hyacinthus	brush stagshorn coral	Kst, Ind, Flg	Consistent component of surf zone on exposed reef crests commonest in less than 3 – 4 m depth but occurs to 35 m depth; indicator (Community B/2,9: reef crests and upper reef slopes exposed to strong wave action)
Acropora cytherea	Stagshorn coral	Kst, Ind, Flg	Common in well-lit shallow water without strong wave action to 20 m depth, often in back-reef conditions with reflective sandy patches

Acropora clathrata	Stagshorn coral	Kst, Ind, Flg	Widespread but not abundant; in clear but sheltered areas in Red Sea & Gulf; indicator (Community 7)
Acropora pharaonis	Stagshorn coral	Kst, Ind, Flg	Fair indicator (Community D/3,5,8: moderately exposed reef cusps); (Community 7) common in sheltered lagoons, often among sand patches
Acropora valenciennesi	Stagshorn coral	Kst, Ind, Flg	Sheltered well-lit areas 5 – 20 m deep on lee sides of reefs and among sand patches; indicator (Community 7)
Acropora hemprichii	Stagshorn coral	Kst, Ind, Flg	Extensive stands on exposed shallow reefs, esp. 3 – 10 m depth but to20 m depth; indicator (Community B/2,9: reef crests and upper reef slopes exposed to strong wave action); (Community 8)
Acropora cf. danai	Stagshorn coral	Kst, Ind	Extensive monospecific stands on very exposed shallow reefs, esp. 0 – 3 m deep on outer patch reefs & exposed fringing reefs, almost never deeper than 7 m; indicator (Community B/2,9: reef crests and upper reef slopes exposed to strong wave action)
Acropora horrida	Stagshorn coral	Kst, Ind	Shallow, often sedimented water on gentle slopes in sandy & lagoonal habitats to about 5 m depth, often forming extensive thickets in southern Red Sea & Gulf, rare in northern Red Sea
Acropora formosa = A. muricata	Stagshorn coral	Kst, Ind	Shallow lagoonal areas without strong wave action, often forming extensive thickets; southern Red Sea
Acropora nobilis	Stagshorn coral	Kst	Locally abundant in southern Red Sea, especially on gentle gradients of shallow fringing reefs; uncommon in northern Red Sea

Acropora squarrosa	Stagshorn coral	Kst	Small bushy colonies in sheltered water 5 – 25 m deep
Acropora variolosa	Stagshorn coral	Edm, Kst Flg	Endemic
Acropora arabensis	Stagshorn coral	Kst Flg	In the Gulf
Acropora lamarcki	Stagshorn coral	Kst Flg	Newly named / revised
Acropora gemmifera	Stagshorn coral	Kst Ind	Indicator (Community B/2,9: reef crests and upper reef slopes exposed to strong wave action)
Astreopora gracilis		Ind	Indicator (Community A/6,10: exposed to semi-exposed lower reef slopes)
Alveopora ocellata		Edm	Endemic; 10 – 45 m depth on fringing reefs, darkened areas
Siderastrea savignyana		Kst	Tolerant of high salinity, fluctuations in temperature; shallow water
Pavona decussata		Ind	Indicator (Community C/4,7,11,13: sheltered turbid areas on the protected sides of patch reefs, in lagoons behind barrier reefs, and inside sharms)
Gardineroseris planulata		Kst, Ind	Common on reef slopes from near crest in sheltered conditions to 25 m deep, in clear to moderately turbid water
Pachyseris speciosa		Kst, Ind	Indicator (Community A/6,10: exposed to semi-exposed lower reef slopes) deeper water on steep to sheer reef walls 20 – 45 m deep, darker habitats
Cycloseris patelliformis	Mushroom coral	Edg Ind, Ecn	On sand between reefs in sheltered locations in Red Sea; sought by collectors
Cantharellus (Cycloseris) doederleini	Mushroom coral	Edg, Edm	Endemic, rare, Gulf of Al-'Aqabah & northern Red Sea; sought by collectors
Fungia (Cycloseris) tenuis	Mushroom coral	Edg, Edm, Ecn	Gulf endemic; sought by collectors
Fungia (Pleuractis) scutaria	Mushroom coral	Edg Ind, Ecn	Common in clear water on hard reef substrate & coral rubble; sought by collectors

Merulina scheeri		Edm, Ind	Endemic; mid to deep water on reef slopes low diversity areas in moderately deep silted slopes, with poor light from depth or sediment (Community A/6,10: exposed to semi-exposed lower reef slopes)
Caulastrea tumida		Edg, Edm	Endemic, found only in northern parts of the Gulf of Al-'Aqabah; rare
Erythrastrea flabellata		Edg, Edm	Endemic found only in far northern parts of the Red Sea, Gulf of Al-'Aqabah & Aden; very uncommon
Favia stelligera		Kst, Ind, Flg	Indicator (Community B/2,9: reef crests and upper reef slopes exposed to strong wave action) Very shallow water, mainly in northern Red Sea; large colonies in sheltered sites such as protected fringing reefs
Favia laxa		Kst, Ind, Flg	N & C Red Sea in clear water reef slopes 10 – 25 m deep, rare in S Red Sea; common member of the high-diversity faviid zone, tolerates all habitats except very exposed & very turbid conditions
Barabattoia amicorum		Ind	Indicator (Community D/3,5,8: moderately exposed reef cusps)
Goniastrea (Favites) peresi		Kst, Ind	Common member of the high-diversity faviid zone at mid-depths on unsedimented reef slopes in the Red Sea; mid to deep water
Platygyra daedalea	Brain coral	Kst, Ind, Flg	Large conspicuous colonies; important component of the high-diversity faviid zone on fore-reef slopes; tolerant of high salinity
Leptoria phrygia	Brain coral	Kst, Ind, Flg	Indicator (Community B/2,9: reef crests and upper reef slopes exposed to strong wave action) abundant and consistent component: shallow water to 4 m deep on exposed & moderately exposed reef crests & seaward facing reef slopes, or reef flats with good water exchange; fairly turbulent habitat

