Forests and Climate Change Working Paper 9

Forests and Climate Change in the Near East Region

Forests and Climate Change Working Paper 9

Forests and Climate Change in the Near East Region

Food and Agriculture Organization of the United Nations
Rome, 2010

Table of Contents

Acknowledgements

FAO wishes to express its gratitude to Ahmed El-Baha and Talat Omran of the University of Alexandria for the preparation of the first draft of this report. Pedro Regato is acknowledged for synthesizing and finalizing the document. Mohammed Saket, Susan Braatz, Moujahed Achouri, Jesper Tranberg and Simmone Rose provided valuable comments to earlier drafts. The manuscript was prepared for publication by Simmone Rose.

Foreword

This document is part of the publication series of FAO's Forest and Climate Change Programme. The programme works to strengthen countries' capacities to mitigate and adapt to climate change through actions consistent with sustainable forest management and to promote regional cooperation and international policy development related to forests and climate change.

Climatic changes already have complex effects on the bio-physical processes that underpin natural ecosystems, with positive and negative impacts. In arid regions, such as the Near East countries, rising atmospheric CO2 concentration, higher temperatures, changes in annual and seasonal precipitation patterns and in the frequency of extreme events such as droughts and forest fires are severely impairing the production, quality and stability of agriculture, forests and other natural ecosystems. Climatic variations have consequences for the availability of water resources in the region, crop yields, the spread of climate sensitive diseases such as malaria, an increased risk of extinction of plant and animal species, increased susceptibility to infection by pests and diseases as well as desertification of soil, leading to significant changes in the conditions for forests, agriculture and livestock production in the region. In extreme cases, the degradation of forest and agricultural ecosystems has led to desertification and resulted in the loss of the productive capacity of the land. The aridity of the region and the low forest cover coupled with the high deforestation rates in some countries make forests, other natural ecosystems and agricultural land more vulnerable to the negative consequences of climate changes.

The primary objective of this document is to provide an overview of the actual and potential impact of climate change on forests and forest dependent people in the Near East region, of climate change mitigation opportunities in the forestry sector, and of needs for effective national and regional responses.

The study examines the major issues and developments related to climate change impacts and responses in the region as regards forests and highlights related opportunities for regional action to address gaps and needs. FAO is working through its Regional Forestry Commissions as well as other regional and sub-regional processes to encourage regional cooperation in the area of forests and climate change.

This publication is intended to provide a point of departure for identifying and catalyzing regional action to complement and enhance national efforts. The publication will be of interest to specialists and policy-makers in forestry and climate change in the Near East region as well as forest managers, students and general audiences interested in learning more about forests and climate change in the region.

Susan Braatz
Senior Forestry Officer, Forests and Climate Change
Forest Conservation Team
Forest Assessment, Management and Conservation Division
FAO Forestry Department

1. Forests in the Near East

The geographic context

This analysis of forests and climate change in the Near East region covers 24 countries : Afghanistan, Algeria, Bahrain, Cyprus, Egypt, Iraq, Islamic Republic of Iran, Israel, Jordan, Kingdom of Saudi Arabia, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Occupied Palestinian Territories, Qatar, Sudan, Syria, Tunisia, Turkey, United Arab Emirates and Yemen.

Because of the dominant desert conditions in most of the region, the extent of the potential forestland in the Near East is rather low. According to the 2005 Forest Resource Assessment, forestland covers less than 6% of the region, with an estimated total of 195 million hectares in 2005 (about 3% of the world forest area) - of which 11 million ha. are plantations (8 M ha are productive plantation, and 3 M ha are protection plantations, [Annex 1]). Other woodland areas cover an additional surface of about 60 million ha. Of the 24 countries included in this report, only four have a forest cover exceeding 10% of country area: Sudan (28.4%), Cyprus (18.9%), Lebanon (13.3%) and Turkey (13.2%). Four countries have a forest cover of 5 - 10% -Morocco, Israel, Tunisia and Iran. The totality of the forest area in part of the Gulf countries - Bahrain, Kuwait, Oman, Qatar, the United Arab Emirates- Egypt and Libya are tree plantations. Plantations also represent a significant component of the total forest cover in Israel (59.1%), Syria (57.3%), Jordan (47.6%) and Tunisia (47.2%).

