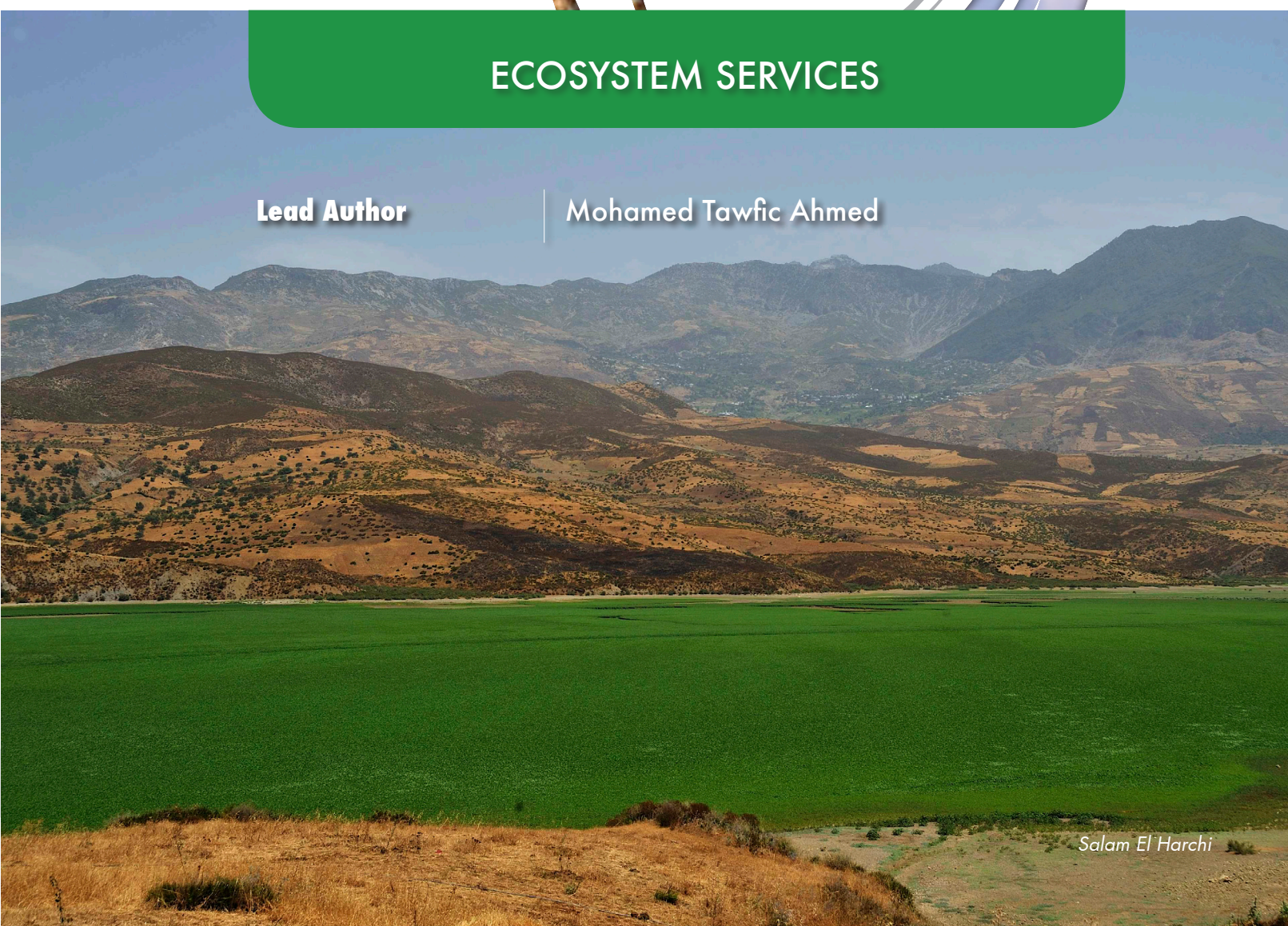
CHAPTER 3

ECOSYSTEM SERVICES

Lead Author | Mohamed Tawfic Ahmed



Salam El Harchi

Main Messages

Productive ecosystems provide communities with resources and options they can use as insurance in the face of natural catastrophes or social upheaval. Well-managed ecosystems reduce risks and vulnerability. Poorly managed systems can increase the risks of flood, drought, crop failure, or disease.

An ecosystem is subject to numerous externalities that might impede its ability to provide its regular service, either temporarily or permanently, depending on the nature and magnitude of that externality. Examples include any natural or human-induced factors that directly or indirectly cause a change in an ecosystem.

In each of the Arab Sub-global assessments, ecosystems provide numerous services, inherent to each. Provisioning services are the most dominant in the three assessments.

Common ecosystem services in the three assessments include water, agriculture, grazing and raising cattle, aromatic and medicinal plants and biodiversity.

The three case study areas are vulnerable with regard to water resources, as rain is the main source of water. Water scarcity is the most influential driver on ecosystem services. Both natural and anthropogenic factors impact the quantity and quality of water resources. Drought and lack of precipitation are the most natural influential drivers that limit the ecosystem's ability to provide water.

Change in land-use patterns is a major cause for a number of repercussions that affect the environment and its ability to keep on providing its regular services.

Agriculture is the most well established and inherent ecosystem service. However, intensity, quality, and profitability of agricultural practices are significantly different in each assessment. Impacts on agriculture tend to have a series of drawbacks with direct and heavy bearing on people's welfare and prosperity.

Biodiversity, in its widest scope, is the main repository of all services that an ecosystem can provide to its inhabitants. 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 that ecosystems provide. Poverty is probably the most potential driver, with direct and deleterious impact on biodiversity. In many unprivileged communities, mostly in rural areas where the majority of people are poor, ecosystem services become life-supporting elements, and their role becomes more conspicuous.

3.1 ECOSYSTEM SERVICES, TRENDS AND CONDITIONS

Ecosystem services are the benefits people obtain from the ecosystems they live within. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services such as nutrient cycling that maintain the conditions for life on Earth. The concept "ecosystem goods and services" is synonymous with ecosystem services.

Ecosystem Services Definitions

An ecosystem is "a dynamic complex of plant, animal, and micro-organism communities and the non-living environment interacting as a functional unit" (UNEP 2003). Ecosystems form a landscape and are connected often by streams, rivers, and wildlife. Ecosystem services represent the benefits human populations derive, directly or indirectly, from ecosystem functions (UNEP 2003, Daly and others 1997).

Humanity has always depended on the services provided by the biosphere and its ecosystems. Furthermore, the biosphere is itself the product of life on Earth. The composition of the atmosphere and soil, the cycling of elements through air and waterways, and many other ecological assets are all the result of living processes – and all are maintained and replenished by living ecosystems. The human species, while buffered against environmental immediacies by culture and technology, is ultimately fully dependent on the flow of ecosystem services. Ecosystem services are the benefits people obtain from ecosystems. These include provisioning, regulating, and cultural services, which directly affect people, as well as the supporting services that are needed to maintain the other services. Changes in these services affect human well-being through impacts on security, the basic material for a good life, health, and social and cultural relations. These constituents of well-being are, in turn, influenced by and have an influence on the freedoms and choices available to people.

