

Sustainable Mountain Development in the Middle East and North Africa

From Rio 1992 to Rio 2012 and beyond

2012



Sustainable Mountain Development
Middle East and North Africa (MENA)
from 1992 to 2012 and beyond

Report by

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List of Abbreviations

ANP	—	Asir National Park
CAPMAS	—	Central Agency for Public Mobilization and Statistics
CEPF	—	Critical Ecosystem Partnership Fund
CITES	—	Convention on International Trade in Endangered Species
CNEARC	—	Centre National d'Etudes Agronomiques des Regions Chaudes
DRR	—	Disasters/natural hazards/disaster risk reduction
EMP	—	Environmental Management Plan
EU	—	European Union
FAO	—	Food and Agriculture Organisation
GDF	—	Global Diversity Foundation
GEF	—	Global Environment Facility
GIS	—	Geographic Information System
IFAD	—	International Fund for Agricultural Development
INPA	—	Israel Nature and Park Authority
IPCC	—	Intergovernmental Panel on Climate Change
ISIIMM	—	Institutional and Social Innovations in Irrigation Mediterranean management
IUCN	—	International Union for Conservation of Nature (Now World Conservation Union)
JNF	—	Jewish National Fund
LMTA	—	Lebanon Mountain Trail Association
LMT	—	Lebanon Mountain Trail
MAB	—	Man and Biosphere
MEDPO	—	WWF Mediterranean Programme Office
MENA	—	Middle East and North Africa
MEPS	—	Mountain Environment Protection Society
MoA	—	Ministry of Agriculture
MTE	—	Mid Term Evaluation
NGO	—	Non Government Organisation
OPEC	—	Organization of the Petroleum Exporting Countries
PAM	—	Protected Area Management
PES	—	Payment for Ecosystem Services

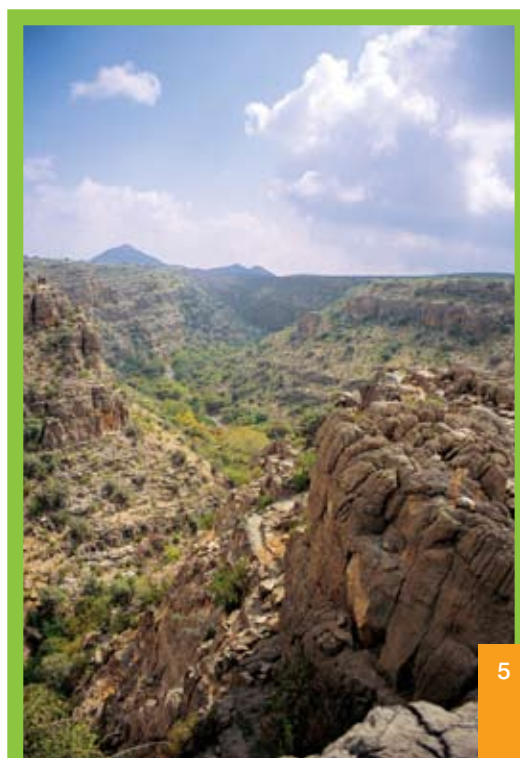


SDC	—	Swiss Agency for Development and Cooperation
SMD	—	Sustainable Mountain Development
UNDP	—	United Nations Development Programme
UNEP	—	United Nations Environment Programme
UNESCO	—	United Nations Educational, Scientific and Cultural Organization
UNFCCC	—	United Nations Framework Convention on Climate Change
USAID	—	United States Agency for International Development
WHO	—	World Health Organisation
WWF	—	World Wide Fund for Nature
YAVA	—	Yemen Armed Violence Assessment

Superscripts as numbers in the text refer to Web links

Abbreviations of Units of Measurement

°C	—	Degree centigrade or Celsius
cm	—	Centimetre
ha	—	Hectare
kg	—	Kilogram
km	—	Kilometer
km ³	—	Cubic kilometer
m	—	Meter
m ³	—	Cubic meter
mm	—	Millimeter
Myr	—	Million years
sq km	—	Square kilometer
t	—	Tonne



Mountains of the Middle East and North Africa (MENA): Call for Action

Following the invitation of the Swiss Agency for Development and Cooperation and the Mountain Partnership Secretariat (FAO), international experts and policy makers met in Lucerne on 11 and 12 October 2011 to convey the importance of mountains to the Rio +20 summit. Protecting future water supplies, reducing poverty in mountain populations and unlocking the economic potential of mountains resulted in the Lucerne Call for Actions, 2011. Here the call for action specific to the MENA Mountains is presented.

Mountains of the MENA region are important for sustainable development in national, regional and global contexts. All mountains in this region with the exception of a few do not supply fresh water to fulfill the needs of the entire population, but the goods and key ecosystem services provided by these mountains are vital for the sustainable development. These goods and services are under increasing pressure from urban expansion and environmental changes. For the sustainable mountain development (SMD) in the region, the following actions are needed:

1. **Protect** natural resources and assist with strategies for their sustainable use to improve the socioeconomic well-being of the mountain communities.
2. **Involve** mountain communities in decision making processes and political representation to ensure best use of resources, environmental protection, and food security.
3. **Facilitate** mountain communities to gain fair access to resources and share benefits of their use equitably.
4. **Strengthen** and develop national and regional institutions and establish links with global institutions to address highland-lowland interactions and trans-boundary cooperation, support capacity building, generation and dissemination of knowledge, technical expertise and innovation for sustainable mountain development.
5. **Provide** enabling conditions and incentives for investment in sustainable development in mountain areas and include appropriate funding in national budgets in order to enhance well-being and reduce disparities.
6. **Evaluate** how mountain issues were handled within the three Rio conventions and identify reasons that can be attributed to the action plans, their success and failure.
7. **Recognize** the vulnerability issues of the mountain ecosystems that still exist within the three Rio conventions, based on the experience of last 20 years, and recommend implementation strategies that must be adopted to achieve sustainable development goals.
8. **Promote** the transition of these mountains' dependence from Brown Economy to Green Economy.
9. **Identify** special issues that impact MENA mountain communities such as illegal drug production, terrorism and political disputes, and establish intervention procedures at international level to alleviate these problems.
10. **Make best use of** all new and existing funding mechanisms to address issues related to Sustainable Mountain Development and challenges of environmental changes in the MENA region.

Executive Summary



This report is presented in three parts: the first sets up the stage for the discourse on MENA Mountains, the second provides an evaluation of sustainable mountain development discussing progress, changes and lessons learnt, and the third addresses challenges to green economy and issues relevant to Rio +20 in the MENA region.

The MENA region is defined and this report covers 19 countries that are commonly accepted as MENA members. Major mountain ranges in the MENA region have been identified and the major themes relevant to the MENA Mountains are recognized. The institutions and governance supporting sustainable mountain development have been noted and the absence of a central hub to foster partnerships within the MENA region has been indicated.

Major physical characteristics, resources and key issues in the mountains of 19 MENA countries have been compiled. It is apparent that the physical diversity of these mountains is matched by the diversity of resources, services and key issues. The economic environment in MENA as a driver has a significant impact on sustainable mountain development. The governance in the MENA can be broadly classified into monarchies, republics and others. The nature of governance is an important driver that has impact on sustainable mountain development. The present political climate in the region is likely to have a negative impact on sustainable development initiatives including those in the mountains.

Ecosystem services are discussed under (a) Provisioning, (b) Regulating and supporting and (c) Cultural services following the Millennium Ecosystem Assessment for mountains. Supply and demand for ecosystem services in the MENA Mountains are poorly understood.

Key issues in the MENA Mountain region are climate, water resources, wildlife and biodiversity, agriculture, livestock and land use, and tourism. Others include specific issues like the establishment of biosphere reserves, special programs like that of Global Diversity Foundation (GDF), terrorism, cannabis cultivation, disasters, natural hazards and disaster risk reduction (DRR) and socioeconomic and political issues. The discussion of each issue includes information known from specific MENA countries. For example, the issue of water resources includes management of water resources in Morocco, water stress in Lebanon, over-exploitation of groundwater in Oman, revitalisation of traditional water harvesting in Iran, water scarcity in Yemen and the famous water conflict of Palestine and Israel.

Evaluation of sustainable mountain development in the whole MENA region is an extremely difficult task. However, it is possible to attempt a discussion on the basis of what had happened in the MENA countries over the past 20 years assuming that mountains are firmly embedded in the systems and are subject to impacts both positive and negative, affecting the countries as a whole. The 10 themes considered are (1) the effects of oil-boom economy; (2) technological development; (3) improvement in road networks; (4) political changes; (5) climate change and natural disasters; (6) epidemics; (7) impacts and threats on biodiversity; (8) expanding tourism; (9) mining activities, and (10) monitoring and research.

Selected case studies are presented here to show the variety of existing challenges, attempts made to meet these challenges, triumphs and failures and the lessons learnt. The case studies chosen are: (1) Protection and conservation of the unique Wadi al Wurayah in Fujairah of the United Arab Emirates. (2) Managing the protected area of Al-Shouf Cedar Biosphere Reserve in Lebanon. (3) Human impacts on the biodiversity of Socotra Island of Yemen. (4) Barbary macaque conservation in Morocco where lessons learnt show the general lack of ecosystem awareness and the lack of knowledge on the ecology of this macaque even at the management level of governance.

There is a need for environmental education, awareness and multi-dimensional conservation campaigns. (5) The Arabian leopard conservation in Oman where the lessons learnt show that a well publicised all out conservation effort increases the awareness of the local populace resulting in their proud participation in the project. (6) Ecotourism in Lebanon and (7) Geotourism in Iran which show that a well planned and integrated management of the tourism trade is crucial to avoid irreparable damages to the ecosystem. (8) Israel-Palestine water conflict and (9) the River Jordan dispute between Jordan and Israel have been persistent problems blocking the peace process in the area where the lessons learnt show that any attempt at conservation, management and resource sharing is only possible if there is political willingness among neighbouring countries to compromise and cooperate for the common good of humanity. (10) Coffee industry in Yemen is struggling against Qat cultivation; the lessons learnt emphasise the importance of government intervention by using incentives rather than strong-arm tactics and the need for environmental education in matters concerning good over the bad. (11) Cannabis cultivation in Morocco shows the power of poverty; lessons learnt show that poverty can push marginalized communities to engage in illegal activities that may not be easy to reverse; damage caused to societies beyond areas where the drug is produced is a global concern. (12) On a positive note the final case study highlights an age old traditional custom of rose water making from a very ancient variety of rose in the northern mountains of Oman.

The status of green economy in the MENA Mountains and challenges faced are presented in line with millennium development goals. Actions needed include (1) regulatory frameworks; (2) a shift in government spending priorities to support green economy initiatives; (3) financial incentives to green investment and innovation; (4) capacity building through training and education; (5) strong links to international governance.

MENA mountain issues relevant to Rio +20 are qualitatively analysed. Eight issues identified in this report as priority are: (1) climate, (2) water resources, (3) wildlife and biodiversity, (4) agriculture and land use, (5) land degradation, (6) mining, (7) energy and (8) tourism. MENA countries do not have a forum or mountain partnership network to share experiences and lessons learned from tackling various issues in their respective countries. The need for the establishment of a MENA Mountain Partnership Network is called for.



PART 1

Setting the stage

1.1 Definition of the MENA region

The Middle East and North Africa region, commonly referred to as the MENA region extends from Morocco in the west to Iran in the East and includes most of the Middle Eastern and Maghreb countries. The definition of the MENA region seems flexible and the

numbers of countries range from 19 to 30. In this report, 19 countries that are commonly accepted as MENA countries are covered (**Figure 1**).¹ Of the total world population, about 6% live in the MENA region and again the estimates vary from 381 to 523 million depending on the number of countries included in the region.² As of 2009, the MENA region has 60% of global oil reserves

Figure 1: Map of the MENA region. Sudan, Malta and Djibouti are not included in this report



Source of MENA Map: Modified after UNICEF-The Humanitarian Action Report, 2010.

Figure 2: Composite of maps showing some major mountain ranges in the MENA region



Source: Middle East – <http://www.worldatlas.com/webimage/countrys/me/nd.htm>
 Lebanon – <http://www.worldatlas.com/webimage/countrys/asia/lb.htm>
 Atlas Mountains – <http://en.wikipedia.org/wiki/File:Atlas-Mountains-Labeled-2.jpg>

and 45% of natural gas reserves. Eight of the 12 OPEC countries are in the MENA region and this region is very important for global economic stability.

1.2 Mountains of the MENA region

The available information on MENA Mountains is patchy at best. The coverage of issues is heterogeneous in

themes as well as contents and the significance of issues also varies widely. In general, the institutional framework and networks linking disparate units of administration, research, education and extension in the MENA mountain region are poor. In the global arena of mountain agenda, MENA Mountains are relatively little known despite the commonality in the nature of crises faced. For example, out of a total of 416 delegates

attending an international conference on Global Change and the World's Mountains held in Perth, Scotland from 26-30 September 2010, only five, representing Oman, Morocco and Iran, were from the MENA region.

Figure 2 shows some major mountain ranges in the MENA region. Detailed descriptions of all major Mountain ranges in the MENA region are compiled in **Annexe 1**. Among MENA countries, Kuwait, Qatar and Bahrain are not of any significance to mountain development while available information on the mountains of Iraq, Jordan, Libya, Tunisia, Syria and United Arab Emirates is scanty. However, the sustainable development of mountains in the perspective of at least one or more issues such as water resources, biodiversity conservation, overgrazing, urban development, ecotourism and socioeconomic problems have been documented for Morocco, Lebanon, Oman, Iran, Saudi Arabia, Yemen and Israel. Therefore, these MENA countries have been dealt with here in greater detail than the other listed countries. The research for this report indicated that there is a considerable amount of gray literature buried within the confines of several public and private sector organizations in the MENA countries and these are neither available nor accessible. A comprehensive report on the mountains of the MENA region would require a more significant effort involving the mandatory representation of governments and other experts on mountain studies from these MENA countries.

1.2.1. Major themes of initiatives

The major themes in all MENA mountains are the climate, water and soil, wildlife and biodiversity, socioeconomic and political issues, agriculture and land use, land degradation, mining, energy and tourism.

1.2.2 Institutions /Governance supporting sustainable mountain development (SMD)

The key players in all MENA mountain areas are the government, international agencies, universities, NGOs and specific, special interest groups. Policies and decision making is under the purview of the governments and others contribute through supplementary funding for projects and research, expertise and in some cases voluntary manpower. Roles of non-government sectors

are theme- and often project specific (**Annexe 2**). There is no centralised hub in the MENA region to coordinate the sharing of information, data and expertise on mountain issues; especially those that are common to several member countries (e.g. water resource management, biodiversity conservation, ecotourism).

1.3 Key characteristics

1.3.1 Environment

Table 1 summarises some physical characteristics and key issues in the mountains of 19 MENA countries. Details of the geographical, geological, climatological and others features of the mountains of MENA region are given in **Annex 1**. It is apparent that the physical diversity of these mountains is matched by the diversity of services and key issues. The socioeconomic environment is also widely different. Even among the members of the Middle East group and the North Africa group there are big differences. For example, Kuwait and Saudi Arabia with large oil reserves are very different from Yemen and Oman. Such differences are common among North African countries as well. The economic environment in MENA as a driver thus has a significant impact on sustainable mountain development.

1.3.2 People

The mountain regions are mostly discontinuous and scattered in the MENA region. So much so, the mountain ranges are mostly treated as an integral part of the country in which they lie. Over the ages, the mountains have always been inaccessible and isolated, creating cradles of tribes and cultures. But the modernisation in the current times has facilitated a lot of integration of the mountain communities into other areas of the countries in general.

Morocco is known for its cultural heritage. The great heritage of Moroccan people is a matter of great pride to them. Although they have started embracing modernity, still their ancient heritage reigns supreme. In earlier times, Libyans and Ethiopians were the main inhabitants of Morocco. They were known as Barbaroi or Berbers. They traditionally lived in tribal groups. Later, several other groups such as the Arabs, Phoenicians, Byzantines, Romans, Spaniards, Portuguese, Turks,

Table 1: MENA Mountains, maximum altitudes and some key issues			
Country/Mountain Range	Peak / Max Altitude (meters)	Range of Annual Temp. and Rainfall	Key Issues
MOROCCO Atlas Mountains	Jabal Toubkal 4,167	Regional variation. -9 - 20°C 430-1,524mm	<ul style="list-style-type: none"> • Cannabis cultivation in Rif Mountain. • Snow sublimation. • Rapid soil erosion. • Barbary Macaque conservation in the Middle Atlas. • Local extinction of conifers in the Rif and Middle Atlas region.
ALGERIA Tell Atlas	Jabal Warsenis 1,985	4-28 °C 400-600mm	<ul style="list-style-type: none"> • Poverty of mountain communities. • Mining and geology issues.
Sahara Atlas	Jabal Aissa 2,236		
TUNISIA Aures mountains (Sahara Atlas)	Jabal Chaambi 1,554	7-38°C 100- 1,524mm	<ul style="list-style-type: none"> • Water shed management. • Reforestation • Food security and nutrition in mountain areas.
LIBYA Nafusa Mountains	Bikku Bitti 2,267	13- 36°C 400-600mm	<ul style="list-style-type: none"> • Conservation of endemic plant species in Jabal Akhdar. • Mountain refugee problem. • Conflict between Berber community and the Government.
Jabal Akhtar Mountains			
Tibesti Mountains			
EGYPT Sinai	Mt. Sinai 2,285	2-33°C 50-102mm	<ul style="list-style-type: none"> • Mount Sinai controversy. • Conservation of biodiversity.
JORDAN Abarim Mountains	Jabal Umm ad Dami 1,854	-7.2-21.4 °C 200-600mm	<ul style="list-style-type: none"> • Conflicts over Wadi-Rum Reserve. • Conservation of Blanford's fox.
ISRAEL Galilee Mountains	Mount Hermon (Southern slopes) 2,224	6-30°C 300-700mm	<ul style="list-style-type: none"> • Dispute between Israel and Palestine over shared mountains aquifer resources. • Increasing incidences of forest fires. • Threat to the Mediterranean ecosystems due to increased desertification.
Judean Mountains			
PALESTINIAN TERRITORIES Galilee Mountains	Tall Asur 1,022	10-27°C 600-800mm	<ul style="list-style-type: none"> • Palestinian- Israeli mountain aquifer water conflict
LEBANON Lebanon range	Qurnat as Sawda' 3,088	0-26°C 890-1,300 mm	<ul style="list-style-type: none"> • Terrorism. • Rangeland degradation. • Environmentally un-friendly motorised activities related to tourism. • Water management. • Threatened extinction of wildlife stock being replaced by imported breeds.
Anti-Lebanon range			
SYRIA An-Nusayriyah Mountains	Mount Hermon (Jabal el-Sheikh) 2,814	7.2 -26.6 °C 250-1200mm	<ul style="list-style-type: none"> • Changes in grazing areas and feed resources. • Water issues.
KUWAIT	Not applicable		<ul style="list-style-type: none"> • Not applicable
BAHRAIN	Jabal ad Dukhan 134		<ul style="list-style-type: none"> • Not applicable
QATAR	Not applicable		<ul style="list-style-type: none"> • Not applicable

Country/Mountain Range	Peak / Max Altitude (meters)	Range of Annual Temp. and Rainfall	Key Issues
SAUDI ARABIA Sarawat Mountains	Jabal Sawda 2,982	-3-26°C >300mm	<ul style="list-style-type: none"> • Conservation of Arabian Leopard and Juniper forest. • Protection against deterioration of traditional communities. • Rain water harvesting. • Excessive mining.
OMAN Al Hajar Mountains	Al Jabal Al Akhtar 2,980	-3.5 – 34.5 °C 300-350mm	<ul style="list-style-type: none"> • Conservation of Arabian leopard in the mountains of Dhofar. • Arabian Tahr conservation. • Degradation of rangeland. • Rapid unchecked expansion of tourism. • Long term pollution problems caused by contamination of springs by diesel. • Threat to endemic mountain flora.
Dhofar Mountains	Jabal Al Qamar (Moon Mountain) 2,500	16.5-30°C 200-350mm	
YEMEN Sarawat Mountains	Jabal an-Nabi Shu'ayb 3,666	0-30 °C 520-1500mm	<ul style="list-style-type: none"> • Poverty • Water management problems. • Qat cultivation. • Declining coffee cultivation

Europeans and the French came to Morocco. Berbers are continuously distributed from the Atlantic to the Siwa oasis in Egypt and from the Mediterranean to the Niger River. Historically they spoke the Berber language or varieties of it. Maghrebi colloquial Arabic is spoken by a large section of the Berbers, in addition to the Berber language itself. Spanish and Italian are also known by some Berbers in Morocco and in Libya. Today, most Berber-speaking people live in Morocco, Algeria, Tunisia, Libya, Western Sahara, Mauritania, Mali and Niger. Morocco has the main Berber concentration of 10.4 million (40% of the population).³

Algeria comes next with 6.5 million (25% of the population). Tunisia has 200,000, Libya and Egypt each have about 150,000 Berbers, whilst Mauritania has some 50,000 (mainly Tuaregs). Niger and Mali have 650,000 each-mainly Tuareg tribesmen and Burkina-Fasso 300,000 Tuaregs.

A Berber is not necessarily only someone who happens to speak Berber. The Berber identity is usually wider than the language and ethnicity and encompasses the entire history and geography of North Africa. Berbers are not a homogenous ethnic group and encompass a range of phenotypes, cultures and ancestries. The one unifying force is the Berber language. Despite the fundamental homogeneity of the Berber society,

there is a considerable diversity in different mountain localities. The Shluh of the High Atlas and Anti-Atlas in Morocco inhabit the river valleys that cut down deeply into the massif. Their villages, with populations of several hundred inhabitants in each, are often located at an altitude of more than 1981 m. They live in terraced houses dominated by communal fortified threshing floor (*Kasbah*) and a gathering place for assembly of elder (*Jama'ah*). The Shluh language is called Tashilhait and has many local dialects.⁴

Traditionally, men take care of livestock. They migrate by following the natural cycle of grazing, and seeking water and shelter. They are thus assured of an abundance of wool, cotton and plants used for dyeing. For their part, women look after the family. They also make handicrafts - first for their personal use, and secondly for sale in the souks in their locality. The Berber tribes traditionally weave kilims. The tapestry maintains the traditional appearance and distinctiveness of the region of origin of each tribe, which has in effect its own repertoire of drawings. The textile of plain weave is represented by a wide variety of stripes, and more rarely by geometrical patterns such as triangles and diamonds. Additional decorations such as sequins or fringes are typical of Berber weave in Morocco. The nomadic and semi-nomadic lifestyle of the Berbers is very suitable for weaving kilims. The customs and traditions differ from one region to another.

The Berraber are semi-nomadic pastoral tribes of the Middle Atlas. They live in permanent villages for part of the year and also move between summer pastures in highlands and the lower lying winter grazing grounds. Their area is less densely populated than that of most other Berber groups, and so they tend to migrate less. The Ait-Atta is a famous nomadic Berraber tribe. The Harratin are "Black Berbers" descendants of African slaves and tribes that moved north into Berber territory. They mostly live in the plains.⁵

The present day Moroccans are usually Sunni Muslims belonging to Arab, Berber or Arab-Berber races.⁶ Only a small portion of the Moroccan population is considered purely Arab in origin. Approximately three quarters of the Moroccan people have Berber origin. Majority of the Moroccan population now practices Islam. Remaining are followers of Christianity and Judaism.

The Rif of Morocco and the Kabyle of Algeria resemble in many ways. Both Berber tribes inhabit the same type of wet mountain slopes covered with oak forests and both are inclined to isolationism. Some thirty tribes live in the Rif Mountains, a district bordered by two rivers and about 234 km of Mediterranean coastline. In contrast to the way of life of Berbers in High and Middle Atlas, stock raising played only a secondary role in their village life. They are not so much agriculturists as arboriculturists, although they grow a little sorghum and women grow vegetables in small gardens near houses. However, the fig and olive trees covering the mountain slopes they inhabit constitute their principal resources. The Kabyle live in the mountainous coastal region in northern Algeria known as Kabylia that stretches from the Mediterranean Sea to the southern slopes of the Grand Kabylie Mountains. They are also Berbers and their culture has survived relatively unscathed. Kabyle villages contain stone houses with red tiled roof. Traditionally, each village is administered by an assembly of adult males (Jama'a). Their main work is farming and herding goats. The Kabyle are also skilled craftsmen working with wood, silver and wool. Recently, there has been government sponsored investments in the area in an effort to ameliorate the wide spread poverty of the area.⁷

The Rifians are Berber people who inhabit the Rif in

northern Morocco. The mother tongue of the Rifians is called Rifian, though many speak Moroccan Arabic, Spanish or French as second or third languages. In the Moroccan Rif, Rifian is spoken by about 4 million people with a few speakers across the border in Algeria. A substantial Rifian- speaking community exists in Netherlands as well as in other European countries including Belgium, Germany, France and mainland Spain. Its own speakers simply call it Tamazight or Tamazight, a term also often applied in a broader sense to Berber languages in general.

The Rif Berbers of North Africa call themselves Amazigh, which means the Free People. This proud and spirited people originate from an area in north-eastern Morocco, around the northeastern Rif mountain ranges and in plains and valleys in this area towards the Algerian border. The Rif Berbers are among the original inhabitants of this area. Their language, Rarifit, distinguishes them from other Berber peoples in North Africa. Many of the Rif Berber families eke out an existence from subsistence farming, others are engaged in small businesses, and some smuggle as a way to make a living. The mountains of the region have had severe erosion problems, which have affected productivity.

Unemployment is severe in these mountains with as much as 50 to 60% unemployment recorded. Adult literacy in males are 10 to 15% and in females less than 1%. Mainly barley, some wheat, rye, maize and *kif* are grown. The Rif supplement their primary diet of barley bread with other products such as maize, potatoes, tomatoes, onions, garlic, squash, peppers, fruits (including prickly pears) and nuts. In 1967 estimate, the gross annual per capita output from all farming activities was about US\$ 60. Due to the deterioration of tribal identity and traditional life-styles, this figure is not expected to have increased. Animal husbandry includes cattle, goat, sheep, donkey, mule, chicken and dogs (for shepherding and protection). Foreign labour opportunities in Europe attract as much as 1/3 of the adult male population for better part of each year.⁸

About sixteen percent of all children of ages 0-4 years suffer from moderate underweight condition and about four percent are severely underweight. Rural women

wear colourful long dresses and long coat-like djellabas, head scarves and sometimes face veils. Middle-aged men traditionally wear a long djellaba cloak made of wool or cotton. Younger men usually wear western clothes. Facial tattoos among women of some tribes are common but it is a dying art form. Their access to modern health services is very limited.

The Aures Mountain, standing alone in the northeastern Algeria is perhaps the least developed mountain region in the Maghreb. The Shawia (also spelt Shawiya) populations who inhabit them follow a semi-nomadic style of life, which is partially agricultural and partially pastoral. They live in terraced stone villages dominated by *guelaa*, (or Kasbah) or the fortified granary. During winter, the inhabitants of the high valleys lead their flocks to the low lands surrounding the massif, where they pitch tents or live in caves. Returning to the uplands in summer, they irrigate the land to grow sorghum and vegetables and maintain apricot and apple orchards, while shepherds take the sheep to pastures on the hill tops.⁷

Despite the precarious living conditions, the Atlas Mountains are densely populated or over populated in certain localities. In the area around Tizi Ouzou in the great Kabylie for example, densities reach about 270 per sq km. Emigration is a necessity. The Mountain regions have become a human reservoir upon which the Maghrebian countries draw to obtain the labour force needed for development. Commercial agriculture attracts a large number of farm workers to the plains either on seasonal or permanent basis.

In Mount Sinai of Egypt, 99.6% of the population is Egyptians. The remaining 0.4% of ethnic groups includes Bedouins, Nubian, Greeks and Berbers. The Bedouin populations in the southern Sinai (descendants of tribesmen who settled here some 800 years ago) are broken into eight tribes. About 7,000 people live around St. Catherine's. While a large number belong to the Jabaliya tribe, others are from the Muzeina, Gharaja, Sawalha, Aligheit, Awlad Said and Beni Hannan. Apart from the Jabaliya, who were brought into Sinai from the vicinity of Macedonia in the sixth century to provide security and services to the monks, others are all Arabs.⁹

Jabaliya, the tribe of the mountain, probably are about 1,500 people and they have a very small tribal territory around Mt. Sinai. This tribe occupies the area of St. Catherine's and has been guarding the monastery for centuries. The Jabaliya consider themselves as the descendants of Romans or Greeks. While most other Bedouin groups are desert dwellers, the home of the Jabaliya is in the labyrinth of high altitude wadi (plural of wadi). Traditionally the families had gardens at different locations in the valleys where they lived in the summer months. When the weather became colder, people moved to lower altitudes. Today they still practice this seasonal migration to some extent, as many families like to spend some time in the mountains in the summer school holidays. There are still a few older people who stay there for prolonged periods, but younger people, in general, are not too keen on spending much time out. The gardens are a unique feature of the Jabaliya. The gardens called karm or bustan are encircled by massive stone walls which keep larger animals out, and protect the garden during flashfloods and retain the soil. Gardens are built in the water course in the wadi floor or in basins, where water remained underground for longer periods. The houses are usually built a bit further up from the wadi floor, so sudden floods do not cause damage to people. In the gardens they grow many crops not common in Egypt such as apples and almonds. Other crops include olives, apricots, figs and grapes. They are expert gardeners who received their first seeds from monks, and developed drought resistant strains by grafting branches of higher yielding varieties from the low land onto tougher indigenous plants. They kept and still keep animals, such as camel, sheep, goat and poultry, although due to dry conditions grazing is more difficult and fodder has to be purchased from outside, making this a more costly venture. On the average, a family according to a Protectorate survey owns between 5 to 10 animals in settlements around St. Catherine City, and 15-20 in the mountainous areas. Good camels cost as much as 5,000 LE (US\$ 800) and are the focus of pride. The Jabaliya hold an annual camel race in Wadi Sheikh.¹⁰

Today the Jabaliya are sedentary and live in stone or concrete-block houses. The Jabaliya, traditionally used stone buildings because of the cold climates, but also used tents like the Bedouins. Homes are divided into a

guest area and one reserved for the family, and in most cases there are separate entrances to the different areas. The «sitting room», where the guests stay is called Majma, Magaad or Majlis. Sitting often takes place outside, next to the house, in the garden, or in the arisha, a sitting area covered loosely with canes or other leafy materials ('el arish' actually means palm leaf). In most places the traditional tents are no longer in use apart from a few places where it is erected next to the house to serve as the arisha.¹¹

The Managed Resource Protected Areas of Nabq and Abu Galum are inhabited by two of the Bedouin tribes- the El Mezeina and the El Tarabin. The El Mezeina, one of the largest and most powerful tribes inhabits the Southern Gulf from Nuweiba to Sharm el Sheikh. Of the eight Bedouin tribes of South Sinai, El Mezeina has by far the greatest share of Nabq than other tribes and has a set lifestyle. Bedouins are used to many environmental limitations and they are very much aware of their environment. For them cutting a tree is a major crime that warrants a trial in which the culprit would be severely punished. To encourage Bedouin crafts in southern Sinai, a Bedouin Support Programme has been started. The flora and fauna of the region is reflected in the embroidery of the women and their work is marketed at the St. Catherine Protectorate Visitor's Centre.¹²

The Jordanian population is made up of people of mostly Arab origin. There are some Circassians and Chechens. Jordan also has a small Armenian population. Sunni Muslims account for 92% of the population and about 6% are Christians of various denominations. Several small Shi'a and Druze populations can also be found in Jordan. One of the best known groups from Jordan's population is the Bedouin. They are referred to as Bedu in Arabic. The word literally means the 'desert dwellers'. Only a small portion of Bedouin can still be regarded as true nomads. Most have settled down to cultivate crops but some of them still practice pastoralism. These days most of them own pick-up trucks.¹³

The Druze and Circassian people live in a variety of villages in the Galilee Hills. They are fiercely loyal to their homelands with their philosophy of *taquyya*, which calls for complete loyalty by its adherents to the government of the country in which they reside, and

most of their men serve in the armed forces at present times. Only of late, both Druze and Circassian are beginning to open their homes and attractions of their villages to outsiders. Over 120,000 Druze live in Israel. One-fifth of the population is located in Golan Heights. The remaining Druze resides on Mount Carmel and in Galilee. The Druze religion is an offshoot of Islam.¹⁴

The total population in Mount Lebanon is reported as about 1.5 million in about 371,289 households. This constitutes about 40% of the total population of Lebanon.¹⁵

In Jabal al-Nusayriyah, the mountain ranges of northwestern Syria that overlook the Mediterranean Sea, the 'Alawi community has maintained itself for over one thousand years, fiercely clinging to its syncretistic secret religion. The 'Alawis have survived as a distinct group in spite of repeated persecution and threat of extinction posed by the Sunni majority and rulers who considered them as pagans and heretics who were not eligible for the status of a protected religion.

Also known as Nusayris, they are an Arabic speaking ethno-religious community, who also live in the Latakiah province of Syria and in the adjacent districts of northern Lebanon and southern Turkey. In recent years, many 'Alawis have moved to the large cities of Syria. A small number still survive in Wadi al-Taym south of Mt Hermon.

Worldwide there are 2.2 million 'Alawis of whom 1.6 million live in Syria where they constitute 13% of the population and are the largest minority group. The second largest group is in southern Turkey (0.5 million), where they are known as Alevis, a Turkish cover name for all extreme Shi'a groups.

Kurdistan roughly encompasses the north western Zagros and the eastern Taurus mountain ranges and cover small portions of Armenia. Despite its mountainous nature, Kurdistan has more arable land than most of the Middle Eastern countries. Expansive river valleys form a fertile lattice in Kurdistan. Kurds are Indo-European in origin. They speak an Iranic language known as Kurdish and are the majority population in that region. Mountains are important in Kurdish life both geographically and

symbolically as evidenced by the saying “Kurds have no friends but the mountains”. The symbiosis between the Kurds and their mountains has been so strong that they have become synonymous; the home of Kurds end where the mountains end. The most important feature of the Kurdish society is its strong tribal organization. Kurds now also live in parts of Turkey, Syria, Iraq, Iran, Armenia and Azerbaijan. Their population worldwide is estimated at about 25 million and they form the fourth largest ethnic group in the Middle East after Arabs, Persians and Turks.