The Near East forest ecosystems

The Near East falls within 5 different bio-climatic regions. It occupies the southernmost limit of the cold and humid Euro-Siberian region, in the Black Sea coastal mountains of northern Turkey and in northern Iran; the southern part of the summer drought-prone Mediterranean region, extending all along the coastal lowlands and mountains of North Africa and the Near East; a large part of the cold and dry Irano-Turanian region, covering most of Iran, inner Anatolia, inner Syria, Iraq and part of Jordan; the hyper-arid Saharo-Arabian region, covering all the desert land from Morocco to Iran; and the north-eastern part of the sub-tropical Sudano-Zambezian region, in Sudan and the southern part of the Arabian Peninsula.

This variety explains the high diversity of forest types that characterises the region:

- The Euxin-Hyrcanian humid forests in the Black Sea coastal mountains of northern Turkey and the Caspian coastal mountains of northern Iran are mainly characterised by broadleaf deciduous trees. At lower elevations, oaks (i.e. *Quercus petraea, Q. robur, Q. pontica, Q. castaneifolia*), hornbeam (*Carpinus betulus*) chestnut (*Castanea saliva*), and several maple and lime trees predominate, while the oriental beach (*Fagus orientalis*) characterises the upper zones (and *Quercus macranthera* up to 3,000 m in northern Iran). Fir, spruce and pine conifer forests (*Abies nordmanniana, A. Bornmuelleriana, Picea orientalis, Pinus sylvestris*) are also found in the mountains of northern Turkey. Numerous tertiary relics occur in these forests. These include deciduous trees, like *Zelkova carpinifolia, Pterocarya fraxinifolia, Parrotia persica,* and evergreen shrubs, like *Rhododendron ponticum, Laurocerasus officinalis,* and *Buxus colchica*. The mountains of Iran are home to limited extents of tertiary relics like *Cupressus sempervirens* and *Thuya orientalis.*
- The Mediterranean forests in North Africa and the Levant region are characterised by evergreen broadleaf and conifer trees. In the driest and warmest Atlantic lowlands of south-western Morocco (extending into Algeria) the argan tree (*Argania spinosa*) predominates, together with *Acacia, Prosopis* and *Hyphaene* species. Carob (*Ceratonia siliqua*), wild olive (*Olea europaea*), araar (*Tetraclinis articulata*) Aleppo pine (*Pinus halepensis*), holly oak (*Quercus coccifera*), juniper (*Juniperus phoenicea*) and pistacia (*Pistacia atlantica*) trees are typical of the coastal and inner dry lowlands. Mid elevations are characterised by a mix of evergreen oaks (*Quercus ilex*; *Q. suber* in the western part of the region), deciduous oaks (Q. faginea, Q. canariensis, and Q. afares in the west; *Q. infectoria, Q. libani, Q. Pseudocerris, Q. ithaburiensis* in the east) and conifers (*Pinus pinaster* in the west; *P. brutia, Cupressus sempervirens* in the east). The high mountain forests host relic endemic conifers with a narrow distribution (*Cedrus atlantica, Abies maroccana, A. numidica, Pinus mauretanica*,

Juniperus thurifera in the west; *Cedurs libani, C. brevifolia, Abies cilicica, Pinus pallasiana, Juniperus excelsa* in the east).