Diploastrea heliopora		Ind	Indicator (Community D/3,5,8: moderately exposed reef cusps) shallow and mid-depths in sheltered water on protected fringing reefs and back-reef slopes, usually silty environments
Cyphastraea micropthalma		Kst	Tolerant of high salinity, fluctuations in temperature; common on reef flats & reef slopes to a depth of 40 m
Cyphastraea serailia		Kst	Tolerant of high salinity, fluctuations in temperature; common on reef flats & clear water reef slopes to a depth of 40 m
Echinopora forskaliana		Ran	Not endemic; limited range
Turbinaria mesenterina		Ind	Indicator (Community C/4,7,11,13: sheltered turbid areas on the protected sides of patch reefs, in lagoons behind barrier reefs, and inside sharms) sedimented and sandy conditions at 10 m depth or more; on clear water reef slopes to 45 m depth
Earthworms (Class: *Oligochaeta*)	earthworm	Kst, Ind	Important role in soil formation
Mollusks (Phylum: *Mollusca*)			
Trochus (Tectus) dentatus	top shell	Edg, Ecn	Sought by collectors; a source of mother-of-pearl
Turbo petholatus	tapestry turban, cat's-eye turban	Edg, Ecn	Sought by collectors
Strombus tricornis	three-knobbed conch	Edg, Ecn	Sought by collectors
Lambis lambis	spider conch	Edg, Ecn	Sought by collectors
Lambis truncata sebae	Seba's spider conch	Edg, Ecn, Flg	Sought by collectors
Tibia insulaechorab	Arabian tibia	Edg, Ecn, Flg	Sought by collectors
Tibia curta		Edg, Ecn, Flg	Sought by collectors
Cypraea arabica (= C. grayana)	Arabian cowrie	Edg, Ecn, Flg	Sought by collectors
Cypraea camelopardalis	giraffe cowrie	Edg, Ecn, Flg	Sought by collectors
Cypraea carneola	carnelian cowrie	Edg, Ecn, Flg	Sought by collectors
Cypraea caurica	caurica cowrie	Edg, Ecn, Flg	Sought by collectors
Cypraea cicercula	chick-pea cowrie	Edg, Ecn, Flg	Sought by collectors
Cypraea cribraria	sieve cowrie	Edg, Ecn, Flg	Sought by collectors
Cypraea exusta	burnt cowrie	Edg, Ecn, Flg	Sought by collectors

Cypraea isabella	isabelline cowrie	Edg, Ecn, Flg	Sought by collectors
Cypraea lynx	lynx cowrie	Edg, Ecn, Flg	Sought by collectors
Cypraea macandrewi	MacAndrew's cowrie	Edg, Ecn, Flg	Sought by collectors
Cypraea nebrites	fawn cowrie	Edg, Ecn, Flg	Sought by collectors
Cypraea pantherina	panther cowrie	Edg, Ecn, Flg	Sought by collectors
Cypraea pulchra	lovely cowrie	Edg, Ecn, Flg	Sought by collectors
Cypraea talpa	mole cowrie	Edg, Ecn, Flg	Sought by collectors
Cypraea turdus	thrush cowrie	Edg, Ecn, Flg	Sought by collectors
Cypraea walkeri	Wakler's cowrie	Edg, Ecn, Flg	Sought by collectors
Cypraea ziczac	zigzag cowrie	Edg, Ecn, Flg	Sought by collectors
Tonna perdix	partridge tun	Edg, Kst Ecn, Flg	Sought by collectors
Charonia tritonis	triton trumpet snail	Edg, Kst, Ecn, Flg	Sought by collectors; predator on crown-of-thorns starfish
Conus aulicus	princely cone shell	Edg, Ecn, Flg	Sought by collectors
Conus catus	cat cone shell	Edg, Ecn, Flg	Sought by collectors
Conus geographus	geography cone shell	Edg, Ecn, Flg	Sought by collectors
Conus nigropunctatus	blackspot cone shell	Edg, Ecn, Flg	Sought by collectors
Conus pennaceus	feathered cone shell	Edg, Ecn, Flg	Sought by collectors
Conus striatus	striate cone shell	Edg, Ecn, Flg	Sought by collectors
Conus textile	textile cone shell	Edg, Ecn, Flg	Sought by collectors
Bulla ampulla	ampulle bubble shell	Kst, Ecn	Sought by collectors; component of sandy bottoms / algal communities & seagrass communities
Levantina spp.		Edg, Edm Rlc, Ind	Which species
Boysia spp.		Edg, Ran, Rlc, Ind	Which species
Other freshwater / terrestrial snails		Edg, Ran, Rlc, Ind	Which species
Pinna bicolor	bicolor pen shell	Edg, Ecn, Flg	Harvested
Pinna muricata	prickly pen shell	Edg, Ecn, Flg	Harvested
Streptopinna saccata	baggy pen shell	Edg, Ecn, Flg	Harvested
Atrina vexillum	flag atrina	Edg, Ecn, Flg	Harvested
Pteria aegyptiaca	winged pearl oyster	Edg, Kst, Ecn	Harvested
Pteria penguin	penguin's wing pearl oyster	Edg, Kst, Ecn	Harvested
Electroma alacorvi	raven's wing pearl oyster	Edg, Kst, Ecn	Harvested
Pinctada margaritifera	blacklip pearl oyster	Edg, Kst, Ind, Ecn	Pearl oyster; indicator species by virtue of its sensitivity to pollution