The demand for ecosystem services are now so great, that trade-offs among services have become the rule. There are many indications that human demands on ecosystems will grow still greater in the coming decades. The current estimates of 3 billion more people and a quadrupling of the world economy by 2050 imply a formidable increase in demand for, and consumption of biological and physical resources, as well as escalating impacts on ecosystems and the services they provide.

This combination of ever-growing demands being placed on increasingly degraded ecosystems seriously diminishes the prospects for sustainable development. Human well-being is affected not just by gaps between ecosystem service supply and demand but also by the increased vulnerability of individuals, communities, and nations. Productive ecosystems, with their array of services, provide people and communities with resources and options they can use as

insurance in the face of natural catastrophes or social upheaval. While well-managed ecosystems reduce risks and vulnerability, poorly managed systems can exacerbate them by increasing risks of flood, drought, crop failure, or disease.

3.1.1 Ecosystem, the Relationship between People and Environment

The concept of an ecosystem provides a valuable framework for analysing 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.

3.1.2 Drivers of Ecosystem Change

An ecosystem may be subject to a number of externalities that may impede its ability to provide its regular service, either temporarily or even permanently, depending on the nature and magnitude of that externality. The MA defines such externalities, "drivers" in the broadest possible sense: any natural or human-induced factor that directly or indirectly causes a change in an ecosystem. The approach adopted here is to distinguish between direct and indirect drivers. A direct driver unequivocally influences ecosystem processes and therefore can be identified and measured in 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 direct observation of the ecosystem; its influence is established by understanding its effect on a direct driver.

The indirect drivers of change are primarily demographic, economic, socio-political, scientific and technological, cultural and religious. The interaction of several of these drivers in turn affects the overall level of resource consumption and disparities in consumption within and between countries.

Clearly these drivers are changing. For example, population and the global economy are growing, there are major advances in information technology and biotechnology, and the world is becoming more interconnected.

Changes in these drivers are projected to increase the demand for food, fibre, clean water, and energy, which will in turn affect the direct drivers. The direct drivers are primarily physical, chemical, and biological, such as land cover change, climate change, air and water pollution, irrigation, use of fertilizers, harvesting, and the introduction of alien invasive species as discussed in previous chapters.

Changes in drivers that indirectly affect biodiversity, such as population, technology, and lifestyle, can lead to changes in drivers directly affecting biodiversity, such as the catch of fish or the application of fertilizers.

Box 3.1 Typologies of Drivers

Several typologies of drivers were considered for the Millennium Ecosystem Assessment conceptual framework – primary versus proximate, anthropogenic versus biophysical, dependent versus independent, primary versus secondary. The proximate and primary driver terminology, for example, is widely used in the land-use change and climate change literature (Turner II and others 1995, IPCC 2002).

Proximate and primary drivers are conceptually similar to direct and indirect drivers respectively, but tend to be used when analysing specific spatial processes in which the human intent (primary) is linked with actual physical actions (proximate). The explicit cross-scale linkages and inclusion of physical activities of this typology made it too complex, however, for characterizing the drivers in the Millennium Ecosystem Assessment conceptual framework. Other typologies have been developed for specific purposes and have their limitations. The distinction between direct and indirect drivers, in contrast, provides an opportunity to include highly diverse types of drivers that seem acceptable to the broadest possible community.

This leads to changes in ecosystems and the services they provide, thereby affecting human well-being. These interactions can take place at more than one scale and can cross scales. For example, an international demand for timber may lead to a 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. Different strategies and interventions can be applied at many points in this framework to enhance human well-being and conserve ecosystems.

3.2 ECOSYSTEM SERVICES IN THE ARAB ASSESSMENTS, AN OVERVIEW

In the Arab sub-global assessments, ecosystems provide numerous services, inherent to each other. Provisioning services are most dominant in the three assessments. Other types, such as cultural and regulatory services, are also present, deeply embedded in ecosystem construct. Nevertheless, the spectrum of services in each assessment tends to have some commonalities with other assessments, while maintaining some special services, as part of its inherent difference.

In the three assessments, similar ecosystem services complement inhabitants' needs of food and other materials used in daily life. In both El Maghara and Tafilalet, where poverty is a common concern, supplements from ecosystem services are the most effective way to combat poverty. In these assessments, environmental degradation, and diminishing ecosystem services are direct causes of poverty and inferior quality of life.

Water and agriculture are the most common ecosystem services in the three assessments. In Asir, forest products, fisheries, and tourism are other provisioning ecosystem services. In El Maghara, the main provisioning services

are water, agriculture, and medicinal plants. In Tafilalet, agriculture, including animal production, medicinal and aromatic plants, along with fuelwood are major ecosystem services. Cultural services have some significant presence in the three assessments, with tourism as a significant service in Asir, and Tafilalet, while in El Maghara Sheikh Hemid, one of the religious shrines in Sinai is a major cultural and religious landmark of Bedouin culture and heritage.

3.2.1 Water

The provision of water is probably the most valuable service provided in the three assessments alike, with rain as the main source of water, in all three.

Ministry of Energy, Mines, Water & Environment, The Kingdom of Morocco

Provision of Water is One of the Main Services in Tafilalet Ecosystem

Source: UNEP, 2009

Mohamed Tawfic

Bedouin Ladies Fetching Water at El Maghara, Sinai, Egypt

Source: UNEP, 2010

A variety of techniques are used to harvest rainfall (flash floods), including dams built to store and regulate rainwater throughout. Local knowledge is highly manifested in the management of such scarce and sporadic rainfall, using locally devised and developed methods.

Water from flash floods, in addition to being the main source to replenish exhausted stock of groundwater, is also used for agriculture, ridding the soil of salt content, while improving soil fertility and productivity. However, flash floods can turn destructive causing some serious damage.

Flash floods are also a major source of irrigation in the three sites where inhabitants seed their land and wait for the flash floods to come. Alternatively, inhabitants may allow flash floods to pass over their land, and then soon after plant their crops on wet land.

Destruction Caused by Flash Floods, Tafilalet, Morocco
Source: UNEP, 2009

Destruction Caused by Flash Floods, Sinai, Egypt
Source: UNEP, 2010

Wells, the main sources for potable water are shallow in Asir, but rather deep in ElMaghara. Groundwater quality differs in the three sites. In Asir, water quality is sufficiently good for human consumption, with an average TDS (Total Dissolved Solids) ranging between 350 - 1080 ppm, with a tendency of increased salinity towards the Red sea.

In El Maghara, the quality of groundwater is often not good enough for human consumption, and Bedouin depend on storing rainfall in deep ground storage sites. Bedouin also buy fresh water from nearby village centres, where fresh tap water is available.

In Tafilalet, 'Khettarat', a technique developed some centuries ago, is a common system of abstraction of groundwater. Khettarat was invented in Iran and was introduced into the Maghreb by Arabs during their conquests.