- The cold and dry high plateaus and mountains of inner Anatolia and Iran are characterised by deciduous oaks (*Q. brantii, Q. infectoria, Q. pubescens, Q. persica*) and juniper trees (*Juniperus excelsa, J. oblonga, J. phoetidissima, J. polycarpos*). Lower elevations host almond (*Prunus amygdalus*), *Pistacia* and *Pyrus* species.
- The desert and semi-desert lands are characterised by the presence of scattered trees and stands of Acacia (i.e. *A. tortilis, A. ehrenbergiana, A. nilotica, A. seyal A. radiana, A. mellifera), Balanites aegyptiaca, Commiphora africana, Cassia acutifolia, Maerua crassifolia, Prosopis africana, Salvadora persica, Populus euphratica*), which mainly grow along wadis or in savannah woodlands of Sudan. Few tertiary relics, like *Cupressus drupeziana* and *Olea laperrini* occur in the form of scattered trees in the Saharan Mountains. Palm tree (*Phoenix dactilifera*) groves are typical of the oasis systems.
- In the mountains of the southern Arabian Peninsula, the lower elevations are characterised by *Acacia* and *Commiphora* deciduous woodlands, including the economically valuable *Boswellia papyrifera*. Mid altitudes have *Olea Africana* and *Tarchonanthus camphoratus* woodlands, and the higher altitudes are hope to juniper forests (*Juniperus procera*). *Aloe* species occur in dry, barren slopes.
- High rainfall savannah woodlands only occur in Sudan and are characterised by *Khaya senegalensis*, *Combretum hartmannianum*, *Parkia africana*, *Daniellia oliveri*, *Isoberbinia doka* and *Anogeissus leiocarpus*.
- Mangrove forests are found in some areas along the Red Sea coast of Egypt and Sudan, the Arabian Peninsula, Kuwait and Iran. Due to the arid conditions of the region, the species diversity and forest complexity is very reduced, and mainly consists of narrow stands of *Avicenna marina* or *Rhizophora mucronata* in tidal areas, seasonal river mouths and offshore islands.
- Riparian forests occur in all bio-climatic zones, and play a key ecological role. They guarantee best water flow regulation, better water quality, and minimise the occurrence and damage of fast-flood risk, especially in dry regions with torrential watersheds and high erosion risk. Numerous habitat types characterise permanent and ephemeral rivers, endorheic freshwater and brackish basins, coastal wetlands and mountain lakes. Many riparian zones have acted as refugia for the tertiary relics that characterised the Near East forest ecosystems (i.e. *Phoenix theophrasti, Pterocarya fraxinifolia* and *Liquidambar orientalis* in southern Anatolia; *Rhododendron ponticum* and *Prunus laurocerasus* in Northern Anatolia; *Prunus lusitanica, Betula pendula* subsp. *fontqueri, Frangual alnus* subsp. *baetica, Laurus azorica, Fraxinus dimorpha* in The Rif and Atlas mountains of Morocco) (Quézel & Médail 2003).

As a result of the intensive transformation of lowlands into agriculture land since ancient times, nowadays the region's forests are mainly found in mountain areas. Lowland forests only survive in those areas that are unsuitable for agriculture, like the southern Morocco coastal plains, abrupt coastal zones, the savannah woodlands of Sudan and wetlands.

Biodiversity values

Most the Near East forests are considered globally outstanding and critically endangered from the biodiversity point of view. They are well represented in four biodiversity hotspots: Mediterranean Basin, Caucasus, Irano-Turanian, and Horn of Africa (Myers *et al*. 2000), and in five Global 200 Ecoregions: Mediterranean Forests, Woodlands and Scrub; Caucasus-Anatolian-Hyrcanian Temperate Forests; Arabian Highland Woodlands and Shrublands; Sudanian Savannas; South-Sahelian Flooded Grasslands and Savannas (Olson & Dinerstein 2002).

The Mediterranean Forests, Woodlands and Scrub ecoregion has the highest global rate of plant endemism - about 12,000 species, corresponding to almost 50% of the regional flora - after the Tropical Andes (Myers *et al.* 2000). The mountain forest landscapes of the Rif, the Middle and High Atlas (Morocco), the island of Cyprus, the Taurus and Amanus Mountains (Turkey), and Mount Lebanon all have plant endemism rates higher than 20% (Médail & Quézel 1997). The mountains around the Mediterranean Basin are home to 36 endemic conifer species and subspecies with a narrow

distributional range. About 15 conifers and 24 broadleaf trees from the Mediterranean portions of North Africa and the Middle East are included in the 1997 IUCN Red List of Threatened Plants (Walter & Gillett 1998). Lower rates of plant endemism occur in the southern mountains of the Arabian Peninsula (2750 species), the Irano-Turanian region (2500 species) and the Caucasus (1600 species)[1].