Pinctada radiata = P. vulgaris	rayed pearl oyster	Edg, Kst, Ind, Ecn	Pearl oyster; indicator species by virtue of its sensitivity to pollution
Tridacna crocea	crocus giant clam	Edg, Ecn	Harvested
Tridacna maxima	giant clam	EDG, Edg, Ecn	Harvested for food LR/cd
Tridacna squamosa	fluted giant clam	EDG, Edg, Ecn	Harvested for food LR/cd
Solen corneus	finger oyster	Edg, Ecn	Harvested for food
Circe arabica	Arabian venus clam	Edg, Edm, Ecn	Sought by collectors
Circe corrugata	corrugate venus clam	Edg, Edm, Ecn	Sought by collectors
Circenita (Circe) callipyga	pretty-backed venus clam	Edg, Ecn	Sought by collectors
Gafrarium divaricatum	forked venus clam	Edg, Ecn	Sought by collectors
Gafrarium pectinatum	comb venus clam	Edg, Ecn	Sought by collectors
Lioconcha castrensis	chocolate flamed venus clam	Edg, Ecn	Sought by collectors
Lioconcha ornata = L. picta	ornate venus clam	Edg, Ecn	Sought by collectors
Periglypta (Venus) reticulata	reticulated venus clam	Edg, Ecn	Sought by collectors
Tapes literatus	lettered venus clam	Edg, Ecn	Sought by collectors
Tapes sulcarius	venus clam	Edg, Ecn	Sought by collectors
Venus lamellaris	venus clam	Edg, Ecn	Sought by collectors
Venus verrucosa	warty venus clam	Edg, Ecn	Sought by collectors
Sepia pharaonis	pharoah cuttlefish	Edg Ecn	Commercial cuttlefish
Sepia dollfusi	cuttlefish	Edg Ecn	Commercial cuttlefish
Echinodermata			
Chaetodiadema granulatum		Kst	Important to coral reef ecology: influences the distribution of algal habitats
Diadema setosum	porcupine sea urchin	Kst	Important to coral reef ecology: influences the distribution of algal habitats
Echinothrix calamaris	banded sea urchin	Kst	Important to coral reef ecology: influences the distribution of algal habitats
Echinothrix diadema	crowned sea urchin	Kst	Important to coral reef ecology: influences the distribution of algal habitats
Echinometra mathaei	hedgehog sea urchin	Kst	Important to coral reef ecology: influences the distribution of algal habitats
Heterocentrotus mammillatus		Kst	Important to coral reef ecology: influences the distribution of algal habitats
Heterocentrotus trigonarius		Kst	Important to coral reef ecology: influences the distribution of algal habitats

Crustacea			
Penaeus semisulcatus	green tiger prawn	Ecn	Commercial prawn
Penaeus latisulcatus	western king prawn	Ecn	Commercial prawn
Penaeus japonicus	kuruna prawn	Ecn	Commercial prawn
Penaeus monodon	black tiger prawn	Ecn	Commercial prawn
Penaeus indicus	Indian white prawn	Ecn	Commercial prawn
Metapenaeus monoceros	ginger prawn, brown shrimp, speckled shrimp	Ecn	Commercial prawn
Metapenaeus affinis	jinga shrimp	Ecn	Commercial prawn
Metapenaeus ensis	greasyback shrimp, sand shrimp	Ecn	Commercial prawn
Palaemon serratus	common prawn	Ecn	Commercial prawn
Panulirus penicillatus	green rock lobster	Edg, Ecn	Commercial rock lobster
Panulirus versicolor	painted rock lobster	Edg, Ecn	Commercial rock lobster
Panulirus ornatus	ornate rock lobster	Edg, Ecn	Commercial rock lobster
Thenus orientalis	flathead sand lobster	Edg Ecn	Commercial slipper lobster
Scyllarus rugosus	hunchback locust lobster	Edg Ecn	Commercial slipper lobster
Scyllarus gibberosus	locust lobster	Edg Ecn	Commercial slipper lobster
Scyllarus lewinsohni	locust lobster	Edg Ecn	Commercial slipper lobster
Scyllarus pumilus	locust lobster	Edg Ecn	Commercial slipper lobster
Scyllarides tridacnophaga	clam-eating slipper lobster	Edg Edm Ran Ecn	Commercial slipper lobster; endemic
Scyllarides haanii	ridgeback slipper lobster	Edg Edm Ran Ecn	Commercial slipper lobster; endemic
Portunus pelagicus	blue swimmer crab	Ecn	Commercial crab
Portunus sanguinolentus	three-spot swimmer crab	Edg, Ecn	Commercial crab
Scylla serrata (incl. S. tranquebarica, S. olivacea)	mangrove crab, mud crab	Kst, Ecn	Important crab of mangrove ecosystems & muddy bottoms; a commercial crab
Metaplax indicus H. Milne Edwards 1852	shore crab	Ran	Near endemic
Uca lactea albimana	fiddler crab	Edm	Endemic
Uca inversa inversa	fiddler crab	Edm	Endemic
Ocypode saratan (Forsskal 1775)	ghost crab	Ran	Near endemic
Ocypode rotundata Miers 1882	rounded ghost crab	Ran	Near endemic
Ocypode cordimana	common ghost crab	Ran	Near endemic
Nasima dotilleformis (Cleistostoma dotilleforme)	stalk-eyed crab	Edg, Kst	A source of bioturbation in the saltmarshes and mangroves of the Gulf; vulnerable to oil spills
Triops numidicus	triops shrimp	Rlc, Ind	

Other freshwater shrimp		Rlc, Ind	
Insects (Class: *Insecta*)			
Pseudagrion arabicum	dragonfly		VU B1ab(iii); D2
Paragomphus sinaiticus	desert dragonfly, nimba flycatcher	Edg, Ran, Rlc	VU A2c+3c
Urothemis thomasi	dragonfly	Edg, Ran, Rlc	DD
Acherontia styx	death's-head hawkmoth	Rlc, Flg	
Acherontia atropos	death's-head hawkmoth	Rlc, Flg	
Daphnis nerii	oleander hawkmoth	Rlc, Flg	
Papilio machaon syriacus	swallowtail butterfly	Rlc Flg	
Papilio saharae	swallowtail butterfly	Rlc Flg	
Papilio demodocus	swallowtail butterfly	Rlc Flg	
Apis mellifera	honeybee	Kst, Ecn, Flg	vital ecological role in pollination; important economic role through the provision of wild honey

Note: **EDG**: globally endangered, **Edg**: nationally endangered, **Edm**: endemic, **Ran**: critical range, **Rlc**: relict, **Kst**: keystone, **Ind**: indicator, **Ecn**: economic, **Flg**: flagship

List of Various species of reptiles found in ANP.