The Hejaz and the Asir territories of Saudi Arabia include the mountain regions, but all four regions of the Kingdom (Najd, in central Arabia, Hejaz in the west, Asir and the Gulf coast or the Eastern Province) have nomadic and semi-nomadic populations. As recently as 1950, at least one half of the total population of Saudi Arabia was considered as nomadic. The Hejaz region, being the home to the holy sites of Islam was infused for centuries by the descendants of foreign Muslims who came for the pilgrimage and stayed. In the recent past, the Hejaz towns were populated by the elite and powerful mercantile families. Most of the tribes in the Asir region are the branches of Qahtani tribe, but there are also some Adnani tribes. Al Baha province in the Hejaz Mountains is the tribal area of Ghumad and Zahran branches of the Qahtani tribe. Al Baha was one of the most isolated places in the country until the 1970s, when all-weather roads opened up modern travel.¹⁶

There are a lot of similarities in the life of mountain dwellers in the United Arab Emirates and Oman. The mountain settlements often are at or near wadi. There are countless villages and hamlets in the wadi, which belong most frequently to just one clan or sometimes even a single family. There are also some fairly large settlements shared by more than one tribe. They traditionally practice terrace cultivation fed by open runnels called *ghayl*, which follows the wadi at a gentle gradient, in places forming a gallery above the valley floor, until it arrives at the terraced field. Terracing was known in these mountains since prehistoric times and this technique of increasing the potential for agriculture played an important role for these small tribal communities. Traditionally, the homes are made with walls of wadi stones with a roof of palm fronds, beams

of sidr tree (*Ziziphus sp.*) or brushwood and earth. They also have what is called *bayt al qufl*, a ‘house of the key’. This is a small house often built against a rock with walls made from very large stones, with floors no more than one metre below the ground level. The large and intricately carved lock on the heavy door gives this type of house its name.

Herding sheep and goats constituted the major economic activity. Donkeys were their preferred beast of burden before the appearance of four-wheel drives and pick-up trucks. In some areas even camels and bulls were kept to assist in the drawing of water from the wells. Some tribal people of these mountains, called Shawawi were semi-nomadic pastoralists, forming a part of the village community, but wandering in the mountains with their herds of sheep and goats.

The Musandam peninsula (locally called Ru’us al-Jibal) north and east of Ra’s al-Khaimah consists of precipitous limestone mountains reaching the height of 2,000 m within a distance of barely 20 km from the sea. Two major tribes of this area are the Shihuh and Dhahuriyin. The lands of most members of these tribes belong to Oman. But many of them now live in UAE or depend economically on her northern ports. The inhabitants of Musandam developed methods with which they could exploit the resources of the sea and the wadi to the full and grow essential staple food in the mountains.

The economy of one of the two groups found in Musandam is based on the combination of agriculture and husbandry. They refer to themselves as Badu. The other group has fishing added as a third economic activity and are called Sayyadin. The agriculture consists of building, tending and sowing terraced fields in various locations, on the very top of the mountains, on a high slope or just above the wadi bed. The crop is wheat (*burr*) or barley (*sha’ir*). Fig trees are also grown on such terraces high up in the mountains. A network of dams and stone lined canals has long been used to collect rain water from vast areas of the rocky surroundings (Heard-Bey, 2001).

Comprehensive data on the peoples of the northern mountains of Oman are not available. However, most

villages in the high altitudes of Al Jabal al Akhdar are untribal. The western slopes are occupied by two main tribes, Owemerri and Janmoodi, but three Shuraiki villages are also found among them in very remote areas. These people were probably nomadic pastoralists in the past moving up the slopes in search of grazing and forming small settlements where water was either available or where rain water could be collected and stored in small, traditionally built impoundments. None of these tribes mix and consanguineous marriages seems to be the rule. The Saiq Plateau and its villages is occupied by different tribes like Fahidi, Riyami, Nabhani, Subhi, and Zakwani and these tribes seem to have their origin from culturally advanced lowland areas of the interior which once was a part of the Imamate of Oman. They are better educated and many hold posts in the Armed Forces and also in the government sector. These people usually live in the cities and towns of the plains and visit their villages during weekends and holidays. Because of this, the permanent residents of most villages are old people, women and children. Access to Saiq Plateau and its environs was restricted in the past, but now it is open to all visitors. Urban development of the area is very fast and the tourism industry is likely to thrive in the near future. Most inhabitants who left the mountains for livelihoods elsewhere are now returning to construct modern houses. Both the resident and transient population of the area is increasing and this is imposing severe stress on water resources. Other environmental problems are anticipated in the near future and the sustainable development of this area is a priority.

This plateau of the Hajar is the fruit basket of the region where pomegranates and apricots are cultivated in relatively large orchards. Farming and herding are the major occupations. A variety of crops like wheat, barley, garlic, saffron and alfalfa are grown in this area. Shurajjah and Al Ayn, two villages on the plateau are also famous for the production of rose water in early spring. Wild berries, *bút* and local honey are popular among visitors and tourists in spring and early summer.¹⁷

In the southern mountains of the Dhofar region, independent, cattle-tending tribal people, known as Jabali, (people of the mountain) have lived since time immemorial in a fairly balanced relationship with the

environment. The 1977 estimate puts the Jabali (also spelt as Jebali, or Jibali) population at around 20,000 with perhaps about 50,000 heads of their special breed of small cattle. The 2010 census reports a population of 163,456 in the Dhofar region, but it includes the plains population as well. They speak South Arabic Languages, which are largely unintelligible to speakers of the northern Modern Standard Arabic. One of the most common languages spoken by many mountain tribes is called Shehri. Jabali houses are fairly permanent, consisting of a circular dry stone wall covered by a domed roof frame made from the branches of trees and covered with grass and soil. Some goats and sheep are also kept especially in the foothills where the jabal vegetation is marginally characteristic of semi-desert conditions. A large number of camels are also found in this area. In former times, the Jabalis cultivated land on a small scale, growing crops within circular stone-wall enclosures adjacent to their settlements. Unfortunately, very little cultivation takes place in the mountains at the present time. A number of women in the area are making a living out of preparing Omani bread known as *raqiq*, while the men are engaged in camel rearing. In this region, the camels are part and parcel of the households they belong to. During the monsoon season, the camels are brought from the mountains and remain in the plains until the rains subside. The management of camel populations in the Dhofar Mountains is a serious problem and the large numbers of camels are responsible for overgrazing and land degradation. A few camels are slaughtered for food during special occasions like *Eid al Fitr* and the consumption of raw camel milk carries the risk of brucellosis.¹⁸

Nearly four hundred Zaydi tribes with a total of about five million members live in the rugged mountains of northern Yemen. For over one thousand years they have been the dominant community in Yemen. The Zaydi tribal society is still very conservative, with many pre-Islamic and Islamic traditions determining customs and behaviour. Houses in the fortified mountain villages are generally multi-storey buildings, quite different from the one or two storied houses common in most other Arab lands. Most Zaydi tribesmen carry the traditional curved dagger called *Jambia* and a gun around at all times. *Qat*, a mildly stimulant plant is cultivated on

arable lands, often replacing coffee. The chewing of Qat, usually sitting on cushions in a *mafrai* (a guestroom) at the top of multi-storeyed houses is a very widespread social custom with a negative impact on the society. The houses in these mountains are built by stone and cement. The western mountain slopes are the natural habitat of coffee. Yemeni coffee is called Mocha. Large groves of papaya, mango and banana are grown in the highland valleys.

Jabal Milhan, in the northwestern region of Yemen is a massif that has been one of the most neglected regions for a long time. Milhanis believe that they have been completely forgotten by their government. This area still has very few schools and healthcare is almost non-existent. Malaria and brucellosis are prevalent in this area. Infant mortality is very high. On November 24, 2010, the Yemeni Council of Ministers declared the 'Jabal Milhan Protected Area'. This announcement was received with jubilation in the area. People were hoping for instant 'developments', with very little understanding of what a protected area is actually supposed to be.

1.3.3 Transportation

Mountains are often dividers and barriers. They are difficult to cross and so they form natural borders, dividing empires and keeping out invaders. Because of the difficulty they create for transportation and communication, they are the most difficult areas for governments to control. They also often protect minority populations and their cultures who take refuge in the rough terrain.

The Atlas Mountains have their own system of transportation. Villages are linked by paths that avoid the valley bottoms and follow the crest lines of the hills. Travel is on foot, by mule or by local buses that can negotiate the terrain. The relative impenetrability of the mountains is the major obstacle to modern roads and railroads and this has resulted in the retention of ancient transport systems. Between Algeria and Morocco both the road and railroad pass through the Atlas along the Taza Pass which breaks the continuity of the mountain system between Er-Rif and the Middle Atlas. In the Saharan Atlas, between deserts and the plains the nomads use synclinal corridors (i.e. corridors formed

by folds in the rocks in which the strata dip inwards from both the sides towards the centre) that separate ridges of the Saharan Atlas range.¹⁹

Nafusa mountain transport system in Libya depends on roads which are not good for fast driving. Currently, the route to western Libya and the Nafusa Mountain region faces serious challenges for transportation due to insecurity in some areas and lack of fuel.

In Sinai area of Egypt only the local traffic between villages makes use of land routes, which scarcely exist. By the end of the year 2006, a strategic project was launched to connect the Red Sea with the south of Upper Egypt governorates via a new road and five horizontal pivots that connect every governorate with a city on the Red Sea. The new road costing about US\$160 million makes the south of Upper Egypt's governorates the greatest area to attract investments and development. The National Programme for Integrated Rural Development, «Shorouq» is one of the effective means to promote and develop Egyptian villages. It started in 1994 and provided opportunities to implement many local development projects including roads in the Sinai area.²⁰

In the mountain areas of Israel, rail system is currently used for rapid transit. The most popular trail is the Israel National Trail (INT), which connects Mt. Hermon, in the upper Galilee with Eilat, at the southernmost tip of Israel. Mount Carmel area also has bus and train services. There are currently six tourist and leisure oriented cable car systems in Israel and the Israeli-occupied territories. Several chairlifts and cable cars are used in Mount Hermon, the Golan Heights.

The road system was expanded in the 1960s and 1970s in Iran. After the 1978-79 Revolution, the road construction programs focused on connecting rural areas to provincial cities. Golestan National Park in northern Iran is a mountainous area with temperate rainforest ecosystems, lush steppes, scrub woodlands, high rocky cliffs, hills, undulating terrain and lotic and lentic ecosystems. It is faced with the construction of a road through the forest, allegedly for the ease of traffic for villagers and loggers, but at the expense of losing the only national park in Iran with a range of varying

climates from humid near the Caspian Sea and to the desert farther south.

Lebanon Mountains have a high road density, with a lot of secondary networks. On the western side of the Lebanon Mountains, a “toothcomb” pattern of roads serve mountain communities. Lebanon Mountains have never been an obstacle for transportation. Many of these mountain roads dangerously go straight up the steep slopes and are therefore vulnerable to accidents. There are also many secondary roads that run north-south, like between Baalbek and Marjaayoun on the Bekaa Plain.

In spite of increasing economic demands on the Mountains, the road system remains inadequate in mountain areas of Syria.²¹ Most villages in Saudi Arabia, even in remote mountain areas are now connected by road networks. The road system also has connected Saudi Arabia to its neighbours, both literally and diplomatically. The Hejaz Railway in Saudi Arabia was originally built to transport pilgrims from Damascus to Madinah from where they would travel on to Mecca. It was completed in 1908, but was severely damaged during the First World War (1914-1918) by Lawrence of Arabia and the Arab Revolt. Parts of the Hejaz Railway exist, and some of the sections are still functioning. The camel caravan owners were far from pleased by the construction of the railway line as it posed a serious threat to their livelihood.

Jabal Hafeet Road in UAE is one of the greatest driving roads in the world. It stretches for 11.75 km and climbs nearly 1,217 m; it boasts 60 corners and a surface so smooth that it would flatter a racetrack. Some of the mountain tribal people called Shawawi, are semi nomadic pastoralists and still use donkey or rarely camels for transportation through mountains.

Till about 15 years ago, most of the mountains roads in the Hajar Range as well as in the Dhofar mountains of Oman were graded and many also were rough tracks that could be negotiated only by four-wheel drive vehicles. Some areas of the mountains were so remote that the traditional practice of using donkeys as the beasts of burden was prevalent. People had to walk long distances to get to the market and healthcare facilities.

But recent rapid developments have completely changed the scenario in the mountains in Oman. Most of the graded roads are now tarmac and the prevalence and availability of four-wheel drive vehicles has made almost all areas completely accessible. Some roads, for example, the road from Mugsayl to the Yemeni border in the Dhofar region is considered as a marvel of engineering.

Relative to the area of Yemen, the road transportation system is very limited. In Sarawat Mountain slopes, most of the roads are too small and so motorcycles are the chief means of transportation. In November 2005, the World Bank approved a US\$40 million project to upgrade approximately 200 kilometres of intermediate rural roads and approximately 75 kilometres of village access roads. This project is a part of the larger effort to strengthen Yemen's capability for rural road planning and engineering. Plans are underway to build an estimated US\$1.6 billion highway linking Aden in the south and Amran in the north.

1.3.3 Governance

The governance in the MENA can be broadly classified into monarchies, republics and others. Qatar, Saudi Arabia, Oman, Kuwait, Bahrain, UAE, Morocco and Jordan are monarchies; some of these are absolute, while others are constitutional, parliamentary or elected. Republics are constitutional (Tunisia), democratic (Iraq, Yemen), presidential (Algeria), parliamentary (Lebanon, Syria) or Islamic (Iran). In other categories, Israel practices parliamentary democracy; Palestinian Territory is governed by the Palestinian National Authority; Egypt, a former republic is under military rule and Libya is under National Transitional Government.

The nature of governance is an important driver that has impact on sustainable mountain development. Governance determines national priorities and how important mountains are in these priorities determines the development initiatives. International instruments like Agenda 21 may be binding on signatory nations and there may even be strategies and action-plans, but their implementation in full has always been a problem. In most MENA countries mountains are marginal environments, occupied by ethnic minorities with very

Figure 3: Karaj Dam, near Tehran, Iran (Photograph by Mehrdad Tadjini)



<http://chyzmyz.wordpress.com/2010/01/12/iran-facing-a-growing-water-crisis/>

little influence in governance. Multi-tribal occupation of these areas strife with intertribal conflicts impedes development. Some well known conflicts in the MENA are related to water rights, rangeland use, competition for marketable ecosystem services and uneven sharing of subsidies.

MENA countries at present are plagued by political unrest with various forms of protests ranging from those that are partially peaceful (Oman) to those that are extremely violent (Libya, Syria) demanding change and reforms in governance. This political climate is likely to have a negative impact on sustainable development initiatives including those in the mountains.

1.4 Ecosystem goods and services

Following Chapter 24 of Millennium Ecosystem Assessment, ecosystem services in the MENA Mountains could be considered as three types: (a) Provisioning services, Regulating and supporting services (c) Cultural services.

1.4.1 Provisioning services

Provisioning services are those that provide direct benefits like water, agricultural plant products, plants used in traditional medicine, wild foods and meat and dairy products from animals.

Water is limiting in the MENA Mountains with some exceptions like Morocco and Iran which produce hydroelectricity that is used by populations downstream. Most MENA mountains have aquifers that can sustain local needs except during periods of extended drought (e.g. Oman). Flood events originating in these mountains despite being unpredictable and irregular, especially in the Arabian Peninsula carry enormous quantities of erosion substrates that contribute to the accumulation of soil for arable lands downstream. Construction of flood control and recharge dams in the foothills of many MENA mountains augments groundwater recharge. Retention dams built in the mountains, if managed well, supply water for domestic use. **Figure 3** presents one such dam in Iran. Floodwater discharges from arid mountains also

Table 2: Natural Water Resources of the MENA Region

Country	Average Precipitation (mm/yr)	Annual Rainfall (km3/yr)	Internal Renewable Water (km3/yr)	Internal Renewable Ground water (km3/yr)	Internal Renewable Surface water (km3/yr)	Overlap Surface and Groundwater (km3/yr)	Total Renewable water(natural) (km3/yr)	Total Renewable water(actual) (km3/yr)	Dependency Ration (%)	Exploitable water (km3/yr)
Morocco	346	154.7	29.0	10.0	22.0	3.0	29.0	29.0	0	20.0
Algeria	89	211.5	11.2	1.4	9.8	0.0	11.6	11.6	3	7.9
Tunisia	313	51.3	4.2	1.5	3.1	0.4	4.6	4.6	9	3.6
Libya	56	98.5	0.6	0.5	0.2	0.1	0.6	0.6	0	0.6
Egypt	51	51.4	1.8	1.3	0.5	0.0	86.8	58.3	97	49.7
Jordan	111	9.9	0.7	0.5	0.4	0.2	0.9	0.9	23	0.88
Israel	435	9.2	0.8	0.5	0.3	0.0	1.7	1.7	55	1.64
Palestine Territory	316	0.1	0.1	0.1	0.0	0.0	0.1	0.1	18	0.06
Lebanon	661	6.9	4.8	3.2	4.1	2.5	4.8	4.4	1	2.19
Syria	318	58.9	7.0	4.2	4.8	2.0	46.1	26.3	80	20.6
Iraq	216	94.7	35.2	1.2	34.0	0.0	96.4	75.4	53	75.42
Iran	228	375.8	128.5	49.3	97.3	18.1	137.5	137.5	7	137.51
Kuwait	121	2.2	0.0	0.0	0.0	0.0	0.0	0.0	100	0.02
Bahrain	83	0.1	0.0	0.0	0.0	0.0	0.1	0.1	97	0.12
Qatar	74	0.8	0.1	0.1	0.0	0.0	0.1	0.1	4	0.05
Saudi Arabia	59	126.8	2.4	2.2	2.2	2.0	2.4	2.4	0	2.4
UAE	78	6.5	0.2	0.1	0.2	0.1	0.2	0.2	0	0.15
Oman	125	38.7	1.0	1.0	0.9	0.9	1.0	1.0	0	0.99
Yemen	167	88.3	4.1	1.5	4.0	1.4	4.1	4.1	0	4.1

Legends to Table 2:

Internal renewable water resources: Account for annual surface flow of rivers and the recharge of the groundwater generated from endogenous precipitation.

Dependency Ratio: Dependency on incoming water from external sources.

Renewable resources: Total of internal and external surface and groundwater resources.

Exploitable water: This potential was estimated if available or was set equal to the renewable water value (FAO, 2007).

Source: <http://www.worldwater.org/data.html>
FAO/AQUASAT estimates from <http://www.fao.org> (2007)

carry enormous loads of faecal matter from sheep and goats that provide nutrient enrichment to lowland soils.

Table 2 given below detailing the natural water resources of the MENA region gives information on annual average precipitation, internal renewable ground and surface water data, dependency ratio and exploitable water resources. The legends following the table give all the necessary information of the data. **Figures 4 and 5** give an idea of the rivers and lakes and the groundwater aquifers of the MENA region. The Ministry of Regional Municipality, Environment and Water Resources of Oman have conducted several groundwater exploration projects throughout the Sultanate. Water suitable for agricultural use has been discovered in the Nejd area in Dhofar region, while potable groundwater stock has been found in Wadi Rawnab in the Al Wusta.²²

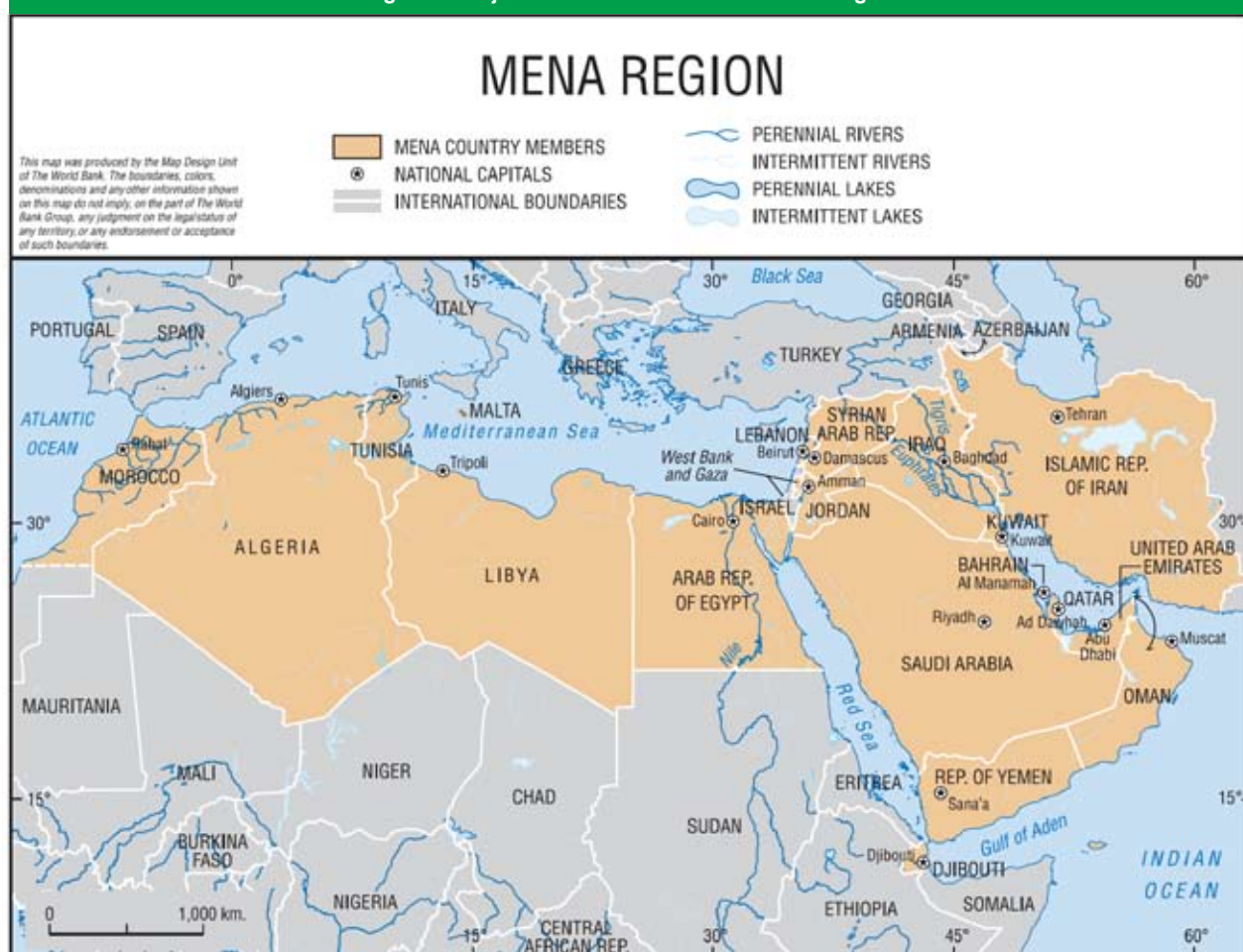
Even though most of the MENA countries come under arid, semi-arid and dry sub- humid areas, the mountains

of the region provide extensive economically important forest zones (**Table 3**).

All MENA Mountains produce food crops, but in many cases food production is enough only for sustenance. In some countries, there is enough fruit production for export (e.g. pomegranates, dates, apricot etc). The considerable forest and agricultural resources provided by the MENA Mountains are shown in **Table 4**.

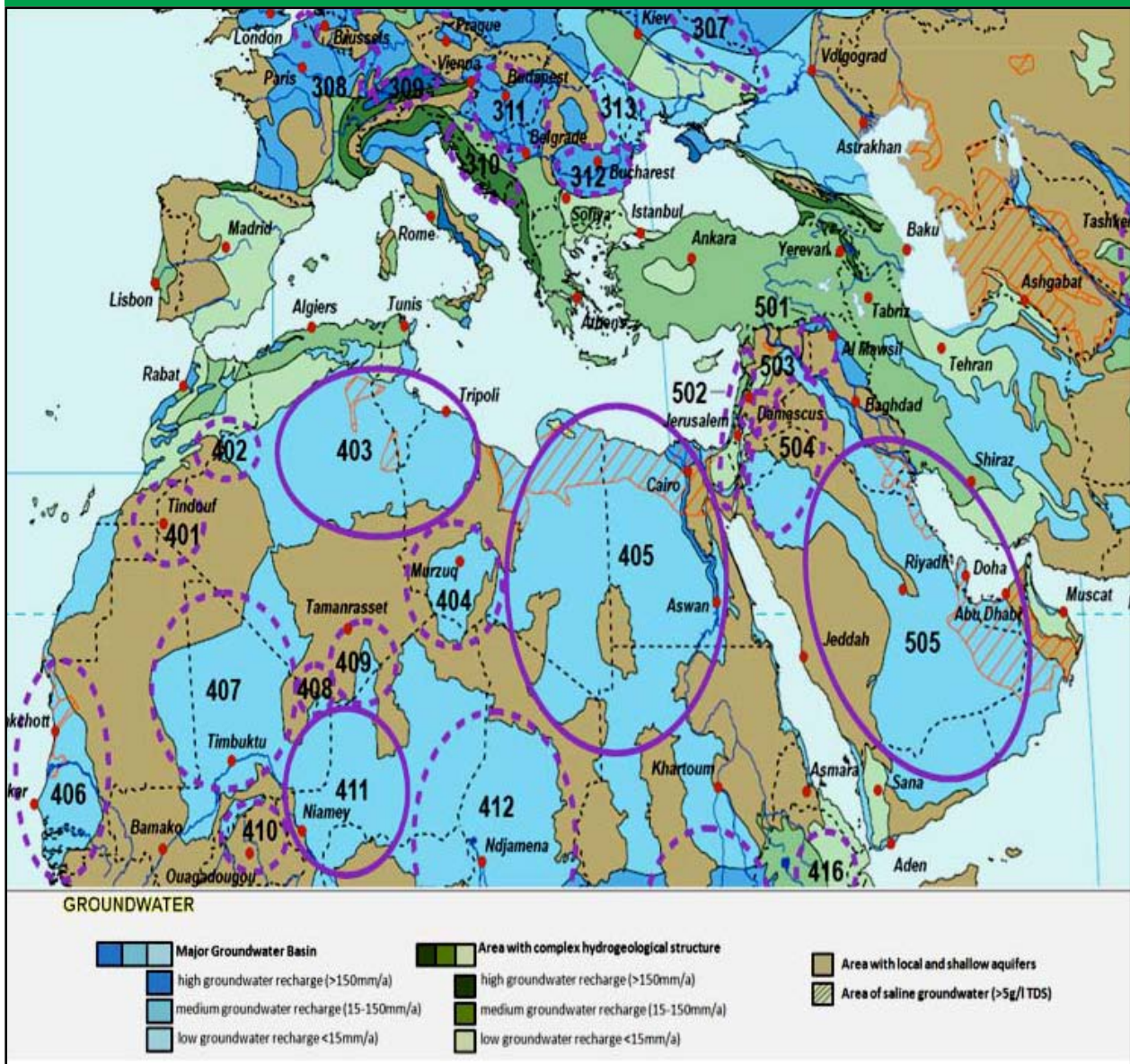
Supply and demand scenarios for MENA Mountains are very variable and data are either not available or accessible to make generalisations. All MENA countries had been invaded by Botanists for hundreds of years and all have compendiums on medicinal plants. There are many pharmacognosy texts attributing medicinal properties to these species, but the translation of their active ingredients into commercially viable healthcare products is not very common in the MENA countries. MENA Mountains are good hunting grounds for

Figure 4: Major rivers and lakes in the MENA Region



Source: Modified after AQUA-CSP Final Report, 2007. Concentrating Solar Power for Seawater Desalination, German Aerospace Center (DLR); Chapter 2: Natural Water Resources of the MENA Region.

Figure 5: Groundwater aquifers of the MENA Region



Source: Modified after AQUA-CSP Final Report, 2007. Concentrating Solar Power for Seawater Desalination, German Aerospace Center (DLR); Chapter 2: Natural Water Resources of the MENA Region.

bio-pirates from developed countries. Traditional medicine thrives in MENA Mountains and often one plant allegedly cures many diseases and many plants cure one disease. There is very little research on these traditional knowledge systems to validate the claims made. Wild foods like honey collected from forests and woodlands, pine nut, seasonal wild berries like *bút* (*Monothea buxifolia*) and *nimt* (*Sageretia thea*) in Hajar Mounatins, *zaatar* (*Oreganum syriacum*) in Lebanon and *El Yas* (*Myrtus communis*) in all mountains of Arabia are popular among tourists and fetch good prices.

Food products from animals like milk, cheese and

meat are of commercial value. Many MENA countries have thriving markets where the mountain people sell their animals. Local people in some countries believe that free ranging mountain animals like goats and sheep provide tastier meat than those grown in farms. Mountain goats and sheep command better prices than farm grown animals in many countries. There is however a disturbing trend in oil-rich MENA countries where herd size symbolises wealth and prestige and herd animals are not utilised as much as they should be. It looks absurd when herders despite having a number of animals, buy imported meat for consumption. These large herds cause a lot of environmental damage through overgrazing.

Table 3: Forest Cover Data in MENA countries, 2010

Country	Total Land Area (1000 sq km)	Total Forest Area (1000 sq km)	Percent Forest Cover
Morocco	44,630	51.31	0.11
Algeria	238,174	14.92	0.006
Tunisia	15,536	10.06	0.06
Libya	175,954	2.17	0.001
Egypt	99,545	0.7	0.0007
Jordan	8,824	0.98	0.01
Israel	2,164	1.54	0.07
Palestine territory	6,065	260	4.3
Lebanon	1023	1.37	0.13
*Syria	184,051	4500	2.44
Iraq	43,737	8.25	0.02
Iran	162,855	110.75	0.07
Saudi Arabia	200,000	9.77	0.005
UAE	8,360	3.17	0.04
Oman	30,950	0.02	0.00006
Yemen	52,797	5.49	0.01

Source: Modified after <http://rainforests.mongabay.com/deforestation/>*Data on Syria from wikipedia.org/wiki/Forestry_in_Syria

Table 4: Forest and agricultural resources in MENA countries

Country	Forest and Agricultural resources
Morocco	<ul style="list-style-type: none"> Timber, charcoal, raw material for paper and cellulose industry, and paper pulp (Eucalyptus), cork (cork oak). Wheat, barley, olives, tomato, potato, beans, onions. Oranges, grapes, apples, strawberries, melons, citrus fruits. Anise, Star anise, fennel, coriander and saffron. Almonds Cattle, sheep, goat, chicken. Illegal hashish (resin from cannabis).
Algeria	<ul style="list-style-type: none"> Oak, cork. Wheat, barley, oats, rye. Potato, olives and other vegetables. Fruits especially citrus, figs and grapes for wine and table. Tobacco, esparto grass. Crin vegetal (vegetable horse-hair). Cattle, sheep, goat, horse.
Tunisia	<ul style="list-style-type: none"> Aleppo pine, home oak, kermes oak, juniper, berber thuya (a conifer), cork oak and other evergreen trees. Oat, barley, wheat, rye. Potatoes, onions, chillies, geothermal tomatoes, artichokes, olives, asparagus, sugarbeets and other vegetables. Tunisian maltese (half-blood orange), other citrus fruit, peaches, nectarines, melons, prickly pears and other exotic fruits Cattle, sheep, goat.
Libya	<ul style="list-style-type: none"> Juniper, a few conifers, planted Aleppo pine, carob and cypress, eucalyptus. Barley and wheat. Olives, tomatoes, soybeans. Grapes, citrus fruits and watermelon. Almonds and peanuts. Cattle, sheep and goat.

Country	Forest and Agricultural resources
Egypt	<ul style="list-style-type: none"> • Oak trees • Wheat, Beans. • Cattle, sheep, goat.
Jordan	<ul style="list-style-type: none"> • Oak, pine, cedar, eucalyptus. • Wheat and barley. • Olives, egg plant, cucumber, squash, cauliflower, onions, cabbage. • Table grapes, citrus stone, pome fruits, water and sugar melons. • Pistachios
Israel	<ul style="list-style-type: none"> • Oranges, grape fruit, apples, pears, cherries, grapes, pomelit (hybrid of grape fruit and pomelo), plums, strawberries, prickly pears, pomegranates, avocados, nectarines, persimmon, loquat (<i>shesek</i>) and citrus fruits. • Tomato, cucumber, zucchini. • Tobacco • Cattle, Sheep, goat.
Palestine territory	<ul style="list-style-type: none"> • Olive trees, grapevines, figs and citrus. • Dry onions, tomatoes, okra, snake cucumber, squash, cauliflower, and potatoes. • Almonds • Cattle, sheep and goat.
Lebanon	<ul style="list-style-type: none"> • Timber, stone pine tree, oak, cedar, quercus and juniper trees. • Wheat, barley. • Potatoes, tomatoes, egg plants, lettuces, squash, cucumbers, beans. • Citrus, grapes, figs, apples, cherries, melons. • Almond, walnut, pine nuts, sage and carob. • Honey and bees wax. • Sugar beet and tobacco. • Poultry and dairy products. • Opium, marijuana, medicinal and aromatic plants. • Cattle, sheep and goat.
Syria	<ul style="list-style-type: none"> • Chestnut, oak, and walnut trees. • Edible mushrooms. • Resins, dyestuffs, tannins and truffles. • Medicinal and aromatic plants. • Wheat, barley • Tomatoes, potatoes, olives, cumin, soybeans. • Grape fruit, grapes, water melons. • Pistachio, walnut, chestnut. • Sugar beets and tobacco. • Cattle, goat, sheep, horses, asses.
Iraq	<ul style="list-style-type: none"> • Oak, maple, walnut and cypress trees. • Wheat, barley and sorghum. • Beans, egg plants, okra, cucumber, tomatoes, onions. • Melons, grapes, apples, apricots, pears, oranges and citrus. • Honey, sugar beet and sugar cane. • Tobacco • Medicinal plants.
Iran	<ul style="list-style-type: none"> • Oak, ash, elm, cypress, poplar, willow, walnut, beech and maple. • Wheat, barley. • Figs, apricot, peaches, sweet and sour cherries, apples, plums, pears, pomegranates and many varieties of grapes and melons. • Tomatoes, cucumbers, green onions, egg plants and potatoes. • Saffron, Tea, tobacco and other medicinal plants. • Sheep, cattle, goats and mules.

Country	Forest and Agricultural resources
Saudi Arabia	<ul style="list-style-type: none"> • Acasia, Christ thorn tree, juniper, olive, corkwood, prune, fig. • Wheat, sorghum, barley, millet. • Tomatoes, potatoes, onion. • Water melon, citrus and grapes. • Alfalfa • Honey • Cattle, sheep, goat.
UAE	<ul style="list-style-type: none"> • Figs, mangoes, oranges, pomegranates, grapes, banana and lime. • Cattle, sheep, goat
Oman	<ul style="list-style-type: none"> • Apricot, grapes, peaches, pomegranates, pistachios • Garlic • Rose • Cattle, sheep, goat and donkey.
Yemen	<ul style="list-style-type: none"> • Sorghum, wheat, barley, maize, millet, sesame. • Grapes, almonds, peaches, apricot, pomegranate, figs, apples. • Coffee, <i>qat</i> and tobacco. • Cattle, Sheep, Goats and donkeys.