Most Near East forests also harbour a remarkable concentration of economically important plants, particularly wild crop relatives, such as wheat, rye and barley, as well as nuts and fruits like pistachio, olives, walnuts, chestnuts, almonds, apricots, pears and apples.

As far as the fauna is concerned, the Near East forests are a crossroads of palearctic species such as the brown bear, the lynx, the chamois and the wolf and more sub-tropical species, including the mountain gazelle, several leopard subspecies, the striped hyena, and the jackal (Regato 2001). Only a few large mammals are endemic to the Near East: among these, the Barbary Ape in the Rif and Atlas mountains of Morocco and Algeria; the Barbary Deer (*Cervus elaphus barbarus*) in the coastal mountain forests between Algeria and Tunisia; several subspecies of mouflon (*Ovis orientalis*) in Cyprus and Iran; the Turkish chamois (*Rupicapra rupicapra asiatica*); the almost extinct Arabian tahr (*Hemitragus jayakari*) in Oman and United Arab Emirates; and several subspecies of the Atlas Barbary sheep (*Ammotragus lervia*) in North Africa and Sudan.

The Near East forests contain significant numbers of breeding bird species and millions of birds pass through major migration routes in north-western Anatolia and the Mediterranean.

Environmental Services

Provisioning Services

Grazing is an important practice in the Near East forests, and its economic significance may be higher than that of wood (WFPs) and other non-wood (NWFPs) forest products. This is especially true in the Maghreb countries, where the grazing economic values are highest – $US 95/ha in Tunisia, $US 42/ha in Algeria and $US 36/ha in Morocco (Croitoru 2008). If properly integrated in the management of forestland, grazing can play an important ecological and socio-economic role (Papanastasis 2009) in all these countries. Unsustainable grazing practices have reduced significantly the fodder production value in West Asia, and they are compromising the grazing potential in many forest areas of North Africa.

Fuelwood and charcoal are the most important wood products in the Near East, and their volume of production is about two-thirds that of all industrial wood products (FRA 2005). These commodities meet important energy needs of the rural populations.

When it comes to roundwood, only Turkey and, to a lesser extent, Iran and Sudan, produce significant quantities (FRA 2005). These three countries account for 96% of the region's total roundwood production. All the countries of the region are largely dependent on imports for meeting their needs for wood and wood products. Even Turkey, which has the largest forest area in West Asia, imports approximately 1.75 million m^3 of roundwood each year. There are no or few statistics regarding the contribution of forest products to the GDP of the Near East countries, as more attention is given to agricultural products.

The Near East forests provide a wide range of non-wood forest products (NWFP) - including medicinal and aromatic plants, fruits, honey, mushroom, gum, dyes, fodder, and game - that make up an important share of the local economies, although their production is hard to quantify. These products supply household needs and are a source of supplementary income. In some cases, NWFP also contribute to the national economies, and in countries like Yemen and Iran, the revenues from the exports of NWFP exceed those from wood products exports. Some examples of NWFP with high economic value are:

- Cork (*Quercus suber*) plays a significant role in the forest economy of the Maghreb countries. It generates 7% of the total economic value in Tunisia with a benefit of about €200/ha, and provides an annual income of approximately €10m to rural communities in Morocco, representing 30% of the total income from forest products (Merlo & Croitoru 2005).
- The Argan (*Argania spinosa*) is a spiny, evergreen tree endemic to Morocco. Argan woodlands cover an area of approximately 820 000 ha. in southwest Morocco - a

[1] www.biodiversityhotspots.org

desertification-prone region where rainfall hardly exceeds 300 mm/year (Moussouris & Regato 2002). Argan woodlands are managed for oil production, pasture and fuelwood, and they ensure the subsistence of 2 million rural Moroccans. Despite the protection status, which regulates the rights of use by local people since 1925, Argan woodlands are being increasingly degraded. Unsustainable wood collection, fruit gathering and grazing magnify the natural regeneration problems. The regression of Argan woodlands is estimated at a minimum of 600 ha./year. The sound management and conservation of this unique ecosystem is of outmost importance, as its further degradation could have adverse effects on the livelihoods of millions of people.