Taxon: Scientific Name	Common Name	Criteria
Mauremys caspica caspica (Gmelin, 1774)	Caspian pond turtle	Edg; Rlc
Chelonia mydas (Linnaeus, 1758)	Green turtle	EDG; Ecn Flg
Eretmochelys imbricata (Linnaeus, 1766)	Hawksbill turtle	EDG; Ecn Flg
Caretta caretta (Linnaeus, 1758)	Loggerhead turtle	EDG; Flg
Lepidochelys olivacea (Eschscholtz, 1829)	Olive ridley turtle	EDG; Flg
Dermochelys coriacea (Vandelli, 1761)	Leatherback turtle	EDG; Flg
Pelomedusa subrufa (Lacepede, 1788)	Side-necked turtle	Edg; Rlc
Stellio (Agama) adramitana Anderson, 1896	Agama	Edg Edm
Stellio (Agama) stellio brachydactyla Haas, 1951	Stellio	Edg; Ran; Rlc
Stellio (Agama) yemenensis Klausewitz, 1954	Yemen Agama	EDG Edm
Trapelus (Agama) blanfordi fieldi Haas & Y.L. Werner, 1969	Persian Agama	Edg Rlc Ran
Uromastyx aegyptius microlepis Blanford, 1874	Small-scaled dhabb	Ran; Ecn; Flg
Uromastyx ocellatus ornatus Hayden, 1827	Ornate dhabb	Edg Ran; Flg
Uromastyx ocellatus philbyi Parker, 1938	Philby's dhabb	EDG Edm; Flg
Chamaeleo calyptratus calcarifer Peters, 1869	veiled chameleon	EDGEdm
Chamaeleo chamaeleon (Linnaeus, 1758)	Chameleon	Edg Rlc
Chalcides levitoni Pasteur, 1978	Leviton's Skink	Edm
Eumeces taeniolatus (Blyth, 1854)	Alpine Punjab skink	Edg; Rlc
Scincus hemprichii Wiegmann, 1937	Wiegmann's skink	Edg;
Scincus mitranus mitranus	Arabian sand skink	Edg Edm
Scincus scincus meccensis	Saharan sand skink	Edm
Varanus griseus (Daudin, 1802)	Desert monitor	Kst
Varanus yemenensis n.sp.	Yemen monitor	EDG; Edm; Kst
Ramphotyphlops braminus	flowerpot blind snake	Kst Ecn
Leptotyphlops macrorhynchus	beaked blind snake	Kst
Leptotyphlops nursii	Nurse's blind snake	Edm; Kst
Eryx jayakari Boulenger, 1888	Jayakar's sand boa	Edm Kst
Coluber ventromaculatus Gray, 1834	Glossy-bellied racer	Edg Rlc Kst
Coluber rhodorachis rhodorachis (Jan, 1865)	Cliff racer	Ran; Kst
Coluber elegantissimus (Gunther, 1878)	Elegant racer	Ran
Coluber manseri Leviton, 1986	Manser's black racer	EDG; Edm
Coluber insulanus		EDG; Edm
Eirenis coronella fennelli	crowned dwarf racer	Edm
Lytorhynchus gasperetti	Leviton's leafnose snake	Edm
Malpolon moilensis (Reuss, 1834)	Moila snake	Ran; Kst
Spalerosophis diadema cliffordi (Schlegel, 1837)	Diadem snake	Kst

Telescopus dhara dhara (Forsskal, 1775)	Arabian cat snake	EDG Edm; Ecn
Atractaspis microlepidota Gunther, 1866	Burrowing asp	Edg; Ecn
Naja haje arabica Scortecci, 1932	Arabian cobra	EDG; Edm; Ecn Kst
Walterinnesia aegyptia Lataste, 1887	Black desert cobra	Edg; Ran; Ecn
Bitis arietans arietans Merrem, 1820	Puff adder	Edg; Rlc; Kst: Ecn
Echis pyramidum (E.&I. Geoffroy St. Hilaire 1827)	Egyptian saw-scaled viper	Edg; Rlc; Ecn
Echis coloratus Gunther, 1878	Burton's carpet viper	Edg; Ran; Ecn

Note: **EDG**: globally endangered, **Edg**: nationally endangered, **Edm**: endemic, **Ran**: critical range, **Rlc**: relict, **Kst**: keystone, **Ind**: indicator, **Ecn**: economic, **Flg**: flagship