1.4.2 Regulating and supporting services

These services include biodiversity, watershed protection, hazard reduction, climate modulation and migration.

The biodiversity of the MENA region is extensive and unique. There is a very high degree of endemism in the whole region and it is much better documented for the Mediterranean Basin. Given below are some examples. In southwestern Morocco, the argan tree (*Argania spinosa* (L.), Sapotaceae) is an endemic and is very much appreciated for its edible, high nutritional oil extracted from the kernels of the drupe-like fruit. Argan forests cover over 800,000 hectares in the Atlas and Anti-Atlas regions. Information on the endemic reptiles, amphibians, birds and butterflies restricted to Morocco can be obtained from various websites like <http://www.teline.far/eng/> and <http://www.intreasures.com/morocco.html>. Algeria hosts 3,139 plant species with several endemics such as the Saharan Cypress (*Cupressus dupreziana* A. Camus, 1926), the fir tree of Numidie (*Abies numidica* L.) and the European black pine (*Pinus nigra*). This country also has 107 species of mammals, 47 of which are protected species like the Fennec fox (*Fennecus zerda*), 336 species of birds, about 2,125 inventoried species of insects with enormous potential estimate range of up to 20,000 species, 13 species of amphibians, 60 species of

reptiles and 300 species of fish.²³ Unfortunately this list is a comprehensive country profile and does not distinguish between the mountain and plains species.

Egypt has 2,066 species of higher plants, 102 species of mammals, 153 species of birds, 83 species of reptiles and 6 species of amphibians (Winer, 1999). The Arab world houses unique biological diversity in terms of species and ecosystems represented by arid, semi-arid and Mediterranean Biomes.²⁴ The richest countries documented in terms of plant diversity with more than 3,000 species include Egypt, Lebanon, Morocco, Syria, Algeria, and Tunisia while animal diversity is highest with more than 5,000 species in Algeria, Lebanon, Syria and Tunisia. The density is estimated at 1,000-2,000 plant species per 10,000 km² in Jordan, Lebanon, Morocco and Syria and less than 1,000 per 10,000 km² for the remaining Arab countries. The density of mammal species ranges between 21-50 animal species per 10,000 km² in Egypt, Iraq, Jordan, Morocco, Syria and Tunisia, with a high range of 51-100 in Lebanon and a range of less than 20 in the remaining countries. (Mackay, 2005; Talhouk & Abboud, 2009)

The Mediterranean is a biodiversity hotspot with its huge plant diversity. Around 10% of the world's vascular plants (25,000) are found in the Mediterranean Basin on less than 2% of the earth's surface and almost half of these species are found nowhere else on earth.²⁵ The

importance of biodiversity including agro-biodiversity is well recognized in all MENA countries. The roles of keystone species are well understood and there is good support for conservation of these species at local, regional and international levels (e.g. Barbary macaque, Arabian Leopard, Arabian Tahr). There are number of protected areas and reserve areas for conservation of nature (e.g. Oman, Saudi Arabia and Israel). There are two biosphere reserves in the MENA under the MAB program of UNESCO (Morocco and Israel) and a third (Oman) is being processed. Watershed management in the MENA is an important issue and there are dedicated Ministries for the management of water resources including those in the mountains. In several MENA countries, traditional water management systems are still in operation (*afraj* management system in Oman for water distribution; *qanat* system for sustainable water harvesting and conveyance in Iran). Even in very dry MENA Mountains, the vegetation helps to stabilise soil surface and prevent erosion. Stabilisation of valley slopes and prevention of landslides are ecosystem services like in other mountains of the world. MENA Mountain climate in summer months is moderate and cool providing an escape from very hot lowland temperatures that may record more than 40°C (e.g. All Gulf Cooperation Council countries). MENA Mountains regularly lose manpower due to the migration of workers seeking better livelihoods in cities. Remote and rural mountain villages in some MENA mountains are entirely occupied by old people, women and young children (e.g. Oman, Yemen).

1.4.3 Cultural services

Each mountain in the MENA region is characterised by an impressive diversity of tribes but with very similar occupations, primarily farming and herding. The value systems are basically grounded on Islam with a few exceptions like in Israel and Lebanon. The spiritual values of these mountains are well within the confines of Islamic norms. The cultural diversity in MENA region is attractive to tourists for various reasons. Tourism is a recently encouraged activity in the Middle East countries of the MENA and countries like Saudi Arabia and Oman which were not open to tourists just a decade ago are experimenting with various models of tourism and mountains of these countries are service providers.

All MENA mountains, even those with one significant site like Jabal Hafeet in the UAE offer opportunities for recreation. Well supervised recreational activities are available in Saudi Arabia, Oman, and Morocco. Tourism products like handicrafts, carpets and traditional art are income earners for the mountain people as in the rest of the world. Cultural services offered by MENA Mountains have negative impacts like added stress on water resources, environmental degradation, and violation of local traditions causing cultural perturbations (e.g. photographing women). Regulatory mechanisms to curtail and control negative impacts in these countries are far from satisfactory.

1.4.4 Supply and demand for ecosystem services

A look into the economy of different countries in the region indicates a lot of demand for certain goods provided from the mountains. In some instances, the supplies may not meet the demands for both local and export markets. A few examples are given here.

About 70% of the wild plants in North Africa are known to be of potential value in fields such as medicine, biotechnology and crop improvements. Over 10% of these have the potential for commercial exploitation as a source of drugs and pharmaceuticals. There is a huge potential for developing herbal-based industry in the region. About 102 species out of the 316 plant species recorded in the Sinai Peninsula of Egypt are used for their medicinal, aromatic, cosmetic and/or culinary properties. Forty seven species have been considered as potential medicinal plants for human use and nine species for veterinary purposes. The demand for medicinal and aromatic plants is increasing both in domestic and international markets. The Egyptian pharmaceutical industry was worth US \$ 649.60 million in 2000. The annual export of medicinal plants is more than US \$ 43.17 million (Vashisht & Kumar, 2004). Egypt is the main supplier of German chamomile (*Matricaria recutita* L.). About 500 to 600 tons of Egyptian henbane (*Hyoscyamus muticus* L.) is exported annually to Germany. But surprisingly the report by Gutberlet (2000) also indicates that there has been an increase in the import of herbal medicines in Egypt in 2000 as compared to that in 1999.

In terms of export volume, in the late 1990s Morocco was the second largest exporter of medicinal plant materials from Africa and the ninth in international ranking (Lange & Mladenova, 1997). This country predominantly exports aromatic plants and essential oils. In 1994, about 508,200 tons of aromatic plants and essential oils worth about US\$ 168.91 million was exported (Hmamouchi, 1997). In the period between 1992 and 1995, Morocco exported 6,850 tons of medicinal plants worth US\$ 12.85 million to the international markets. In 1996, Tunisia earned foreign revenue of US\$ 2.4 million by exporting essential oils to many other countries in Africa and the Middle East (Chemli, 1997). The sale of rosemary and myrtle in the early 1990s earned foreign revenue of US\$ 0.43 million per annum (El Adab, 1993).

In 2004, Lebanon exported wine produced from the grapes grown in the mountains to the tune of 1,433 metric tons valued at around US\$ 7 million. Lebanon is also known for its fruits export. In 2008, Israel exported wines worth US\$ 26.7 million.²⁶ Morocco exported 786,606 tons of fresh fruits and vegetables in 2009. This contributes 20% of annual exportation and 18% in GDP of the country. The citrus export of the same year was 483,147 tons.²⁷

According to FAO statistics (2004), Iran is the number one exporter of saffron in recent years. Iran accounts for about 90-93% of global production of saffron. Iran exported 90 tons of saffron in 2010 to 46 countries including Europe and Arabian Gulf.²⁸ The country also exported fruits valued at about US\$ 2 billion in 2010-2011.²⁹ It exports 15-20 kg of *Rosa damascena* oil per year which costs over US\$ 6000/kg.³⁰

Economic Opportunities Programme Report by Republic of Yemen (2005) reports that the annual Yemeni coffee export varied from 4000 to 6000 metric tons valued at about US\$ 20 million. Export value for honey from this country was 8.4 million in 2005. (International Trade Statistics, 2005)

The Hajar Mountains of Oman produce very exclusive honey that is very much in demand in the Middle East countries. Honey produced during 2008 stood at 96,026 kg. Unfortunately this is not enough to meet the

local and international demands and hence Oman also imports honey from various sources.³¹

Tourism is a service that is in high demand of late in many countries of the region. In Morocco, tourism contributed to 9.1% of GDP in 2011. In the same year 9.4% of the GDP of Lebanon was from tourism. In Jordan, the tourism sector contribution to GDP reached 8.3 % in 2011. In Oman, tourism contributed 3% to total GDP in 2011. 6% of total GDP was contributed by tourism in UAE in 2011.

This area in MENA Mountains is one of the research priorities because very little information is currently available in the published literature. The impact of land and water use on ecosystem services in the context of global changes, decision making drivers controlling supply-demand situations and payment for ecosystem services (PES) (Koellner, 2009) are all areas that need study.

1.5 Key issues

1.5.1 Climate

Research on paleo-climate has always connected the prehistoric climate changes to the disappearance of species or ecosystems of the past. But the current rates of climate change are more rapid, and could exceed the inherent adaptive capacity of natural systems. Anthropogenic greenhouse emissions, which have risen dramatically since the beginning of the industrial revolution in the second half of the 19th Century, are expected to lead to average global warming of 1.1 to 6.4°C, over the period 1990-2100, according to various climate change scenarios (Kohler & Maselli, 2009).

The average temperature increase in the mountain systems globally in the 21st Century (up to 2055) is predicted to be between two to three times greater than the average change recorded in the 20th Century. Mountain areas have a marked and complex topography and so their climates vary considerably over short distances. Climate change projections are therefore difficult to make. Unfortunately, reliable long-term and high altitude records of mountain climate which allow verification of regional climate models exist for only a very few areas such as the European Alps (Nogués-Bravo et al., 2007).

Two of the mountain systems of the world that are critically important for water supply are the mountains of the Middle East and the Atlas Mountains. Temperature and precipitation in the form of rainfall and snow largely determine the hydrological cycle including run-offs. Changes in these factors will thus impact freshwater supplies from the mountain areas and have implications for water availability in the lowlands. Changes in water availability due to climate change are taking place at a time when pressure on water resources for irrigation, food production, industrialization and urbanization is increasing. The effects will be the greatest in the semi-arid regions and monsoon belts. Globally the climate change is very likely to increase the pressure exerted by non-seismic hazards. This is especially true of the East African Rift zone and the Middle East. But the two most deadly natural hazards, the earthquakes and volcanic eruptions, are not directly affected by global warming.

Mountains are characterized by a high level of endemism. In recent decades, climate change has emerged as a threat to diversity along with expansion and intensification of land use. The speed of the global climate change may very well expose the fragile mountain systems to extreme events such as intensive rainstorms, severe insect and disease outbreaks, longer fire seasons and more severe fires. Until recently, economic, political and social changes such as globalization and migration were taken to be the main drivers of change in mountains. Today it is increasingly acknowledged that climate change and its consequences are likely to have similar or greater impact (Nogués-Bravo et al., 2007). The same source also points out that the climate change may bring regional and local benefits. In the higher mountains, increase in temperature could mean that trees produce higher yields of timber and crops can be grown at higher altitudes. Extended growing seasons and accelerated soil decomposition may well increase the growth and productivity of trees and other plants.

The MENA region is particularly vulnerable to the impact of climate change. It is expected that the southern and eastern Mediterranean will experience greater warming trends than the global annual mean warming, with a predicted increase of 2.2 to 5.1°C. (Al Yaqubi, 2008). At the same time, MENA have the fewest renewable water

resources and the least arable land per person of any region in the world (Abu Zaid, 2008). Climate change impact for the MENA region includes intensification of the following trends (Sowers & Weinthal, 2010).

- Decreased precipitation and therefore decreased river flows for the eastern Mediterranean.
- Lower yield of major food crops.
- Accelerated salt water intrusion to coastal freshwater aquifers due to sea level rise.
- Long-term salinization of inland aquifer systems.
- Accelerated desertification of marginal areas.
- Increased likelihood of sand and dust storms.
- Accelerated sea-level rise in low lying, often densely populated coastal areas.
- Accelerated snow-melt in mountainous areas.
- Increased duration and intensity of drought.

MENA region emission of Greenhouse Gases (GHG) are generally small in absolute (less than 5% of the world's total), and in per capita terms. However, the amount of these emissions and consequent contribution of this region to climate change varies among countries with the oil producing countries of Algeria, Egypt, Iraq, Saudi Arabia and UAE accounting for 74% of the region's total. Moreover, at +88%, the increase of CO₂ emissions in the MENA was the third largest in the world in 1990-2004 and this acceleration is more than three times faster than the world average. Most of this increase had come from fuel combustion (World Bank, 2007).

Although the projection in the precipitation changes is less reliable, the inherent water constraints of dry climates and the location of all dryland mountains near desert zones may result in dramatic changes. A decrease in precipitation in the Mediterranean Basin and Saharan mountains is predicted by the IPCC 2007 report (Solomon et al., 2007).

It seems clear that the most significant effects of climate change are related to the increase in frequency, magnitude and severity of extreme weather events like heat waves, droughts, strong winds, hurricanes and torrential rainfall. The resulting large scale disturbances such as wild forest fires, massive forest dieback, pest outbreaks, rangeland degradation, and lower yields

of crops, floods, and pollution are expected to leave a much greater impact on human society (Regato, 2008).

Expected serious impacts of climate changes, specifically in the Dryland Mountains include:

1. The local or regional loss of significant number of species and habitat types. In the mountains of the Mediterranean Basin it is predicted that approximately 60% of the total flora will be extinct by 2080 (Thuiller et al., 2005).
2. Forest loss caused by large scale fires may significantly increase in the Mediterranean Basin with a predicted 1 to 7 additional weeks of fire risk by 2080, depending on the region (Giannakopoulos et al., 2005).
3. The predicted temperature increase beyond 3°C in most dryland mountain regions is likely to have very adverse impacts on agriculture, water resources, ecosystem production and human health (Hitz & Smith, 2004).

In West Asia, climate change scenarios predict a decrease of over 170,000 km² in viable rain-fed agricultural land by the end of the 21st Century. The useful grazing period of most rangelands will shrink because of the longer dry seasons, while shifting growing seasons due to altered precipitation patterns will force changes in cropping strategy or even crop types (Evans, 2009).

The severe drought of the past few years in the eastern part of MENA region spanning Syria, Iraq, Lebanon, Palestine and Israel provide a stark example of the interactions between climate-induced variability and the adaptive capacity of governments. The drought high-lighted the fragility of rural areas (many of which occur in mountains) in several countries where, local and national governments were unable to cope with insufficient rainfall to sustain local agricultural production. In eastern Syria for example, prolonged drought (2006-2009) without effective intervention affected an estimated 1.3 million people; the loss of the 2008 harvest accelerated the migration to urban areas and increased levels of extreme poverty (UN, 2009).

The available data on climate and climate changes in the MENA region are sparse. Ecosystem vulnerabilities have been analyzed using remote sensing observations,² climate data and socioeconomic attributes to develop results of clear value for integrated assessments of global climate change impacts in the subtropical ranges of the High Atlas Mountains of Morocco. Lebanon Mountains are deemed to be under serious threat from climate changes and have been listed as among the top conservation priorities of the first ever comprehensive plan to preserve this unique ecology of the Mediterranean Basin. In Oman, the northern mountains are warming over the past decade while the plains are showing a reverse trend of cooling (Kwarteng et al., 2008). There is some evidence that climate change in mountains have impact on biodiversity in Iran (Kamyabi & Farahani, 2011) and impacts of climate on plant communities have also been reported in Saudi Arabia.³² Capacity to assess topics on climate change, particularly the main focal areas of inventories, mitigation analysis and vulnerability assessment is reported as a problem and building a national capacity to ensure meaningful debate on the issue of climate change is a priority in Yemen. The frequency, intensity and extent of the mountain fires that are threatening the mountains in Israel are due to changes in climatic factors that prolong droughts, increase water evaporation and the frequency of intense heat waves.³³ At a warming of 1.5 degrees by the year 2100, the desert is predicted to expand northward by 300 to 500 kilometres.

Despite increasing efforts to reduce the emission of greenhouse gases, results from global circulation models show that major changes in the current climate cannot be avoided and hence sector-specific adaptation measures are needed. Lack of understanding of (a) the likelihood of change, (b) vulnerability of the specific sectors to the predicted change, and (c) the local-scale possibilities for mitigation or adaptation are the main factors leading to the failure of management. Lack of methodology and tools for connecting the global and regional scale climate changes to sub-regional and local scale changes is also another factor. Authorities and stakeholders acting at these different scales need the necessary information, provided in a suitable format, for understanding and planning adaptation measures.

1.5.2 Water resources

Water scarcity, stress on water resources and water resource management are extremely important in all MENA mountains. **Figure 6** shows the aridity zoning of the region. Rapid population growth in the MENA region has exacerbated the water scarcity issues. While natural factors such as intermittent droughts and limited freshwater reserves can cause scarcity, high population growth imposes additional pressures (Falkenmark et al., 1992). Experts measure water availability in terms of the amount of annual renewable fresh water per person. A country is considered “water stressed” when its total renewable freshwater resources lie between 1,000 cubic metres and 1,700 cubic metres per person per year. With an average of only 1,383 cubic metres of renewable water resources per person per year in 2006, the MENA region falls far below the global average of 8,462 cubic metres per person per year. Environmental problems resulting from water issues cost MENA countries between 0.5 and 2.5 percent of GDP every year. People and economies also suffer from the consequences of droughts, floods and water-

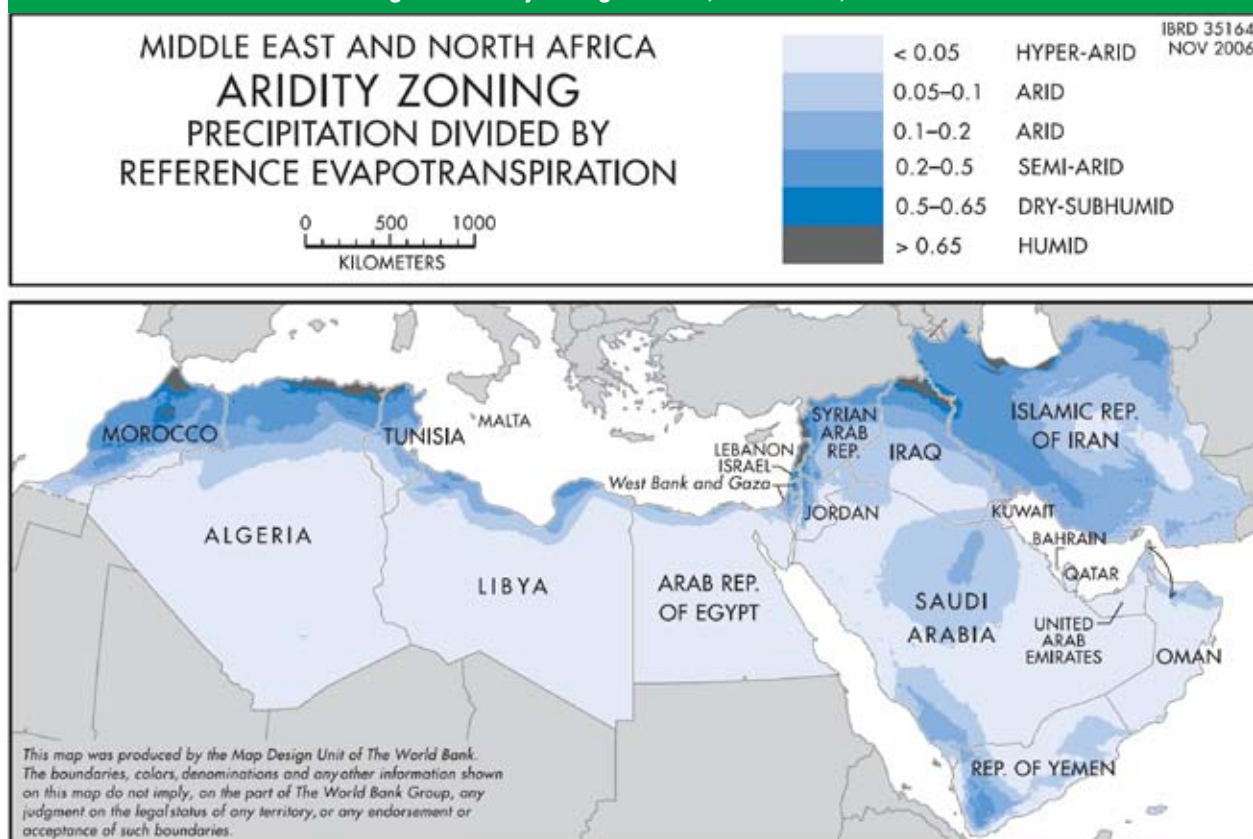
related public health issues. The region has responded to these water challenges with some of the best hydraulic engineers in the world, who have pioneered sophisticated irrigation and drainage systems as well as cutting edge desalinization technologies.

The thresholds for water scarcity and water stress do not reflect the freshwater resources that may eventually become accessible for human use. Accessibility is determined by a nation’s ability to collect and transport water to users and by the quality of the water. Human activities often pollute existing sources of fresh water, making it unusable or expensive to treat and reuse. Once water is available for human use, however, many factors affect how that water is used (Roudi-Fahimi et al., 2002).

1.5.2.1 Balancing water scarcity and human demand

MENA countries have increasingly been adopting new strategies for balancing their scarce water resources and growing demand for fresh water, although their

Figure 6: Aridity zoning in MENA; World Bank, 2007



Source: Modified after <http://earthtrends.wri.org/updates/node/171>

options may be dictated by a number of different factors. For example, low-income countries, such as Yemen, would not be able to purchase the high-tech equipment available to high-income countries, such as Saudi Arabia. Even for high-income countries, purely technological solutions relieve only some of the demand for water. In the long term, slowing population growth in the region and creating effective policies and programs for improved water management are keys to the region's sustainable development.

1.5.2.2 Strategies for increasing supply

Most governments have traditionally focused on increasing access to fresh water by locating, developing, and managing new sources, despite the high costs often involved. As new natural sources of water become scarcer and more expensive, however, MENA countries are turning to other options, such as desalination and treatment and reuse of wastewater, while continuing to use older methods.

1.5.2.3 Qanats and rainwater harvesting

Qanats or chain wells, a traditional method for bringing water to the surface, consist of a series of horizontal tunnels bored into a cliff or mountainous area. These interconnected tunnels are sloped, allowing water to drain out and create an oasis in an otherwise arid area. The largest number of qanats is found in Iran. Rainwater harvesting, another ancient method for collecting water from roofs, cisterns, and other sources diverts runoff into ponds and reservoirs for agricultural use.

1.5.2.4 Sequential water use

Sequential water use involves capturing and treating water that has been used in one sector so that it can be directed to other uses. Domestic use requires the cleanest water, so the ideal order is for water to be used in the household first, then in industry, then in agriculture. Urban wastewater, often referred to as "brown water," can be treated and channelled from towns and cities onto nearby farms, increasing crop yields and decreasing the need for chemical fertilizers. For example, most of Israel's sewage is purified and used to irrigate farm land. Wastewater from Tunis is used to

irrigate citrus and olive orchards near the city, as well as golf courses, hotel gardens, and certain crops (Gleick, 2000). Sequential water use is rarely practiced in MENA Mountains. Climate change, decrease in annual rainfall and water scarcity associated with population increase may soon force mountain townships to consider sequential water use and wastewater recycling as necessary strategies.

1.5.2.5 Desalination

Extracting salt from seawater is extremely expensive. Desalination provides a clean and reliable source of water, but it uses large quantities of heat and has some negative environmental consequences. Sixty percent of the world's desalination capacity lies in the oil-rich Gulf States; 30 percent of the world's total is in Saudi Arabia, which has facilities on the coasts of both the Red Sea and the Gulf of Aden. Pumping desalinated seawater up the slopes to supply potable water to villages and towns in high altitudes would be an unthinkable option for most countries in the world, but there are such projects in progress in the Arabian Gulf countries (e.g. Oman).

1.5.2.6 Trading water

There are a number of ways to transport water from one part of the mountain to another. The most commonly used practice is by using motorised water tankers for overland transport. Pumping water from one watershed to another is also an option, but this may have serious impacts on local ecosystems and hydrology.

1.5.2.7 Country specific highlights

In Morocco, water crisis, snow sublimation and soil erosion are the major issues. Water crisis investigations conducted have been extensive, highly participative and diagnostic of the current status of water resources. Water resources by watersheds were mapped in detail. The current and projected demand for water was estimated. Water sector was thoroughly analyzed in the context of organization, governance and judicial processes. Major environmental challenges to water sector were evaluated in the context of the socioeconomic development. Stakeholder involvement was comprehensive in identifying issues to formulate

solutions and develop strategies. The major stakeholders were, Al Akhawayn University, Ifrane, Morocco, Centre National d'Etudes Agronomiques des Regions Chaudes (CNEARC), Institutional and Social Innovations in Irrigation Mediterranean Management (ISIIMM), the Government of Morocco, and the World Commission on Water, Mexico. A quantitative model has been built to visualize the deficits and surpluses, both current and projected, to evaluate the impact of proposed strategies. This study predicts that Morocco will face a water shortage of 1.5 billion m³ by 2030 resulting in the overexploitation and depletion of groundwater reserves (Osman-Elasha, 2010). The pitfalls in the current governance and inadequacies of the judicial infrastructure for the protection of water resources have been highlighted. Highly participative diagnostics and involvement of the stakeholders are the key factors that led to the success of this effort. Participation and commitment of international organisations were also

important. Use of snow as an alternate source of water has been highly recommended by research studies and this strategy needs to be explored (Schulz & de Jong, 2004). **Table 5** presents the rate of fresh water withdrawal in MENA countries.

It has been established that growing water stress in the Lebanon Mountains poses a threat to flora and fauna and the natural habitat as well as human development and livelihood, mainly among the poorest and most vulnerable populations living in semi-arid rural areas. Water policies in these areas have been dominated for many years by a supply oriented approach. These days, such a policy orientation is unable to confront the growth in demand, the competition for water resources by the various economic sectors and the arising serious environmental problems. Some forecasts suggest that by 2020 the Lebanese population will face problems due to water scarcity.³⁴ This is not only due to the

Table 5: Fresh water withdrawal in MENA countries, 2010

Country	Total Fresh Water Withdrawal (km ³ /yr)	Per Capita Withdrawal (m ³ /p/yr)	Domestic Use (m ³ /p/yr)	Industrial Use (m ³ /p/yr)	Agricultural Use (m ³ /p/yr)	2010 Population (millions)
Morocco	12.6	389	39	12	339	32.38
Algeria	6.07	171	38	23	111	18.99
Tunisia	2.64	254	36	10	209	10.37
Libya	4.27	652	91	20	541	6.55
Egypt	68.30	809	62	49	695	84.47
Jordan	0.94	145	45	6	95	6.47
Israel	1.95	268	97	16	156	7.29
Palestine Territory	0.42	95	46	7	43	4.41
Lebanon	1.31	308	89	34	185	4.25
Syria	16.69	742	67	30	653	22.51
Iraq	66.00	2097	147	315	1657	31.47
Iran	93.30	1243	85	12	1143	75.08
Kuwait	0.91	299	132	6	162	3.05
Bahrain	0.36	442	221	27	199	0.81
Qatar	0.44	294	115	6	174	1.51
Saudi Arabia	23.67	902	81	27	793	26.25
UAE	4.00	849	127	17	705	4.71
Oman	1.32	455	45	5	400	2.91
Yemen	3.40	140	11	3	126	24.26

Source: <http://www.worldwater.org/data.html>
FAO AQUASAT estimates from <http://www.fao.org> (March, 2004)

lack of water resources that are unevenly distributed but, more importantly, due to their undervaluation and mismanagement.

Overexploitation of groundwater, water management and improvement in water use efficiency are serious problems in Oman Mountains. The proximate causes for these are urbanization, tourism development and intensive agriculture. Construction of reservoirs to enhance water availability has not produced desired results due to poor physical and microbiological water quality (Victor et al., 1998; Victor et al., 1999; Al-Kharusi et al., 2009). Consequently water in these reservoirs is under-utilized. Simple sustainable practices like the utilization of available surface water and construction of perimeter walls to reduce eutrophication have not been received well and expensive mitigation measures are planned (See 1.5.2.5 Desalination). Water supply of most of the mountain oases is stable enough to allow crop cultivation during drought periods, but not during the dry spells of ten or more years (Luedeling, 2007).

The revitalization of traditional water harvesting and supply technology in the mountain areas of Iran has been encouraged (Boustani, 2009). A *qanat* system (see 1.5.2.3, *Qanats* and rainwater harvesting) consisting of environmentally sustainable water harvesting and conveyance techniques through which groundwater can be obtained without damaging the tapped aquifer, has had a profound influence on the lives of water users in the arid mountain regions. Rainwater harvesting and utilization is considered as a strategy to reduce the water crisis in Saudi Arabia, but few studies are available on direct rainfall utilization methods (El Atta et al., 2009). Efforts are also underway to explore the sustainable exploitation of groundwater.

In addition to the ubiquitous water scarcity, the Ta'iz area, in the southern highlands of Yemen, represents a situation where urban and rural water problems are mixed, and conflict with each other creating an extreme case of water management problem (Mohiedeen, 1999). A 2009 study also suggested that 70 to 80 percent of rural conflicts in the nation were related to water (Glass, 2010). The shortage and cost of water have also had negative effects on livestock production. This has led to an increase in poverty among communities in some

rural areas. In the remote areas where people do not have easy access to water, girls are forced to drop out of school as they are needed to collect water from wells far from their houses. Many poor people in rural areas have resorted to drinking unsafe and contaminated water.³⁵ Yemeni government attributes water problems to its rapidly increasing population and to *qat* (*Catha edulis*) cultivation (Milich & Al-Sabbry, 1995). The movement of people from rural areas to cities is adding to the already existing urban load. According to a report by Yemen Armed Violence Assessment (YAVA), violence over land and water kills far more people in Yemen than internal political conflicts.³⁶ Around 4,000 people are killed over land and water disputes each year. Poor water-related educational programs and lack of capability to determine or monitor proper water-use norms due to the lack of technically capable institutions are the key factors which are leading to failure of water resource management in Yemen highlands.

The dispute between Israel and Palestine over shared water resources of the mountain aquifer is one of the major potential obstacles in resolving differences in the Middle East. This aquifer is the only source of water for the Palestinians in the West Bank and also the main source of water for Israel. The majority of the natural recharge areas lie within the West Bank territories with two of its three basins flowing naturally toward Israel. In the Declaration of Principles, Israelis and Palestinians created preconditions for the coming negotiations and the Israelis recognised water rights for Palestinians. There is no clear indication of the extent to which water would be under Palestinian control during the interim period, but there is an implicit recognition of the need to reform the existing water allocation system. In the Final Status Negotiations, the Joint Mountain Aquifer Committee, members of the Israeli Government and the Palestinian National Authority must make decisions regarding the equitable distribution and joint management of the shared water mountain aquifer (El-Fadel et al., 2001).

Despite the limits on water withdrawal, due to global warming and frequent droughts, the regime of the natural flows in Israel are decreasing. At the same time, the influx of pollutants from human activity and negligence above the aquifers is increasing, resulting

in the increase of mineral and other pollutants in the groundwater. Due to unbalanced exploitation and return flow from irrigation, an increase in salinity of the groundwater has occurred in many wells (Shevah, 1999). The policy for the water sector, particularly in the past decade, combined with the absence of adequate actions facing the impending water shortage situation, has contributed to the severity of the water crisis. The agricultural sector has suffered most because of this crisis. Due to shortage, water allocations to the sector had to be reduced drastically causing a reduction in the agricultural productivity.

1.5.3 Wildlife and biodiversity

Wildlife and biodiversity issues in the MENA region are country specific. The projects and issues are supported or dealt with by specific stakeholders.

The interdisciplinary project on the conservation of Barbary macaque (*Macaca sylvanus*), a flagship species that has been on decline due to habitat loss and poaching in northern Morocco, aims to protect this species from extinction by amassing biological and ecological data, promoting awareness and working with all concerned stakeholders to develop a long term management plan that also includes the livelihood concerns of the local communities (Lavieren & Wich, 2009). However, there are limitations due to the inadequacy of management skills and capacity to manage the existing habitats. Resolving the complex socioeconomic issues relating to poverty and land tenure is difficult. Poaching is driven by the local and foreign demand for macaques and further enabled by poor law enforcement, lack of awareness and poverty.

The Moroccan government has recently identified 154 sites of biological and ecological interest, basically corresponding to those of the important Moroccan forest areas (Laalam et al., 1997). A World Bank/Global Environment Facility (GEF) project on biodiversity conservation aims to expand the network of national protected areas, establish new national parks, declare sites of importance as nature reserves, and improve the management systems through management plans, capacity building and community participation. These details can be obtained in many websites such as;

http://gridnairobi.unep.org/chm/roa/project_profiles/MoroccoUNEPPProjects.pdf.

Studies on mountain vegetation and research management and conservation have also been conducted (Romo, 2009). The biodiversity conservation project in the southern highlands of Morocco has increased the analytical understanding of economic, social and ecological benefits derived from pastoral management systems. This project has addressed key bottlenecks that prevented the revival of mobile lifestyles; cultural denigration of trans-human culture; limited provision of services in transhumant areas; and the unfounded belief in the economic superiority of settled agriculture. It has tested mobile schools to provide education and has facilitated the installation/restoration of basic pastoral infrastructure to open up new spaces for grazing (Ministry of Agriculture and Fisheries in Morocco, 2008).