Various Irrigation Methods, Tafilalet, Morocco
Source: UNEP, 2009

Khettarat in Tafilalet, Morocco
Source: UNEP, 2009

The management and maintenance of 'Khettarats' are made by traditional groups of water rights holders. Maintenance consists mainly of a flushing of the earth and sand accumulated in the gallery of 'Khettarat' and on the well walls.

Water Scarcity and Drought Spills

The Middle East and North Africa regions have witnessed prolonged harsh spells of drought for some time, with some unfavourable repercussions.

In Tafilalet, prolonged drought was reported during the last century and the beginning of this century (Benmohammadi and others 2000, Kabiri and others 2003).

The province of Errachidia, where Tafilalet is located, is largely characterized by limited water resources, low and irregular precipitation and successive droughts, creating a sensitive water balance that may cope with growing demand. Similar drought spells were also observed in El Maghara, Sinai with some significant impacts on all walks of life, including food production, health, and socio-economic fabric.

In Asir, groundwater abstracted from upper parts of Baba valley is estimated to be 5.5 million m^3 per year, while groundwater extraction from upper parts of Hala valley is estimated at 11 million m^3 annually. Downstream, near the shore, water abstraction from Baba and Hala valleys used in agriculture is estimated to be 47 million m^3 per year. In Asir, water desalination is also carried out to supplement groundwater, with Shuqaip desalination plant producing

Table 3.1 Areas, Lengths and Annual Discharges of Wadi Basins in Asir

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**

Source: UNEP, 2010

120 000 m^3 per day, with a second phase expected to produce 212 000 m^3 per day. Desalination of brackish well water is sporadically practiced in El Maghara, but at a very minor level.

Signs of Drought, El Maghara, Sinai
Source: UNEP, 2010

Potable water consumption in the three assessments is a function of availability and suitability. In the Asir assessment, potable water consumption in the governorates 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 groundwater wells, desalination plants and dams. The consumption rate per person is 250 litres in Abha city while in other small cities it is slightly lower, at 200 litres per day. In rural villages, each inhabitant consumes 100 litres per day on average. This would count for all water resources in the area that include water provided through groundwater, desalination, and dams.

Oughrour, One of the Traditional Methods of Irrigation Tafilalet, Morocco
Source: UNEP, 2009

In El Maghara, there is great disparity in current per capita water availability for each watershed in the area. Wadi Mezara has over 4 000 m^3 per person per year. While the average for both Wadi El-Khariq and Wadi El-Fatah watersheds are under 1 000 m^3 per person per year, and that for Wadi El-Massajid is about 1 756 m^3 per person per year (UNEP 2010).

In Tafilalet heavy pressures on groundwater resulted in the decline of water supplies and even their disappearance in some cases. In some cases, wells dried up and were eventually abandoned, or became places to dump waste or even septic tanks that pollute groundwater.

Impact on Water, Quality and Quantity

Water is the elixir of life; all other ecosystem services are directly related to the quantity

and quality of water. 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 is the quantity of water of concern to decision-makers, but quality of water as well. Water pollution can adversely affect practically all other ecosystem services.

In the three Arab sub-global assessments, water resources are subjected to both natural and anthropogenic impacts that influence water quantity and quality. Drought and lack of precipitation are the most natural influential drivers that limit ecosystem ability to provide water in the three assessments. It is even expected that climate change and global warming may increase the intensity of water shortage in the three assessments alike. Arab countries, including Egypt, Morocco and Saudi Arabia, are among the world's dry regions with the least global water per capita, at about 1 000 m^3 (UNEP, CEDARE and LAS 2010). All predictions are that climate change will reduce the overall amount of rainfall by at least 20 per cent, increase variability (droughts and floods), make it harder to manage the rain that does fall, and increase evaporation through higher temperatures.

Rapid population growth is bound to affect water availability to a drastic extent, with per capita set to drop to half by 2050. Development of the tourism industry is emerging as one of the driving forces with notable impact on water availability, with special reference to Tafilalet and Asir.

Desalination is a Major Source of Water in Saudi Arabia

Water Pollution

In Asir, El Maghara and Tafilalet, water pollution is a potential limiting factor that adds up, and exacerbates water scarcity problems. In El Maghara, the various industrial and extractive activities are one of the main reasons for the inferior quality of water. Coal processing wastewater and dewatering processes also involve the emission of heavy metals and other organic pollutants. Wastewater and dewatering flows are disposed of around the mine, allowing contaminants to leach to groundwater causing potential damage to water quality. Water samples collected from various wells in the assessment area were analysed to monitor concentrations of heavy metals and other anionic constituents. The results (see Table 3.2) indicate the presence of a wide spectrum of contaminants in almost all water samples.

Microbial Contamination

Another and equally serious source of pollution is microbial contamination of groundwater in the El Maghara area. Samples from main wells in the assessment area were analysed for their microbial load. Results indicate hazardous levels of microbial contamination in almost all water samples tested. The Bedouin store their water supply in open tanks, exposed to dust and air, with almost no sanitary precautions.

In Tafilalet, discharge of municipal wastewater is the main source of water pollution. The province of Errachidia, where Tafilalet is located, is characterized by the lack of sanitation and wastewater treatment. The liquid discharges from urban centres are directly discharged into rivers, which have a low capacity of natural purification especially during the periods of low water level. The results of tests carried out by the RDH 2003 - 2004 (Mahboub and Kelly 2006) indicate that 22 per cent of measured points (surface water) are beyond the standards required for ammonia. The most affected sites (more than 8 mg/l of ammonia) are located around the largest cities in the region; Goulmima, Errachidia and Rissani – in the ponds of Ghèris and Ziz. Further up from these places water has a better quality (0.1 mg/l of ammonia).

In Asir, water pollution caused by wastewater discharge from Abha and Al-Birk wastewater treatment plants and septic tanks flow down the wadi into the Red Sea and adversely affects the fish population. 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 (persistent organic pollutants (POPs)) mix with run-off water and are discharged into the sea, fish populations suffer. In addition, floods can erode the topsoil, removing essential nutrients for crop production.

Table 3.2 Residues of some Heavy Metals in Water Samples in some Wells, El Maghara

Sr.No.	Well Name	Manganese ppm	Iron ppm	Nickel ppm	Copper ppm	Cobalt ppm	Lead ppm
1	Bir 5	0.06	n.d	0.4	0.06	1.43	0.26
2	Bir 12	0.06	0.22	0.4	n.d	0.71	0.26
3	El Feteh 1	0.06	0.15	n.d	n.d	n.d	n.d
4	El Feteh 1	n.d	n.d	n.d	n.d	n.d	n.d
5	El Masoura	n.d	n.d	n.d	n.d	n.d	n.d
6	Bir Raghwi	0.09	0.22	n.d	n.d	n.d	n.d
7	Coal Mine (Wadi Massajed)	0.09	0.19	n.d	n.d	n.d	n.d
8	Coal Mine (Wadi Safa)	0.09	0.76	0.4	n.d	1.79	0.4
9	Bir Unwerib	0.06	n.d	n.d	n.d	n.d	n.d
10	Bir El Maghara	0.12	n.d	0.8	n.d	n.d	n.d
11	Bir El-Hodod	0.06	n.d	0.8	n.d	n.d	n.d
12	Cistern *(Haraba)*	0.32	0.72	n.d	n.d	n.d	n.d
13	Bir El-Malahi	0.09	n.d	n.d	n.d	n.d	n.d
14	Bir El-Masoutia	0.09	0.31	n.d	n.d	n.d	n.d