List of various species of birds in ANP

Taxon: Scientific Name	Common Name	Criteria
Struthio camelus	*Ostrich*	*Edg/Ext, Ecn, Flg*
Phaethon aethereus	*Red-billed tropicbird*	*Edg, Edm Ran*
Sula leucogaster	*Brown booby*	*Edg Ran*
Phalacrocorax nigrogularis	*Socotra cormorant*	*Edg, Edm/Ran*
Pelecanus rufescens	*Pink-backed pelican*	*Edg, Ran Kst*
Ardea goliath	*Goliath heron*	*Edg Ran*
Geronticus eremita	*Northern bald ibis*	*EDG*
Platalea leucorodia	*Spoonbill*	*Edg, Ran*
Tadorna ferruginea	*Ruddy shelduck*	*Edg Ran*
Aythya nyroca	*Ferruginous duck*	*EDG, Ran*
Gypaetus barbatus	*Lammergeier*	*EDG / Edg, Kst*
Gyps fulvus	*Griffon vulture*	*Edg, Ran, Kst*
Torgos tracheliotus	*Lappet-faced vulture*	*Edg, Kst*
Terathopius ecaudatus	*Bateleur*	*Edg, Kst*
Micronisus gabar	*Gabar goshawk*	*Edg, Edm, Kst*
Aquila clanga	*Greater spotted eagle*	*EDG, Kst*
Aquila heliaca	*Imperial eagle*	*EDG, Kst*
Aquila verreauxii	*Verreaux's eagle*	*Edg, Kst*
Pandion haliaetus	*Osprey*	*Edg, Kst*
Falco concolor	*Sooty falcon*	*Edg, Ran, Kst*
Falco biarmicus	*Lanner*	*Edg, Kst, Ecn, Flg*
Falco cherrug	*Saker*	*Edg, Kst, Ecn, Flg*
Falco naumanni	*Lesser kestrel*	*EDG*
Falco peregrinus	*Peregrine*	*Edg, Kst, Ecn, Flg*
Falco pelegrinoides	*Barbary falcon*	*Edg, Ran Kst, Ecn, Flg*
Alectoris philbyi	*Philby's partridge*	*Edg, Edm, Ecn*
Alectoris melanocephala	*Arabian red-legged partridge*	*Edg, Edm, Ecn*
Numida meleagris	*Helmeted guineafowl*	*Edg, Edm Ecn*
Crex crex	*Corncrake*	*EDG, Ran*
Grus grus	*Eurasian crane*	*Edg, Ran*
Grus (Anthropoides) virgo	*Demoiselle crane*	*Edg, Ran, Flg*
Chlamydotis (undulata) macqueenii	*Houbara*	*Edg, Ran, Ecn, Flg*
Ardeotis arabs	*Arabian bustard*	*Edg, Ran Ecn, Flg*
Himantopus himantopus	*Black-winged stilt*	*Edg, Ran*
Recurvirostra avocetta	*Avocet*	*Edg, Ran*
Dromas ardeola	*Crab plover*	*Edg, Ran*
Larus hemprichii	*Sooty gull*	*Edg Ran*

Larus leucophthalmus	*White-eyed gull*	*EDG, Ran*
Sterna bergii	*Swift tern*	*Edg Ran*
Sterna bengalensis	*Lesser crested tern*	*Edg, Ran*
Sterna repressa	*White-cheeked tern*	*Edg, Ran*
Sterna anaethetus	*Bridled tern*	*Edg Ran*
Sterna saundersi	*Saunders' little tern*	*Edg Ran*
Anous stolidus	Brown noddy	Edg, Ran
Pterocles lichtensteinii	Lichtenstein's sandgrouse	Edg, Ran
Pterocles coronatus	Coronetted sandgrouse	Edg, Ran
Pterocles senegallus	Spotted sandgrouse	Edg, Ran
Pterocles exustus	Chestnut-bellied sandgrouse	Edg
Pterocles alchata	Pin-tailed sandgrouse	Edg
Strix butleri	Hume's owl	Edg, Ran
Halcyon (Todirhamphus) chloris	White-collared kingfisher	Edg, Ran
Tockus nasutus	Little grey hornbill	Edg
Picoides (Dendrocopos) dorae	Arabian woodpecker	Edg, Edm
Oenanthe lugentoides	South Arabian wheatear	Edm
Turdus menachensis	Yemen thrush	EDG, Edm
Parisoma buryi	Yemen warbler	EDG, Edm
sPica pica asirensis	Asir magpie	Edg, Edm, Rlc
Passer euchloris	Arabian golden sparrow	Ran
Estrilda rufibarba	Arabian waxbill	Edm
Serinus rothschildi	Arabian serin	Edm
Serinus menachensis	Yemen serin	Edm
Rhynchostruthus socotranus	Golden-winged grossbeak	Ran
Carduelis yemenensis	Yemen linnet	Edm
Carpodacus synoicus	Sinai rosefinch	Edg, Ran

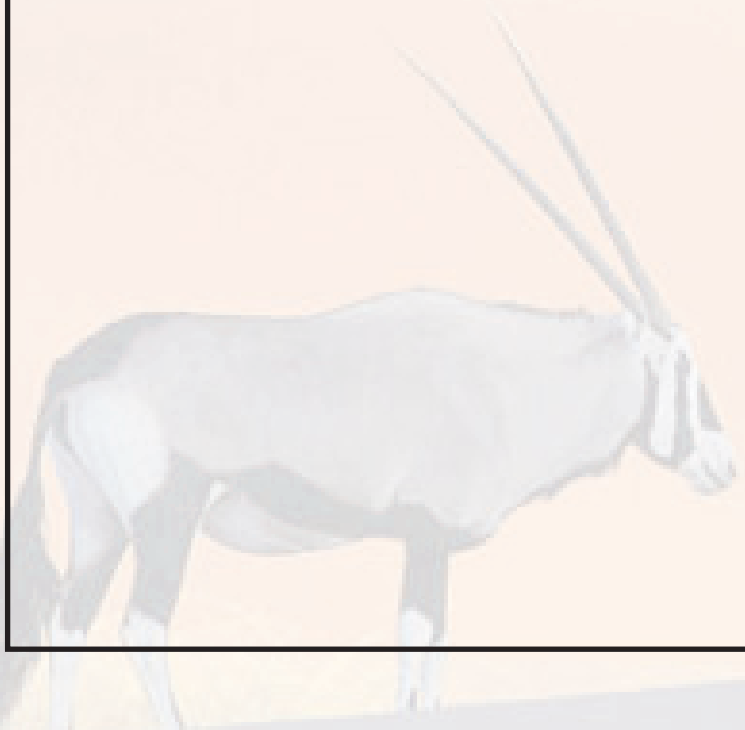
Note: **EDG**: globally endangered, **Edg**: nationally endangered, **Edm**: endemic, **Ran**: critical range, **Rlc**: relict, **Kst**: keystone, **Ind**: indicator, **Ecn**: economic, **Flg**: flagship