- The estimated value of stone pine nuts (*Pinus pinea*) In Lebanon exceeds €350/ha over the entire forest area, although this data is certainly over-estimated (Merlo & Croitoru 2005). In Tunisia, the traditional cuisine includes the use of flour from Aleppo pine seeds (*Pinus halepensis*) (Torres *et al.* 2008). This flour is used to prepare custard, ice creams, yogurts, and other specialities, and is prepared from the whole seeds (including the hard shell). At present, there are approximately 297 000 ha. of Aleppo pine forest in Tunisia - 35% of the country's forest area (DGF 1995) - but only 152 000 ha. are actually exploited. The annual production of Aleppo pine cones ranges from 450 to 600 tonnes and represents approximately 1.8 million Tunisian Dinars (just over €1 million). There are approximately 3 000 families that collect and process Aleppo cones and the revenue per season is around 600 Dinars.
- Turkey exports approximately 28 000 tonnes of medicinal and aromatic plants per year, the equivalent to $US 50 million in foreign currency. The trade of bulbous plants for horticultural purposes is another important component of the NWFP related economy of the country. The data from Lange & Schippmann (1997) indicate that Turkey is the third largest exporter of medicinal plants of wild origin, after China and India.
- Turkey ranks among the top five countries in chestnut (*Castanea sativa*) production. The product is mainly consumed locally, and only a small portion is exported, mainly to other countries of the Middle East (Özkan & Acar 2000).
- The tragacanth gum is an important commercial gum produced by several shrubby plants of the genus Astragalus, particularly in Iran and Turkey (Anderson, 1989). The exudate is produced spontaneously on the bark of the shrub, but the yield is often increased with artificial incisions. About 70% of the supplies of tragacanth gum originate from Iran, but small quantities are also produced in Afghanistan. Iran's average annual production potential is estimated at 400 tonnes and in 1988 export was 142 tonnes which increased to 257 tonnes in 1990. Tragacanth gum is mainly exported to the EU, US, Japan and the countries of the former Soviet Union.
- *Boswelia papyrifera*, the source of frankincense, is an important species from both economical and ecological perspectives in Yemen and Sudan. Frankincense is used in the manufacturing of varnishes, adhesives, fumigation powders, and dye. It is also used as a flavour in bakeries and other food industries - from dairy products to alcoholic and soft drinks (Gebrehiwot *et al.* 2003). The distinctive flavour of frankincense also makes it valuable for chewing gum industries. Frankincense is an important source of income, contributing significantly to many rural households in the region. Marketing studies should be encouraged, in order to sustain the export sales and income generated by this commodity. Improvements of tapping practice and strict regulations are also required to minimize damage to trees and seedlings during incense harvesting.

Regulating Services

The Near East forests and trees play an important role in land stabilization, watershed protection, desertification control, air quality and microclimate. A good example of climate regulation is found in the forested mountains bordering the arid coasts of the Arabian Peninsula, which show an outstanding capacity to intercept fog water and perhaps triggers rainfall and produce a humid microclimate.

The Near East is mostly characterised by water stress climate conditions and soils susceptible to erosion, foods and landslides. In such extreme environments, forests play a particularly important role in protecting water supplies, purifying water, regulating water flows, and conserving soil. The estimated value of watershed protection range from about €20/ha of area covered by Saharan acacias

to about €38/ha of are covered by Mediterranean forest types in Morocco, Tunisia and Algeria (Merlo & Croitoru 2005). In general terms, watershed protection benefits tend to be high in the Near East, and in several countries like Syria they account for more than the 50% of the total economic value (Croitoru 2008).

Supporting Services

Forests play an important role in storing carbon in soil and forest biomass. In the Near East countries, many forest areas are sources of carbon rather than sinks due to the combination of slow forest growth and strong human pressure. For instance, net carbon losses in Algeria, Morocco and Lebanon vary from 0.08 - 0.53 tC/ha/yr, with an economic loss of $US 3 - 14/ha (Croitoru 2008).