Source: Ahmed, M.T. and others, 2010

Table 3.3 Levels of Bacterial Contamination of Water Samples Taken from some Haraba in Central Sinai

Sample Name	TVB cfu/ml	FC cfu/ml	FS cfu/100 ml
Mazarea Harraba	1 600	Nil	Nil
El Menissi harrab	1 900	1	Nil
Karama Dam	2 500	160	Nil
Egyptian Standard	1 100	Nil	Nil

TVB = total viable bacteria; CFU = colony forming unit; FC = faecal coliform; FS = faecal streptococci
Source:Ahmed, M.T. and others, 2010

Impact of Drivers on Water

The three assessments have shown clearly that change in land-use pattern is a major driver for a number of repercussions that have affected the environment and its ability to keep on providing its regular services. The three assessment reports have portrayed a number of cases, in which changes in land-use pattern have caused some potential damage to major ecosystem services and attributes.

For example, in the Asir assessment, road construction is one of the most apparent manifestations of land-use change, with some significant influence on water conditions. The construction of roads is indispensable for community development and prosperity. However, it is also considered responsible for an alteration in the natural set-up of land resources, with some implications on groundwater movement patterns.

Local inhabitants of Asir predict that land-use changes will continue to take place; for example, forest areas will be cleared and replaced by croplands, because of the economic advantage of crops over forest products. Forests have an instrumental role over cropland in that they protect soil from erosion by transforming intense rainfall into a more gentle rainfall.

Land-use change in Asir, caused by the expansion of urban centres as a result of migration of populations toward urban centres is another pressure on forest areas as the land for expansion comes from forests. This also leads to increased demand for agricultural products which results in the expansion of agricultural activities, converting forest areas into agricultural land.

In El Maghara, the unlawful construction of alleys by gravel contractors is one of the main drivers that affect the full exploitation of flash floods.

In El Maghara, flash floods constitute a prominent component of fresh water that the Bedouins use in their daily lives, and for growing their crops. The Bedouin of El Maghara, know through intuition and long experience, the route that flash floods will take to reach them from the highlands down to the downstream valleys where they live and grow their crops. As the season of flash floods approaches, they start checking these paths, removing all obstacles that may

Road Construction, Obstructing Flash Flood Reaching the Bedouin in Sinai

Source: UNEP, 2010

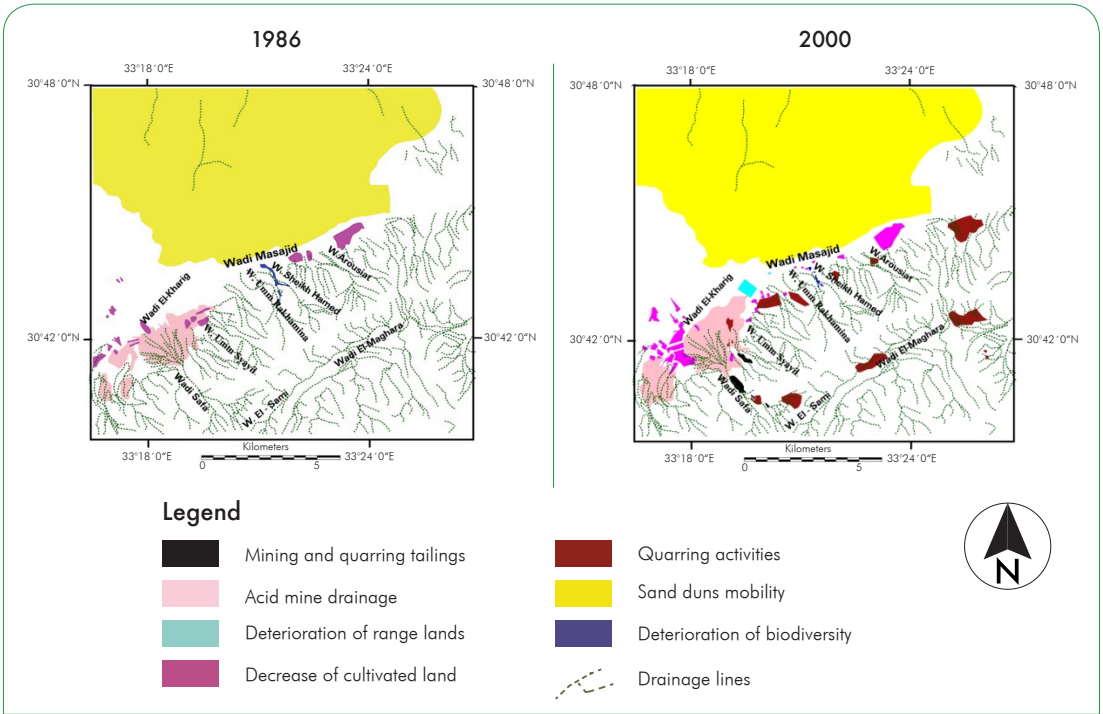


Figure 3.1 Land-use Pattern in El Maghara Area, 1986 and 2000

Source: UNEP, 2010

obstruct the floods to ensure a high harvest. With the large increase in demand for stone and marble, quarry contractors have constructed new alleys and roads to reach highland sites, that were never used before. The Bedouin claim that most of these newly built roads are intercepting flash flood supply, dispersing water and causing the loss of a large potential source of water.

3.2.2 Agriculture

Agriculture is the most well-established and inherent ecosystem service in the three assessments, though intensity, quality, and profitability of agricultural practices are significantly different in each assessment.

In Asir, agriculture seems to be a well-established ecosystem service, with wide practice and advanced technology. Terrace agriculture on mountains and slopes area is most common. Agriculture is also practiced in the plains towards the Red Sea.

Most of the farms at higher altitude areas are terraced. They depend on rain as well as irrigation from groundwater. Main crops grown in the area are wheat, millet, sorghum, barley, as well as some maize and sesame. Due to the migration of inhabitants from rural areas to urban zones in order to gain access to jobs, education and better opportunities, large

areas of farms are left fallow or are rented to others. Generally, these farms grow two crops per year.

In El Maghara, agricultural practice is modest in comparison to Asir and Tafilalet. The chronic shortage of water is a potential factor affecting agriculture and related activities in El Maghara. As a result, agriculture is sporadic, restricted to areas where rainfall is likely to take place, or in the vicinity of wells, depending on water salinity and suitability for agriculture. The main crops grown in the area are olives, peaches, cantaloupe, barley and almonds. There are no reliable figures on agricultural productivity, but, considering the prevailing conditions, one would expect a very low production rate. The potential for agriculture is reasonable, however, if a source of water is ensured. Research conducted by the Desert Research Centre indicated the ability to grow a number of economic crops such as nuts, spices, and fruits. Olives are a staple food in the area and olive oil is widely used.