List of various species of mammals in ANP

Taxon: Scientific Name	Common Name	Criteria	Notes
Rhinopoma microphyllum asirensis	Greater mouse-tailed bat	Edg Edm	
Nycteris thebaica najdiya	Egyptian slit-faced bat	Edg Edm	
Asellia patrizii	Patrizi's trident leaf-nosed bat	EDG, Rlc	VU D2
Myotis emarginatus	Notch-eared bat	EDG, Rlc	VU A2c
Eptesicus nasutus	Sind serotine bat	EDG, Ran Rlc	VU A2c
Otonycteris hemprichii Peters	Hemprich's long-eared bat	Edg Ran	
Papio hamadryas (Linnaeus)	Hamadryas baboon	EDG Ran	LR/nt
Canis lupus arabs Pocock	Arabian wolf	EDG Edm, Kst	
Canis aureus Linnaeus	Asiatic jackal	Edg	
Vulpes rueppelli sabaea Pocock	Rueppell's fox	EDG Ran	DD
Vulpes cana Blanford	Blanford's fox / Hoary fox	EDG, Rlc	VU C1
Mellivora capensis pumilio Pocock	Ratel / Honey badger	EDG Edm	
Mellivora capensis wilsoni Cheesman	Ratel / Honey badger	Edg Ran	
Genetta felina granti Thomas	African small-spotted genet	Edg Edm	
Hyaena hyaena sultana Pocock	Striped hyaena	EDG Edm	LR/nt
Felis margarita harrisoni Hemmer, Grubb & Groves	Arabian sand cat	EDG Edm	NT
Felis caracal schmitzi Matschie	Caracal	EDG Edm, Kst, Flg	
Panthera pardus nimr Hemprich & Ehrenberg	Arabian leopard	EDG, Edm, Kst, Flg	CR C2a(i)
Acinonyx jubatus	Cheetah	Ext, Kst, Flg	VU C2a(i)
Procavia syriaca jayacari Thomas	Rock hyrax	Edg, Edm or Ran	
Dugong dugon Muller	Dugong	EDG, Ran, Flg	VU A1cd
Equus hemionus	Onager / wild ass	Ext	E. h. hemip-pus EX
Capra (ibex) nubiana F. Cuvier	Nubian ibex	EDG, Ran, Ecn, Flg	EN C2a
Oryx leucoryx Pallas	Arabian oryx	EDG, Edm, Ecn, Flg	EN C1
Gazella gazella (incl. G. g. cora) H. Smith	Arabian mountain ga-zelle (idmi)	EDG, Edm, Ecn, Flg	VU A2ad (G. g. cora VU C1)
Gazella saudiya Carruthers & Schwartz	Saudi dorcas gazelle ('afri)	EDG/Ext, Edm, Ecn, Flg	EW
Gazella subgutturosa marica Thomas	Arabian sand gazelle (reem)	EDG, Edm or Ran, Ecn, Flg	VU C2a(i)
Lepus capensis cheesmani Thomas	Rub' al-Khali hare	EDG Edg, Edm, Ecn	

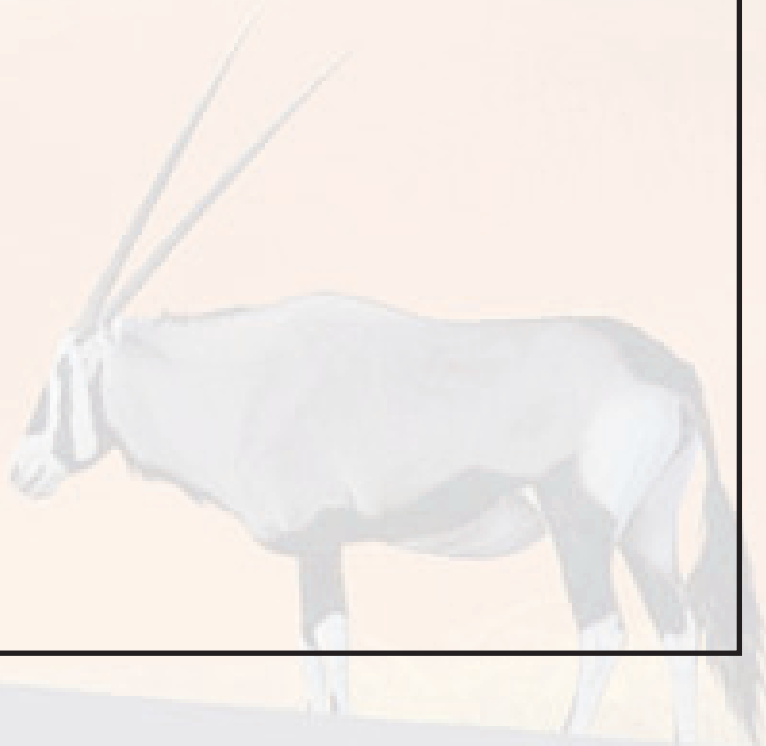
Lepus capensis arabica Ehrenberg	Arabian hare	Edg, Ran Ecn	
Hystrix indica Kerr	Indian crested porcupine	Edg, Rlc	
Gerbillus poecilops	Large Aden gerbil	Edg Edm	LR/nt
Meriones arimalius	Arabian jird	EDG, Edm	EN B1+2c
Tursiops truncatus (Montagu) / *T. aduncus*	Bottlenose dolphin	Edg, Flg	
Delphinus delphis	Common dolphin	Edg, Flg	
Stenella longirostris (Gray)	Long-snouted spinner dolphin	EDG Edg, Flg	LR/cd
Sousa chinensis	Humpback dolphin	EDG Edg, Flg	DD
Neophocaena phocaenoides (G. Cuvier)	Finless porpoise	EDG Edg, Flg	DD
Balaenoptera edeni Anderson	Bryde's whale	EDG Edg, Flg	DD