The biodiversity conservation in Lebanon includes *in situ* and *ex situ* conservation issues. The conservation of birds³⁷ and the status of Lebanese cedar are of interest.³⁸ Major threats to biodiversity, especially along the western slope of Mount Lebanon are due to the destruction of rural habitats and forests by rapid urbanisation. Quarrying and sand removal activities have had a major impact on the flora and fauna for quite some time. However, the decisions to properly regulate such activities are helping in the conservation of remaining areas. Biodiversity of wild species is quickly reducing because they are no longer considered as economic assets; they are further threatened by extinction due to excessive hunting and local changes in the habitat.³⁴ A five-year strategy unveiled recently will dedicate special attention to biodiversity conservation in the Orontes Valley and Lebanese Mountains, a large natural corridor which reaches from the mountain ranges to the sea and supplies almost all of Lebanon's needs.³⁹

Both the Ministry of Agriculture and the Ministry of Environment actively encourage the legislature to take decisions for the benefit of biodiversity conservation and environmental protection in Lebanon. International stakeholders are the International Union for Conservation of Nature (IUCN), Food and Agriculture

Organisation (FAO) and Critical Ecosystem Partnership Fund (CEPF). The Protected Area system for *in situ* conservation of biodiversity is becoming more extensive and the biodiversity, for both human development and environmental conservation has gained importance in the social agenda. Efforts towards the declaration and protection of natural reserves are gaining momentum. The establishment of Al Shouf Mountain Reserve is a good example for successful conservation of wildlife in mountain areas.

Although the biodiversity inventory of the Oman Mountains is far from complete, the data available are extensive. Research projects conducted in the Hajar Mountains over the last two decades have provided a lot of baseline data on flora and vertebrates. Faunal diversity inventory of vertebrates in the mountains is almost complete. Bird diversity in these mountains is fully known (Eriksen, 2008). Lizard endemism is extremely high (*Pristurus spp*). There are seven to nine undescribed species. There are three new species of *Hemidactylus* described in Oman Mountains. Four mountain endemics of the genus *Assacus* are known and several more are to be described. The genus *Omanosaurus* and *Echis omanensis* are endemic to Hajar Mountains. (Personal communication with Dr. M.D. Robinson, Sultan Qaboos University; IUCN Reptile Redlist Assessment meeting in Sharjah in February 2012; Molecular Genetics Project; Sultan Qaboos University). Aquatic biodiversity in the mountains are poorly known except for some specific groups (Victor et al., 1999; 2002). Invertebrate diversity is not well known except for some specific groups of insects, arachnids and snails.

Plant genetic diversity mainly of wheat landraces and alfalfa in the mountains has also been investigated (Buerkert et al., 2005). Conservation status of plant and vertebrate species are known. Endemic species of plants and those requiring protection have been identified. Rangeland vegetation for the Al Jabal al Akhdar region has been well described. Oman mountain flora show high degree of endemism (Patzelt, 2009). Management plans are still needed for this biodiversity hotspot. As an outcome of the multidisciplinary study, "Al Jabal al Akhdar Initiative, 2004-2007", a Nature Reserve has recently been established on the higher elevations of Saiq Plateau in Al Jabal al Akhdar.

Two successful flagship conservation programs in the mountains of Oman are those of Arabian Tahr (*Arabitragus jaykari*) in Wadi Sereen Reserve of the northern mountains and Arabian Leopard (*Panthera pardus nimr*) in Jabal Samhan Nature Reserve area of Dhofar Mountains. These two projects cover both conservation and sustainable development issues including socioeconomic considerations. These projects also will complete a wildlife inventory of the areas, describe the primary habitats of the target species, shed light on their biology and ecology, investigate historical records and produce management plans. A Biosphere Reserve in the Jabal Samhan area of the Dhofar region including the valley slopes and associated coastal plains has been established under the Man and Biosphere (MAB) program of UNESCO.

In Iran, the conservation of biodiversity has received attention in the Zagros Mountains supported by World Wild Fund (WWF) and the Global Environment Facility (GEF), USA (Mc Ginley, 2008). The Government of Iran has a Protected Area Network (PAN)⁴⁰ to conserve the rich biodiversity of central Zagros Mountain. The Mountain Environment Protection Society (MEPS), Iran is the major stakeholder in the problems related to the protection of the mountain ecosystems. A project called the Conservation of Biodiversity in the Central Zagros Landscape Conservation Zone was designed as a five year plan with US \$ 9.6 million initiative by the Government of Iran, supported by the UNDP and GEF. The project started in 2005 and has been implemented for the past 5-6 years. An independent review and evaluation of this project was carried out in January-March of 2011. The main strategy of the project is referred to as 'biodiversity conservation mainstreaming' which means enabling the agencies that govern the main economic or resource use sectors to incorporate conservation and ecological sustainability measures into their own policies, programs and sectoral practices. But the overall view formed by the Mid-Term Evaluation (MTE) is that the standard of supervision and direction of the Zagros Project have not been adequate. Unclear leadership, lack of strategic guidance and management are likely to have been the main contributors to the limited progress and achievements of this project over the six years of implementation.⁴¹

The major issues in Saudi Arabia are forestland degradation and rehabilitation, conservation of the Arabian leopard (*Panthera pardus nimr*), conservation of mountain biodiversity, regeneration and growth of *Juniperus procera* on the Sarawat Mountains in south western Saudi Arabia (El Atta, 2009), and the impact of climate on plant communities. Related topics such as habitat characteristics, current distribution and prey of the leopards, the human impact on biodiversity conservation were also investigated by the Saudi Wildlife Commission, World Wide Fund for Nature (WWF) and Range and Animal Development Centre, an NGO. Saudi Wildlife Commission is also involved in the study of the impact of climate on plant communities. They are taking necessary actions to protect the woodlands along with other flora and fauna. At present the Commission manages 15 protected areas, which have been ratified by its Board of Directors. Ecosystem assessment project in Asir Mountains were carried out by the Presidency of Meteorology and Environment, and the Ministry of Agriculture (MoA)⁴² and the sustainable development of Asir National Park (ANP) is receiving attention.

According to the studies conducted so far, species occurring in the Hejaz Mountains are at the risk of losing habitats as a result of changes in climate. Extreme temperature conditions may cause these areas to undergo major changes and the habitat diversity of the natural mountain environment is likely to be impacted by wide variations of climatic factors (UNFCCC, 2005). A range monitoring program has been started by the Range and Animal Development Centre at Al-Jouf to determine the effects of climate and the recovery of vegetation.

The Arabian leopard (*Panthera pardus nimr*) existing in Haql in the northern part of the Median Mountains, and in Hejaz and the Sarawat Mountains were classified as critically endangered by IUCN since 1996 (Al-Johany, 2007). Less than 200 animals remained in 2006, and the population trend is decreasing. Leopards have been placed in special conservation breeding centres in order to increase the existing number of animals (Al-Jumaily, 2006).

Extensive studies are in progress on the conservation and maintenance of forest ecosystems in the arid and

semi-arid mountainous areas of Yemen. The Protected Area Management (PAM) project funded by the World Bank was intended to conserve biodiversity of global significance in Yemen through the protection, maintenance and enhancement of forest ecosystems in arid and semi-arid areas, by promoting sustainable, community based management of two selected forest ecosystems and by developing replicable systems for preserving biodiversity in Yemen. The approach followed in the implementation of the project includes the following three key elements: (a) enhancement of the policy, institutional, legal and regulatory framework to support and sustain the community management of protected areas; (b) preparation of detailed protected area management plans; (c) enhancement of the quality and quantity of biological resources in the two areas and the development of mechanisms for long-term biodiversity monitoring. Effective progress has been achieved in several areas of the project's activities, with the active involvement of local stakeholders and the creation of the Community Based Organisation that is now taking an active role in decision making.⁴³

Over 150 nature reserves and 65 National Parks were established throughout Israel under the supervision of Israel Nature and Park Authority (INPA) and encompass nearly 1000 square kilometres.⁴⁴ About 20 reserves have been developed for public use with visitors' centres, roads and hiking trails, attracting over two million people every year. One of Israel's important regions, Mt. Carmel, was declared a biosphere reserve within the framework of the Man and Biosphere Program (MAB) of UNESCO. The Hai Bar wildlife projects in the Arava and on Mt. Carmel were set up to reintroduce animal species, which once roamed the hills and deserts of the land, into their former natural habitats.⁴⁵ Animals now being raised include ostriches, Persian fallow deer, oryxes, onagers and Somali wild asses. The Jewish National Fund (JNF) carries out development, reclamation and afforestation projects in Israel. Today over 200 million trees in forests and woodlands covering some 12,000 ha provide Israelis with a wide range of opportunities for outdoor recreation and appreciation of nature. In efforts to conserve the natural environment, stringent laws for protection of nature and wildlife have been enacted, making it illegal to pick even the most common roadside flowers.

1.5.4 Agriculture, livestock and land use

1.5.4.1 General considerations

Agriculture, livestock and land use are interrelated and often have cumulative impact on other issues such as biodiversity, rural development and livelihoods. These issues, especially those that are mountain specific need to be examined country-wise in the background that more than 50% of the food consumed in the MENA region is imported, making it the largest food importing region in the world. High rates of population growth combined with severely constrained water and land resources suggest that dependence on imports will increase or remain at current levels for the foreseeable future.⁴⁶ Most of the areas in MENA Mountains are rural and the strategic importance of the rural sector in terms of food security, poverty alleviation, unemployment, growth and liberalisation and water revolves around agriculture, livestock and land use.

Mounting food import bills and unreliable markets is fuelling interest in increasing cereal production. Several MENA countries are trying to expand grain production as a way of decreasing exposure to international food markets. While such a strategy is rational and gains in productivity are possible, it requires overcoming significant land and water constraints. The cost of pursuing such a strategy may be prohibitive and there may be better market based strategies for securing food supplies and reducing exposure to international price volatility.

Government spending is on blanket subsidies instead of targeted investments. Most MENA countries, for example Iraq, Morocco, Tunisia, Egypt, and Syria, offer their farmers guaranteed prices for staple and industrial crops, as well as a large gamut of input subsidies. The political aims are to encourage traditional farming, to placate landowning elites and to reduce dependence on foreign supplies. Fertilizer, pesticide, fuel for pumps and irrigation subsidies are also common across the region. Such untargted subsidies are not focussed on the poor, have a fiscal cost, reward low-value cropping, and encourage the overuse of water.

Governments have been much more focussed on damming water than on helping farmers to use it

efficiently. Water tariffs and cereals, fuel and input subsidies, which are becoming very expensive with the energy crisis, have encouraged the use of water for low-value activities. But some countries are now experimenting with more purposive water management approaches like changing tariff policies, providing subsidies for water-saving equipment, and promoting integrated water resource planning.

Farmers need more responsive research and extension services. Farmers' associations and co-operatives have often been an arm of government and do not act as the vital two-way link between farmers and the private sector or government. Yet for smallholders to be able to compete and take advantage of lucrative markets, they need efficient organizations of their own.

Agriculture ministries are typically mandated to modernise the sector on one hand and to preserve traditional farming communities on the other. Often the livelihood-protection policies like trade protection, regulation of markets, water and cereal subsidies discourage modernisation. Decoupling farm support from production could allow agricultural policy instruments to concentrate on sector modernisation objectives.

Rural livelihoods are usually the mandate of agriculture ministries. But supporting spatial development requires buy-in from infrastructure and social service ministries as well. Moreover, MENA's rural poor, who are often landless, labourers or women, are not effectively reached by the region's farm subsidies and productivity enhancement policies, and tend to depend on opportunities in the non-farm, rural informal sector. So a major challenge is to identify an institutional home for rural development. Experience from Egypt, Morocco and Tunisia shows that strong leadership from sub-national and local authorities, linked to some degree of deconcentration and decentralization, is an important strategic approach to improve rural development.

Marketing has been too much a question of delivering basic commodities to government agencies. However, marketing dairy products, fruits and vegetables, especially abroad for the latter, requires farmers and their associations, agro-processing companies, wholesalers,

transporters and the government to combine to assure quality, predictability and speed of supply.

Population growth and inheritance laws contribute to the fragmentation of landholdings and informal tenure arrangements. In addition, the tradition in many MENA countries is against the division of inherited land, leading to farmers cultivating under a “joint-ownership” situation with their co-heirs, which is a major impediment to farm investment. This situation rules out mechanisation, access to formal credit for many farmers and even investing in inputs.

The risk inherent in smallholder farming, bad loans, inefficiencies in the banking sector, and lack of security exclude many farmers from formal credit. Governments tend to see credit policy in terms of capping the interest rate, which benefits farmers who can get credit already, but discourages banks from lending to poorer clients.

“Traditional” farmers tend to be among the least educated and oldest segments of the population. MENA governments need to invest in rural education and professional training, both formal and informal to help them adjust to the managerial and technological complexities of producing for the modern urban market and to help other family members to access better off-farm income or to be better equipped to migrate to cities.

Many governments have very rudimentary systems for procuring cereals on thin international markets. MENA governments need to modernize the techniques they use in order to reduce their exposure to international markets and also need to modernize the techniques they use in order to reduce their exposure to international price volatility and enhance the reliability of supply.⁴⁷

1.5.4.2 Country specific issues

In Morocco, Global Diversity Foundation’s (GDF) applied research activities focus on documenting diverse local knowledge systems and identifying the agricultural and horticultural products sold in the southern Moroccan marketplaces. Their community conservation projects aim to maintain agricultural and horticultural traditions in the Marrakech Medina, support the residents of

the High Atlas Mountains to develop their ecological knowledge while accessing formal education, and to improve nutrition and income by promoting agro-forestry systems (GDF, 2006).

GDF is also dedicated to building local capacity in Morocco through university courses, community workshops, and collaborative sustainable conservation programs with representatives of diverse institutions. Developing the valleys and the lower slopes of the mountains through terrace cultivation, fruit tree plantations along the watercourses, construction of ‘*seguías*’ (irrigation canals) and the development of a hydrologic network for promoting sustainable practices and enrichment of the local ethnological heritage are also issues.

Main income generating crop in Atlas Mountains are mainly cereals, pulses, and fruit trees in the irrigated valleys. Income generating livestock includes sheep and goats grazing on range, and cattle integrated with crop production.⁴⁸ Suitable strategies for sustainable agriculture including livestock and land use are specifically needed for the Middle and High Atlas.

Deforestation through the advent of livestock production and settlements in the mountains are major issues in Atlas mountain areas. Human impact is high, mainly due to the socioeconomic instability of the Maghreb countries. The collapse of the semi-nomadic Berber pastoral system that has transformed summer camps in the high mountain grasslands into permanent human settlements is a key factor influencing deforestation (Johannesburg Summit, 2002). For example, intensive collection of cedar branches frequently destroys trees. The winter shortage of livestock fodder leads to extensive overgrazing and soil degradation in the forest understory. Deforestation also leads to soil erosion. Therefore its prevention through the sustainable management of 154 sites of biological and ecological interest should be a priority.⁴⁹

Replacing the cultivation of *kif* (*Cannabis indica*) by ordinary cash crops is subjected to several pilot projects in the Rif area (Meklach et al., 2010). The successful eradication of the illegal cultivation of this drug plant and its replacement with edible crops are

due to the involvement of the rural municipality and Austroprojekt Agency, Austria. Empowerment of local village organisations and the improvement of primary healthcare and agricultural facilities are also helping to solve this problem.

In Lebanon land use management is closely linked to agriculture including livestock production. Land resources of mountain regions in Lebanon have been put under pressure for several years. Implication of land use planning based on soil capacity and land suitability is necessary for mountain land conservation. Livestock diversity that is evident in Lebanon mountain regions provides important means by which smallholders self-insure risk and seize income-earning opportunities. The shrinkage of grazing lands caused by the expansion of orchards with no conservation of soil and water harvesting practices has resulted in massive land use changes.³² This also partly explains the reduction in small ruminant flocks.

For example, Aarsal, which is a dry slope of the Anti-Lebanon Mountains, witnessed massive expansion of fruit tree production (cherries and apricots). On the other hand, the animal husbandry livelihood analysis showed that herders have increasingly diversified their income from livestock with other agricultural (33%) and off-farm activities (60%) to satisfy household subsistence requirements, with only 7% depending exclusively on live-stock (Dick et al., 2008).

The combination of participatory approach, land capability evaluation and GIS provided a satisfactory understanding of the physical and biological land management constraints in Aarsal. The dialogue fostered between different stakeholders has created opportunities for the identification of sustainable land management options (Zurayk et al., 2001).

Small scale reforestation has been attempted in Lebanon Mountains since 2001. The results of this effort over the last decade are not available in published literature. Its potential for SMD needs attention (United Nations Forum, 2005).

In the northern mountains of Oman, agricultural productivity had been stable and had apparently been

maintained over the last two millennia. The agricultural land use, the physical and biological environment, the economy of selected households and the regional socioeconomic impacts were investigated. The results were used as indicators and descriptors along with additional aggregated data to create a spatially explicit landscape model that can be used to create future landscape scenarios under varying economic and political conditions and constraints.

The agro-environmental changes in cropping systems have also been studied. GIS-based field research on terraced cropland and groves of date palm (*Phoenix dactylifera* L.) was conducted over two years in two mountain oases of northern Oman to determine their role as hypothesized sinks for nitrogen (N), phosphorus (P) and potassium (K). The data shows that oases presently are large sinks for nutrients. Potential gaseous and leaching losses could at least partly be controlled by a decrease in nutrient input intensity and careful incorporation of manure (Luedeling, 2007). Unfortunately, intensive agriculture also has resulted in the removal of top soils causing severe impacts such as nutrient depletion, degradation of woodlands, erosion and seed bank removal (Victor, 2008).

The northern mountains of Oman are famous for their fruit production. GIS-based field research revealed the structure of orchards and fruit diversity in the northern mountains. Information on the local knowledge and management of the orchards were gathered through farmer interviews. In all, 15 fruit species and six under-utilized fruit species from 14 families were identified. A total of 2,690 date palms comprising 16 varieties cover 8.8 ha of man-made terraces. The palm groves are typical of agro-forestry systems in which the date palms are inter-planted with fruit plants such as banana, lime, papaya and annual crops. In palm groves, inputs of manure, mineral fertilisers and irrigation water far exceeded outputs of harvested products. Absence of soil salinization is attributed to the terraces and adequate drainage (Al-Yahyai & Al-Khanjari, 2008).

Orchards in Al Jabal al Akhdar are the prime areas for pomegranate production. It is the most important cash crop in summer. Its production used to be just enough for local consumption and they were hardly found

outside the mountain markets. In recent years, it has become an expensive commodity because of the influx of tourists, both local and foreign, who are willing to pay exorbitant prices. The local farmers have learnt to exploit this situation. The demand for higher production of pomegranates is likely to threaten sustainable farming practices that were traditional. Excessive use of fertilizers and pesticides are likely to cause environmental impact in the near future. Consumerism and market economy also have serious impacts on cultural norms inherent of small mountain communities.

In the Dhofar region, the traditional form of agriculture that was sustainable, but limited in terms of productivity due to natural/environmental restrictions is being overtaken by more modernized forms of agriculture that are problematic in terms of sustainability despite higher productive capacity. Sustainable agro-forestry development programs in the mountain regions are slow. Past civil war experience and a tendency to avoid contact with the mountain tribes or turn a blind eye in matters which are likely to cause controversy among the local people of the mountains could all be causal factors affecting sustainable mountain development.

The low nutritional quality of the natural vegetation in the mountains appears to limit animal production in the traditional systems, but outputs might differ according to herd management. Modernisation in the Sultanate of Oman has affected and will continue to affect the social, economic and environmental conditions for livestock husbandry on Al Jabal Al Akhdar (Dickhoefer & Schlecht, 2010). According to FAO reports, women, who mainly work in rural livestock husbandry, are increasingly seeking employment elsewhere. This is reflected in the doubling of the number of economically active women. Effective management schemes adapted to seasonal fodder availability and the nutritional requirements of the animals is needed to improve animal production and the economic efficiency of livestock husbandry. Studies have therefore determined key indicators for the productivity of goat herds in the traditional mountain oases systems. Extensive feeding experiments have also been conducted to compare the efficiency of range grazing as opposed to pen-feeding in homesteads (Scholz, 1984). Pen-feeding as opposed to grazing of rangeland seems to be a good strategy

to prevent the degradation of rangelands (Mahgoub et al., 2009). Pen-feeding would also solve the problem caused by the lack of women- and child-labour required to graze herds. It would definitely release the grazing pressure on rangelands and result in better quality milk and meat production, but farmer subsidies would also be needed.

Overgrazing is a serious issue in rangelands, especially those above 2,000 meters above sea level. Feral donkeys are competing with goats and sheep for forage plants as shown by studies on dietary overlap (Robinson et al., 2009). There is a dire need to control the population of feral donkeys in the northern mountains. A strong call has also been made for the revival of the traditional goat management systems by some while others argue for their abandonment (Brinkmann et al., 2009). Goat management system in northern mountains also has been well documented (Buerkert & Schlecht, 2009). Camel numbers are the primary reason for overgrazing and rangeland degradation in the southern mountains, but reducing herd sizes is not easy due to socio-political problems.

In summary, agro-biodiversity of the northern mountains in Oman is well known. Studies on fruit production show how these natural resources could be managed sustainably. Similarly valuable data and analysis are available on animal husbandry issues including goat production. Again the main problem seems to be the tardiness in the translation of research information to solve practical problems. Agriculture and animal production are the major sources of income to the Omani mountain people. Lack of irrigation water, lack of fodder, degradation of pasture, labour cost and plant and animal diseases are the frequently mentioned constraints to agriculture. Poor agricultural management is also affecting the production of crops.

In Iran, income from agriculture, given the general level of the cost of living, is modest in the mountains. The highest income among the dry-farmed crops is from wheat and pomegranate. Some 80 percent of the agricultural products are estimated to be used for subsistence needs and the remainder is purchased by middlemen for local markets. Currently, there is investment in agricultural improvement by government

departments. The low level of commercial production and the poor access roads discourage transport out of the region. The high quality of the pomegranate produced in the Zagros region, the use of organic methods and the high level of the peasants' technical know-how give grounds for believing that if supported, there would be good market potential for this product outside this region.⁵⁰

Land management in the mountainous regions of Iran is a serious issue. The Iranian Government and the UNDP undertook a project which officially got underway in 1998. The aim of the project was, with the participation of eight northern villages, to identify local environmental problems and solutions in that region which was rife with over-grazing, desertification and water scarcity. The results have been slow to materialise in some areas and highly impressive in others. About four years ago, the mountain community of Lazoor was plagued by regular flooding and land erosion. The 3,000-strong village had only 1100 hectares of productive farmland, and herded about 12,000 sheep. The landslides were mainly the result of extensive overgrazing. This triggered an attempt to encourage the villagers to public meetings and even female-only workshops to encourage their involvement in improving the situation. Alongside these attempts at land management improvements, a social transformation has taken place. Only a few years ago, all village-related decisions were made by a group of elders with no part to play for the women. Since the initiation of this project, the women of the villages have started demanding more say in the village affairs. Several projects to improve the women's independence and income have been successfully established since. Mixed group meetings also now take place in local mosques.⁵¹

Studies indicate that in the mountain areas of Yemen, about 47% of family men are working in the agriculture sector. Of these farm labourers, 53% work less than eight hours per day and spend most of the time chewing *qat*. A woman is able to work only six hours a day in the fields since she spends at least three hours for collecting firewood and another three hours for fetching water. High poverty levels have led to environmental degradation. The poor have no other option but to adopt short-term survival strategies which do not incorporate long-term resource management considerations.

Yemen is characterised by terrace cultivation, which is considered as an important national heritage. Terrace cultivation which is an advanced farming system for soil and water harvesting and utilization of mountain lands is facing reduction in their areas due to land degradation (Al-Hebshi, 2005). Over grazing has contributed to significant impacts in the Al-Sarawat mountain slopes. Studies conducted by International Food Policy Research Institute, USA portrayed the effects of land tenure and other socioeconomic factor on terrace maintenance in Hajja province of Yemen mountain area (Al-Hassan et al., 2000). Lack of enforcement mechanism has created insecurity in terms of the number of absolute rights, assurance of existing rights and the cost of enforcing the rights. The uneven power distribution, which favours landlords, has reinforced the lack of clear rules and has made the enforcement difficult. These factors have severely affected the investment incentives for terrace maintenance. The investment in terrace maintenance in dry highlands of Yemen has declined for the past 30 years.

The production of cereals has been very erratic in Yemen due to its dependence on rainfall. Wheat harvest, compared with other cereals has shown the highest growth, but it is not even adequate to meet the domestic needs. Food insecurity and malnutrition are major concerns, reflected by high rates of child malnutrition and maternal mortality being among the highest in the world (Förch & Fakhoury, 2009). A recent Agricultural and Economic Policy Reform program has led to significant positive aspects of agricultural sector performance and a tangible increase in agricultural production.

The shortage and cost of water and its negative impact on livestock production is also a serious issue. Farmers find it harder every day to water and feed their animals. Thus the livestock sector is declining in the highlands of Yemen. The International Fund for Agricultural Development (IFAD) is intending to improve the food security of subsistence farmers, increase family incomes and improve the living conditions of small farm households and village communities in mountain areas of Dhamar. It works also to develop poor people's participation in planning and implementing activities.

The present total area of forestland in Yemen Mountains

is estimated at about 24,000 square kilometres mainly concentrated in zones of sufficient rainfall (Initial National Communication under UN Climate Convention, 2001). But most of the forestland is privately owned and its services are not accessible to local communities.

1.5.5 Tourism

Among the MENA countries, some like Egypt, Jordan and Israel have been attractive tourist destinations for a long time. Other North African countries have accrued variable benefits from tourism depending on the socio-political situations. Tourism is a relatively recent phenomenon in the Arabian Gulf countries and some cities like Dubai in the UAE are popular. Saudi Arabia had been open to Islamic pilgrimage for centuries. However, mountain tourism is fast becoming an income generating activity in the MENA region.

In Morocco, the study data suggests that tourists are attracted to the mountainous scenery (37%), the rural countryside (24%), the agricultural landscape and the forests (16%), traditional architecture (14%) and the panoramas (9%) (Houmaid & Allali, 2002). However, mountain tourism indicates a downward trend due to lack of infrastructure and poor management. Ecotourism promotion is attempted in the Middle Atlas and Rif regions. Nature and ecotourism integrated with the conservation projects with the involvement of local communities should be viewed in relation to income generation in impoverished areas and this could probably lead to sustainable tourism.

With its impressive snow-covered mountain slopes, Lebanon offers numerous ski resorts to the tourists during the winter season. The Lebanon Mountain Trail created as a part of an internationally funded project promises to provide a sustainable environment and socio-economic development to the rural region.⁵² In the region around Mzaar-Kfardebian, an upcoming project aims to extend the tourism offer to all four seasons. The offered attractions include donkey rides, clay pigeon shooting, mini-golf and sun bathing. Some less environmentally friendly motorized activities are also available. Tourism plans and actions of the Ministry of Tourism, tour operators or NGOs and the Lebanon Mountain Trail Association (LMTA) are

boosting the tourism trade in the mountains of Lebanon. Al Shouf Cedar Nature Reserve is a major attraction to tourists. Ecotourism offering a range of activities like hiking, mountain climbing and shopping for food and other items from local rustic shops in small villages is attracting tourists. Lebanon mountain tourism is considered a success story.

According to the Ministry of Tourism statistics, the mountain area of Al Jabal al Akhdar is a major tourist spot in Oman. The importance of developing this area has been recognized and a wide range of ministries and government departments have set up offices here to meet all essential civic, social, healthcare, educational and other needs of the people. Different models of ecotourism that would suit this region have been produced (Chaudhuri & Ramanathan, 2009). These models systematically capture the subjective perceptions of stakeholders about tourism development. The results show that the mountain inhabitants generally prefer a huge increase in tourism activity in the region, although they also anticipate some negative impacts.³⁴ Another model in the same region determined the best combination of several decision parameters in ecotourism management under possible future environments. The socioeconomic impact of tourism on the local people is also known (Ramanathan & Subramanian, 2009). Ministry of Tourism, Oman has been developing several projects to strengthen the Mountain tourism. Among the initiatives planned are alleged ecotourism projects that are yet to be proven as sustainable.

New hotels and lodges are built on Al Jabal al Akhdar and tourism infrastructure has been improved by the construction of new tarmac roads replacing graded roads, a petrol station, shops and restaurants. Nature trails have been marked out and wherever possible paved footpaths have been laid. Isolated villages are now connected and have been made accessible to tourists. Children's playgrounds, constructed picnic spots with gazebos and park benches donated by commercial enterprises advertising their wares are common. Jabal Shams, the highest summit in Oman, is also targeted for development as an attraction for adventure tourists. Access to the summit is being developed, while some lodging facilities are already

in place. Some places in Eastern Hajar also are developed as tourism destinations. Tourism associated degradation of the mountain environment, especially the woodlands and other fragile ecosystems is a worry (Victor, 2008). Impacts on water resources, generation of solid wastes and cultural erosion seem inevitable.

Mountain tourism practiced at present, despite spurious claims, is not ecotourism. None of the tourism operators in the mountains have full knowledge of ecotourism and could not even make the distinction between nature tourism and ecotourism. Currently operating hotels are not ecolodges. Local and regional tourists lack environmental education. Strict implementation of rules and regulations are necessary to control tourist behaviour. Tourism, if not regulated, is likely to accelerate environmental degradation in Oman Mountains.

The geographical breadth of Iran along with being located in the Alp-Himalaya orogenic belt has created a great range of geological phenomena such volcanoes, caves, straits, geysers and a special climatic diversity creating considerably attractive scope for geotourism (Yalgouz-Agaj, 2010). In fact geotourism is emerging as a new industry and offers an opportunity for gaining socioeconomic benefits.

The Mountains in Asir National Park of Saudi Arabia are providing outstanding sporting activities such as paragliding, hang-gliding, rock climbing and mountaineering, all supervised professionally. The Jabal Aja' mountains also contain sites of archaeological and cultural interest which are attracting tourists. Saudi Government is taking necessary action to promote the tourism area with the support of local villagers (Pohner, 2009).

Ecotourism is emerging as a significant source of income for the mountain villagers of Israel. The rapidly expanding tourism trade and the archaeological and historical importance of Mt. Carmel make it a socioeconomically important area in Israel. The Mt. Carmel region is full of tourist attractions and sites. The Druze inhabitants of the villages Daliyat el-Carmel and Isfiya are true tourist attractions with unique heritage. The villages have acquired many authentic restaurants and unique market places that attract both Israelis

and other tourists. The Carmel Hai-Bar, a zoological preserve, is again very popular as a tourist attraction. In this nature reserve, wild sheep, wild goats, deer and fallow deer are raised for the purpose of releasing them back into the wild.

Nahal Mearot Nature Reserve on the west side of Mt. Carmel is of anthropological and archaeological interest. A lot of sites here give a glimpse of the prehistoric man's lifestyle in these regions. This place has been set up with audio-visual shows. A tourist path passes through caves that were used as dwelling by the prehistoric man. At the centre of the mountain is Mahtsevit Kdumim, where the old Byzantine quarries are seen.

The Israel Ministry of Tourism is promoting mountain tourism by opening up the first 2.8 miles of the new 80 mile Sea of Galilee Mountain Bike trail. Nimrod Mountain Eco-lodge, situated on one of the highest peaks in Israel, is an impressive centre for ecotourism and experimental bio-farming. The Eco-lodge sets an example of modern sustainable living on the rugged Golan Heights using down to earth techniques such as grey water systems, construction from recycled materials, natural insulation and bio-farming. The Eco-lodge is in the process of creating a living and working eco-community for people with special needs. The Israel Ministry of Tourism is promoting mountain tourism by developing trails and roads and encouraging establishment of eco-lodges.⁵³ However, sustaining the tourism could be of concern because of geopolitical problems.

1.5.6 Others

1.5.6.1 Biosphere Reserves, Protected Areas and Biodiversity Hotspots

Under the Man and Biosphere (MAB) program of UNESCO, a biosphere reserve has been established in eastern Morocco and encompasses altitudes from 680 to 4,071 metres above sea level. The major activities there are, (a) monitoring of climatic parameters, (b) selection of clones of dates for their tolerance to fungal diseases, (c) date palm research, (d) studies on demography and ethnography, (e) evaluation of cultural and architectural heritage, and (f) evaluation of local knowledge in economy and water management. Thus

MAB is contributing to sustainable development in the biosphere reserve and its community.

One of Israel's important regions, Mt. Carmel, is a biosphere reserve within the framework of the Man and Biosphere Program of UNESCO. An application

has been processed at the MAB program of UNESCO to establish a Biosphere Reserve in the Jabal Samhan area of the Dhofar region in southern Oman.

Table 6 below lists some important mountain protected areas in the MENA region. Although it is not a

Table 6: List of some of the major protected areas in mountains of MENA regions			
Country	Major Protected Areas in Mountains	Area (km ²)	Highlights
Morocco	Toubkal National Park	380	This park is in the central part of the High Atlas, marked by its diversity of rocks and remarkably biodiverse flora and fauna.
	Talassemtane National Park	589.5	Talassemtane National Park is a great destination for hikers seeking quiet camping and views of hills and streams which pass through the Rif Mountains and the oak, fir, and cedar forests.
	Tazzeka National Park	520	Tazzeka National Park in the Middle Atlas Mountains has varieties of colourful wild flowers and cedar and oak forests.
	Ifrane National Park	508	Located in the Middle Atlas Mountains, Ifrane National Park is famous for tourism activities. Hunting is allowed, and those on the trails in search of game should watch for partridges, boars and hares.
Algeria	Chr��a Biosphere Reserve	369.85	The Chr��a Biosphere Reserve and National Park is located along the northern and southern ridges of the Blida section of the Atlas Mountains. The national park hosts 1,210 plant and animal species, such as the Atlas cedar (<i>Cedrus atlantica</i>) and the macaque (<i>Macaca sylvanus</i>). The park is home to broken tectonics, as well as many forests, grottoes, gorges, and important fauna.
	Djurdjura National Park	82.25	
Tunisia	DJabal Bou-Hedma Bioserve	167.86	The DJabal Bou-Hedma Biosphere Reserve and National Park is situated along the southern Tunisian mountain ranges that are extensions of the Saharan Atlas. The biosphere reserve faces mainly problems of desertification, excessive livestock grazing, partial land clearance and ploughing and the resulting effects such as soil erosion.
Libya	Bir Ayyad Nature Reserve	20	Bir Ayyad nature reserve is a protected area that lies along the mountain- plain interface of arid and semi-arid habitats of North Libya.
Egypt	Umm Dababeyya	...	A small geological protected area that was declared in 2007 with the encouragement of the International Union of Geological Sciences. It lies in the sedimentary sequence of the Eastern Desert mountains.
	St Catherine Protectorate	4,300	St Catherine protectorate is an area of great biological interest and includes the highest mountains in Egypt. This high altitude ecosystem supports a surprising diversity of wildlife.
Jordan	Wadi Rum Protected Area	741.8	The Rum village at the bottom of the huge Rum mountain is the entrance gate to country - a protected area of the Royal Society for Conservation of Nature.
	Mujib Wildlife Reserve	205	Mujib wildlife reserve is home for over 300 species of plants, 10 species of carnivores, and numerous species of resident and migratory birds. Some of the remote mountain and valley areas offer safe havens for rare species of cats, goats and other mountain animals.