Bedouin of Sinai Selling their Agricultural Products in a Nearby Market

Source: UNEP, 2010

The intercropping system practiced by the Bedouin is a part of agrodiversity. They use barley with olive trees and cantaloupe for intercropping. Barley can tolerate water salinity and can be used as fodder for camels. The intercropping system enables the Bedouin to protect their lands from degradation and erosion. In addition, it improves water use efficiency and increases productivity. Intercropping is also a way of reducing risks, in case the main crop fails to grow for any reason, especially with the prevailing hardship of the area.

In Tafilalet, agriculture is a central service, representing 68 per cent of economic activity. Traditional, conventional agriculture is prevalent, especially around rivers, and near water resources.

Tafilalet has two farming types: the extensive and the intensive farming systems. The extensive farming type is practiced by nomads and transhumants leading their herds of sheep and goats in the mountains and plains in search of pasture. However, because the climate of the region is marked by long periods of drought and high dryness, pastures are characterized by a predominance of spontaneous and thin vegetation. Intensive farming, on the other hand, is primarily concerned with cattle and sheep. Alfalfa is the main source of food.

Agriculture in Tafilalet exhibits significant biodiversity, with local varieties adapted to the natural conditions. It offers a vast number of agricultural products, such as date, olive, apple and almond trees, cereals, fodder (alfalfa), and market garden productions. Date palm production constitutes the most dominant and is the backbone of oasis agriculture.

Dates are used for consumption, marketing and animal feed (waste of dates and dates of low commercial value). Olive trees are the second largest crop after dates. Similar to El Maghara, intercropping is largely practiced in Tafilalet, as crops are often combined on the same plot. They constitute an additional income source for farmers.

Impacts of Drivers on Agriculture

With agriculture being the main service providing food to the local inhabitants, impacts on agriculture tend to have a series of drawbacks with direct and heavy bearing on human well-being and prosperity. In the three assessments, the main drivers of agriculture are either natural or anthropogenic.

Water Scarcity

Water scarcity is the most influential driver, with the strongest impact on agriculture and agricultural productivity in the three assessments. Water scarcity is also an indirect driver for a number of repercussions that trickle down in various forms. Young inhabitants tend to leave the assessment sites, moving to other places where reasonable income can be ensured. Water shortage, therefore, has affected the age structure of the Bedouin, with the highest ratio being elderly, in comparison to other age groups. Water shortage also has economic repercussions. Cash flow is very limited, as grazing and agriculture, the most important activities in the area, are badly hit by long-lasting droughts.

In Tafilalet, when agricultural lands became incapable of ensuring a sufficient supply of goods and services for the local people, there was an intense immigration to Europe.

Money brought by these immigrants led to a major transformation in the lifestyle of the population. Indeed, it led to the desertion of traditional houses, 'Ksours', built in adobe

Soil With Salt Deposits, a Manifestation of Drought in Tafilalet

Source: UNEP, 2009

soil, to move into new houses built in reinforced concrete in the outskirts of 'Ksours', on agricultural lands. The abandonment of farming by young people, who are attracted by the urban lifestyle and other more promising horizons, are further reasons for immigration.

Sand Encroachment

The phenomenon of sand encroachment, resulting from harsh weather conditions and anthropogenic practices are considered the final stage of the process of physical and biological degradation of the environment.

Wind action can be classified into two main classes: a mobilized sand encroachment from outside the villages, and a mobilized sand encroachment from the villages and farmlands at the edge of the desert.

Change in soil quality and loss of vegetative cover are main causes for sand encroachment recorded in El Maghara. Enhanced images show extensive and large amounts of sand accumulations and encroachment covering large areas. Roads, especially during winter, are often covered with massive volumes of moving sand, hampering the use of roads and posing serious risks to travelers.

The Main Road Of El Maghara Area Covered With Moving Sand

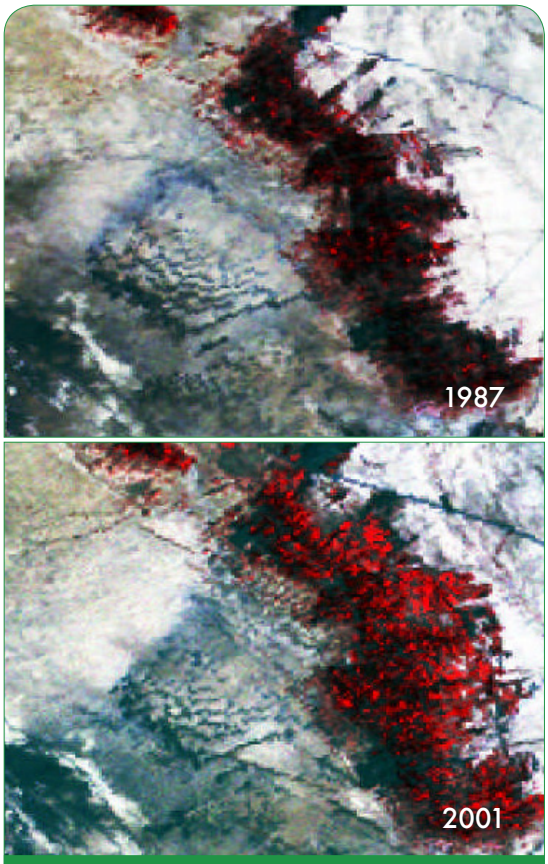


Figure 3.2 Sand Dunes Movement in Tafilalet, Morocco

Source: UNEP, 2009

Moving sand has serious impacts on infrastructure and interrupts the mobility of the already meager public transportation buses serving the area. In El Maghara, sand movement impedes the small trucks Bedouin use to move around, exacerbating their sense of isolation and remoteness.

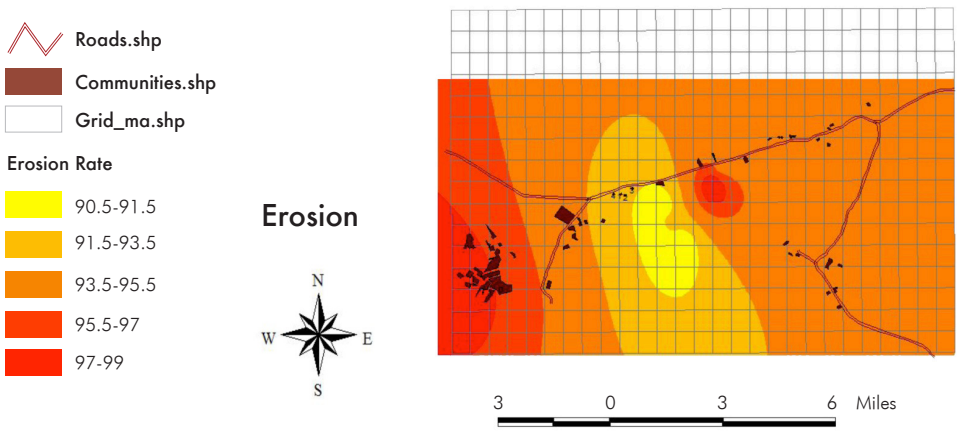


Figure 3.3 Erosion Map, El Maghara, Sinai, Egypt
Source: UNEP, 2009

Water and Wind Erosion

Water erosion threatens agricultural lands. Indeed, flood waters undermine the banks and remove agricultural lands, but also deposit large quantities of sand and cause siltation of irrigation canals. In El Maghara, blowing wind dismantles scarps, deepens hollows, and erodes exposed rock. These eroded particulates are emitted into the atmosphere as dust, or accumulate in the form of sand sheets and dunes, or are left behind as coarse lag deposits.