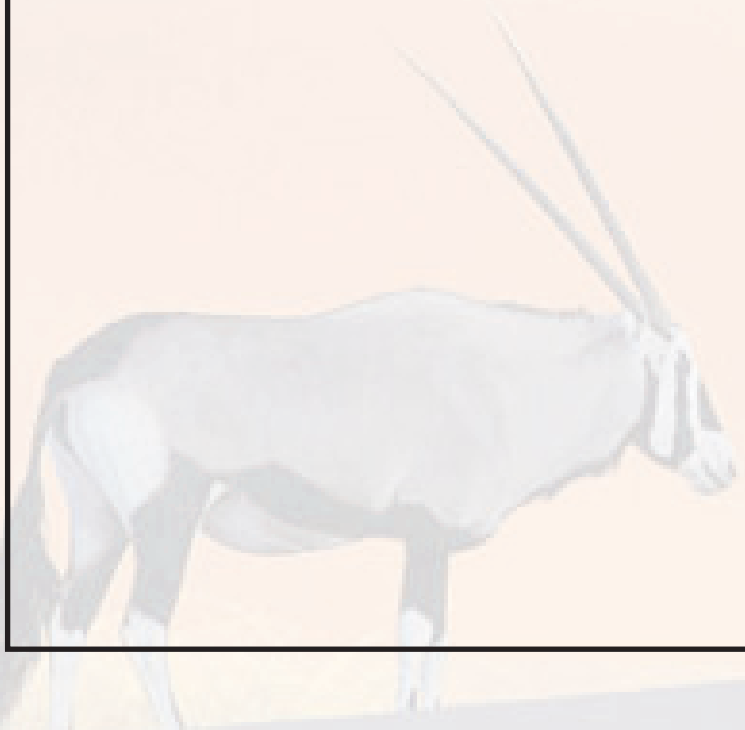
Note: **EDG**: globally endangered, **Edg**: nationally endangered, **Edm**: endemic, **Ran**: critical range, **Rlc**: relict, **Kst**: keystone, **Ind**: indicator, **Ecn**: economic, **Flg**: flagship



Appendix 1

Questionnaires





APPENDIX - 1

Questionnaire on Ecosystem Services

Personal Information:

Full Name .....

Current Profession (work)..... Past Profession (work), if any.....

Father' Profession (work).....

Birth Place..... Age .....

Current Residential Address .....

Tel: ..... Mobile: .....

1. Water

A From where did the local inhabitants get their water at the present time?

- Wells
- Springs
- Valleys
- Desalination
- Others

B From where did the local inhabitants get the water in the past?

- Wells
- Springs
- Valleys
- Desalination
- Others

2. Fuel

A What kind of fuel the inhabitants were using in the past?

- Wood
- Charcoal
- Kerosene
- Dried animal manure
- Crop waste

B What kinds of fuel the local inhabitants are using at the present time?
- Wood
- Charcoal
- Kerosene
- Dried animal manure
- Crop waste
- Cooking Gas
- Electricity

3. Food

A Did the local inhabitants in the past use imported or locally grown food?
- Locally Grown
- Imported

B Did the local in habitants at the present time use imported or locally grown food?
- Locally Grown
- Imported

4. Biodiversity

A Did the vegetation and reptiles of the mountain's forests has a value for traditional medicine?
- Yes
- No
- Don't know

B Is the presence of many different kinds of animals and reptiles in the mountain's forests is necessary for tourism?
- Yes
- No
- Don't know

Questionnaire on the Status of Grazing/Herding

Personal Information:

Full Name .....

Current Profession (work)..... Past Profession (work), if any.....

Father' Profession (work).....

Birth Place..... Age .....

Current Residential Address .....

Tel: ..... Mobile: .....

1. Have you ever grazed animals?

……..……..……..

……..……..……..

……..……..……..

2. Does any one of your family still graze animals?

……..……..……..

……..……..……..

……..……..……..

3. What types of animals are grazed by herders currently?

……..……..……..

……..……..……..

……..……..……..

4. Is animal grazing profession expanding or diminishing at the present time?

……..……..……..

……..……..……..

……..……..……..

5. Is the status of animal grazing good in your area? Is it because of good rangelands and economic profits?

……..……..……..

……..……..……..

……..……..……..

6. What is the attitude of young generations towards animal grazing?

……..……..……..

……..……..……..

……..……..……..