Trees outside forests (agriculture and pastureland) improve the microclimate through decreased evaporation and a reduction of wind speed, improve soil conditions and provide water protection. Integrated tree-crop-livestock management systems using nitrogen-fixing species such as *Acacia* and *Prosopis,* for instance, help restore soil fertility and physical properties, and decrease erosion and desertification (Zaroug 1984). Shelterbelts and windbreaks protect lands and improve agricultural crop production, e.g. in West Nubariah, a newly reclaimed desert area in Egypt, field windbreaks increased the yield of cereals by 10 - 15% more than in the open field (Khalil, 1982). Wind speed was also notably reduced, with a maximum reduction at 1 - 4 times tree height. In arid areas where grasslands do not provide adequate feed year round, tree fodder is a critical source of green fodder during the driest seasons.

Cultural Services

Recreation and landscape quality have always been remarkable benefits of Mediterranean forest landscapes. Their importance has increased significantly over the last decades as a result of the population growth and increased demand for tourism, especially in coastal and mountain areas.

Sacred forests, like the khaloas in North Africa, are a frequent feature of the Near East landscapes. Besides their faith value, these forests hold an important role for ecosystem management and biodiversity conservation, acting as recruitment areas for seed dispersal birds that support the renovation of surrounding ecosystems (Regato & Salman 2008). In some regions, they also represent the sole example of undisturbed habitat, and key reference ecosystems for ecological restoration work.

The socio-economic context

The main designated functions of the Near East forests are protection, multipurpose and production (FRA 2005). Protection forests represent 40% to 100% of the total forest area in countries like Libya, Kuwait, Bahrain, Iraq and Algeria. Production forests make up more than 75% of the total forest area in Oman, Lebanon and Turkey. Forests with a multipurpose function occupy 30%-100% of the total forest area in West Asian countries like Saudi Arabia, Yemen, Syria, Jordan, Iran and Israel.

Forests and trees provide subsistence for the local populations and are deeply integrated into the fabric of rural societies in the Near East. A wide range of wood and non-wood forest products support the livelihood of millions of people and are the basis for small-scale enterprises, which provide income and employment to rural people, especially women. In arid countries with low-forest cover, trees and shrubs can enhance the productivity of agricultural and livestock systems and, at the same time, provide multiple environmental services, which contribute to sustainable rural development.

Women are heavily involved in agriculture, pasturage, fuelwood collection, and the harvesting of NWFPs in most of the Near East. They are the main labour force in tree nurseries, and their role in forestry and agriculture is expected to grow further due to population increase, environmental changes, and internal and international male migration. Yet, the growing role of women in food security and agriculture, and more in general in the overall economy of the Near East, is still broadly under-recognized.

Ownership Patterns and Land Tenure Systems

Most forestland in the majority of the Near East countries is state owned, and communal and private forests only exist on a small scale (FRA 2005). Private forestland represents a significant percentage in Yemen (80%), Lebanon (60.3%, mostly owned by religious groups), Egypt (50%), Cyprus

(38.8%), Algeria (16%) and Libya (16.1%). According to the Global Forest Resources Assessment (2005), other kinds of ownership only exist in Yemen (15%), Jordan (14.5%), Morocco (2.7%) and Lebanon (1.5%), most probably referring to communal forestland.

However, communal property rights used to be the dominant type of forestland ownership before the colonial era. These systems were based on the set up of specific user groups who agreed on flexible rules, and their access was often granted through alliances and socio-political negotiations that served the interest of all partners. In Yemen, for example, certain communities still manage forestlands as a common property, according to sets of traditional rules and rights. Another communal management system of pastures and forestland is the *hima,* which consists of a set of rules for the sustainable use of pasture and forestland in a territory utilised by one or more pastoralist communities (i.e. tribes or villages) (Borrini-Feyerabend *et al.* 2007). The *hima* rules bind all the members of the community and specify the areas where grazing is allow all year around, those where grazing is only allow under exceptional conditions (i.e. drought periods), and those reserved for beekeeping the protection of forest which are held under common property. Those committing offense against the *hima* rules have to pay a fine and are subject to social sanctions.