Figure 3.3 indicates the erosion rate at El Maghara, showing a relatively high rate of erosion around the area where most of the gravel and sand extraction processes take place.

Diseases and Insect Pests

In Tafilalet, plant diseases are potentially harmful, affecting the production of many agricultural crops, with particular reference to date palms that become infected with Bayoud, a plant pathogen.

The incidence of Bayoud is high in areas with abundant supply of water. Thus, the site of Meski is one of the most infested places. The impact of Bayoud varies on different species of dates. 'Boufegous' is the most susceptible variety, with an infestation ratio of about 70 per cent. Such high susceptibility is attributed to the thinner skin of this variety in comparison to other varieties.

In addition, a number of insect pests are causing considerable damage to main crops, especially olive trees, one of the main crops of Tafilalet. Major insect pests are:

- The bark beetle of olive trees (neroun) Phloetribus scarabeioides, Coleoptera. This insect causes devastating effects by

digging tunnels in tree trunks, especially after the weakening of trees due to drought.

- Olive tree cochineal insect (Saissetia oleae olive Homopères, Coccidae). The insect, characterized by black hemispherical shells, can cover all parts of the tree.
- Olive tree flies (Dacus olea Gmal, Diptera, Tryptidae). This fly pierces young fruit to lay its eggs. The larvae feed on the pulp of olives.

Bayoud Infecting Date Palms, Tafilalet, Morocco
Source: UNEP, 2009

3.2.3 Grazing and Raising Cattle

Grazing is the single largest land-use pattern in drylands, including the three MA sites. In Sinai, grazing is primarily an activity of women, with almost no involvement of men. Women have developed a good sense of recognition for various types of herbs that animals feed on, with a remarkable ability to distinguish toxic and harmful weeds.

Grazing provides a long list of supporting services that contribute to the well-being of Bedouin, and supports their presence in the Sinai's harsh arid ecosystem:

- Meat and milk, the primary production of grazing, supply Bedouin needs for protein. Camels provide the primary source of transport.
- Organic manure is an important livestock product.
- Bedouin construct their shelters from animal skins.
- Animal wool is used as the primary material to produce a variety of household an farming tools.
- Wool is also the backbone of some handicraft industries, such as rugs, and it can also be used in bedding and clothing.
- In orchards, sheep are often used to control weeds and thus constitute a profit-producing biological control.
- Animal grazing removes older, less productive plant species and stimulates regrowth of useful plants, and this in turn reduces soil erosion.

In Tafilalet, raising cattle is widely practiced. The number of cattle is estimated at about 30 000 heads, consisting mostly of the local breed, which is hardy and less productive. Improved breeds are also spread mainly around the urban zone of Errachidia and Rich, and represent less than 10 per cent of the total size. Goat milk (450 000 heads) is mostly produced by the local goat called

"Beldia" that coexists with the Canary Spanish milk goat introduced to Morocco two decades ago.

3.2.4 Aromatic and Medicinal Plants

The provision of medicinal and/or aromatic plants is one of the main ecosystem services in El Maghara and Tafilalet. Local inhabitants are well versed in the utility value of many of the medicinal plants available in their vicinity. In both El Maghara and Tafilalet, a considerable number of plant species is endangered, or have even disappeared because of the overuse of rangelands, and land-use changes.

In Tafilalet, pastoral resources were managed through a locally developed, transhumance manner, known as Al Orf, or Agdal, which seem to have lost momentum as part of changing lifestyle and practices. In Asir, medicinal and aromatic plants are among the main non-wood forest products, in addition to some herbs, spices, gums, and resins.

In El Maghara one sector of the questionnaire was to ascertain the relationship between the Bedouin and the available medicinal plants. Information showed clearly that Bedouin 30 years and older are intimately familiar with the use of medicinal plants. This age group's interest in using medicinal plants is 73 per cent higher than those below this age. Those in the younger generation might have the same strong belief in medicinal plants, but they also believe that these plants on their own may not be good enough to treat many diseases

A Bedouin from El Maghara Identifies One of the Threatened Medicinal Plants

Source: UNEP, 2010

and that there is a real need to supplement their use with commercial pharmaceutical products.

The Tafilalet report indicated that the Acacia seyal ('Amrade') which used to be abundant in the mountainous areas, is currently endangered, and approaching extinction. The shrub possesses many medical uses. Most of the medical values are related to Arabic gum formed near the trunk. In addition, the population uses its sap as an anti-asthmatic, and its seed as a medicament against stomachaches. Similarly, fruits of the Olea eurapaea (oleaster, 'Tiwinight', 'Azemour') shrub were extensively used, until recently, as a medicament against kidney stones and injuries. This species has virtually disappeared in the region.

3.2.5 Biodiversity

Biodiversity, in its widest scope, is the main repository of all services that an ecosystem can provide to its inhabitants, as well as beyond. 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. Throughout history, human communities have relied directly on biodiversity to provide food and medicinal products. In poor communities, the role of biodiversity is even more apparent, with a substantial contribution in combating poverty.

Biomass Collection, Tafilalet, Morocco
Source: UNEP, 2009

Biodiversity maintains critical and key processes such as carbon storage, nutrient cycling, plant species diversity, soil fertility, soil erosion, nutrient uptake by plants, formation of soil organic matter, nitrogen fixation, biodegradation of dead plant and animal materials, reduction of hazardous waste, production of organic acids, and control of plant and insect populations through natural biocontrol.

Despite the major role played by biodiversity in the three assessments, some major fears to its fabric have been commonly stated. Signs of species disappearance, reports of alien species, massive mismanagement practices, habitat fragmentation, and negligence have been well documented in the three assessments.

In Asir region, many people 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, fuelwood and charcoal production were carried out according to the traditional way. Trees were cut, dried and sold in fuelwood markets without any consideration of the associated damage of forestry resources. In 1977, the Forest and 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 instated. The executive regulations for the Forest and Rangelands Act were issued. They explained the methods for forest exploitation and transportation of products according to specific models of licensing relative to fuelwood collection and transportation, and charcoal making activities and transportation.

In Asir, inhabitants of rural villages and resettlement areas are most affected by deterioration incurred in forest areas, as they rely on many of the forest products, such as fuelwood, animal grazing, by-products including fruits, seeds, medicines, and honey. Forests also have other environmental roles and fringe benefits that include 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.

In addition, forests play a key role in the development of tourism in the area, as forests represent the natural resources upon which environmental tourism depends. In fact, environmental tourism is one of the fastest

Rich Plant Diversity in Asir, Saudi Arabia

growing sectors of this decade. Through tourism, the awareness of nationals is raised regarding the role of forests, the importance of conservation, and the potential generation of job opportunities for locals in forest regions.