7. From where did the inhabitants get the fodder for their animals in the past?

……
……
……

8. From where do the inhabitants get fodder for their animals at the present time?

……
……
……

9. What is the attitude of the young generation toward the animal grazing?

……
……
……

10. What are the causes of the diminution of grazing?

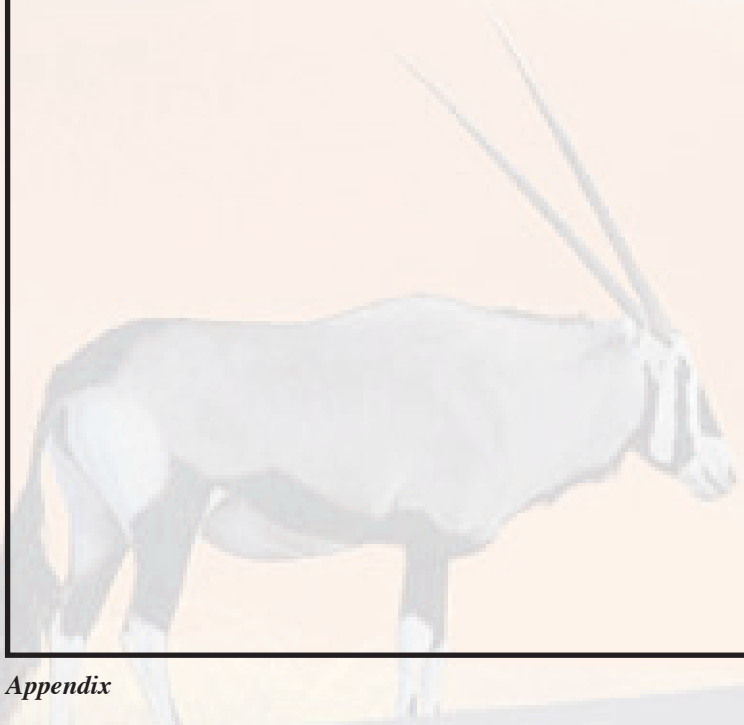
……
……
……

11. Where did the herders sell animals in the past?

……
……
……

12. Where do the herders sell animals at the present time?

……
……
……



Questionnaire on the Status of Marine Ecosystem/Fisheries

Personal Information:

Full Name .....

Current Profession (work)..... Past Profession (work), if any.....

Father' Profession (work).....

Birth Place..... Age .....

Current Residential Address .....

Tel: ..... Mobile: .....

1. Have you ever or any one of your family worked as a fisherman?

……..……..……..

……..……..……..

……..……..……..

2. Do any one of your family member still work as a Fisherman?

……..……..……..

……..……..……..

……..……..……..

3. How was the status of fishing business in the past?

……..……..……..

……..……..……..

……..……..……..

4. Is fishing business expanding and/or deteriorating?

……..……..……..

……..……..……..

……..……..……..

5. What are the cause(s) of deterioration of fishing business, if any?

……..……..……..

……..……..……..

……..……..……..

6. What are the cause(s) of improvement in fishing business?

……..……..……...

……..……..……...

……..……..……...

7. Where did fishermen sell their catches in the past?

……..……..……...

……..……..……...

……..……..……...

8. Where do fishermen sell their catches presently?

……..……..……...

……..……..……...

……..……..……...

Questionnaire on the Status of Forest Ecosystem

Personal Information:

Full Name .....

Current Profession (work)..... Past Profession (work), if any.....

Father' Profession (work).....

Birth Place..... Age .....

Current Residential Address .....

Tel: ..... Mobile: .....

Questions:

1. Forest conditions in your area in the last twenty (20) years have been

(a) Deteriorating ☐

(b) Improving ☐

(c) No Change ☐

2. If deteriorating, specify what type of deterioration and cause(s) of deterioration:

(a) Cutting the forest for firewood ☐

(b) Lack of rain ☐

(c) Urban development ☐

(d) Increased demand for lumber ☐

(e) Others ☐

3. If improving, specify what type of improvement and cause(s) of improvement:

……

……

4. Have you noticed change in the population of Juniper, Acacia and other associated vegetation and what is the cause(s) of change.

	Increased	Decreased	No Change
Juniper	☐	☐	☐
Acacia	☐	☐	☐
Others	☐	☐	☐

5. Have you noticed change in the health of Juniper, Acacia and other associated vegetation and cause(s) of change.

	Improved	Deteriorated	No Change
Juniper	☐	☐	☐
Acacia	☐	☐	☐
Others	☐	☐	☐

6. Has the condition of Terrace Agriculture in Asir Region in the last twenty years:

(a) Improved ☐

(b) Deteriorated ☐

(c) No Change ☐

Give reasons (if any)

……

……

Profession:

6A What are the crops formerly grown on the terraces?

……

……

6B. What type(s) of fertilizers are used, if any?

……

……

7. What is the kind of work (jobs) that people in your area mostly do?

(a) Now

(b) 25 years ago

8. Do you think, change in profession (if any) is caused by

(a) By government policies ☐

(b) Deterioration of natural resources ☐

(c) Other Cause(s) ☐

9. Livestock:

9.1 Size and kind of Herds

(a) Past

(b) Present

9.2 Source(s) of livestock feed

(a) Past

(b) Present

9.3 Marketing of livestock

(a) Past

(b) Present

10. Source(s) of Energy

(a) Past

(b) Present

11. Source(s) of irrigation water

(a) Past

(b) Present

12. Source(s) of drinking water

(a) Past

(b) Present

13. Method(s) of Transportation

(a) Past

(b) Present

14. Marketing of Crops

(a) Past

(b) Present

15. Attitude of younger generation towards livelihood?

……

……

16. What are the non-wood products you get from the Forest?

……

……

17. Where someone can find the most affected areas by wood cutting in the mountain' Forests?

……

……

18. What are the services you get from the Forest?

……

……

19. Has urbanization any role on the total Forest area?

……

……

20. Has the impact of tourism on the Forest been:

(a) Positive ☐

(b) Negative ☐

(c) No Impact ☐

Questionnaire on the Status of Terrace Agriculture

Personal Information:

Full Name .....

Current Profession (work)..... Past Profession (work), if any.....

Father' Profession (work).....

Birth Place..... Age .....

Current Residential Address .....

Tel: ..... Mobile: .....

1. Have you or any one of your in the past worked as a farmer in the area you live in now?

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2. How do you describe the condition of the terraces at the present time? is it good or deteriorated?

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3. What are the causes of the agricultural terraces deterioration?

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4. What were the terraces used for in the past?

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5. What are terraces used for at the present time?

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6. What are the kinds of fertilizers that are used in terraces now?

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7. Where did the terrace's farmers sell their agricultural produces in the past?

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8. Where do the terrace's farmers sell their agricultural products at the present time?

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9. What is the attitude of present generation toward agriculture?

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10. What are the causes for some of the inhabitants to quit farming?

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