Country	Major Protected Areas in Mountains	Area (km2)	Highlights
Israel	Mount Carmel National Park	84	The park covers 8,498ha one third of which is a nature reserve. The national park is entirely dedicated to the protection of Mediterranean habitat and landscape.
	Mount Meron Nature Reserve	500	It is the largest and highest reserve in Israel, at an altitude of 1,208 metres above sea level.
Palestine Territory	Tamoun Mount	192
	Al Kabeer Mount	262.23	
Lebanon	Al Shouf Cedars Nature Reserve	295.4	It is the largest of Lebanon's nature reserves with oak forests, juniper forests and the most famous attractions are its three magnificent cedar forests of Maasser Al-Shouf , Barouk and Ain Zhalta- Bmohary
	Tannourine Cedars Forest Nature Reserve	12	The Tannourine Cedars Forest Nature Reserve protects one of the largest and densest cedar forests in Lebanon. Beside the 70,000 ancient trees, Tannourine Nature Reserves is also known for its various types of birds such as eagles, owls, robins and wild animals such as hyenas, boars, squirrels, snakes and bats.
Syria	Jabal Abdul Aziz Protected Area	490	Jabal Abdul-Aziz lies in the north-eastern part of the Syrian Jezira on an east west axis. Nearly 200 tree species were mentioned in bibliography of the area; 7 of them are endemic.
Iran	Arjan Protected Area and Biosphere Reserve	657.5	Located in the Zagros mountain range which hosts a range of habitats and mammal species.
	Mooteh Protected Area	2,000	It encompasses arid montane and steppe vegetation and is an important protected area for larger mammals and avifauna
	Central Alborz Protected Area	4,108	Central Alborz protected area is one of the most important habitats for the leopard in Iran.
Saudi Arabia	Northern Wildlife Management Zone	100,875	It is the world's sixth largest wildlife protected area.
UAE	Hatta (Khor Kalba) Nature Reserve	16	It is a part of the Hajar Mountains, which is one of the largest mangrove-dominated landscapes in all the Emirates (unusual for mountains). More than 20 endangered bird species have been spotted here, with kingfisher being the most important.
	Wadi Wurayah National Park	127	The site supports 11 threatened species of mammals, such as the Arabian Tahr (<i>Arabitragus jayakari</i>) and hosts 17 reptile species and at least two amphibian species, all of which are endemic to the UAE and Northern Oman.
Oman	Jabal Samhan Nature Reserve	1,500	Reserve consists of an array of barren, scalloped peaks separated by deep wadian and canyons; contains rare and unique plants such as <i>Caralluma</i> spp. and <i>Anogeissus dhofarica</i> .
Yemen	Jabal Bura Valley Forest National Park	42.78	Jabal Bura Valley park are clothed with acacia (<i>A. asak</i>) and myrrh trees, migratory birds and butterflies, hyenas and large troops of <i>Hamadryas</i> baboons; leopards have been seen here quite recently
	Autma Environmental Protected Area	460	Located in the middle of Mountain plateau (The Yemen Mountain Massif) with records of 10 mammals, 48 bird species, and 800 plant species (of which 16 are endangered and six are internationally threatened)

Source: <http://www.nationalparks-worldwide.info/index.htm>

comprehensive list, it gives information on some of the key areas that are protected in the different countries of the MENA region.

The publication 'Mediterranean Basin Biodiversity Hotspots', prepared by Dođa Derneđi (2010) for the Critical Ecosystem Partnership Fund (CEPF) identifies the hotspot regions in the Mediterranean MENA countries (**Table 7**). Many key biodiversity areas in the Mediterranean Basin support exceptionally high numbers of threatened and endemic species. Many of the sites in the Atlas Mountains in Morocco and the mountains in Syria and Lebanon support more than one-quarter of the globally threatened species occurring in the hotspots.

A previous revised analysis of global hotspots identified 34 sites, of which only two are in the Middle East (Mittermeier et al., 1999, 2004; Myers et al., 2000). The Horn of Africa Hotspot includes the lower mountains of south-west Arabia and the coastal regions of Saudi Arabia, Yemen (including Socotra) and Oman (Mallon, 2011). Montane portions of this hotspot in eastern Yemen and southwestern Oman are seasonally bathed in monsoonal fogs, providing the climate for a unique 'cloud forest', of which scant biological information is available. The Eastern Afromontane Hotspot, occupies the higher elevations of southwestern Saudi Arabia and Yemen and shares biogeographic affinities with the high mountains of Ethiopia and those bordering the Rift Valley countries.

1.5.6.2 Desertification

United Nations Convention to Combat Desertification (UNCCD) defines desertification as land degradation in arid, semi-arid and dry sub-humid areas, resulting from various factors, including climatic variations and human activities. Desertification results mainly in a substantial reduction or complete loss in biological and economical productivity of drylands, due to the destruction of soil structure, loss of organic matter, soil chemical changes like salination, acidification and alkalisation and soil erosion (Millennium Ecosystem Assessment, 2005).

A recent study commissioned by the Millennium Ecosystem Assessment indicated with medium certainty

Table 7: Number of Biodiversity Hotspots in some countries of MENA in the Mediterranean Basin	
Country	Number of Biodiversity Hotspots
Morocco	68
Algeria	40
Tunisia	62
Libya	19
Egypt	12
Jordan	14
Israel	10
Lebanon	29
Syria	30
Iraq	0

that about 10-20% of drylands are already degraded; about 1-6% of dryland population lives in desertified areas, while a much larger number is under threat from further desertification (Millennium Ecosystem Assessment, 2005).

Dryland Mountains are especially vulnerable to desertification processes due to deforestation and degradation of vegetation combined with predominance of unstable soils due to steep slopes and extreme weather conditions. Moderate to extreme wind and water erosion problems occur in all dryland mountains (FAO, 2011). One of the areas severely affected by soil erosion is the mountains of North Africa and West Asia. For instance, up to 5,000 t km² of soil is lost in the Rif Mountains of Morocco every year (Fox et al., 1997).

Desertification is caused by a combination of climate and anthropogenic factors. Over-exploitation of natural resources, improper land management practices, rapid land use changes and land conversion into unsustainable uses, altered hydrologic and fire regimes, pollution, unsustainable population densities, armed conflicts and exotic species invasions are all man-made causes. The United Nations Convention to Combat Desertification warns about the tremendous increase of land degradation when desertification processes interact with climate change impacts. There is a vicious cycle of interactions and positive feedbacks between loss of biodiversity, deforestation, desertification

and climate change (FAO, 2011). Vegetation loss and degradation, and soil erosion in Dryland Mountains leading to desertification, cause further reduction of carbon sinks. The estimated loss of carbon to the atmosphere from drylands each year is 300 million tons and this compromises the resilience of ecosystems and people to climate change impacts (Millennium Ecosystem Assessment, 2005).

1.5.6.3 Global Diversity Foundation (GDF)

Applied research activities by Global Diversity Foundation (GDF) are focused on documenting diverse local knowledge systems to enrich the local ethnological heritage in Atlas Mountains. GDF is dedicated to building local capacity in Moroccan mountain areas through university courses, community workshops, and collaborative sustainable conservation programs with representatives from diverse institutions (GDF, 2006). Activities have to be expanded to other areas of need and stakeholder participation needs to be strengthened.

1.5.6.4 Terrorism

Mountains have always been natural hideaways for terrorists in many parts of the world. The presence of Hezbollah's Bekka Organisation introduces a special socioeconomic concern regarding the problems associated with terrorism in Lebanon (Wege, 2010). Yemen is also emerging as a stronghold of terrorism activities.

1.5.6.5 Disasters/natural hazards/disaster risk reduction (DRR)

DRR strategies are needed for forest fires, flash floods, landslides and pollution in the MENA region. For example, forest fires, especially in the catastrophic years of 2007 and 2008 have destroyed the vegetative cover of over 4,200 ha of Lebanon's landscape. The damages from those fires were large and they reduced large amounts of the forest cover in a relatively short period of time. They also raised concern at the national and international levels that they could lead to total eradication of forests if radical steps were not taken to solve the problem. The effects of this forest

destruction have led to fragmentation and loss of the forest ecosystem services, which in turn has had a devastating impact on the livelihoods of local mountain communities (USAID/Lebanon, 2009).

Fire disasters such as the one in the Carmel Mountains near Haifa (Israel) is a real threat that requires monitoring and strategies for disaster management.⁵⁴ Flash floods originating on the northern mountains of Oman cause a great deal of damage downstream to roads, property and people. A large number of flood control dams have been built in the foothills to reduce damage. Landslides causing road closures prevent the movement of goods and services to and from mountain villages and thus have short term impacts on economy.

Wherever there are tourism related activities, the generation of non-degradable solid wastes increase considerably. Plastic bags are consumed by livestock eventually resulting in death. In Oman, long term pollution problems caused by the contamination of a spring by diesel have been identified (Al-Haddabi et al., 2009). Soils irrigated by this spring are also contaminated. All aflaj waters are of poor microbiological quality. Pesticides used in agriculture are also found in surface waters.

Mining operations in mountains cause the degradation of mountain lands. Hence, to conduct environmental impact assessment for Saudi Arabian mining industries, guidelines were developed to ensure that the environmental implications of new developments were recognized and considered along with economic implications during project planning. Technical documents on Environmental Management Plan (EMP) were prepared for each operational mining site. Procedures were established to prevent unnecessary or undue degradation of mountain lands that might result from operations authorized by the mining laws.⁵⁵

1.5.6.6 Socioeconomic and political issues

For mountain livelihood strategies, the recommended criteria by the Global Environment Facility (GEF) to categorize the potential alternative livelihoods involves a preliminary assessment of the nature of the linkage between biodiversity conservation and the sustainability

of the related economic activities in the concerned mountain area.

The GEF has recommended several alternative livelihood components which are clumped into five following programming areas: (a) protected areas and biodiversity conservation programming, (b) forestland and rangeland improvement and rehabilitation projects, (c) sustainable mountain agriculture programs, which would include some of the proposed activities related to the sustainable use of wild plant and animal species, (d) community-based natural resource management planning, and (e) specialty ecotourism which should include commercial handicrafts development. The government of Iran is the major stakeholder of this initiative (Fuller, 2004).

Development versus the deterioration of traditional settlements is an issue in some countries like Saudi Arabia. Economic changes and central government policies of the last 30 years have impacted the traditional socioeconomic structures of the south-western highland villages of Saudi Arabia in different ways. Today the villages are caught between the past and present, represented locally by two competing socioeconomic hierarchies. It is recommended that in order to gain local cooperation in developing new patterns of urban development, innovative steps must be taken to facilitate local participation in program's design, implementation and evaluation. The success of central government programs in such formerly isolated rural areas will largely be contingent on achieving economic benefits for local residents and discovering effective models that can build a bridge between people and state-controlled planning efforts (Saleh, 1999).

The poverty rate in MENA has been declining over the period of 1990 to 2005. The number of people in poverty, however, has not declined since 1990 due to rapid population growth, and in 2005 it still remained at about 50 million people. Projections based on macroeconomic outlook and historic data on poverty show that it will continue to decline in most countries during the period of 2008 to 2011, with the notable exception of Yemen, largely because of the still-positive GDP growth rates. But the recent financial crisis will slow down progress, and at the level of the region, 2.6 million more people are projected to be in poverty by 2011.

Seventy percent of MENA's poor live in rural areas including those in the mountains. Chronic rural poverty is not generalised in MENA with the exception of Yemen. It is concentrated in certain social groups, such as households headed by women, the landless and farm labourers. Mountains and steppes plains of Morocco and northwest Tunisia are good examples. In Yemen, poverty in rural areas of the mountains is a result of the lack of access to basic resources such as land and water and to services such as health care and education. In more remote areas of the mountains, poor rural people are physically, intellectually, economically and socially isolated from the rest of the nation. Isolation makes it even more difficult for poor people to gain access to resources and services (IFAD, 2010).

Rapid modernization in MENA Mountains is not matched by economic and financial stability for local people; upgrading the skills of existing workforce and local human resource development are priorities. Modernization also causes cultural erosion.



PART 2

Evaluation of sustainable mountain development: Progress, changes and lessons learnt

2.1 Introduction

Evaluation of sustainable mountain development in the whole MENA region is an extremely difficult task. As described and discussed in Part 1 of this report, the diversity of sustainable development issues and the varying degrees of progress made in different sectors are the main reasons preventing a coherent synthesis. Similarly, changes and lessons learnt are different and widely vary from one MENA mountain to the other. However, it is possible to attempt a discussion on the basis of what had happened in the MENA countries over the past 20 years assuming that mountains are firmly embedded in the systems and are subject to impacts both positive and negative, affecting the countries as a whole. Lessons learnt could also be supplemented by a few case studies.

2.1.1 Effects of Oil-boom economy

The world demand for oil, high oil prices and its periodic increase has resulted in an oil-boom economy that is characteristic of the MENA region in general.

Figure 7 above shows the oil exploration intensity of the Middle

East region. This has made several developmental initiatives possible, all of them not necessarily sustainable. For example, the desalination of sea water to meet increasing water demand could be argued as sustainable as long as there are energy resources available in any form, renewable or non-renewable to support it. So the mere thought of pumping desalinated water from the coast up the mountain slopes could be daunting elsewhere, but is feasible in oil rich MENA countries. Despite this, water is increasingly becoming an expensive commodity and black and grey water are recycled through sewage treatment facilities even in

Figure 7: Oil exploration intensity in the Middle East



Source of Picture: <http://www.pbs.org>

mountain villages that are not too remote with very small communities.

The oil-boom economy has facilitated the expansion of educational and healthcare facilities to even remote areas of the mountains. This economy also supports a strong import market and consumer goods from all over the world are available at affordable prices. Fifty percent of MENA's food is imported. Fresh milk, poultry and vegetable products are available and the nutritional status of communities in oil rich MENA countries has improved. However, high food prices and international market volatility has made domestic agriculture strategically important in the food producing nations of the region. Non-food producing countries support economically and environmentally expensive agriculture and are looking at ways of securing land in third party countries to produce part of their food needs.

This economy negatively impacts the prices of local produce and results in the competitive exclusion of local goods. Strategies to protect local products then become a necessity, especially in the agricultural sector which rapidly gets disenchanted with the prospect of agriculture for livelihood. Easy availability of pesticides and fertilizers for improving agricultural production has long term negative impacts on groundwater quality, biodiversity and the health of locals.

2.1.2 Technological development

In the last 20 years, technological development in the MENA countries has been very rapid. Modern technological advances like mobile phones, computers and internet and satellite televisions have reached even remote mountain areas. Dissemination of information is fast. Communities that had been cut-off from the rest of the world are now connected. There is a growing awareness to global changes that facilitates the comparison of local conditions to changes happening elsewhere. This awareness imposes increasing demands on local living conditions, which results in rapid changes in lifestyle. Societal values in many mountain communities have drastically changed in the MENA region. In the Middle East countries of the MENA, the amount of greenhouse gas emissions are high thus accounting for large carbon footprints.

2.1.3 Improvement in road networks

One of the most important infrastructures in the mountains is the road. The network of roads in the MENA Mountains has improved tremendously in the last 20 years. Many remote areas are now connected and are easily accessible by motorised transport thus eliminating the need for the beasts of burden like mules and donkeys. The economy permits the acquisition of 4WD vehicles and trucks and the improvement in transportation has a myriad of positive benefits like easy import and export of commodities, improved communication, and rapid access to facilities like schools, hospitals and markets. The negative impacts of roads are increase in accidents and road-kills of wildlife, increase in erosion, habitat fragmentation affecting biodiversity, habitat destruction caused by the increased number of visitors and other problems like solid wastes and cultural anomalies that come with them. In some cases, the redundant beasts of burden like donkeys had become feral causing damage to rangelands. Roads also have increased the migration of labour to urban areas from previously self contained communities.

2.1.4 Political changes

The Israeli-Palestinian conflict in the region had its origin since 1920, but MENA region in general had relatively constant and stable national governance in many countries with the exception of a few (Yemen, Lebanon) until recently. The uprising and unrest in Egypt in January 2011 spread to other countries and unexpected protests sprang up even in quiet countries like Oman. The political problems in the region are not yet over (e.g. Libya, Syria). Any change in the political scene will delay and affect all development plans. It is more so in the mountains with remote and isolated communities and less population concentrations. Some important events that had impacts on sustainable development are as follows: (a) Gulf War of 1990-91 that spanned for 210 days affected Iraq, Kuwait, Saudi Arabia and Israel,⁵⁶ (b) Algerian Government Conflict of 1992-2002 was an armed conflict between the government and rebel Islamic groups destabilising the nation,⁵⁷ (c) South Lebanon Conflict was a part of the earlier conflict from 1982-2000 and Operation Accountability was a seven day war from 25-31 July 1993,⁵⁸ (d) Iraqi Kurdish

Civil war was between rival Kurdish factions in Iraqi Kurdistan during 1994-1995,⁵⁹ (e) Civil war in Yemen lasted from 4 May-7 July 1994,⁶⁰ (f) Second Intifada, September 2000-2005 was a part of Israel-Palestine Conflict,⁶¹ (g) Sheibha Farms Conflict in Israel-Lebanon border was from 2000-2006,⁶² and (h) Iraq war resulting in the invasion of Iraq by the United States of America and its effects are ongoing from 2003-Present.⁶³

2.1.5 Climate change and natural disasters

The effects of climate change on mountain ecosystems in the MENA region are not well documented. The data available on climate change seem sporadic and many countries are data deficient because the infrastructure for data collection and monitoring has been poor and ill coordinated.

There is some evidence from Iran that climate changes are adversely affecting biodiversity. Destruction by forest fires in Mount Carmel, Israel has been attributed to climate change. The fire event of December 2010 burnt 5,000 hectares of vegetation, destroyed 250 houses with 42 fatalities. The estimated loss was € 55 million. Increasing temperatures are implicated in the hastening of desertification.⁶⁴

It is suspected that the increase in the frequency of phenomena like cyclones is caused by the climate change. Gonu, a tropical cyclone that hit Oman in 6 June 2007 caused damage to an amount of U.S \$ 4.4 billion and affected Oman, UAE and Iran.⁶⁵ The bulk of the damage was due to floods originating in the northern Oman Mountains. Cyclone Phet followed in 30 May 2010 affecting Oman and Cyclone Keila⁶⁶ threatened Oman in September 2011. Cyclones in this area that had been considered rare do not seem to be so and the mountains would contribute to repeated flash floods causing damage to roads and property. Disaster Risk Reduction strategies need to be planned for these areas.

Earthquakes also pose a problem in MENA countries. For example, the Zarand Earthquake of 2005 in Iran had a magnitude of 6.4 on the Richter scale;⁶⁷ 612 people died and 990 were injured; 30 to 70 % of 40 villages were damaged and four villages, each with

about 1,000 inhabitants were completely destroyed. Other significant earthquakes in Iran in the last decade alone are: Bam (2003; 6.6 RS), Māzandarān (2004; 6.3RS), Zarand (2005; 6.4 RS), Qeshm (2005: 6.0 RS), Borujerd (2006; 6.1 RS), Bandar Abbas (2008; 6.1 RS), Damghan (2010; 5.9 RS), Hosseinabad (2010; 6.5 RS) and Kahnooj (2011; 5.3 RS). Other earthquakes of note are Egypt (1992), Morocco (1992 and four times in 2004), Saudi Arabia (1995) and Algeria (2003, 2006, 2008). When earthquakes hit rural mountain areas in the MENA it pegs back SMD initiatives.

2.1.6 Epidemics

MENA mountain regions are affected by some serious diseases. In remote areas with rudimentary healthcare facilities, these diseases would have an impact on sustainable development. The primary impact will be on the health of the community and the contagiousness, morbidity and mortality will have direct impact on labour. If there is a social stigma attached to any of these diseases, the community as a whole suffers. Ostracised individuals and families in conservative communities, especially those supported by strong religious beliefs would lead to people leaving their communities.

HIV- the AIDS virus is spreading in epidemic proportions in some MENA countries like Egypt and Tunisia. MENA is endemic for many forms of Leishmaniasis and has hosted many epidemic outbreaks. This disease is Sand Fly transmitted and in the MENA region nearly 100,000 cases were reported in 2008 by WHO. MENA countries with Malaria problems are Iraq, Oman, Iran, Saudi Arabia, Syria and Yemen. An epidemic was reported in Saudi Arabia in 2002.⁶⁸ In 2002 and 2003, Cholera outbreaks had been reported in Saudi Arabia, Iraq and Iran. It is true that some of these parasitic diseases do not originate in mountain climates and are transported through the movement of people like farm workers from the lowlands. Schistosomiasis vector snails occur both at the foothills and in the mountains of Dhofar in southern Oman, but the prevalence of this disease is considerably less in mountain communities.

2.1.7 Biodiversity- impacts and threats

Climatic changes have been implicated as the cause for

the deterioration of biodiversity in the MENA mountain regions as in other mountain areas of the world. However, there is very little direct evidence to support this view, because biodiversity inventories are far from complete in the MENA Mountains. Trees and large animals are often cited as examples, but for each taxon noted there could be a number of reasons other than climate causing decline or extinction.

The replacement of domestic stock of animals with imported breeds reduces the native genetic diversity and its eventual disappearance from the area. This is also applicable to imported agricultural and horticultural crops to replace local varieties and races. Alien species introduced for agriculture could escape into the wild. Pet trade also contributes to this phenomenon (e.g. the spread of Rose-ringed Parakeet in many MENA countries).

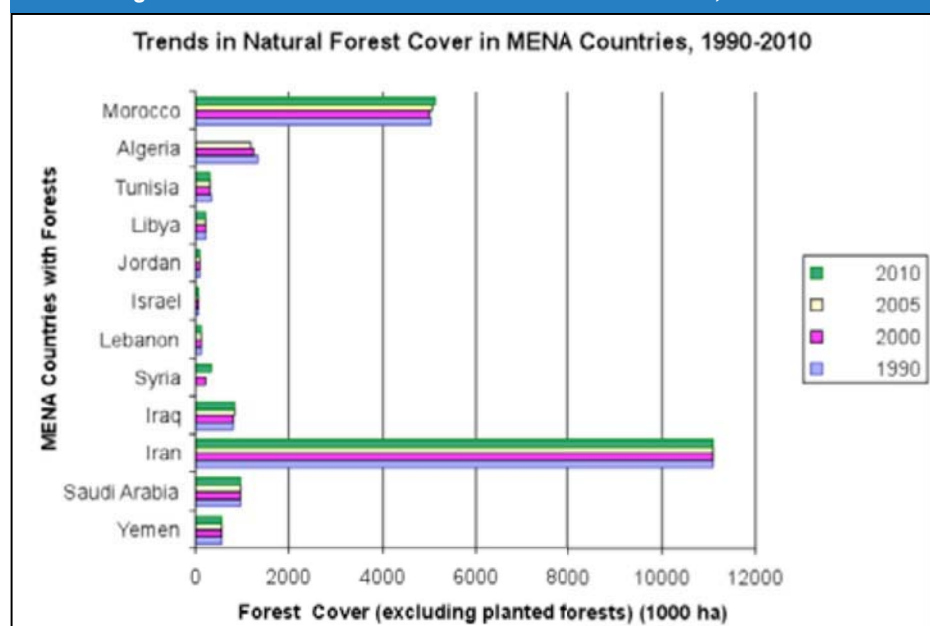
Biodiversity is severely affected by habitat loss resulting from human activities such as urbanisation and unregulated tourism. **Table 8** gives an idea of the biodiversity, endemic and threatened species in MENA countries. The causes may be direct like that in top soil removal for construction or it could be indirect through nutrient depletion or seed bank removal. There are always exceptions to the negative trends observed. In Al Jabal al Akhdar in Oman, the bird biodiversity actually improved in degraded lands; it was suspected that the warming of the mountain in the last decade is permitting lowland birds to move up the slope (Victor, 2008). Careful observations showed that the new bird elements were associated with farms where a wide variety of non-native fruit crops were grown. Availability of new niches due to human activities is allowing new immigrant species to move in and there is a distinct possibility that these species would compete with the native mountain species for resources in the future. In reality, the

increase in the bird biodiversity is an indication of negative impact. **Figure 8** below shows the extent of changes in the forest regime of the region within a short period of 20 years.

2.1.8 Expanding tourism

The sudden expansion of tourism in many of the Middle Eastern countries is a relatively recent phenomenon. In the past 10 to 15 years many of these countries have opened their borders to tourism and business (e.g. Dubai, Qatar, Oman). This has resulted in increased employment opportunities even in remote areas of the mountains, but not necessarily for the local people. There are significant benefits to mountain communities due to the development of infrastructure (e.g. roads, electricity, water supply etc.) As far as direct benefits are concerned (e.g. improvement in income), tourism operators and middle-men often benefit more than the local mountain communities. However, the awareness of tourism and recreational potential in the MENA countries has considerably increased in the global tourism market. Some traditional cottage industries like carpet production have experienced resurgence. Middle East wool carpets are popular among tourists. Mountain handicrafts have gained good market value. This has contributed to the economic well-being of mountain communities in some countries. Arabic music has now special place in the world although it may not have originated in the mountains.

Figure 8: Trends in natural forest cover in MENA countries, 1990-2010



Source: U.N.F.A.O report/2010

Table 8: A glance at biodiversity, endemism and threatened species information in MENA countries

Country	Higher Plants			Mammals			Birds		
	Total number of species	Threatened species	Endemic species	Total number of species	Threatened species	Endemic species	Total number of species	Threatened species	Endemic species
Morocco	3,675	32	1	105	18	4	206	10	0
Algeria	3,164	15	1	92	14	3	183	9	1
Tunisia	2,196	7	0	78	13	2	165	6	0
Libya	1,825	2	0	76	12	4	76	3	2
Egypt	2,076	2	0	98	17	6	123	9	0
Jordan	2,100	1	0	71	13	0	117	10	0
Israel	2,317	0	0	116	15	5	162	13	0
Lebanon	3000	1	0	67	10	0	116	8	1
Syria	2000	3	0	63	16	1	145	14	0
Iraq	3300	0	1	81	13	1	140	16	1
Iran	8000	1	1	140	16	7	293	20	16
Saudi Arabia	2028	3	0	77	9	0	125	15	0
United Arab Emirates	800	0	0	25	7	0	109	11	0
Oman	1204	6	0	56	9	0	109	11	0
Yemen	1650	169	5	66	9	2	93	15	14

Source: IUCN Red list Version, 2011.2, Table 5
<http://earthtrends.wri.org>

Tourism when not planned and regulated causes ecological damage. In conservative Islamic countries of the MENA region, cultural erosion caused by the influence of foreign tourists is a real threat. Increase in crime targeting tourists, unacceptable changes in social behaviour and unrealistic increases in the cost of ecosystem services represent some of the problems.

2.1.9 Mining activities

The potential for mining activities in the MENA countries are huge. For example, mining activities in Morocco contributes 35% of its foreign trade and 6% of GDP. This country had a turnover of U.S \$ 2.7 billion in 2005; 75% of the world's phosphate reserves are in Morocco.⁶⁹ Algeria benefits from the mining of stone, phosphate ores, iron ores and gold; about 28,000 people are employed in the mining industry.⁷⁰ Iran had a huge potential with 68 types of minerals and most of these are mined. Oman is known for its silica mines, dolomite ore for magnesium metal, copper and gold. Mining activities

contribute a considerable portion of the national GDP in many of the North African countries. In general, the mining activities are very limited in many of the Middle Eastern countries inspite of its huge potential.

Table 9 illustrates the mineral richness of the MENA region. Some of these minerals are mined and others occur as reserves. There is a general tendency in the Middle Eastern region of increased prospecting activities of late. Unfortunately the mining industry in the MENA Mountains seldom benefits locals and contributes to dust pollution, habitat degradation and displacement, if not the elimination, of wildlife at least locally.

2.1.10. Monitoring and Research

When compared to the other mountains of the world like the Alps and Hindukush Himalayas, MENA Mountains are data deficient in almost all fields.

Climate data available for these mountains are inadequate. Many MENA countries need more

Table 9: Mineral richness of MENA region.

Countries	Mineral Resources
Morocco	Petroleum products, Phosphate (major), Anthracite, Antimony, Barite, Cobalt, Copper, Fluorspar, Iron ore, Lead, Manganese, Salt, Silver, Zinc
Algeria	Petroleum products, Phosphate (major), Gold, Iron ore, Zinc
Tunisia	Petroleum products, Phosphate rock, Iron ore, Limestone, Clay and other stones.
Libya	Petroleum products, Iron ore, Salt, Limestone, clay and other stones
Egypt	Petroleum products, Iron ore, Phosphate, Limestone, Coal. Exploration for Gold, Tantalum and Niobium
Jordan	No significant petroleum reserves. Phosphate, Pottash, Salt, Calcium carbonate, Treated Zeolite, Silica, Travertine, Oil shale
Israel	Phosphate, Stones and Sands. Prospecting for diamonds
Palestine territory	Petroleum, Natural gas, Gold
Lebanon	Salt, Limestone, Silica, Asphalt, Coal, Iron ore
Syria	Petroleum products, Phosphate rock, Gypsum, Silica, Marble, Natural crude Asphalt, Salt
Iraq	Petroleum products, Phosphate, Sulphur
Iran	Petroleum products. Coal, Iron, Copper, Zinc, Lead, Chromium, Barite, Salt, Gypsum, Molybdenum, Strontium, Silica, Uranium, Gold, Silver, Turquoise, Marble, Travertine, Selenium, Garnet, Calcium, Barium, Yttrium, Zeolite
Saudi Arabia	Petroleum products, Bauxite, Copper, Gold, Iron, Lead, Silver, Tin
UAE	Petroleum products, Copper, Manganese
Oman	Petroleum products, Chromite, Coal, Copper, Gold, Silver, Marble, Limestone, Manganese, Gypsum, Asbestos, Dimension stone
Yemen	Petroleum products, Dimension stone, Gypsum, Salt

Source: www.mbendi.com

<http://www.nationsencyclopedia.com>

www.wikipedia.org

meteorological stations for data collection and monitoring. There is a dire need for the establishment of early warning systems to predict flood events and prevent climate associated natural disasters. Most MENA countries rely on foreign satellites for data acquisition. Attempts should be made to internalise and coordinate data collection among the MENA countries. There are a few earthquake monitoring facilities in the MENA (e.g. Iran, Oman), but these need improvement.

Ministries and government organizations in the MENA have large amount of data on the surface and groundwater resources of the mountain areas. The main problem here is the accessibility of the data for analysis to detect patterns, trends and problems and share the knowledge of lessons learnt. Despite the much talked about water scarcity in the region, hydroelectricity is the only well developed non-fossil form of electricity generation. Morocco and Iran are the front runners in hydropower production in the region because of the water availability in mountain reservoirs. Technology to unlock the potential of repeated floods should be explored.⁷¹

Wildlife conservation in MENA Mountains has been restricted to flagship species. A number of species, despite their inconspicuousness, are important for the ecosystem functioning in these mountains. There is quite a lot of data on the flora and fauna of the MENA region (e.g. Saudi Arabia sponsored Fauna of Arabia Volumes), but there are still a myriad of unknown flora and fauna in the mountains of the MENA. Extensive biodiversity inventories are needed. Biodiversity hotspots in the MENA Mountains are well known, but the establishment of more reserves and protected areas are needed.

Agriculture and livestock related issues have received considerable attention in the MENA mountain region, though perhaps not to the same level of productive lowland areas. Rangeland management and overgrazing issues in the MENA region still require a lot of research. Large scale land degradation studies in these mountains are needed. Land use management strategies and action plans are priorities.

Tourism is well understood in the MENA Mountains, but

ecotourism is poorly understood. There is confusion in discriminating between nature tourism and ecotourism except in few countries like Israel. Tourism is profit oriented as it should be but the benefits gained by the local people are disproportionately low. Participation of local people in tourism planning is a must and regulated tourism is a necessity. Tourists impose stress on resources like water and what they pay as compensation should reach the owners of the resources.

Socioeconomic and political issues and the importance of research in this area depend on the governance of the country. Authoritarian governance does encourage this type of research, but there is room for improvement. NGOs involved in sustainable mountain development are relatively few. Socio-political conflicts in the MENA area need to be resolved. Inter-tribal conflicts within specific mountains have to be tackled. MENA Mountains should be safe for locals as well as visitors and issues like terrorism are detrimental to sustainable mountain development initiatives.

As this report and the references listed show, there are several international stakeholders involved in the issues of sustainable mountain development. Will their efforts and contributions be sustained after they pull out and leave? MENA mountain interest should seriously look at the issue of local capacity building and any project or initiative that does not have a significant capacity building component should be asked to remedy this setback. Capacity thus built should be evaluated and there should be plans in place to sustain this capacity in the long term. Programs to train the trainers using external expertise have not worked very well at least in the oil-rich MENA countries.

2.2 Case Studies

Problems of sustainable mountain development (SMD) are complex irrespective of the region. In the MENA region, the relatively recent economic boom due to oil has destabilised long established sustenance and production practices in the mountains. Traditional practices and knowledge systems are threatened by easily imported, deceptively attractive modern practices of agriculture, livestock rearing and market strategies. Selected case studies are presented here to

show the variety of existing challenges, attempts made to meet these challenges, triumphs and failures and the lessons learnt.

2.2.1 Conservation (Case Studies 2.2.1.1 to 2.2.1.5)

Five case studies (2.2.1.1 to 2.2.1.5) have been presented under this category. Three of them are on whole ecosystem conservation (2.2.1.1 to 2.2.1.3) while two are on specific flagship species (2.2.1.4 and 2.2.1.5). The three ecosystems are a wadi in United Arab Emirates, a forest in Lebanon and a whole island of Socatra in Yemen. The two flagship species are the Barbary Macaque in Morocco and the Arabian Leopard in Oman.

2.2.1.1 Protecting a Wadi

The wadi is a seasonal dryland river and the wadi systems are predominately dry riverbeds except during rains in the MENA region. However, some wadi are fed by springs and are characterised by permanent pools and slow flowing runs and riffles at least for

short distances. Such wadi systems can be considered as quasi wetlands in the middle of arid regions. Such wadi are generally isolated and so are unique in their biodiversity.