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

- Conservation of plant cover that helps in soil fixation by the roots and improved aeration.
- Decreasing velocity of rainwater flow, soil surface and the mountain slopes which prevents soil sliding and erosion.
- Decreasing wind speed and sand creeping process.
- Decreasing temperature and 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 of crop productivity.
- Providing parks and tourism sites.
- Decreasing environmental pollution through the absorption of harmful gases including 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 wildlife by providing suitable shield and safe refuge for animals during their normal migration.
- Production of honey, medicinal substances, and tanning material.

Plant coverage in the El Maghara area and in Sinai at large is a prominent component of Bedouin life and well-being. Plant coverage constitutes a major source of food, beverage, animal feed, raw material for building houses, and medicinal plants. Plants are also used to produce some household and agriculture tools such as ropes, plates, and many other products.

A Bedouin's Home and Household Tools Made of Local Plants, El Maghara, Sinai

Source: UNEP, 2010

The oasis of Tafilalet is endowed with a rich and varied folklore, reflecting the strength of the oral culture, still very much alive, which consists of a popular heritage and a means to communicate the local culture. Biodiversity richness allows the development of nature-based tourism activities such as hiking or riding, sport fishing and nature exploring (fauna, flora and landmarks are still intact and virgin).

Impact of Drivers on Biodiversity

Biodiversity, a subtle web of organisms of various size and nature, is closely connected with a number of in and out flows, and influx mechanisms. Impacts on a distant segment of the web might be of significant influence on the performance of the whole web, though not necessarily recognized. In the three assessments biodiversity is impacted by aridity, poverty, urbanization and tourism.

Impact of Aridity on Acacia Wood in El Maghara

The harsh environmental conditions caused by severe aridity, coupled with other potential man-made impacts have caused damage to the floral and faunal diversity of the area. Frequent meetings with the Bedouin indicate that a number of the plants they use in their daily life have disappeared, or are becoming very rare. At the same time, some other species that they never knew have become frequent, and sometimes cause problems for their crops. This view was not only expressed by the people of El Maghara, but also by

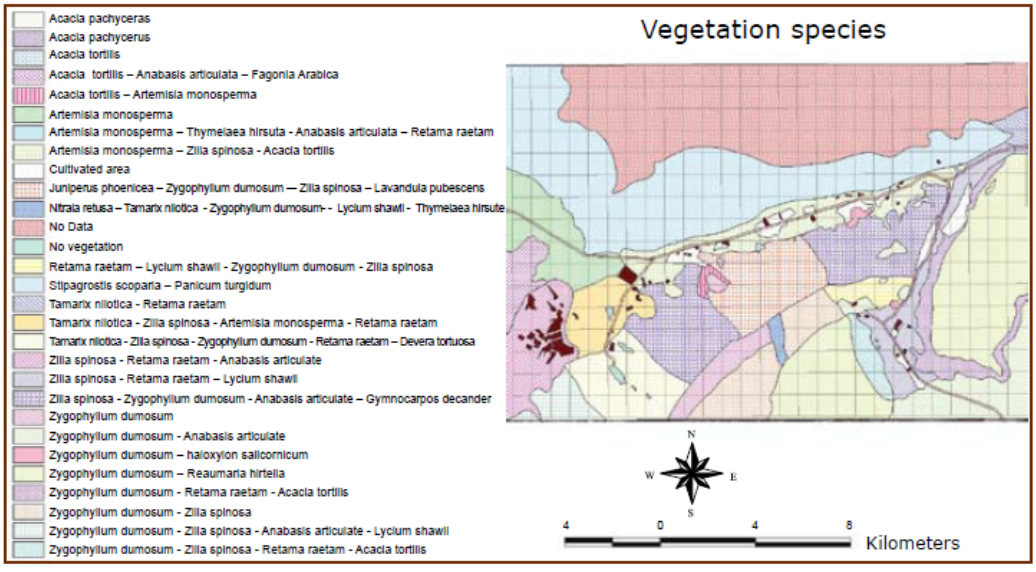


Figure 3.4 El Maghara's Plant Diversity in 2006

Source: UNEP, 2010

Acacia Wood at Sheikh Hemid, One of the Main Ecological Features of El Maghara Area
Source: UNEP, 2010

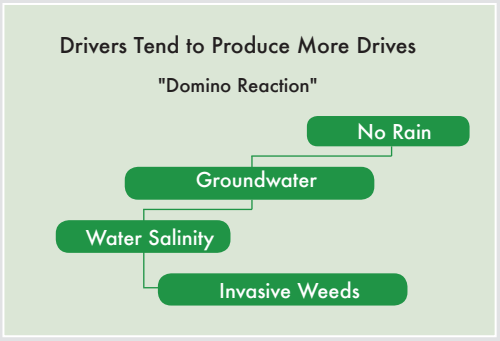
other Bedouin in other parts of Sinai. Impact of quarrying activities in El Maghara was particularly strong on Sheikh Hemid acacia wood.

The acacia wood is one of the main landmarks in Sinai, with its historic, biological, and folkloric value. Quarrying work was ruthlessly performed around the trees, resulting in serious irreparable damage to a vast number. The Acacia is one of the most popular trees in Sinai. It provides a stable browse for camels and goats, its forage available throughout most of the dry season when other sources are scarce. The dense acacia wood makes very good fuelwood that burns slowly and produces little smoke when dry.

Damage Inflicted on Acacia Trees
Source: UNEP, 2010

Box 3.2 Mesembrayanthemum Crystallinum

Drivers and indirect drivers: a case study illustrating a domino reaction. One feature identified in the present study is the introduction of some alien species in Sinai, including Mesembrayanthemum Crystallinum, a pest weed that infests orchards and crops in Sinai, causing serious economic damage. Bedouin report that this potential invasive weed started to spread out a few years ago. They also add that the weed showed up in areas fed with groundwater, where salinity is high, then started to infest other parts of Sinai.



One explanation for the massive spread of crystallinum is the significant drop in rainfall within the last few years that forced Bedouin to depend on groundwater in their agriculture, despite its high salinity. Because Mesembrayanthemum Crystallinum has high tolerance for high salinity, it was able to survive and even flourish under these conditions, and become a potential pest weed.

Mesembrayanthemum Crystallinum: An Invasive Species in Sinai

Source: UNEP, 2010

Impact of Poverty and Change in Lifestyle, on Biodiversity

Poverty is probably the most potential driver, with direct and deleterious impact on biodiversity, with special reference to El Maghara and Tafilalet. The relationship between poverty and the environment, and between poor people and natural resources, is complex and has been the subject of extensive debate.

Poor people are often impoverished by an austere resource base, and thus forced by their circumstances to degrade the environment even further (World Commission on Environment and Development 1987, Durning 1989, Cleaver and Schreiber 1994, Ekbom and Bojo 1999). Poverty

reduction is becoming a global issue. In many unprivileged communities, mostly in rural areas where the majority of people are poor, ecosystem services become life-supporting elements, and their role becomes more conspicuous. A World Bank report (see Figure 3.5) indicated that in low-income countries natural resources account for an estimated 28 per cent of the capital stock, whereas for high-income countries this figure is only 2 per cent.