After the collapse of the communal ownership system, users rights and tenure of forests and pastureland were poorly defined in the region. The public sector, which currently holds the ownership of most forestland –up to 100% in the Gulf countries- often disregards the livelihoods of local communities and marginalized groups, who depend directly on forests and their products (food, fodder, fuelwood, medicines). The lack of participatory planning and management, including insufficient access to forest lands, involvement in participatory approaches, unclear land ownership and land-use rights generated conflicts between the forest dwellers and the administrative authorities, illegal harvesting of forest products, and unsustainable use of forest and pasturelands.

All these factors have been a major obstacle in the sustainable management of non-wood forest products, and in the growth and consolidation of NWFP as an important source of income for the communities living in or around forest areas throughout the region. This is particularly unfortunate if we keep in mind that, because of the climatic and ecological constraints that limit the value of most Near East forests as a source of timber and wood products, NWTP could potentially play a major role in the development of a sustainable economy linked to forest management and conservation.

Although the Near East region was predominantly pastoralist (raising sheep, cattle, camels) in the past, over time most herders have settled into agro-pastoralist rural households, which combine crop production and livestock raising in vast land areas with usually low carrying capacity. Farmers and herders with a subsistence economy are the main direct users of forestland, namely for grazing, fodder and fuelwood collection. Moreover, the collection of several NWFPs often represents an important complementary source of revenues. The least developed countries in the region, such as Sudan and Yemen, have the highest proportion of rural population, ranging from 60% to 74% (Christensen & Veillerette 2007). At the other end of the scale, Lebanon's rural dwellers represent only about 12% of the country's population.

Despite migration and declining population growth rates in absolute terms, the rural population in the region increased by 17 million between 2000 and 2004 (Christensen & Veillerette 2007). This increase - in light of the scarcity of land and off-farm employment opportunities - has likely contributed to the conversion of forestland into farm plots and to increased numbers of poor people. Rural poverty rates are greater than urban poverty in the Near East countries, and often greater than 20% (Iqbal 2006). The nomadic life style, the isolation, and the inordinate time spent by women and children in fetching water and fuelwood represent a distinct gender disadvantage to reach primary education, gender equality and health care in these regions.

Rural households tend to rely heavily on climate-sensitive resources and activities such as local water supplies, arable farming, livestock husbandry and fuelwood collection. Climate change impacts will surely reduce the availability of these local natural resources, limiting the options for rural households that depend on forest commodities for consumption or trade. When livelihood options are reduced due to climate change people leave resource-dependent rural areas and create new migration patterns, looking for new land for crops and forest conversion (Hertel & Rosch 2010). Rural development policies and strategies under a climate change scenario will need to strengthen the capacity of local communities and institutions to undertake adaptation.

Trends in forest and land use in the region

According to the WWF analysis of global patterns of biodiversity on Earth[2], the Mediterranean Basin and West Asia have a very high percentage of critical/endangered ecoregions[3] - 71% and 78% respectively- while the rest are classified as vulnerable.

The state-owned regime for forest and pasturelands and the settlement policies imposed by many national governments in North Africa and West Asia after the colonial period, for instance, have severely disrupted mobile transhumant and nomadic livelihoods. These changes have brought extensive conflicts between pastoral groups and the public administration (Borrini-Feyerabend *et al.* 2007). The expropriation of common lands and their distribution among private individuals has brought to the conversion of important grazing grounds to agriculture - especially in lowlands. Herders have been forced to shift to a more sedentary way of life, and the subsequent lack of control and management rules on the resources previously managed at the communal level has lead to the over-exploitation of pastoral and forest resources all year around.

In addition to the collapse of the communal systems, a suite of inter-related factors stemming from poor forest sector governance are behind forest degradation and loss in the Near East region. These include:

- Complex, inefficient decision-making systems and lack of resources at all levels to ensure compliance with forest policies;
- Lack of institutional capacity at the level of government agencies, including inadequate manpower, skills, equipment and financial resources to implement and enforce laws;
- Scarce cross-sector collaboration, and inadequate mechanisms for inter-agency policymaking, planning and implementation;
- Inappropriate data/Information management;
- Lack of transparency, especially in decision-making processes and the provision of information to stakeholders on use rights, management planning and harvest.