The Wadi Al Wurayah Reserve is located within the Al-Hajar mountain series. The mountain series cut through the entire coastal strip of the Emirate of Fujairah in the United Arab Emirates. The Wadi derived its name from *War`aa*, the local name for the cane plant, known for its affinity to water and is therefore found mostly in areas of permanently filled ponds in the valley. The reserve comprises of three sectors; the ecological tourist sector, the central sector and the protection sector in the periphery of the reserve (Tourenq et al., 2009).

The wadi is a 129 km sq catchment that occupies the northern reaches of Fujairah between the towns of Masafi, Kohl Fakkan and Bidiyah. Due to its permanent water source, the area has been used by local communities for thousands of years and is home to rare and endangered species such as the Arabian Tahr and Arabian Leopard. The wadi is located within the Ecoregion 127 "Arabian Highlands and Shrublands" of the WWF Global 200



Wadi Al-Wurayah, Fujairah, UAE

Source of picture: <http://www.wildlifeextra.com/go/news/wadi-Wurayah.html>



The unique orchid species of UAE, *Epipactis veratrifolia* found in Wadi Wurayah.

http://he.wikipedia.org/wiki/عُقاب:Epipactis_veratrifolia.jpg

Ecoregions which regroup the richest, rarest and most distinctive of the earth's natural habitats. According to the WWF's classification, this part of the region is regarded as an area of international importance.

Wadi Wurayah Fujairah has officially been declared the UAE's first protected mountain area by His Highness Shaikh

discovered in the area is also being threatened by extinction. Nevertheless, it is still hoped that the Arabian leopard, which was thought to be at the verge of extinction, is still in the area.

Seventy-three species of birds have been counted in the area till date and 5% of these are under the threat

Hamad Bin Mohammad Al Sharqi, Member of the Supreme Council and Ruler of Fujairah. Compared to the UAE animals and vegetation resources, the mountainous Wadi Al Wurayah reservation possesses around 44% of the UAE's plants, 42% of land mammals, 24% of reptiles and 73 species of birds. The Wadi is also the home of the only two amphibian species registered in the UAE.

Surveys by UN have also shown evidence of the rare orchid, *Epipactis veratrifolia* and single species of a fish which is on the verge of extinction; 60% of the total number of mammals



Indian Roller, common in the UAE

Source of picture: <http://ibc.lynxeds.com/photo/indian-roller-coracias-benghalensis/low-flying-bird-showing-characteristic-wing-pattern>

of extinction. Seven new species of insects have also been discovered and four of these entirely depend on freshwater for completing their life cycle, and remain most of the time in water. Seventy-four species of arthropods belonging to 12 different groups are also found in the area.

The reserve and nearby waterfalls have become one of the much sought after tourist destinations in the UAE, despite difficult access over rough terrain. The wadi reserve along with other four marine reserves in the Emirate of Fujairah, has recently been receiving large number of visitors and tourist groups. These reserves reflect the commitment of the Fujairah government to protect the ecological wealth and promote sustainable development.

The Wadi Wurayah Reserve is currently prone to numerous short term and long term threats. Over-usage of existing water resources is one of the major threats. Over-grazing is the main reason for the depletion of grass cover. Some inhabitants still tend to collect plants from the valley to feed their sheep. Unlawful hunting is in fact, the most serious threat that directly endangers the already threatened species.

The high cost of maintaining the reserve is compounded by the need to restore the degraded environment to its original state. The destruction of the natural habitat is still continuing due to the arbitrary construction of civil establishments, extension of roads, establishment of high-tension electrical lines and mining activities. All these destructive activities will have an enormous impact on the local environment in the long term.

The increased tourist activities have resulted in indiscriminate disposal of solid wastes. Enforcement of stringent regulations to control the behaviour of tourists is urgently needed.

Wadi Al-Wurayah Reserve is regarded as an ideal example of a freshwater environment in a mountainous area in an otherwise arid zone. It is also characterized by its unique geological and hydrological systems, not only supporting water storage, but also a rich biodiversity of global significance. It should be mentioned that it is now a Ramsar site under Ramsar Convention.

Lessons Learnt

Using systematic research and other exploratory tools it is possible to document the value of a unique ecosystem and convince the government to declare it as a protected area. Protection does not mean the exclusion of people and the prevention of development. Wadi Al Wurayah is a positive example where conservation includes multiple stakeholders to achieve the objectives of sustainable development.

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2.2.1.2 Managing Cedar Forests

Cedar forests in the MENA Mountains enjoy the unique distinction of being known as the oldest documented forests in history, traceable to the earliest written records of the Sumerians in the third millennium BC.

Lebanon: Al-Shouf Cedar Biosphere Reserve

The territory of the Al-Shouf Cedar Reserve runs along the length of the mountain range known as the Barouk Mountain, a southern extension of the Mount Lebanon. The western slopes of the range face the Shouf region and the eastern slopes face Mount Hermon, forming the western escarpment of the Bekaa valley. The area of the reserve stretches over 50,000 hectares. It is surrounded by a buffer zone of 500 metres along its borders. It borders on nine villages with a total population of 50,000 whose municipal lands lie within the jurisdiction of the reserve.



Al Shouf Biosphere Reserve, Lebanon

Source of picture: <http://www.tripmondo.com/lebanon/mohafazat-mont-liban/ain-zhalta/picture-gallery-of-ain-zhalta/>

The famous cedar forests in Al Shouf Reserve are much more than just cedar trees; these coniferous forests include a diversity of landscapes encompassing mountains, plateaus, valleys and coastlines. During the 16 years of war and instability (1974-1990), Lebanon suffered drastic reduction in the productive capabilities needed to properly manage natural resources. Desperate measures to revive the national economy and to survive at the local level led to wholesale felling of trees for charcoal, overgrazing of livestock, unbridled hunting of wildlife and pollution of air and water.

The reserve is exceptionally rich in its biological diversity and is known to be the last remaining sanctuary to shelter an extensive range of wildlife species in Lebanon. The reserve is home to 24 tree species and some of these are estimated to be in existence for the last 2,000 years. The reserve provides shelter to 200 species of birds, of which

19 are considered rare at the national level. More than 22 species have been confirmed to be resident, the rest are migratory or rare visitors, and at least two or three species have been introduced. The reserve holds a combination of birds found in Europe, Africa, and Asia. Al Shouf cedar reserve also serves as home for a rich variety of reptiles and mammals.



Middle East Tree Frog (*Hyla savignyi*)

Source of pictures: http://en.wikipedia.org/wiki/Hyla_savignyi



Blackbird (*Turdus merula*)

Source of picture: http://en.wikipedia.org/wiki/Common_Blackbird

herders of goats with a total of 3,200 heads. It was therefore crucial to establish a sustainable strategy aiming at integrating the grazing activities of these herders into the overall management plan of the reserve. Moreover, grazing if properly managed could contribute to the mitigation of forest fires that occur sporadically at the outskirts of the reserve, and to maintain the landscape mosaic and the traditional land-use practices.

The GEF-UNDP project (2002) promoted national reconciliation by strengthening the capacity of governmental agencies and NGOs to conserve endemic and endangered wildlife and their habitats, and to incorporate wildlife conservation as an integral part of Lebanon's sustainable development planning. In collaboration with local communities, the project established new protected areas and helped draft a new framework of law for protected areas which include Al Shouf Cedar Reserve.

Historically, the rangelands and woodlands of the reserve used to provide grazing for a large number of small ruminant flocks from the surrounding areas as well as from far away regions of Lebanon. Transhumant herds used to converge to the reserve and its foothills during spring and summer. A survey undertaken by Al Shouf Cedar Society in 1997 identified 37 herds of sheep and goats with a total of 42,000 heads grazing in the Barouk forest, the Maaser Al Shouf forest and the Bmohray-Ain Zhalta forest and its surrounding areas. Since that time and thanks to the strict control by reserve rangers, the number of flocks has declined drastically and is now limited to herders from the adjacent villages only.

The Niha forest and its surroundings were grazed by 30,000 heads of goats and sheeps owned by more than 30 shepherds in the past and now it is used by seven

A rapid grazing assessment was conducted in summer and autumn of 2006 to assess grazing activities and to outline an integrated plan aiming at improving sustainable options for the management of the Niha forest, its surrounding and the buffer zones while providing herders with income generating incentives. The assessment revealed an abundance of forage species including grasses and shrubs with a rich concentration of forage legumes.

Lessons learnt

Lebanon forests are a classic example of how war-related hardships can almost completely destroy the natural wealth of a nation. But these bioreserves show how the determined efforts by the government and the NGOs can start the process of healing and restoration of the biosystems towards a stable, sustainable level. The Al Shouf Cedar reserve is a success story of ecosystem restoration.

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2.2.1.3 Human impacts on the biodiversity of islands

The uniqueness of the island ecosystems is such that they form almost 30% of the world's diversity hotspots. The islands are home to unusual and rare species that are usually endemic. The very isolation that fosters unique speciation opportunities is also the reason why the islands are extremely sensitive and vulnerable to human activities and introduction of exotic species.

The Socotra Archipelago (Yemen) is the largest,

biologically most diverse island group in the Arabian Region. It is located 380 km southeast of the coast of Yemen and about 100 km east of the Horn of Africa. The island is populated by at least 50,000 inhabitants (IUCN, 2008). Socotra can be considered as an insular hotspot with exceptionally high marine and terrestrial biodiversity, internationally recognized for its uniqueness. The main island consists predominantly of Paleogene karstic limestone plateaus (on average 700-800 m with a maximum of 1000 m above sea level), bordered by coastal margins and a central depression, joined on a granite base which outcrops in the main Haggeher Mountains, about 1550 m in altitude. In contrast to most of the mainland to which it once belonged, Socotra retains an important amount of water due to its oceanic position, the presence of its central mountains creating a rain shadow, and percolation through karstic limestone. Orographic rainfall and the occurrence of fogs help to maintain biodiversity, allowing relicts to survive and several endemics to evolve.

Socotra is considered as the jewel of biodiversity in the Arabian Sea and is



Socotra Island: Yemen

Source of Socotra Map: <http://warnewsupdates.blogspot.com/2011/07/yemen-island-is-playing-crucial-role-as.html>
Source of picture: <http://www.puretravel.com/itineraries/1725>



Desert Rose (*Adenium obesum*), with bizarre swollen trunks on the island of Socotra.

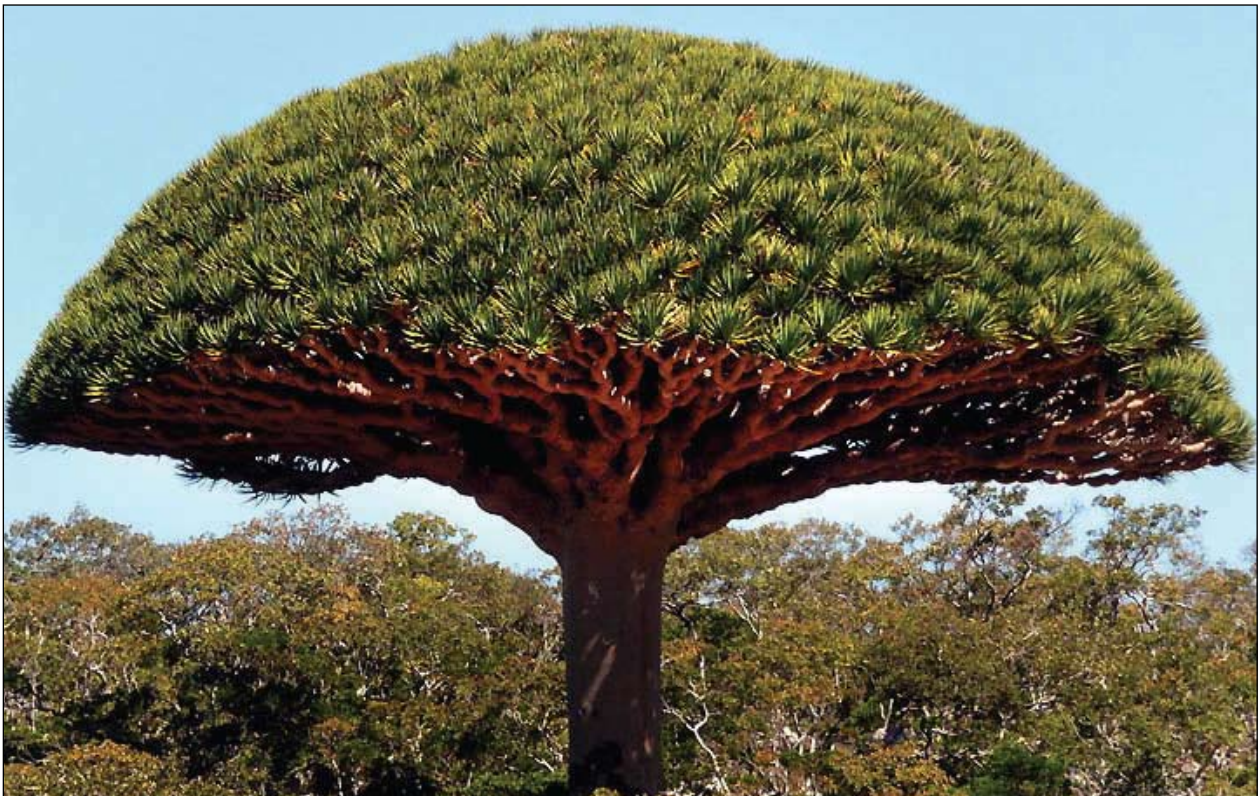
Source of pictures: <http://www.besttourism.com/items/di/331?title=Socotra-Island-in-Yemenandb=47>

home to more than 800 species of plants, of which 240 are endemic to the island, and there are certainly many more plant species that are yet to be discovered. The long geological isolation of the Socotra archipelago and its fierce heat and drought has combined to create a unique and spectacular endemic flora. Botanical field surveys led by the Centre for Middle Eastern Plants

(part of the Royal Botanic Garden Edinburgh) indicate that 307 out of the 825 (37%) plant species on Socotra are endemic, i.e., they are found nowhere else on Earth. The entire flora of the Socotra Archipelago has been assessed for the IUCN Red List, with three critically endangered and 27 endangered plant species currently recognised.

Globalization is impacting the archipelago, exemplified by increased trade activities via sea and air, modern road networks, population expansion, changes in traditional land management and the rapid uncontrolled development of the tourism industry. Such new developments are expected to have an influence on Socotra's ecosystems, yet focused studies correlating impact with biodiversity are lacking.

Macro-waste on Socotra is an important source of pollution, already evident in urban areas and increasing rapidly beyond. Waste expands with urbanization and tends to concentrate along roads. The problem has several effects besides the aesthetics, frequently noted by (eco) tourists, such as health issues through



A Dragon's Blood Tree (*Dracaena cinnabari*) is seen in front of the Skund Mountains on the island of Socotra, Yemen. The tree is so named because any injury to the bark results in a deep red liquid excreting from the scar – compared in the past to the “Blood of Dragons”

Source of pictures: <http://www.besttourism.com/items/di/331?title=Socotra-Island-in-Yemenandb=47>



Socotra Beach: Yemen

<http://www.flickr.com/photos/51545504@N04/4837355108/sizes//in/photostream/>

the attraction of pest species and diseases. Waste accumulates rapidly on the island and solutions hitherto proposed have proven insufficient. Tourism and local agriculture are considered as the major sources of waste on Socotra (Loretz & Martin, 2006). A long-term, sustainable system for waste management alone might not be sufficient - a change in urban planning with an aim to reduce littering is also needed. Waste accumulation and pollution in lagoons could be important factors leading to a reduction in biodiversity and may have contributed to the local extinction of *Rhyothemis semihyalina* (Odonata) in the Hadiboh Plain.

Another important source of pollution may be derived from the now extensive road network in Socotra. Heavy metals, such as lead oxide, result in contamination of roadsides because of the wear of tires. Taken up by the plants in the direct vicinity, lead may have severe toxic effects on consumers, reducing overall fitness higher up the food chain where the accumulative effect increases risks for extinction.

Socotra has been listed as one of 40 'unforgettable islands to escape to before you die' for adventurous

travellers in search of paradise with beautiful white beaches (Davey & Schlossman, 2007). An oasis in a country suffering from poverty and negative media attention, Socotra has now become the number one tourist spot for Yemen. However, the original concept of ecotourism currently does not seem to work in Socotra because of traits inherent in the tourism industry, the search for a 'paradise' destination, combined with a low degree of tourist infrastructure and high visitor numbers. Efforts to combine tourism with nature protection have failed on Socotra, as did the effective management of the sector (Mayer, 2009). The current tourism development does not follow any planning concept - employees in the sector are untrained or unaware of the fragility of the island's ecosystems whereas the majority of tourists do not grasp the importance of respecting local culture and nature (Mayer, 2009). Widely considered to be one of the most aesthetic places, it is now threatened by concrete road construction and waste accumulation by tourists. Despite these negative affects, the added values of increase in economic benefits and the exposure to the ecosystem resulting in raised awareness and public support for conservation, cannot be ignored.

With a steep rise in visitor numbers and an increase in overall attention, the illegal export of live organisms, *ex situ* breeding for commercial benefit and trade in Socotran endemics are increasing rapidly. A few Socotran plants have historically been exported and were commercially exploited for horticulture, such as *Exacum affine* (Persian Violet) and *Begonia socotrana*, both widely sold in European markets (Miller & Morris, 2004). Yet the number of Socotran endemic species currently offered by online plant shops in Europe and the United States is alarming.



Monocentropus balfouri

<http://www.arachnoboard.com/ab/showthread.php?150422-Monocentropus-balfouri-care/page2>

Endemic animals are also being exported alive and bred for sale. One of the most expensive Socotran endemic animals ever to be sold in numbers is probably the Tarantula (*Monocentropus balfouri*). This first appeared on the international market in 2007 for about \$300 per specimen; with prices up to \$400-500 (one adult was even offered in the US for \$650 in May 2009). Socotran live-trade does not appear on the Yemeni market but moves directly through international channels.

Some other major problems are uncontrolled collection of firewood, overgrazing by livestock, and unsustainable resource use. Protection measures against such practices are limited.

The degradation of Socotra's unique culture and nature is an ongoing process. It is absolutely vital to establish a framework for the protection of Socotra's biodiversity - in capacity, manpower, legislation and

decisions based on a consistent scientific basis. A significant number of endemics at high taxonomic level on Socotra may have to receive a higher priority in future for protection measures. Taxonomically isolated groups should hold a special importance in conservation terms, in that their extinction would cause a greater loss of unique genetic and morphological diversity. Efforts for conservation may perhaps be best focused on areas of high human population densities and impacts, as well as on those with the best remaining natural habitat. Future conservation efforts in Socotra should be approached by viewing the ecosystem as a whole, taking also basic species biology into consideration. It is the only way to try and avoid the breakdown of complete ecosystems and singular extinctions.

Lessons learnt

Development if not controlled can lead to a complete degradation of unique island systems that had long been considered as laboratories of evolutionary processes. Loss of biodiversity disrupts ecological integrity that can threaten cultures and civilizations. The ill effects of uncontrolled tourism in Socotra are evident and the lessons learnt globally should warn the authorities of Yemen to take appropriate action.

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2.2.1.4 Morocco: Barbary Macaque

Barbary macaque inhabits the vital forests of oak and cedar in the Moroccan Atlas. The endangered status of these macaques have been caused by climatic changes like prolonged drought, overgrazing of the forest land by the large number of goats herded by the semi-nomadic Berbers, poaching and live pet trade and ill implemented logging control. The paradox of this situation is that, after an almost decade long drought in Morocco, the officials blame the macaques for destroying the Middle Atlas forest. There is a general denial about the scarcity of this species and there has even been some talk about relocating the macaques to save the forest!

Recent field surveys on Middle Atlas of Morocco revealed that the wild Barbary macaque (*Macaca sylvanus*) population in Morocco is facing a serious decline, a decrease of 43 to 84% within only two decades.

The number of macaques in Morocco is currently estimated at 6,000-10,000 individuals, a decline from 44 down to 10 individuals per km² in some regions. The increasing human pressure in the rural mountain areas of Morocco has far exceeded the carrying capacity of the forest ecosystems, especially through overgrazing, uncontrolled logging, and irrational and devastating tree pruning. Forest conservation is a pressing need for ensuring the conservation of the highly threatened Barbary macaque, freshwater supply and for reducing the risks of desertification and other impacts that may be brought about by climate change.

Another factor that affects the Barbary macaque population decline is the illegal live trade of juvenile Barbary macaques to Europe. In fact this illegal

pet primate trade is the second largest threat to the survival of the species. An estimated 300 individuals are caught in the wild and smuggled to Europe per annum and this is 50% above sustainable level.

Macaca sylvanus is listed as “vulnerable” in the World Conservation Union (IUCN) Red List, but this species will most probably meet with IUCN’s criteria for “endangered” species. Mismanagement and ignorance have already made endemic species such as the Barbary lion and leopard go extinct. The Barbary macaque, a unique primate species, is about to follow, and potentially with it the whole ecosystem of the cedar forest (WWF MEDPO, 2007)

Lessons learnt

There is a general lack of ecosystem awareness and the ecology of a flagship species even at the management level of governance. There is need for environmental education, awareness and multi-dimensional conservation campaigns.

References

- WWF MEDPO. Project- Enabling Conditions for Barbary Macaque Conservation in the Middle Atlas, 2007/09



Barbary macaque

Source of picture: <http://www.itsnature.org/trees/mammals-trees/barbary-macaque/>



Arabian Leopard in Oman

Source of picture: <http://iberianature.com/wildworld/guides/wildlife-of-oman/leopards-in-oman/>

2.2.1.5 Oman: The Arabian Leopard

The Arabian Leopard survey was initiated in 1997 by the Omani Government in the Jabal Samhan Nature Reserve in the Dhofar region of Oman. Dhofar in southern Oman is a mountainous region covering 99,300 square km with an atypical Arabian climate. Historically, this region was the chief source of frankincense in the world and still contributes significantly to this trade. The major expedition to survey the existing populations of Arabian leopard (*Panthera pardus nimr*), caracal (*Caracal caracal*), grey wolf (*Canis lupus*), striped hyaena (*Hyaena hyaena*), Arabian tahr (*Arabitragus jayakari*) and the Arabian gazelle (*Gazella gazella*) is in progress since 2006. This expedition attracts eager participants from all over the world.

Arabian leopard is the flagship species for Oman's mountain habitats. It once occurred throughout the mountainous regions of Oman, Yemen, Saudi Arabia, the United Arab Emirates, Palestine and Jordan. However, by the 1990s the leopard became locally extinct in most areas of the Arabian Peninsula and if viable populations remain, they are most likely to be

found in the high mountains of Oman and Yemen. The Dhofar mountains are considered the best habitat for the Arabian leopard in Oman, and it is also where the only large protected area within the range of known Arabian leopard distribution is located, namely the 4,500 square km Jabal Samhan Nature Reserve.

The Arabian leopard is the largest surviving cat species of Arabia which is listed as "critically endangered" in the IUCN List of Threatened Species; it is on Appendix 1 of the Convention on International Trade in Endangered Species (CITES), which bans international trade in listed animals. In 1997, the Office of the Advisor for Conservation of the Environment of the Diwan of Royal Court began a survey of the Arabian leopard in Jabal Samhan Nature Reserve in Dhofar, where a viable population has been shown to exist.

A recent study conducted by Biosphere Expeditions which runs the wildlife conservation expeditions all over the globe revealed in its report that no fresh signs of leopards in the western Dhofar region were found although some of the scats found are of leopard origin beyond any reasonable doubt.

Lessons learnt

A well publicised all out conservation effort increases the awareness of the local populace resulting in their proud participation in the project.

References

- Spalton J. A., Al Hikmani H.M., Willis D and Bait Said A. S. 2006. Critically Endangered Arabian leopards (*Panthera pardus nimr*) persist in the Jabal Samhan Nature Reserve, Oman. *Oryx*. 40: 287-294.

2.2.2. Tourism (Case Studies 2.2.2.1 and 2.2.2.2)

Ecotourism in Lebanon (2.2.2.1) and Geotourism in Iran (2.2.2.2) are chosen as examples. These case studies illustrate and emphasize the problems connected with the tourism trade. The lure of quick profits results in tourism booms with very little attention paid to the environment management plans.

2.2.2.1 Ecotourism in Lebanon

Ecotourism is growing fast in Lebanon Mountains. The country offers impressive snow-covered mountain slopes. There are numerous ski resorts and entire villages which economically depend on the winter tourism season. The Lebanon Mountain Trail (LMT) has been created as a part of an internationally funded project and contributes to the sustainable environmental, social and economic development of rural areas. In the region around Mzaar-Kfardebian, in the mountains, a project is in progress to extend the tourism offer to all four seasons. In addition to the usual winter sports activities, new offers during the remaining time of the year range from donkey rides, clay pigeon shoots, mini golf and sunbathing at outdoor pools to less environmentally friendly motorized opportunities. This removes the high dependency on favourable seasons and simultaneously attracts new target groups. But environmental challenges are looming ahead like lack of land protection, pollution of land by solid wastes



Mountain Trail in Lebanon

Source of picture: <http://homemade-recipes.blogspot.com/2011/10/lebanon-attractions-hiking-trekking.html>

including plastic and casings of shotgun shells. The need for environmental awareness among politicians, tour operators and the general population is essential; tourists should at least be expected to reflect increased awareness as well. The demand for environmentally friendly services is rising and will be a challenge.

Lessons learnt

A well planned and integrated management of the tourism trade is crucial in avoiding irreparable damages to the ecosystem.

References

- <http://www.dailystar.com.lb/News/Local-News/Aug/14/Eco-tourism-in-Lebanon-finds-increasing-interest.ashx##ixzz1MKPqwhtj>

2.2.2.2 Geotourism in Iran

As a result of having diverse climates, various geological features and varied habitats, Iran has geographical and natural phenomena such as mountains, caves, straits, valleys, vast forests, huge geological fissures,

ponds and lakes, mud volcanoes, sandy pyramids, cliff-rocky shores, and ancient mines. Such geological heritages, in the form of numerous geo-parks, can be considered as functional tools for geotourism development. Mountains in Iran, based on their formation and characteristics, fall into three categories: Orogenic, Volcanic and Horst. Orogenic mountains are located in north, west, south and central parts of Iran. Damavand, Sabalan, Sahand, Taftan and Bazman are amongst Iran's volcanic mountains created as the result of volcanic activities of the quaternary period and are currently extinct and at the stage of producing sulphur. There are more than 320 hot springs at the foothills of these mountains, the most important and famous of which are Sarein hot spring complex at the southern foothill of Mount Sabalan near the Ardabil city. These geo-tourist sites receive more than five million domestic and foreign tourists every year.

The vast forests of Iran are located at the northern margin of the country (northern slopes of Alborz Mountain Range) and at the slopes of Zagros Mountain Range in western Iran. They are very valuable as geo-touristic sites of Iran with fossil tree species as old as



Katalah Khor cave, Zanzan (NW Iran)

Source of picture: <http://iran-page.blogfa.com/8909.aspx>

three million years. These mountains are home to 350 species of birds; 12,000 species of plants and more than 300 species of mammals. The forests are dispersed in other parts of Iran such as Arasbaran Forests in the northwest of Iran (Azerbaijan region) and Ahra Forests in Qeshm Island.

Lessons learnt: Natural wealth of a nation could be sustainably managed to cater to the special needs tourism such as geotourism. If the political climate does not assure the safety of tourists, however, the tourism potential cannot be realized.

References

- Yalgouz-Agaj, A.G., Ardebil, L and Karimdoust, S. 2010. Identification of some of the Geotourism sites in Iran. *World Applied Sciences Journal*.11 (11): 1342-1347

2.2.3 Water Conflict (Case Studies 2.2.3.1 and 2.2.3.2)

These case studies involving Israel and Palestinian Territory (2.2.3.1) and the River Jordan conflict (2.2.3.2) are of interest because of the political issues relating to the ownership of water. It is often said that in the MENA region, inter-country conflicts in future will centre on water and here are two examples.

2.2.3.1 Israel – Palestine: Quarrelling over water

The dispute between Israelis and Palestinians over shared water resources of the mountain aquifer is one



Source of picture: <http://www.enduringamerica.com/home/2010/10/24/israel-palestine-analysis-the-water-conflict-el-houry.html>

potential obstacle in the path of peace in the Middle East. This aquifer is the only source of water for Palestinians in the West Bank and the main provider of fresh water to Israelis. At present, Palestinians and Israelis are moving toward a political resolution of their more than half a century old conflict. In the Declaration of Principles, Israelis and Palestinians created preconditions for the coming negotiations and the Israelis recognized water rights for Palestinians. There is no clear indication of the extent to which water would be under Palestinian control during the interim period, but there is an implicit recognition of the need to reform the existing water allocation system. In the Final Status Negotiations, the Joint Mountain Aquifer Committee members must make decisions regarding the equitable distribution and joint management of the shared water of the mountain aquifer.

Lessons learnt

Any attempt at conservation, management and resource sharing is only possible if there is political willingness among neighbouring countries to compromise and co-operate for the common good of humanity.

Reference

- El-Fadel, M., Quba'a, R., El-Hougeiri, N., Hashisho, Z. and Jamali, D. 2001. The Israeli Palestinian Mountain Aquifer: A case study in groundwater conflict resolution. *Journal of Natural Resources and Life Sciences Education*. 30: 50-61.

2.2.3.2 The River Jordan Dispute

The Jordan River is a major source of water for Israel and Jordan. The Jordan River originates in the mountains of eastern Lebanon, Israel and Syria and flows south through the entrance to the Great Syrian Rift Valley. It is spring- and stream fed at various points in Jordan, Israel, Syria, and Lebanon. In Jordan, the main sources of water are the Hasbani River, flowing from Lebanon to Israel; the Banyas River, flowing from Syria to Israel; the Dan River, originating and flowing inside Israel, and the Yarmouk River, originating near Golan Heights and flowing into the Jordan River. Following its flow into 'Lake of Galilee', the Jordan River continues southward to the center of the Jordan Valley, forming the border



The vicinity of the Jordan River

Source of picture: <http://lccdevotions.blogspot.com/2006/07/daily-devotion-for-july-14-2006.html>

between the western edge of Jordan and eastern side of Israel including a part of the Palestinian Autonomous Region. The Jordan continues to flow into the Dead Sea, and then through a small stream it flows eventually into the Red Sea.

Israel and Jordan are not the only nations that wish to control the Jordan River. Syria and the Palestinians are also trying to control sections of the river. Israeli and Jordanian attempts to control the river have been

The Jordan River is the largest and longest river in Israel, but it is small when compared to many major rivers of the world. Moreover, it is the only river within Israel that has a permanent flow year round with a flow distance of 223 km. All other rivers in Israel are seasonal rivers that flow in winter (Menachum, 1992).

There is an obvious link to environmental issues and the geopolitical conflict over the Jordan River between Jordan and Israel. The scarcity of water involves real threats to public health, agricultural, and industrial productivity.



Source of Map: <http://egyptianchronicles.blogspot.com/2006/08/old-plans-or-what.html>

exemplified by constructions such as the King Talal dam, built by the Jordanians, and the National Water Carrier, built by the Israelis. These acts led to reactions that often were followed by military attacks. The Israeli War of Independence in 1948 and the Six-Day War in 1967 highlight this dispute.

Lessons learnt

Interstate conflicts over water are a global problem and global interventions mediated by international organizations are necessary to bring about conflict resolution.

References

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2.2.4 Cultivating the correct crop

The first case study is about traditional coffee growing in Yemeni mountains. The increased market value of the narcotic, *Qat* (*Catha edulis*) which is chewed widely in Yemen is posing a threat to the age old practices

of coffee cultivation. A timely intervention from the Government is attempting to reverse this trend. The second case study concerns the cultivation of Cannabis (*Cannabis sativa*) in Morocco. It is presented to show the negative side of mountain agriculture promoting the production another illegal narcotic product to ensure the survival of poor people. In addition, cannabis cultivation causes forest land degradation. The third case study is on the cultivation of rose and rose water production in Al Jabal al Akhdar in Oman. The cash value of this cultivation may not be significant in a nation depending on oil- wealth, but it is the conservation of the culture and heritage of small mountain communities that deserve attention.

2.2.4.1 Yemen: Coffee or Qat?

Yemeni Mountains reach altitudes of more than 3,000 metres above sea level. Until the present day the best coffee of Yemen is grown there on the rain-fed terraces, carefully protected from much sun by the surrounding mountains. The ways of cultivating these terraces are still the same as it was some 300 - 400 years ago. Therefore it is worth noting that this coffee is grown organically in the "rich soil" of Yemen's mountains.



Qat plantation in Yemen

Source of picture: http://www.yemenfox.net/news_details.php?sid=572

Yemen produces all types Arabica, Mocha and Organic coffee. *Coffea arabica*, the Arabian coffee is endemic to Yemen. Yemeni coffee is called Yemeni Harazi.

Clearly, as the population increases, the demand for water increases as well. In the case of the Jordan River, the lack of alternatives for fresh water increases the dependency of both Israel and Jordan on the river. Control over the river by one party indicates a decrease in the amount of water for the other party. The 40 years of war between Israel and Jordan, in addition to the struggle over water, has emphasized the link between conflict and the environment.

Haraz Mountains are located in the northwest Highlands of Yemen. Up to five varieties of coffee beans are grown throughout the region, identified from the differences in the appearance. Some cultivars produce beans continuously throughout the year, some produce beans at specific times once a year and others only produce a crop in alternate years. This composite of diverse varietal types contribute to the complex, unique and unusual cup taste with characteristics arising from ancestral roots. The varied bean ranges from screen 13-15, making this coffee challenging to roast, producing the uneven, irregular colour that would be unacceptable from any other origin but distinguishes Harazi from others.

The economic, political and geographic instability of Yemen has diminished coffee farming in the Haraz mountains and *Qat*, a narcotic crop has become more attractive because it is easier to grow and more profitable to sell. Apart from the obvious detriment of narcotic farming as a way of life, *Qat* causes destruction to the soil, robbing it of nutrients and the scarce water supply. *Qat* chewing is associated with depression and other psychiatric problems. The Yemeni government has directed Non-Government Organizations to work with farmers and encourage production of other vegetables instead of *Qat* farming.

In 2006, farmers were offered agricultural and technical support as well as a guaranteed premium price as incentive to produce coffee. Farmers were educated about the amount of water required to grow *Qat*, and how coffee was a better investment because it produced

plentiful crop using less water. Though *Qat* is still the main income in rural areas because of its market value, villagers in Haraz are beginning to turn back to their traditional coffee crop.

Lessons learnt

The importance of government intervention by using incentives rather than strong arm tactics and the need for environmental education in matters concerning good over the bad.