Impact of Urbanization on Biodiversity in Asir

The gradual development of roads, and the expansion of towns is affecting both forest and agriculture ecosystems. The clearing of forests and agricultural land for construction of roads, houses, and industry, reduces forests' ability to absorb heavy rainfall, thus creating greater amounts of run-off. Changes to agricultural production introduce additional services and means of income for the local population, thus reducing dependence on agriculture and increasing dependence on 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. The forest ecosystem in Asir will be affected by the expansion of urban centres, roads, and land conversion to cropland.

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 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 agricultural land. Since forests in ANP are home to most of the diverse plant and animal wildlife, biodiversity will be lost.

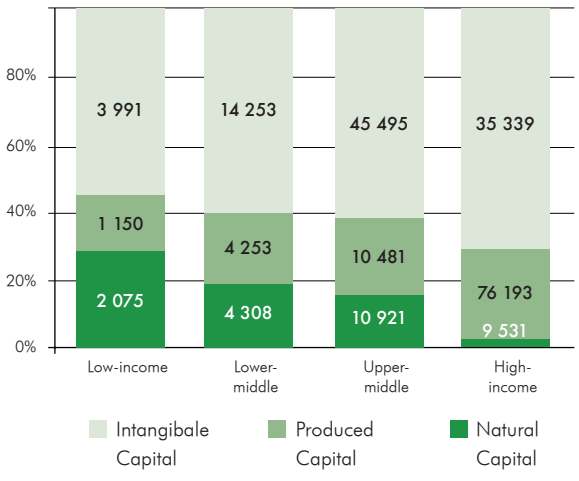


Figure 3.5 Proportion of Capital Stocks In-country in Different Income Groups

Source: World Bank, 2007

Impact of Tourism on Biodiversity

In Tafilalet, biodiversity, often endemic and remarkable, is quite unique in variety and number, characterized by cultural and architectural diversities. This richness and

Impact of Dredging and Filling Activities on Mangroves, Around Asir
Source: UNEP, 2010

diversity allow the development of nature-based tourism activities such as hiking or riding, sportive fishing, nature exploring (fauna, flora and landmarks are still intact and virgin).

However, much of this heritage is threatened with extinction mainly because of direct or indirect human actions. Deterioration of natural habitats is mainly due to overexploitation. Accordingly, the number of species, animals or plants is declining due to the increase and acceleration of the extinction rate of species and destruction of their habitats. The impacts of this degradation will be reflected negatively on human well-being by reducing the quantity and quality of goods and services provided by the ecosystem and on the functioning of the ecosystem.

Tourism development exerts pressures on natural resource. Hotels' infrastructure and the development of upscale hotels necessitate the exploitation of the resources to meet the demands and requirements of customers, who often exceed the supply and the limits of the environment.

In Asir, tourism is expected to increase within the next few years and the number of tourist visitors to the mountainous area of the Asir National Park will reach a rate that is at least equal to the population growth rate generally, estimated to be in the vicinity of 2.5 per cent. With no control, the increased number of visitors will result in an increase in the rate of environmental degradation of the Park, which is a major determinant factor, affecting biodiversity.

References

Ahmed, M.T and others, 2010. Chapter Two: El Maghara Ecosystem Trends, Conditions and Impacts. In UNEP and SCU. *Ecosysytem and Human Well-being, El Maghara, Nortern Sinai, Egypt* (pp.31-71). UNEP, Nairobi

Benmohammadi, A., Benmohammadi, L., Ballais, J.L. and Riser, J. (2000). *Analysis of anthropic and natural interrelations: their impact on the recrudescence of stranding and desertification phenomena in the south-east of Morocco valley of Drâa and valley of Ziz. Dryness;* 11 (4) : 297-308

Boudad, L., Kabiri, L. (2002). *Desertification and Crisis of some Oasis in the basins slopes of Ziz and Ghèris (Errachidia, Morocco)*. Review of Geography of Morocco (RGM), vol. 20, New series, N° 1 and 2 pp. 97-106

Cleaver, K.M., and Schreiber, G.A. (1994). *Reversing the Spiral: The Population, Agriculture, and Environment Nexus in Sub-Saharan Africa*. World Bank, Washington, DC

Daly, G.C., Matson, P.A. and Vitousek, P.M. (1997). *Ecosystem services supplied by soils. In: Natures services: Social Dependence on Natural Ecosystem* (Daily, G (ed.) Island Press, Washington, DC pp. 400

Durning, A.B. (1989). *Poverty and the Environment: Reversing the Downward Spiral*. World watch Paper 92. World watch Institute, Washington, DC

Kabiri, L., (2004). *Contribution to knowledge, safeguarding and valorization of South Moroccan oasis: Case of Tafilalet*. Thesis of university aptitude, FSTE-UMI- Morocco pp. 262, 24fig, 13tab, 35 photos, 11pub

Kabiri, L. (2005). *Contribution to knowledge of wind dynamics in South Moroccan oasis: case of Tafilalet (Errachidia, Morocco)*. Acts of the international symposium on: Sustainable development of oasis systems; 08- March 10th, 2005, Erfoud, Morocco, pp. 202-212

Kabiri, L. (2007). *Support of conservation of south Moroccan oasis*. Project FEM/PNUD/AOFEP/ 2001-2007 pp. 90

Kabiri, L. (2005). *Management of water resources in South Moroccan oasis: case of Ferkla (Tinjdad, Errachidia, Morocco)*. Acts of the international symposium on: Sustainable development of oasis systems; 08- March 10th, 2005, Erfoud, Morocco, pp. 497-506

Kabiri, L., Boudad, L., Krimou, A., Khardi, A. and Elmrani, L. (2003). *Preliminary study of the continental dunes dynamics in the Moroccan South-East*. Dryness, n° 3, vol. 14, September, pp. 149-156

Mahboub, A. and Kelli, Y. (2006). *Water resources in Guir-Rheris-Ziz areas, Acts of the international symposium "Future of oasis vis-à-vis desertification"* FSTE, UMI, September 2006, Errachidia, Morocco

Margat, J. (1958). *Hydrogeologic research and exploitation of subterranean water inTafilalet*. Mines and Geology, Rabat, 4, pp. 43-68

UNEP (2010). Millennium Ecosystem Assessment. *Ecosystem Services and Human Well-being: El Maghara, North Sinai, Egypt*. UNEP, Malta

UNEP (2010). Millennium Ecosystem Assessment. *Saudi Arabia Millennium Ecosystem Assessment for Asir National Park*

UNEP (2009). Millennium Ecosystem Assessment. *Evaluation of Tafilfalet Oasis Ecosystem by the Approach of Millennium Ecosystem Assessment, Kingdom of Morocco*

UNEP (2003). Millennium Ecosystem Assessment. *Ecosystem and Human Well-being: A Framework for Assessment*. Island Press, Washington, DC

World Commission on Environment and Development (1987). *Our Common Future, Report of the World Commission on Environment and Development*. Oxford University Press, Oxford