References

- <http://www.unionroasted.com/about/farms/haraazi-haraaz-mountains-yemen.html>

2.2.4.2 Morocco: Controlling cannabis

Morocco, the world's leading producer and exporter of *kif* (the dried bud of the female marijuana plant), according to the United Nations, has for decades tolerated the illegal production of cannabis that allows an entire region to survive. More than 70 percent of European countries in 2008 claimed that Morocco was their prime source of cannabis either directly, or via Spain or the Netherlands. According to the most recent figures from the United Nations Office on Drugs and Crime, these European countries have put pressure on Morocco to take action to significantly reduce the production of this drug. *Kif* plantations cause serious problems of deforestation and soil erosion, leading to eradication of 8,000 ha of cork oak forest cover in the Ketama region in only six years (1984-90) (Benabid, 2000).

In the past few years, the country has started to crack down on the production of cannabis and has invested millions in not only burning the fields but also in helping the farmers cultivate other kinds of crops. Since 2003, Morocco has received €28 million (\$38 million) from the European Union to eradicate the cultivation of cannabis and has signed several treaties pledging to do so. In addition, the United States donated \$43 million to help farmers find new crops to replace hashish. In theory, such a plan should work. In reality it has faced many challenges and experts say it is likely to fail in the long run.



Cannabis field in Rif Mountains

<http://www.flickr.com/photos/36394452@N03/3365089243/lightbox/>

United Nations Office on Drugs and Crime (UNODC) estimates that Marijuana crops extended over approximately 72,500 ha in 2005, with a reduction of 40% since 2004 due to a combination of factors including unfavourable climate conditions, governmental eradication policies and pressure on local farmers.

attempted raid on the house of a farmer. Thousands of people took to the streets to denounce the corruption of the authorities, of which farmers claim to be victims. Hashish production is prohibited by law but tolerated by authorities who could be influenced by bribes. Despite the European Union pressure on the government

Moroccan government, often accused of inaction on drug trafficking, has intensified its campaign against this activity not only because of the pressure from the European Union (EU), but also to protect its recently conferred advanced status. Recently, the town of Bab Berre, nestled in the heart of the Rif Mountains, was the scene of violent clashes between farmers and the Royal Gendarmerie after an



Cannabis being rolled for smoking

Source of picture: <http://listverse.com/2009/08/12/top-10-most-popular-recreational-drugs>

of Morocco to eradicate cannabis and the efforts of various projects to reduce the production of cannabis, almost all farmers continue growing it possibly with the knowledge of the authorities.

Lessons learnt

Poverty can push marginalized communities to engage in illegal activities that may not be easy to reverse; damage caused to societies beyond areas where the drug is produced is a global concern.

References

- Benabid, A. 2000. Flore et écosystèmes du Maroc: évaluation et préservation de la biodiversité. Rabat: Librairie et éditions Kalila wa Dimna and Paris: Editions Ibis Press, 360 pp.
- UNODC, 2007. Enquête sur le cannabis au Maroc, 2005.

2.2.4.3 Oman: Al-Jabal Al-Akhdar Rose

Al Jabal Al Akhdar (= The Green Mountain), is part of the Al Hajar Mountains Range in Oman, which extends about 300 km northwest to southeast, between



Rosa damascena

50-100 km inland from the Gulf of Oman coast. It comprises the central section of the Al Hajar Mountains Range which is mostly desert, but at higher altitudes it receives around 300 mm of precipitation annually, moist enough to allow the growth of shrubs and trees and support agriculture. It is this that gives the mountains their 'green' name.



Al Jabal Al Akhdar Mountain terrace cultivation

Al Jabal al Akhdar, whose peaks vary in height from 2000 to 2743 m, turn into an area of pink in a few villages in March/April engaging several hundred people in the cottage industry of rose water production. The rose cultivation area is about 5 acres and has about 90 small farms. The rose that is grown in these mountains is *Rosa damascena* Mill., commonly known as the Damascus rose. It is one of the old cultivars, probably a hybrid of *Rosa gallica* and *Rosa moschata*. It is a perennial deciduous shrub growing to about 2 meters tall. The roses are of light to moderate pink in colour and are relatively small occurring in bunches. The rose gardens are in graduated mountain terrace steps and are irrigated using the falaj (man-made channel) systems.

Harvesting of rose petals and the distilling of rose water is done using traditional methods by the mountain communities in villages like Shareija, Al Aqr, Al Ain, Wadi Bani Habib and Saiq. During the season men and women rise early to pluck the blossoms before the day's heat degrades their fragrance. The harvest collected is taken to many traditional extraction units in the village. As soon as the rose petals are sorted, they are laid out on a cloth sprayed with water to keep them fresh.

The harvested rose petals are distilled at the traditional mud ovens called "Al-duhjan." The petals are allowed to simmer gently for about four hours in a vessel called "Al-burmah," which is covered by another vessel



Omani woman harvesting rose petals

Source of picture: <http://earabgirls.com/the-rose-harvest-in-oman>

made of copper called 'qars'. The resulting extract then condenses into a vessel called 'Salha'. The old petals are then replaced with fresh petals using a traditional tool. After boiling, the rose water is poured into a large pot known as "Al-karas," where it remains for at least 30 days. The rose water is then ready for use. Bottled rose water is offered for sale.

During distillation, the rose oil called 'Attar' floats on the distillate. Attar is also commercially valuable. Rose water was distilled by Arabs as early as the ninth



Source of picture: <http://www.arabstoday.net/en/omans-rose-water-a-history-of-tradition.html>

century when Al Kindi wrote his *Kitab Kimya' Al Itr wa Al-Tas'idat* (Book of Perfume Chemistry and Distillation), but the origin of attar as a derivative of rose water is credited to India.

Rose cultivation and rose water distillation is fetching farmers a tidy income in some of the villages in Jabal Al Akhdar. Today about 25 units of rose distillation are flourishing in the mountains. Each bush yields about 15-20 kg of petals during the season and it takes about 2 kg of petals to generate 750 ml of rose water valued at RO 5.

The Ministry of Agriculture is trying to promote the industry of rose water distillation. According to the Ministry of Agriculture, the government is exploring investment opportunities in rose water making units in Al Jabal Al Akhdar. The government has apparently called for entrepreneurs to pool resources and invest in the rose water distillation business, but till today there has been no progress. Perfumed rose water used in Oman mainly comes from India and Pakistan. The potential of

Jabal Akhdar rose for use in perfume industry is yet to be explored.

Rose water is mainly used for medicinal and culinary purposes. It renders a smoky flavour to the food material to which it is added. It is an acquired taste that is popular in the Middle East. Rose water is traditionally added to Omani coffee, tea and Omani halwa. It is believed to be used as a cosmetic. Rose water is popular among tourists from other Middle-Eastern countries. Western tourists enjoy watching the process of rose water distillation.

Lessons learnt

Despite progress, modernization and development, the cultural and traditional values of the mountain people need conservation.

References

- <http://www.omaninfo.com/news/roses-bring-scent-success-highlands.asp>
- Times of Oman Sunday. November 13, 2011.



PART 3

Challenges to green economy and issues relevant to Rio +20

3.1 Green economy and sustainable mountain development: the MENA region

A simple way of looking at green economy is as low-carbon economy and how its goals can be achieved by sustainable development. As UNEP (2010) says it should result in improved human well-being and social equity while significantly reducing environmental risks and ecological scarcities. According to the recent reports, the MENA region has 60% of the world's oil reserves and 45% of the natural gas reserves. Eight of the 12 OPEC nations are within the MENA region. Oil and its derivatives are natural capital; these are not sustainable, but they are economically visible and valuable. They are also the vital sources of global economic stability and therefore demand investments. It is in this background that green economy through sustainable development should be considered.

What is the status of green economy in the MENA Mountains? Using UNEP's Green Economy, A Synthesis for Policy Makers (UNEP, 2010), the following rough generalizations could be reached.

The investment in the natural capital of the mountains is inadequate. Most of the non-oil natural capital is economically visible only rarely and it is subjected to undervaluation and poor management.

The problem of poverty alleviation is sensitive in oil-

based MENA economies. There is very little evidence that investment in mountain ecosystem services have improved livelihoods. Improvement in livelihoods and protection against natural disasters and economic shocks are attributable largely to brown economy.

Green economy is employment intensive. In few cases, it can be demonstrated that sustainable mountain development has increased job opportunities, but the real question is who benefits from these jobs. A fair percentage of these jobs are benefitting non-mountain people. MENA Mountains are still a long way from achieving social equity.

The efforts to substitute fossil fuels with renewable energy and low-carbon technologies are only a few (e.g. hydroelectric power generation in Iran and Morocco). Most of the MENA countries are arid. The options are limited to solar and wind energy, the uses of which are not prevalent in most of the mountains.

Green economy does not grow faster than brown economy in the MENA Region. Sustainable mountain development (SMD) had not contributed to overall economic growth.

Oil and gas are finite resources and long term plans for transition to green economy are needed in the MENA Region. Actions needed include (a) regulatory frameworks; (b) a shift in government spending priorities to support green economy initiatives (c) financial incentives to green investment and innovation;

Table 10: Checklist of MENA Mountain Issues Relevant to Rio+20; + signs denote issues that are already receiving attention irrespective of the intensity of activity; - signs indicate areas that need attention									
No.	Countries	Climate	Water and Soil	Wildlife and Nature Resources	Agriculture and land uses	Land Degradation	Mining	Energy	Tourism
North Africa									
1.	Morocco	+	+	+	+	-	+	+	+
2.	Algeria	-	+	-	-	-	+	-	-
3.	Tunisia	-	+	+	+	-	-	-	-
4.	Libya	-	-	+	-	-	+	-	-
5.	Egypt	-	+	+	-	-	-	-	+
Near East									
6.	Israel	+	+	+	-	-	+	-	+
7.	Palestinian Territories	-	+	-	-	-	-	-	-
8.	Lebanon	+	+	+	+	+	+	-	+
9.	Jordan	+	-	+	+	-	-	-	-
10.	Syria	+	+	-	+	-	-	-	-
Gulf Region and Arabian Peninsula									
11.	Iraq	+	-	+	--	-	-	-	-
12.	Iran	-	+	+	+	-	+	-	+
13.	Saudi Arabia	-	+	+	-	+	+	-	+
14.	UAE	-	+	+	-	-	+	-	+
15.	Oman	+	+	+	+	-	+	-	+
16.	Yemen	+	+	+	+	-	+	-	-

- (d) capacity building through training and education;
(e) strong links to international governance.

3.2 MENA mountain issues relevant to Rio + 20

Table 10 below provides a checklist of mountain issues relevant to the MENA mountain region. This compilation is based on the amount of information available and despite this limitation it gives an overview of the present status. This is a two-way table that could be qualitatively analysed in terms of issues and also countries.

In the 16 MENA countries included, issues related to water and wildlife and biodiversity received the best attention (13 countries each) followed by climate, agriculture/land use and tourism (8 countries each). Surprisingly land degradation has not received much attention except in two countries and mining is also of concern to two countries. Energy related issues do not seem to be of much concern to anyone except Morocco.

As justified earlier in this report, mountain issues have

received more attention in seven countries than in others. This is probably a reflection of how important the mountain ecosystems are to socioeconomic well-being of these countries. Again being concerned is not the reflection of success achieved in resolving mountain issues. Eight issues are identified in this report and some issues may not be relevant to some countries.

One important observation while compiling this report is that MENA countries do not have a forum or mountain partnership network to share experiences and lessons learned from tackling various issues in their respective countries. Each country seems to be working in isolation, sometimes in cooperation with international agencies and NGOs. Co-operation and cross-country collaborations within the MENA mountain region seem to be only a few. In the region, there are other initiatives to support marine ecosystem protection, desertification, oil and petroleum sector development and desalination issues. So, the formation of a MENA Mountain Partnership Network seems to be a worthwhile idea and this could be placed under the Mountain Partnership Initiative of FAO/UNEP.

PART 4

References

4.1 Weblinks

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Annexe 1

The Mountain Environment of MENA region

Atlas Mountains^{1, 2}

The Atlas Mountains are a series of mountain ranges in northwestern Africa, running generally southwest to form the geologic backbone of the countries of Maghreb (Morocco, Algeria and Tunisia). They extend more than 2,000 km from Moroccan port of Agadir in the southwest to the Tunisian capital of Tunis in the northeast. These ranges rise high to form a barrier between the Mediterranean in the north and the Sahara in the south. The Atlas mountain system takes the shape of an extended oblong, enclosing within its forms a vast complex of plains and plateaus.

The northern section of Atlas is formed by the Tell Atlas which receives enough rainfall to bear fine forests. From the west to east, several massifs occur. The first of these is Er-Rif which forms a half moon shaped arc in Morocco between Ceuta and Melilla. Its crestline exceeds 1,500 m above sea level at several points, reaching about 2,456 m at Mount Tidirhine. East of the gap formed by the Moulouya River, the Algerian ranges begin. The southern section is the Saharan Atlas and it consists of a central palisade of short ranges, grouped into massifs between two mighty ranges, the High Atlas to the west and the Aurès Mountains to the east. The High Atlas culminates in Mount Toubkal at 4,167 m, the highest point in Atlas Mountains. The Aurès Mountains are formed of long parallel folds which reach a height of 2,328 m at Mount Chélia. The Tell Atlas and the Saharan Atlas merge in the west into the long folds of Middle

Atlas and in the east join together in the Tebessa and Medjerda Mountains.

The seasonal character of the rains which fall in torrents determines the characteristics of the drainage in Atlas. The run-off feeds streams that are of great erosive capacity and form deep narrow gorges. The great Maghrebian wedian (water courses that are dry except during periods of rain) issue from the Atlas ranges. Among the more perennial rivers are the Moulouya which arises from the Middle Atlas and the Chelif which arises from the Amour Mountains. These cause a lot of erosion in the higher altitudes and deposit their loads of silt at the foot of the mountain ranges or else leave a long line of conical deposits known as "dors" (hills).

The Atlas Mountains are the meeting places of two different kinds of air masses, the humid and cold polar air masses coming from the north and the hot and dry tropical air masses moving up from the south. Rain is more plentiful in the Tell Atlas, and more so in the northeast than in the southwest. The highest rainfall is recorded east of the Tell Atlas. Ayn ad-Darahim in the Khoumirie Mountains receives 1,524 mm a year. Nowhere in the Anti Atlas Mountains south of the High Atlas is the total rain fall more than 431.8 mm in a year.

Despite proximity to the sea, the coastal massifs are cold regions. At 2,004 m the summits of Mount Babor in the Little Kybylie region are covered with snow for 4 to 5 months a year while the Moroccan High Atlas retains

snow until the height of summer. Winter in the Atlas is hard, imposing severe conditions on the inhabitants.

In the Atlas Mountains about 101,000 sq km are forested. On Er-Rif, the Kabylie and the Kroumirie ranges moist forests of cork oaks occur. Cane apple (*Arbutus unedo*), heather shrub, rock roses and lavender are found in that area. In areas with less than 762 mm of rainfall with limestone, green oak and arborvitae (*Thuja occidentalis*, a species of cedar tree) occur. Stands of cedar occur at high altitudes. On the dry summits of the Saharan Atlas, the vegetation is reduced to scattered stands of green oak and juniper.

The Atlas Mountains were formed during three phases of Earth's history. The first tectonic deformation phase involves only the Anti Atlas, which was formed in the Paleozoic Era (about 300 million years ago) as a result of continental collisions. The second phase took place during the Mesozoic Era (before about 65 myr) and consisted of a widespread extension of the Earth's crust that rifted and separated the continents of North America, Europe and Africa. This extension was responsible for the formation of many thick intra-continental sedimentary basins including the present Atlas. Most of the rocks forming the surface of the present High Atlas were deposited under the ocean at that time. Finally in the Tertiary Period (about 65 million to about 1.8 million years ago), the mountain chains that today comprise the Atlas were uplifted as the land masses of Europe and Africa collided at the southern end of the Iberian peninsula.

The Atlas Mountains have played an important part in the modern development of Maghrebian countries. The mountain massifs constitute catchment areas with considerable potential. The construction of reservoir or retention dams not only has permitted the storage of enormous amounts of water for irrigating the plains but has also made it possible to generate hydroelectric energy. In Morocco efforts have been made in the last half of the 20th century to exploit the potential of the mountain wadian. In addition to the dams across Wadi el-Abid and Wadi el-Rhira on the northern slopes of the High Atlas, dams on the southern face have been constructed across the Drâa and Ziz water courses. In Algeria, the Kabylie region

has been developed with hydroelectric stations on the Agrioun and Djendjene wadian.

The geological formations of the Atlas are rich in minerals. The Moroccan High Atlas in particular contains important deposits. Among these, the most economically important is phosphate, mined mainly in the Khouribga area. Other major deposits include lead and zinc from the Middle Atlas and the Oujda area, and copper, silver and manganese. Anthracite coal is mined in Oujda. In Algeria, iron ores are extracted from Seba Chioukh Mountains, Mount Zaccar Rherbi, the area near Ouenza and Bou Khadra. Phosphate is mined at Mount Onk and El Kouif. In Tunisia the High Tell Mountains produce phosphate at Al-Qul'ah al Jardâ, iron ore from Mount Djerissa and lead from Sâqiyat Sîdâ Yûsûf.

The Aurès Mountains are part of the Saharan Atlas in northeastern Algeria. They are fronted by rugged cliffs in the north and open out in the south into two parallel fertile valleys of the wadian Abiod and Abdi, facing the Sahara. The highest peaks, which are snowcapped during winter, include Mount Chélia (2,328 m) the highest point in northern Algeria, and Mount Mahmel (2,320 m). The upper slopes are covered with pine, cedar, and oak forests that give way to xerophytic (dry-climate) vegetation on the lower slopes.

Standing alone in eastern Algeria, the Aurès Mountains represent one of the less developed areas in the Maghreb. The Shawia (eastern Berber) population practices traditional transhumance, farming fixed stone terraces in the mountains where they grow sorghum, other grains, and vegetables, but seasonally moving livestock to relatively warm areas in the lowland valleys where they pitch tents or live in other temporary structures and tend livestock through the winter.

Nafusa Mountains and Jabal Akhdar Mountains³

There are two distinct low elevation mountains and surrounding plateaus in Libya. Western Mountain (Nafusa Mountain) in the northwest of Jamahiria, and the green mountain (Jabal Akhdar) in the Northeast. These mountains are composed of lime and sand

stones intertwined with a number of valleys that bring rain water to the north. The rate of annual rainfall in the western mountain region ranges between 200 to 300 mm, while the green mountain receives the largest amount of rainfall ranging between 250 to 600 mm.

The Nafusa Mountains, called the Western Mountains (Al Gabal al Gharbi) are in the western Tripolitania region of north western Libya. These mountains form the boundary between the Libyan coastal plain, known as the Jefara to the north and the Tripolitanian Plateau to the south. The strata of the Tripolitanian Plateau slope downwards to the south and tilt upwards towards the north creating the highest portion of the plateau as the Nafusa Mountains, which rise to over 750 m. The plateau ends abruptly on the north with an escarpment which has up to 350 m of topographic prominence. A series of deep valleys drain north toward the Jefara cut into this escarpment. It extends some 250 kilometres within Libya, from just east of the city of Gheryan, located about 60 km south of Tripoli in the east to the city of Wazzin at the Tunisian border in the west. Spurs and isolated up-thrusts continue into Tunisia, but this region is almost unpopulated, in marked contrast to the situation in Libya.

The mountain area is rarely more than 25 km in depth. The southern boundary is a flat arid plateau some 650 m above sea level and the northern boundary falls below 150 m. This mountain area still shelters most of Libya's Berber-speaking population and has a language of its own, the Nafusi language. The mountain villages raise primarily goats, olives and grains, but also have fig and apricot orchards.

The towns and villages in the Nafusa Mountains and surrounding areas were liberated from control by forces loyal to Colonel Gadaffi in the early summer of 2011. While fierce fighting continued, Berber exhibitions and workshops sprang up to share and spread the Tamazight culture and language after four decades during which there were severe punishments for speaking and writing Tamazight openly (Simpson, 2011).

The Jabal Akhdar (The Green Mountain) is Libya's wettest region. Annual rainfall averages from 400 to

600 millimetres. This mountain is heavily forested and is a fertile upland area. The Jabal Akhdar consists of a mountainous plateau rising to an altitude of 500 m cut by several valleys and wedian. It lies northeast of Benghazi and south of Derna and the Mediterranean Sea. The region is one of the very few forested areas of Libya, one of the least forested countries on Earth. The high rainfall contributes to the area's large forests, and enjoys rich fruit, potato, and cereal agriculture.

The Tibesti Mountains found in the southern portion of Libya are group of volcanic mountains with inactive volcanoes. These mountains are mostly in Chad. This is a very remote area occupied by people called the Tubu. The highest peak in Libya, the Bikku Bitti (2,267m) is found in these mountains.

Mount Sinai⁴

Mount Sinai, also known as Mount Horeb, Mount Musa or Gabal Musa (Moses' Mountain) is a mountain near St. Catherine in the Sinai Peninsula of Egypt. Mount Sinai is 2,285 m high. It is next to Mount St. Catherine (at 2,629 m, the tallest peak in the Sinai Peninsula). It is surrounded on all sides by high peaks of the mountain range. The famous St. Catherine's Monastery is a popular pilgrimage site.

Mount Sinai rocks were formed in the late stage of the Arabian-Nubian Shields (ANS) evolution. Mount Sinai displays a ring complex that consists of alkaline granites intruded into diverse rock types, including volcanics. Generally the nature of the exposed rocks in Mount Sinai indicates that they originated from different depths.

This region is of great importance for the three major religions of the world, namely the Judaism, Christianity and Islam. This is the only place in Egypt where it snows on a regular basis. The snow is the best source of water as it melts slowly, thus releasing water at a steady pace replenishing the downstream catchment areas. Water from the rains tends to flow down fast in the barren mountains resulting in flash floods. Climate change is strongly affecting the area with reduction in snow and rain. The Jabaliya Bedouin of the region have practiced agriculture for ages and are skilled gardeners.

Abarim Mountains⁵

The Highlands of Jordan separate the Jordan Valley and its margins from the plains of the eastern desert; 700 to 1,200 m high plateau forms most of Jordan. This region extends along the entire length of the western part of the country, and hosts most of Jordan's main population centers including Amman, Zarga, Irbid and Karak. The fabled ruins of Jerash, Karak, Madaba, Petra and others are found in the Mountain Heights Plateau. These areas receive Jordan's highest rainfall and are the most richly vegetated in the country. This region extending from Umm Qais in the north to Ras an-Naqab in the south is intersected by a number of wadi. All of these wadi including Wadi Mujib, Wadi Mousa, Wadi Hassa and Wadi Zarqa eventually flow into the Jordan River, the Dead Sea or the Jordan Rift. Elevation in the highlands varies considerably from 600 to about 1,500 meters above sea level with temperature and rainfall patterns varying accordingly. The northern part of the Mountain Heights Plateau, known as the Northern Highlands displays a typical Mediterranean climate and vegetation. This region is known historically as the Land of Gilead and is characterized by higher elevations and cooler temperatures. South and east of the northern highlands are the northern steppes, which serve as a buffer between the highlands and the eastern desert. This high altitude plain receives little annual rainfall and is consequently lightly vegetated.

The summits of the highlands reach 1,200 m in the northern part and 1,700 m in the southern part. The highest peak in the southern region is Jabal Ramm at 1,754 m. The highest peak in all of Jordan is Jabal Umm al Dami at 1,854 m.

The majority of the highlands and interior deserts of Jordan, especially in the north, are composed of limestone. Hard limestone alternates with softer, more easily eroded layers with or without chert beds. The combination of limestone and a humid climate, as in the NorthWest Highlands leads to fertile soils and a rich natural flora. Jordan's best soils are found in these highlands, but increasingly the area is being built on for urban expansion.

Jordan's oldest rocks (Precambrian, 570 myr old)

form the mountains behind Aqaba. They mainly consist of granites, which are crisscrossed with sheets of intruded igneous rock, known as dykes. At the time of dyke formation, the granitic rocks were still deep below the surface. The rocks were affected by great tensional stresses, and the cracks thus created were subsequently filled by molten rock. Today, the dykes form the characteristic dark stripes across the hillsides. Intense fluvial erosion of the Aqaba granites has produced extensive alluvial fans which fill the wadi and mantle the lower hill slopes. With the availability of water supplies at depth beneath these fans, acacia-savannah woodlands have developed in many places.

Copper has been mined at the base of Wadi Dana since time immemorial. Most of the mines are not in operation today and attempts to reopen many of these mines have not been successful.

Judean hills, Golan Heights and Mount Carmel^{6, 7, 8}

Israel, slightly larger than Massachusetts, USA, lies at the eastern end of the Mediterranean Sea. It is bordered by Egypt on the west, Syria and Jordan on the east, and Lebanon on the north. Its maritime plain is extremely fertile. The southern Negev region, which comprises almost half the total area, is largely a desert. The Jordan, the only important river, flows from north through Lake Hule (Waters of Merom) and Lake Kinneret (also called Sea of Galilee or Sea of Tiberias), finally entering the Dead Sea at 411 m below sea level, the lowest land elevation in the world.

The inland area of central Israel is dominated by the Judean Hills of the West Bank, whilst the central and northern coastline consists of the flat and fertile Israeli coastal plain. Inland, the northern region contains the Mount Carmel mountain range, which is followed inland by the fertile Jezreel Valley, and then the hilly Galilee region. The Sea of Galilee is located beyond this, and is bordered to the east by the Golan Heights, which contains the highest point under Israel's control, a peak in the Mount Hermon massif, at 2,224 m. The highest point in Israel's internationally recognized territory is Mount Meron at 1,208 m.

To the north of this region lie the mountains and hills of Upper Galilee and Lower Galilee which are generally 500 m to 700 m in height although they reach a maximum height of 1,208 m at Mount Meron. South of the Galilee, in the West Bank, are the Samaritan Hills with numerous small, fertile valleys, rarely reaching the height of 800 m south of Jerusalem. Also mainly within the West Bank, are the Judean Hills, including Mount Hebron. The central highlands average 610 m in height and reach their highest elevation at Har Meron, at 1,208 m in Galilee near Safed. Several valleys cut across the highlands roughly from east to west; the largest is the Jezreel Valley, also known as the Plain of Esdraelon, which stretches 48 km from Haifa southeast to the valley of the Jordan River, and is 19 km across at its widest point.

Running north to south, the Judaean Mountains encompass West and East Jerusalem, Hebron, Bethlehem and Ramallah. The range forms a natural division between the Shephelah coastal plains to the west and the Jordan Rift Valley to the east. The Judaean Mountains were heavily forested in antiquity. The hills are composed of terra-rosa soils over hard limestone.

Mount Lebanon and Anti-Lebanon^{9, 10}

There are three fundamental divisions of Lebanon; a western Mount Lebanon rising to 3,083 m, a central Bekaa Valley and an eastern Jabal Lubnan al Sharqi or Anti-Lebanon Range with Mount Hermon at 2,814 m. The Bekaa is almost everywhere above 850 m in altitude and this is as high as some of the highest mountains of many countries.

Mount Lebanon is known as the Western Mountain Range of Lebanon. It extends along the whole country for about 160 km, parallel to the Mediterranean coast with the highest peak, Qurnat as Sawda, at 3,088 m. Lebanon has historically been defined by these mountains, which provided protection for the local population. In Lebanon the changes in scenery are not connected to geographical distances, but with altitudes. The mountains were known for their oak and pine forests. Also, in the high slopes of Mount Lebanon are the last remaining groves of the famous Cedars of Lebanon (*Cedrus libani*).

The Anti-Lebanon Mountains is the name for the Eastern Lebanon Mountain Range which is a southwest-northeast-trending range between Syria and Lebanon. Its name, Anti-Lebanon comes from the Greek word for 'opposite'. The majority of this mountain range lies in Syria. The border between Syria and Lebanon is largely defined along the crest of this range. At its southern end it is also within the Golan Heights. The range lies east of and parallel (opposite) to the Mount Lebanon range. To the west are the Beqaa Valley in the north and the Hasbani River valley in the south. These valleys separate it from the Lebanon range in central Lebanon. To the east, in Syria, lies the Eastern Plateau which contains the city of Damascus.

The Anti-Lebanon Range is approximately 150 km in length. To the north, it extends to almost the latitude of the Syrian city of Homs before tapering off. To the south, the range coalesces with the Golan Heights plateau but includes the highest peaks of Mount Hermon (= Jabal el-Shaykh), at 2,814 m, and Ta'la't Musa, at 2,669 m. These peaks are snow-covered for much of the year and are located on the Lebanese-Syrian border. This snow cover may be the origin of the name as L-B-N is 'white' in the Semitic languages, giving the name Lebanon to the country and the mountains.

Israel's longest and most famous river is the 320 km long River Jordan, which rises on the southern slopes of Mount Hermon in the Anti-Lebanon Mountains.

The rivers of Lebanon can be divided into two groups. The first group is made up of the east-west Rivers, mostly cut into steep gorges, which drain Mount Lebanon. The second group is that of the two large rivers of the Bekaa: the Litani, which flows south and eventually cuts through to the Mediterranean and the Nahr al Assi which flows northwards into Syria. The chief natural resource is water. The mountains experience high rainfall, widely over a meter a year in Mount Lebanon, and the porous fractured limestone makes an excellent aquifer which is refilled over spring and early summer by the slow melting of snow. The resulting abundant springs and rivers, unique to the Arab world, gave the country its once abundant forests and legendary fertility. However, due to the steep slopes and the stony, shallow soils this fertility has proved hard to harness for agriculture and

the removal of the forests has tended to produce only short lived farming lands.

The major geological structures of the area, Mount Lebanon, the Bekaa and the Anti-Lebanon are basically two very large NNE-SSW trending anticlines separated by a large syncline. Almost all the rocks in Lebanon are sedimentary rocks and most of these are pale limestones, largely Jurassic and Cretaceous.

Lebanon has limited geological resources. Iron oxides occur locally in the mountains and were some of the first iron ores to be exploited. By the 7th century BC Lebanese iron was being exported to Babylon. Unfortunately iron smelting requires high temperatures and as wood was the only fuel, this resulted in catastrophic deforestation. The limestone has also been used as a building stone and for fertilizer and cement. The last two processes also use wood and have contributed to the deforestation.

An-Nusayriyah Mountains¹¹

An-Nusayriyah Mountains also known as Al-Alawiyeen Mountains and by the Syrian official name, Coastal Mountain Range, in northwestern Syria runs north-south, parallel to the coastal plain. The mountains have an average width of 32 km, and their average peak elevation is just over 1,200 meters with the highest peak, Nabi Yunis, reaching 1,562 m, east of Latakia. In the north the average height declines to 900 m, and to 600 m in the south.

The Jabal an-Nusayriyah, a mountain range paralleling the coastal plain, has an average elevation of just over 1,212 m, and includes the peak Nabi Yunis. The western slopes catch moisture-laden western sea winds and are thus more fertile and more heavily populated than the eastern slopes, which receive only hot, dry winds blowing across the desert. Before reaching the Lebanese border and the Anti-Lebanon Mountains, the Jabal an-Nusayriyah range terminates, leaving a corridor, the Homs Gap through which run the highway and railroad from Homs to the Lebanese port of Tripoli. For centuries the Homs Gap has been a favorite trade and invasion route from the coast to the country's interior and to other parts of Asia. Eastward, the line of An-Nusayriyah Mountains is separated from the Jabal

as-Zawiyah range and the plateau region by the Al Ghab valley, a fertile, irrigated trench crossed by the meandering Orontes River. Inland and farther south, the Anti-Lebanon Mountains rise to peaks of over 2,700 m on the Syrian-Lebanese frontier and spread in spurs eastward toward the plateau region. The eastern slopes have little rainfall and vegetation and merge eventually with the desert.

In the southwest, the lofty Mount Hermon (Jabal al-Shaykh), also on the border between Syria and Lebanon, descends to the Hawran Plateau, frequently referred to as the Hawran that receives rain-bearing winds from the Mediterranean. All but the lowest slopes of Mount Hermon are uninhabited, however. Volcanic cones, some of which reach over 900 m, intersperse the open, rolling, once-fertile Hawran Plateau south of Damascus and east of the Anti-Lebanon Mountains. Southwest of the Hawran lies the high volcanic region of the Jabal al-Druze range, renamed Jabal al-Arab, home of the country's Druze population.

The entire eastern plateau region is intersected by a low chain of mountains, the Jabal ar-Ruwaq, the Jabal Abu Rujmayn, and the Jabal Bishri, extending northeastward from the Jabal al-Arab to the Euphrates. South of these mountains lies a barren desert region known as the Hamad. North of the Jabal ar-Ruwaq and east of the city of Homs is another barren area known as the Homs Desert, which has a hard-packed dirt surface.

Northeast of the Euphrates, which originates in the mountains of Turkey and flows diagonally across Syria into Iraq, is the fertile Jazira region. This region is watered by two tributaries of the Euphrates, the Balikh and the Khabur. The area underwent irrigation improvements during the 1960s and 1970s, and it provides substantial cereal and cotton crops. Oil and natural gas discoveries in the extreme northeastern portion of the Jazira have significantly enhanced the region's economic potential.

The western slopes catch moisture-laden winds from the Mediterranean Sea and are thus more fertile and more heavily populated than the eastern slopes. The Orontes River flows north alongside the range on its eastern verge in the Ghab valley, a 64 km longitudinal

trench, and then around the northern edge of the range to flow into the Mediterranean. South of Masyaf, there is a large northeast-southwest strike-slip fault which separates An-Nusayriyah Mountain from the coastal Lebanon Mountains.

Between the humid Mediterranean coast and the arid desert regions lies a semiarid steppe zone extending across three-quarters of the country and bordered on the west by the Anti-Lebanon Mountains and the Jabal an-Nusayriyah on the north by the Turkish mountain region, and on the southeast by the Jabal al-Arab, Jabal ar-Ruwaq, Jabal Abu Rujmayn, and the Jabal Bishri ranges.

Rainfall in this area is fairly high, with annual precipitation ranging between 750 and 1,000 mm. Most of the rain, carried by winds from the Mediterranean, falls between November and May. The annual mean temperature ranges from 7°C in January to 27°C in August. Because the high ridges of the Jabal an-Nusayriyah catch most of the rains from the Mediterranean, the Al Ghab depression, located east of these mountains, is in a relatively arid zone with warm, dry winds and scanty rainfall. Frost is unknown in any season, although the peaks of the Jabal an-Nusayriyah are sometimes snow covered.

Farther south, rain-bearing clouds from the Mediterranean pass through the gap between the Jabal an-Nusayriyah and the Anti-Lebanon Mountains, reaching the area of Homs and, sometimes, the steppe region east of that city. Still farther to the south, however, the Anti-Lebanon Mountains bar the rains from the Mediterranean, and the area, including the capital city of Damascus, becomes part of the semiarid climatic zone of the steppe, with precipitation averaging less than 200 mm a year and with temperatures from 4°C in January to 40°C in July and August. The vicinity of the capital is, nevertheless, verdant and cultivable because of irrigation from the Barada River by aqueducts built during Roman times.

Zagros and Alborz mountains^{12, 13}

The Zagros Mountains are the largest mountain range in Iran and Iraq. With a total length of 1,500 km from

northwestern Iran, and roughly correlating with Iran's western border, the Zagros range spans the whole length of the western and southwestern Iranian plateau and ends at the Strait of Hormuz. The highest points in the Zagros Mountains are Zard Kurd (4,548 m) and Mt. Dena (4,359 m). The Hazaran massif in the Kerman province of Iran forms an eastern outlier of the range, the Jabal Barez.

The Zagros fold and thrust belt was formed by collision of two tectonic plates-the Eurasian and Arabian Plates. Recent GIS measurements in Iran have shown that this collision is still active and the resulting deformation is distributed non-uniformly in the country, mainly taken up in the major mountain belts like Alborz and Zagros. Stresses induced in the earth's crust by the collision caused extensive folding of the pre-existing layered sedimentary rocks. Subsequent erosion removed softer rocks, such as mudstone and siltstone while leaving harder rocks, such as limestone rich in calcium with remains of marine organisms and dolomite containing calcium and magnesium. This differential erosion formed the linear ridges of the Zagros Mountains. The depositional environment and tectonic history of the rocks were conducive to the formation and trapping of petroleum, and the Zagros region is an important part of Persian Gulf oil production. Salt domes and salt glaziers are a common feature of the Zagros Mountains. Salt domes are an important target for oil exploration, as the impermeable salt frequently traps petroleum beneath other rock layers. The mountains are divided into many parallel sub-ranges varying from 10 to 250 km wide and have the same age as the Alps.

The Kuhrud Mountains form one of the parallel ranges at a distance of approximately 300 km to the east. The area between these two impressive mountain chains is home to a dense human population that lives in the intermediate valleys which are quite high in altitude with a temperate climate. Their rivers, which eventually reach salt lakes, create fertile environments for agriculture and commerce.

The Zagros Mountains contain several ecosystems. Prominent among them are the forest and steppe forest areas which have a semi-arid temperate climate. The annual precipitation there ranges from 400 to 800 mm,

and falls mostly in the winter and spring. The winters are severe, with temperatures often below -25°C. The summer and autumn are very dry. These mountains are home to the Zagros Mountains Mouse-like Hamster (*Calomyscus bailwardi*).

Alborz, also written as Alburz or Elborz is a mountain range in the northern Iran, stretching from the borders of Azerbaijan and Armenia in the northwest to the southern end of the Caspian Sea, and ending in the east at the borders of Turkmenistan and Afghanistan. The tallest mountain in West Asia, Mount Damavand is located in the range. This range is only 60-130 km wide and consists of sedimentary series dating from Upper Devonian to Oligocene, prevalently Jurassic limestone over granite core. Its higher elevations, in the Elburz Range Forest steppe ecoregion are arid with few trees, but its northern slopes, in the Caspian Hyrcanian mixed forests ecoregion are lush and forested.

The Caspian and the inland, or the southern slopes of the Alborz differ markedly from each other in climatic and vegetational aspects. The Caspian slope has a humid climate due to the northerly air movements, enriched with moisture from the sea, which collide with the steep faces of the mountains to cause precipitation. This precipitation amounts to more than 1,000 mm annually in the lowlands of the Gilan region and is even more in higher elevations. This rainfall is enough to nourish a humid forest for the whole length of the Caspian side where the soils are mostly the brown-forest type. The lowest levels of these slopes have luxuriant Hyrcanian forest, the middle levels a beech forest and magnificent oak forests from the elevation of 1,700 m. In some sheltered valleys there are extensive stands of wild cypress. The sheltered valleys near the Safid River constitute the only major olive growing area of Iran.

The southern slopes of Alborz, by contrast, share the arid character of the Iranian plateau. Annual precipitation varies between 280 and 500 mm and is very irregular. The soils are mostly of the type associated with the steppe (treeless, grassy or shrubby) vegetation. These slopes have become more steppe-like ever since the almost complete destruction of the original dry forest of junipers.

The Hyrcanian tigers for which the Caspian forests are famous are now very rare, but other wild cats such as the leopard and the lynx are still numerous in Alborz. The bear, the wild boar, red and roe deer, the mouflon (wild mountain sheep), and the ibex are also present.

While large areas of Alborz Mountains are almost uninhabited, some are being occupied only by nomads and there are still several well-settled districts. Extensive grain cultivation occurs on both slopes. Alpine pastures dotted with flocks of sheep occur in higher altitudes. The land distribution pattern in the Alborz includes a high proportion of peasant ownership. The holdings are often much fragmented.

The wild (natural or original) forests of the Alborz Mountains cover more than 3,000,000 ha, of which some 1,214,056 ha can be exploited commercially for timber and other wood. There are also a few modern coal mines, as well as some deposits of iron and other ores. The most important is the water of the rivers, which is used for irrigation, for generating hydroelectricity and for the use of fast growing urban areas.

Sarawat Mountains¹⁴

The Sarawat Mountains or the Sarat is the mountain range running parallel to the western coast of the Arabian Peninsula and is among the peninsula's most prominent geographical features. The Sarawat start from the border of Jordan in the north to the Gulf of Aden in the south, running through Saudi Arabia and Yemen. The northern half of the range is known as Sarat al-Hejaz, which rarely rises above 2,100 m, while the middle and the southern portions are called Sarat Asir and Sarat al-Yemen respectively and these reach heights of over 3,300 m.

The Hejaz or Hejaz Range of Mountains is located in the Hejaz region, close to the western coast of Saudi Arabia. The western coastal escarpment is composed of two mountain ranges, the Hejaz and the Asir, with a gap between them near the middle of the peninsula's coastline. From an elevation of 2,100 m, the range declines towards the vicinity of the gap to about 600 m. The mountain wall drops abruptly on the western side

toward the Red Sea, leaving little or no coastal plain. The eastern slopes are not as steep, allowing rare rainfall to help create oases around the springs and wells of the wadi.

After Medina, the mountain chain seems to disintegrate until they reappear around Ta'if. Farther south, below Ta'if, there is Asir Province in Saudi Arabia where rugged mountains can reach near 3,000 m, with Jabal Sawda claimed to be the highest at 2,982 meters above sea level. South of Ta'if, the Hejaz which means "barrier" is almost entirely around 2,000-2,600 meters above sea level.

Nearing the Yemeni border, the Sarawat begins to spread into individual peaks, and the Hejaz turns from a cliff to a gradual ascent up to the Yemeni Plateau. All of the mountains over 3,000 m are located in Yemen. The highest is Jabal an-Nabi Shu'ayb, which is the highest peak in the Arabian Peninsula. It is 3,666 m high, located near the capital Sana'a. In Yemen, the Sarawat is divided into the Western and Central highlands, where the western highlands receive plenty of precipitation, more than anywhere else in the peninsula, and the central highlands have the highest mountains in the peninsula. A very dramatic part of the Yemeni Sarawat is the Haraz Mountains, where a few peaks top 3,000 m, but the descents and views from the mountains are staggering; some foothills of the mountains are only at 500 meters above sea level yet their peaks are at 2,800-3,300 m.

Geologically, the Sarawat are part of the Arabian Shield, and are made up mostly of volcanic rock. The western slopes end abruptly near the Red Sea coast, while the eastern side of the mountain range slopes downward more gently and is intersected by wadi that support agriculture, especially in the southern reaches of the Sarawat, where the mountains face the monsoons.

Among the cities located within the Sarawat are the Muslim holy city of Mecca, which is located in a valley in approximately the middle of the Sarawat mountain range, and the Yemeni capital, Sana'a, located near some of the Sarawat's highest peaks.

The Hejaz mountain area includes the Cradle of Gold

(Mahd adh-Dhahab), the only known Arabian source of workable quantities of gold.

The western highlands in Yemen have peaks reaching around 3,000 m with relatively fertile soil and sufficient rainfall. The central highlands are more like a plateau of about 2,000-3,200 m, with rolling hills, small knolls, and some very prominent peaks, but are still relatively more elevated. Less rainfall can be seen in this region, but the summer months give enough to sustain crops.

Aden is nestled in the arms of Jabal Shamsan, Taiz nestles at the base of Jabal Sabir, Hodeidah's Jabal Bura' is renowned for the remnants of its once extensive forest, and every day millions of Yemenis eat *saltah* served in the grey soapstone pots quarried from Jabal Raza' in Sa'adah. Jabal an-Nabi Shu'ayb rises above Sana'a to almost 3,700 m, making it the tallest summit on the Arabian Peninsula. It is these and countless other peaks which give Yemen the moniker, "Roof of Arabia."

The highland regions are interspersed with wadi that are dry in the summer months. Yemen has no permanent rivers. Most notable is the Wadi Hadhramaut in eastern Yemen, the upper portions of which contain alluvial soil and floodwaters and the lower portion of which is barren and largely uninhabited. Both the eastern plateau region and the desert in the north are hot and dry with little vegetation.

The central highlands are drier than the western highlands because of rain-shadow influences, but still receive sufficient rain in wet years for extensive cropping. Its diurnal temperature variations are among the highest in the world; ranges from 30°C in the day to 0°C at night are normal. Water storage allows for irrigation and the growing of wheat and barley while the western highlands are famous for sorghum, coffee, and some tropical fruits like bananas and mangos. The highlands enjoy a temperate, rainy summer with an average high temperature of 21°C and a cool and moderately dry winter with temperatures occasionally dipping below 0°C.

Al Hajar Mountains¹⁵

The Hajar Mountains (Arabic for stone mountains) in

northeastern Oman and also the eastern United Arab Emirates are the highest mountain range in the eastern Arabian Peninsula. They separate the low coastal plain of Oman from the high desert plateau, and lie 50-100 km inland from the Sea of Oman coast.

The mountains begin in the north, forming the Musandam peninsula. From there the Western Hajar (Hajar al-Gharbi) runs southeast, parallel to the coast but moving gradually further away as it goes. The central section of the Hajar is Al Jabal al Akhdar (2,980 m), one of the highest terrains in the country. Jabal Akhdar and the smaller Jabal Nakhl range are bounded on the east by the low Samail Valley, which leads northeast to Muscat. East of Samail are the Eastern Hajar (Hajar as-Sharqi), which run east, much closer to the coast, to the fishing town of Sur, almost at the eastern point of Oman. The mountains extend for 500 km in total. The Oman Mountains have long been known to have more structural and petrological features in common with the mountains of southwestern Iran than with neighbouring parts of Arabia.

Oman's varied and spectacular landscape is a blend of its geological history and its climate over the past few million years. Superb rock outcrops in Al Hajar Mountains, the Huqf and Dhofar are a paradise for international geologists. The rock records span about 825 million years and include at least three periods, namely Paleozoic, Jurassic and Cretaceous, when the country was covered by ice, somewhat surprising given its present latitude and climate. The mountain core is of Mesozoic sediments, in part metamorphosed, uplifted and folded in Oligocene and Miocene times. The geological picture is complicated by the presence of great superimposed masses of igneous rocks, and ophiolite nappes.

The oldest of the rocks of the mountains are igneous and metamorphic. The oldest sedimentary rocks provide evidence of an Ice age that Oman experienced 600 myr ago. The younger sediments of the pre-Permian were deposited as the land drifted northwards to warmer latitudes. The detailed geology of the Al Hajar range and the Dhofar Mountains can be found in Hanna (1995).

Perennial running waters in the mountains are rare. The

major wadi in the region have dams built across to retain the water flowing through during the rains. There are some spring fed wadi flows in some areas. The mountains are an important ecoregion. The climate is cool and wet from December to March and warmer, but still with occasional rain from April to September.

The mountains are rich in plant life compared to most of Arabia, including a number of endemic species. The vegetation changes with altitude, the mountains are covered with shrub land at lower elevations, growing richer and then becoming woodland including wild olive trees between 1,100 to 2,500 m and junipers in elevations higher than 2000 m. Fruit trees such as pomegranate and apricot are grown in the cooler valleys. The flora shows similarities with mountain areas of nearby Iran but also with the continent of Africa, for example the tree *Ceratonia oreoethauma* is found here and also in Somalia. There are many rocky outcrops with little vegetation.¹⁶

The Dhofar Mountains¹⁷

The Dhofar Mountains of Oman is a crescent shaped range of mountains extending some 200 km eastwards from the border with Yemen. The western sector of the range, Jabal Qamr, rises directly from the coast. The central part, Jabal Qara, rises sharply from the flat Salalah plains which separates it from the sea by some 12 km at the widest point. In the east, Jabal Samhan rises gradually from the coast at first, but then rises vertically in a 1400 m escarpment, the highest point reaching over 2000 m. To the north, the mountains give way to gravel hills and desert along the entire range. The top of the range constitutes a relatively flat plateau, for the most part between 700 to 900 m above sea level and some 10-25 km wide. The southern escarpment is dissected by a number of large steep sided wadi, of which some contain water, but most of them only flow after heavy rains.

The main range is composed of Ummerradhuma limestones which are lower Tertiary and Cretaceous in age and lie on a belt of chalky dolomite. This in turn lies unconformably on Infra-Cambrian hard sand stone, overlying basement rock. Caves are commonly formed where the soft strata have been dissolved away. Several of these caves are large and

very old. One such notable cave is the sink hole at Tawi Attair which reportedly has its own endemic fauna. The soils of the plateau are rather shallow, silty to sandy clay up to 60 cm depth (Halcrow, 1975). In areas where the limestone is fissured, deeper soils occur. In many areas the limestone protrudes through the thin soil layer and in the north there are some entire hills of exposed limestone completely devoid of soil cover.

There are no permanent rivers in the area, but there is sustained flow in a few of the main wadian such as Darbat during and immediately following periods of heavy rainfall. Dhofar lies within true monsoon belt and most of the rain falls as drizzle during the summer north-west monsoon in July and August. There are on an average, thirty rain days during these two months. During the rest of the year, heavy showers and occasional cyclonic storms occur particularly in March to May and in October and November. The mean annual rainfall in the region is 100 mm. But historical rainfall data shows enormous variations in precipitation over long periods of time. Jabal Qara receives higher amounts of rains. There is very little temperature and humidity data for the mountain areas of Dhofar.¹⁸

With the exception of the corridor between Jabal Qamr and Jabal Qara and the eastern half of Samhan, the mountains are well vegetated. Thickly wooded southern slopes and wadi sides have trees and shrubs. In some areas the trees occur with a complete canopy. The gentler slopes and the flat tops of the mountains are covered with dense grassland.

Weblinks

1. <http://www.britannica.com/EBchecked/topic/41302/Atlas-Mountains/36950/Climate>
2. http://en.wikipedia.org/wiki/Atlas_Mountains
3. http://en.wikipedia.org/wiki/Nafusa_Mountains
4. http://en.wikipedia.org/wiki/Mount_Sinai
5. <http://en.wikipedia.org/wiki/Abarim>

6. http://en.wikipedia.org/wiki/Judaeen_Mountains
7. http://en.wikipedia.org/wiki/Golan_Heights
8. http://en.wikipedia.org/wiki/Mount_Carmel
9. http://en.wikipedia.org/wiki/Mount_Lebanon
10. http://en.wikipedia.org/wiki/Anti-Lebanon_mountains
11. http://en.wikipedia.org/wiki/An-Nusayriyah_Mountains
12. http://en.wikipedia.org/wiki/Zagros_Mountains
13. <http://en.wikipedia.org/wiki/Alborz>
14. http://en.wikipedia.org/wiki/Geography_of_Saudi_Arabia
15. http://en.wikipedia.org/wiki/Al_Hajar_Mountains
16. http://www.worldwildlife.org/wildworld/profiles/terrestrial/at/at0801_full.html
17. <http://www.fao.org/ag/AGP/AGPC/doc/Counprof/oman/oman.htm>
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Annexe 2

Summary of major mountain projects and stakeholders studying these issues for all 16 MENA Countries

Country	Event/Project	Stakeholders(supporting institutions)
Morocco	Climate Studies	<ul style="list-style-type: none"> University of Marrakesh and CDRT(Centre for Development Research and Training) Centre for Development and Environment (CDE) Swiss agency for Development and Cooperation (CDS)
	Water Crisis	<ul style="list-style-type: none"> Al Akhawayn University in Ifrane, Morocco CNEARC (Centre National d'Etudes Agronomiques des Régions Chaudes)-CICDA (Centre International de Coopération pour le développement agricole) ISIIMM (Institutional and Social Innovation in Irrigation Mediterranean Management) Government of the Kingdom of Morocco World Commission on Water, México
	Snow Sublimation	<ul style="list-style-type: none"> University of Bonn, Germany
	Mountain Geology	<ul style="list-style-type: none"> Institute of Earth Sciences– CSIC, Barcelona, Spain
	Wildlife and Nature Resources	<ul style="list-style-type: none"> WWF(World Wildlife Fund) Mediterranean Programme Office (MEDPO) BMCRif(BarbaryMacaque Conservation in Rif) University of Lincoln, U.K UNESCO(United Nations Education Social and Cultural Organisation) MAB(Man and Biosphere) Botanical Institute of Barcelona (CSIC-ICUB- Spanish National Research Council

	Sustainable development of Rural Tourism	<ul style="list-style-type: none"> University of Derby, UK Al Akhawayn University in Ifrane-Morocco Government of Morocco
	Cultural Diversity	<ul style="list-style-type: none"> The Global Diversity Foundation 2006, UK registered charity Lonely Morocco-Local Organisation National geographic magazine GDF-GobalDiversity Foundation,U.K
	Cannabis Cultivation and trading	<ul style="list-style-type: none"> Clarion University of Pennsylvania, U.S Moroccan People at Rif area
	Renewable Energy Source	<ul style="list-style-type: none"> Michigan technological university, U.S
	Sustainable Regional Development	<ul style="list-style-type: none"> Austroprojekt –Agency for Technical Cooperation Ltd, Austria
Algeria	Mountain mining and geology	<ul style="list-style-type: none"> Ministry of Energy and Mines, Algeria Southwest Missouri State University, USA
	Helping the poor in mountain communities	<ul style="list-style-type: none"> International Fund for Agricultural Development (IFAD) Government of Algeria
Tunisia	Mountain watershed management	<ul style="list-style-type: none"> Centre for Water Research and Technologies, Tunisia
	Mountain and forest area development	<ul style="list-style-type: none"> The Northwest Sylvo-pastoral Development Agency/ Office du Développement Sylvo-Pastoral du Nord Ouest (Odesypano) World Bank Government of Tunisia
Libya	Food security and nutrition in mountain	<ul style="list-style-type: none"> Food and Agriculture Organization of the United Nations (FAO)
	Conservation of biodiversity	<ul style="list-style-type: none"> University of Al-Faateh Government of Libya
	Sustainable development of green mountains, endemic plant species of Al-Jabal Al-Akhdar region (there is a mountain with the same name in Oman)	<ul style="list-style-type: none"> University of Reading Centre for Middle Eastern Plants-Royal Botanic Garden, Edinburgh

	Sufferings of Libyan mountain refugees	<ul style="list-style-type: none"> • Government of Libya • Mountain Berber communities
Egypt	Fog as complementary water resources	<ul style="list-style-type: none"> • Environment and Climate Research Institute, Egypt • National Water Research Centre, Egypt
	Conservation of biodiversity	<ul style="list-style-type: none"> • Egyptian Environmental Affairs Agency (EEAA) • Government of Egypt
	Mountain geology	<ul style="list-style-type: none"> • Cairo University, Egypt
	Tourism	<ul style="list-style-type: none"> • Government of Egypt
	Mount Sinai Controversy	<ul style="list-style-type: none"> • Government of Egypt
Jordan	Climate changes	<ul style="list-style-type: none"> • International Institute for Sustainable Development (IISD), Canada
	Conflicts over Wadi-Rum Reserve	<ul style="list-style-type: none"> • Royal Society for the Conservation of Nature (RSCN)
	Conservation of Blanford's fox	<ul style="list-style-type: none"> • Royal Society for the Conservation of Nature (RSCN), Jordan • University of Science and Technology, Jordan
	Incorporating land use mapping and participation of two mountain areas	<ul style="list-style-type: none"> • International Mountain Society (IMS), Switzerland
	Tourism	<ul style="list-style-type: none"> • Ministry of Tourism (MT), Jordan • World Bank • Rum Tourism Co-operative (RTC), an NGO, Jordan
Israel	Climate Studies	<ul style="list-style-type: none"> • Helmholtz Centre for Environmental Research (UFZ) • Ben-Gurion University of the Negev • The Hebrew University of Jerusalem
	Water Issues	<ul style="list-style-type: none"> • Government of Israel • Mekorot Water Company Ltd (NGO)
	Scorpion Biodiversity at Mt. Carmel	<ul style="list-style-type: none"> • University of Haifa, Israel

	Wildlife Conservation	<ul style="list-style-type: none"> • University of Haifa, Israel • Israel Nature and Parks Authority (INPA) • The Society for the Protection of Nature, Israel
	Ecotourism	<ul style="list-style-type: none"> • Israel Ministry of Tourism • GoEco Volunteers, NGO, Israel
Palestine Territory	Palestine- Israel mountain aquifer water issue	<ul style="list-style-type: none"> • Governments of Palestine • Government of Israel
Lebanon	Water Scarcity	<ul style="list-style-type: none"> • Lebanon Government- Lebanese Ministry of Energy and Water • Regional Water and Environment (ESIB) , Lebanon
	Mountain soil properties study	<ul style="list-style-type: none"> • National Council for Scientific Research (NCSR)
	Isotopic composition of Rainwater	<ul style="list-style-type: none"> • Laboratory of Water and Environmental Science, Lebanon • Lebanese University • Lebanese Atomic Energy Commission
	Conservation of Birds	<ul style="list-style-type: none"> • Society for the Protection of Nature in Lebanon (SPNL),Bieurt,Lebanon • Bird Life International, UK • Local Conservation Groups: Chouf Cedars Nature Reserve Hima Ebel es-Saqi SSG, Ebel es Saqi, Hima Kfar and Zabad Birds
	Threats to Mountain Biodiversity	<ul style="list-style-type: none"> • International Union for Conservation of Nature (IUCN) • Ministry of Agriculture andMinistry of Environment –Lebanon • Food and Agriculture Organization (FAO) • Critical Ecosystem Partnership Fund (CEPF)
	In situ and Ex situ Conservation	<ul style="list-style-type: none"> • Global Environment Facility (GEF) • United Nations Development Program (UNDP)
	Lebanon's Cedar Conservation	<ul style="list-style-type: none"> • American University of Beirut (AUB), Lebanon
	Deforestation	<ul style="list-style-type: none"> • NGO- AFDC (Association for Forest Development and Conservation)

	Mountain livelihood strategies	<ul style="list-style-type: none"> American University of Beirut (AUB), Lebanon
	Rangeland Degradation	<ul style="list-style-type: none"> National Council for Scientific Research (NCSR). National Centre for Remote Sensing, Lebanon
	Sustainable Land Management	<ul style="list-style-type: none"> American University of Beirut (AUB), Lebanon
	Tourism	<ul style="list-style-type: none"> Ministry of Tourism, Lebanon Tour operators or NGOs International Eco-tourism Society(NGO) American development Agency USAID Lebanon Mountain Trail Association(LMT)
	Mountain Terrorism	<ul style="list-style-type: none"> Hizballah's Bekka Organization
Syria	Climate changes	<ul style="list-style-type: none"> United Nations Framework Convention on Climate Change (UNFCCC), Germany Intergovernmental Panel on Climate Changes (IPCC)-Switzerland Ministry of Agriculture and Ministry of Irrigation, Syria
	Water scarcity	<ul style="list-style-type: none"> Syrian Ministry of Agriculture and Ministry of Irrigation
	Changes in grazing areas and feed resources	<ul style="list-style-type: none"> Japan International Research Centre for Agricultural Sciences (JIRCAS) Kyoto University, Japan
Iraq	Conservation of <i>Neurergus microspilotus</i> (Kurdistan newt) in Zagros Mountain areas	<ul style="list-style-type: none"> Razi University, Iran
	Drought impacts and climate changes	<ul style="list-style-type: none"> UNDP FAO
	Biodiversit conservation	<ul style="list-style-type: none"> Government of Iraq
Iran	Climate Studies	<ul style="list-style-type: none"> Payame Noor University (PNU), Iran Centre of Applied Meteorological Researches of Sistan and Baluchestan, Iran.

	Water Issues	<ul style="list-style-type: none"> World Resources Institute, U.S.A UN Development Programme (UNDP) Government of Iran Villagers of Iran mountain area
	Mountain Geology	<ul style="list-style-type: none"> University of California, USA University of Durham, UK University of Kansa, USA Tehran University, Iran Human and Environment R and D Engineering Company (HEENCO), Iran Columbia University, USA Rutgers University, USA
	Mountain soil properties study	<ul style="list-style-type: none"> Shahrekord University, Iran Mc Grill University, Canada
	Conservation of Zargos mountain	<ul style="list-style-type: none"> World Wild Fund (WWF) Global Environment Facility (GEF),USA
	Protection of Mountain Ecosystem	<ul style="list-style-type: none"> Mountain Environment Protection Society (MEPS), Iran
	Study on Calcareous Algae of Zargos Mountain	<ul style="list-style-type: none"> Payame Noor University (PNU), Iran
	Mountain livelihood strategies	<ul style="list-style-type: none"> International Mountain Consultancy Islamic Republic of Iran
	Occurrence of ticks on ruminants of Zargos Mountain	<ul style="list-style-type: none"> Tehran University, Iran
	Sustainable Land Management	<ul style="list-style-type: none"> World Resources Institute, U.S.A
	Tourism	<ul style="list-style-type: none"> Armenian Federation of Alpinism and Mountain tourism, Armenia
Saudi Arabia	Water Issues	<ul style="list-style-type: none"> King Saud University, Riyadh, Saudi Arabia King Abdulaziz University, Jeddah, Saudi Arabia National Centre, US Geological Survey, Reston, USA Food and Agriculture Organization (FAO)

	Forestland degradation and Rehabilitation	<ul style="list-style-type: none"> King Saud University, Riyadh, Saudi Arabia
	Conservation of the Arabian Leopard <i>Panthera pardus nimr.</i>	<ul style="list-style-type: none"> College of Science, King Saud University International Union for Conservation of Nature (IUCN), Switzerland
	Conservation of Mountain Biodiversity	<ul style="list-style-type: none"> Saudi Wildlife Commission World Wild Fund (WWF) Range and Animal Development Centre -NGO, Al-Jouf, Saudi Arabia
	Regeneration and growth of <i>Juniperus roceria</i> Hochst. ex Endlicher	<ul style="list-style-type: none"> King Saud University, Riyadh, Saudi Arabia
	Impact of Climate on Plant Communities	<ul style="list-style-type: none"> Saudi Wildlife Commission
	Ecosystem Assessment in Asir National Park	<ul style="list-style-type: none"> Presidency of meteorology and environment, Kingdom of Saudi Arabia Ministry of Agriculture (MoA), Saudi Arabia
	Development versus Deterioration of Traditional Settlements of Southwest Saudi Arabia	<ul style="list-style-type: none"> King Saud University, Saudi Arabia
	Tourism/Pilgrimage	<ul style="list-style-type: none"> Saudi Government
	Tourism	<ul style="list-style-type: none"> Villagers of Asir Province, Saudi Arabia
UAE	Mining	<ul style="list-style-type: none"> Enviroisk International, Inc., Canada
	Biodiversity conservation in Jabal Hafeet	<ul style="list-style-type: none"> Management of Nature Conservation (MNC), UAE
	Conservation of Wadi Wurayah Mountain protected area	<ul style="list-style-type: none"> Government of Fujairah HSBC Bank Middle East Limited Emirates Wildlife Society World Wide Fund for Nature (EWS-WWF)

	Extinction of the Arabian Tahr	<ul style="list-style-type: none"> • Government of UAE • MAB • WWF
	Geological study on Al-Hajar mountains of UAE	<ul style="list-style-type: none"> • British Geological Survey
	Tourism	<ul style="list-style-type: none"> • Government of UAE
Oman	Climate	<ul style="list-style-type: none"> • Institute of Crop Science, University of Kassel, Witzenhausen, Germany) • Centre for Environmental Studies and Research (CESAR) at Sultan Qaboos University
	Water resource management	<ul style="list-style-type: none"> • Sultan Qaboos University ,Oman- • University of Frankfurt, Germany • Tokyo Metropolitan University
	Mountain Geology	<ul style="list-style-type: none"> • Geological Society of London • University of Oxford • Petroleum Institute, Abu Dhabi • Societe Geologique de France (Geological Society, France) • Geological Society of Oman (GSO) • University of Bern, Switzerland
	Soil Study	<ul style="list-style-type: none"> • Department of Soil Biology and Plant Nutrition, University of Kassel, Germany • Institute of Soil Science, University of Hannover, Germany • Department of Environmental Sciences, University of California Riverside, USA • Gyeongbuk Institute for Marine, Gyeongbuk, Republic of Korea • Organic Agriculture and Agroecosystems Research in the Tropics and Subtropics, University of Kassel, Germany • Department of Biology,Sultan Qaboos University,Al Koud,Oman
	Ecological Adaptations	<ul style="list-style-type: none"> • University of Kassel, Witzenhausen, Germany
	Evaluation of Fruit Production in Mountain Oasis	<ul style="list-style-type: none"> • University of Kassel, Organic Plant Production and Agroecosystems Research in the Tropics and Subtropics, Germany

	Biodiversity and Conservation	<ul style="list-style-type: none"> • Office for Conservation of the Environment, Diwan of Royal Court, Muscat • Government of Oman • University of Nizwa, Oman • WWF • Ministry for Environment and Climate Affairs, Oman • University of Stuttgart, Germany • Institute of Evolutionary Biology, Barcelona, Spain and Sultan Qaboos University, Oman.
	Aquatic Life in Hajar mountain areas	<ul style="list-style-type: none"> • Zayed University, UAE
	Mountain livelihood strategies	<ul style="list-style-type: none"> • University of Gottingen, Germany
	Agro-environmental changes in cropping system	<ul style="list-style-type: none"> • University of Kassel, Organic Plant Production and Agroecosystems Research in the Tropics and Subtropics, Germany
	Sustainable development of Jabal Akhtar	<ul style="list-style-type: none"> • University of Gottingen, Steinstr, Germany
	Tourism	<ul style="list-style-type: none"> • Ministry of Tourism, Oman
Yemen	Climate	<ul style="list-style-type: none"> • Sana'a University, Yemen
	Water resource management	<ul style="list-style-type: none"> • Agricultural Research and Extension Authority (AREA), Yemen • Farmers of Republic of Yemen • Arab Centre for the Study of Arid Zones and Dry Lands (ACSAD), Syria • Ministry of Water and Environment (MWE), Yemen • Water Issues Study Group, School of Oriental and African Studies (SOAS), UK • The Netherlands Climate Assistance Program (NCAP), The Netherlands • National Water Resource Authority (NWRA), US
	Conservation of Biodiversity	<ul style="list-style-type: none"> • World Wide Fund for Nature (WWF) • International Union for Conservation of Nature (IUCN), Switzerland • Wetland International, The Netherlands • Global Environment Facility (GEF), USA • United Nations Development Program (UNDP), USA • National Environmental Protection Council (NEPC), Australia • The International Bank for Reconstruction and Development (IBRD)

	Plant Breeding in Mountain Slopes of Yemen	<ul style="list-style-type: none"> • International Centre for Agricultural Research in Dry Area (ICARDA) • Agricultural Research and Extension Authority, Republic of Yemen
	Impacts of Overgrazing on Al-Sarawat Mountain Slopes	<ul style="list-style-type: none"> • University of King Abdulaziz, Saudi Arabia
	Socioeconomic Factors on Mountain terrace Maintenance in Yemen	<ul style="list-style-type: none"> • International Food Policy Research Institute, USA • The International Fund for Agricultural Development (IFAD)
	Assessment of the coffee industry in Yemen Haraz Mountain	<ul style="list-style-type: none"> • Rural and Agricultural Incomes with a Sustainable Environment (RAISE) IQC-US Agency for International Development
	Role of Terrace Management on Land and Water conservation	<ul style="list-style-type: none"> • International Development Research Centre, Canada





In 1992, at the United Nations Conference on Environment and Development – commonly referred to as ‘Rio 1992’ or ‘the Rio Earth Summit’ – mountains received unexpected high political attention. They were granted a chapter in the ‘Agenda 21’ as fragile ecosystems that matter for humankind.

Since then, efforts by different actors have been undertaken to promote Sustainable Mountain Development. Some of them relate to the above event, others just emerged on their own. However, in view of the UN Conference Rio+20 – United Nations Conference on Sustainable Development in 2012 it seemed relevant to assess and understand what has been achieved by whom and how. It appears equally important to learn what has worked and what has not worked, and why, in order to draw lessons for more effective interventions in future. The anticipation of possible future challenges or opportunities may further help to be better prepared for their management. This will certainly encompass the adaptation to and mitigation of global change as the mainstream concern of the last decade as well as the new, albeit disputed paradigm of a Green Economy. As in the past, major unexpected and unpredictable political, social, economic or technological innovations may overshadow such mainstreams.

The Swiss Agency for Development and Cooperation, committed to sustainable mountain development since many decades, has commissioned a number of regional reports to assess achievements and progress in major mountain regions such as in particular Central Asia, Hindu Kush-Himalaya and the South East Pacific, South and Meso America or the Middle East and North Africa. The Swiss Federal Office for Spatial Development has commissioned - in the context of the Swiss Presidency of the Alpine Convention 2011/12 – a report on the European Alps. In addition, UNEP has facilitated the production of the report on Africa’s mountains and mountains in Central, Eastern and South Eastern Europe; and the Aspen International Mountain Foundation together with the Telluride Institute has prepared a report on the mountains of North America.

The insights gained through these reports, which were presented at the Lucerne World Mountain Conference in 2011, and in which key local, regional and global actors have been actively involved provided the inputs for a mountain section in the outcome document of Rio+20. They are also meant to feed into future global and regional processes, institutional mechanisms, and initiatives that emerge as a result of Rio+20 in support of Sustainable Mountain Development.