Forests in the Near East are seriously impacted by the absence of adequate management and the unsustainable use of their natural resources, with severe negative effect on the natural forests and rangelands. Overgrazing, illegal logging and the irrational collection of fuelwood and forage wood due to bad management practices, excessive livestock numbers and sedentarisation of nomadic people in mountain areas are a major cause of land degradation. The lack of fuel and alternative energy sources has doubled or tripled fuelwood consumption in many forest regions of North Africa, Northern Anatolia and Iran. The irrational collection of wood often entails mutilating trees and scrubs and thus favours the spread of pests, one of the main reasons behind the increase of forest dieback events in the last decades. Diebacks especially affect conifers in mixed mountain forests (i.e. cork oak forests and cedar trees in mixed – *Cedrus atlantica* and *Quercus ilex*- and monospecific forests in Algeria and Morocco; oak and pine forests in Turkey; juniper and fir forests in Lebanon; juniper forests in Saudi Arabia, Oman and Yemen) (Allen *et al.* 2009). Moreover, stands of relic forests and unique tree species, like the dragon tree (*Dracaena cinnabari*) in Socotra and the relic cypress trees in Morocco (*Cupressus atlantica*) and Algeria (*C. dupreziana*), are increasingly becoming over-mature with little regeneration.

Overgrazing and wood collection for forage have strongly reduced the overall productivity and species diversity of natural pastures (Schlecht *et al.* 2008) - leading to significant soil erosion and land degradation rates. The abandonment of traditional rangeland conservation systems like the *hamiyaat* and *hima* in West Asia, has led to increased grazing pressure and further loss of suitable habitat for wildlife, namely for wild ungulates like *Hemitragus jayakari* in Jabal Al Akhdar (Insall 1999). Moreover, factors such as poaching, grazing competition, feral dogs, and pathogens from livestock pose significant problems to wildlife in many regions, and are particularly serious in politically instable areas, such as southern Sudan. In the mountains of Yemen, hunting with firearms and large numbers of domesticated and feral dogs has increased pressure on wildlife: more and more leopards are captured for sale to zoos, and for use in traditional medicine (Lagrot & Lagrot 1999).

[2] www.worldwildlife.org/science/ecoregions

[3] Ecoregions as the unit of scale for comparison and analysis. Ecoregions are large areas of relatively uniform climate that harbour a characteristic set of species and ecological communities.

The over-collection of plants and wildlife also has a major impact on biodiversity. The collection of wild bulbs in the mountains of Turkey, for instance, exceeded 60 million per year in the 80s of the 20th century, a quantity which is far from a sustainable level (Atay, 2000).

Unsustainable land-use practices cause important erosion problems and prevent forest regeneration in large areas. Habitat loss is a major threat in the Arabian Peninsula and Iran, where original mountain conifer forests are nowadays reduced to scattered isolated trees (i.e. the juniper forests on the southern slopes of the Elburz Mountains of Iran, Kharazipour *et al.* 2008). The intense use of fire as a management practice in agriculture and livestock grazing, and the increase of neglect and arson fires due to land use changes and conflicts, often causes uncontrolled fires, which burn significant forestland every year. This problem is magnified in areas with political tensions, armed conflicts and military operations, like Iraq, Iran, Algeria and Turkey.

Land use and management changes have also created fire-prone landscapes with a high risk of savage fires that are difficult to control: a) homogenization of mosaic-like heterogeneous and highly diverse rural landscapes into homogeneous landscapes with significant accumulation of biomass and fuel load continuity, due to both rural abandonment with the colonisation of terraced slopes and grasslands by dense young forests and shrubs, and to the increase of artificial tree plantations, namely fire-prone pine and eucalyptus species; b) degradation of mature forests, with increased disease rate and the accumulation of dry biomass.

Reports from countries in the Near East region show increases in fire frequency and severity[4]. Between 1995 and 2004, the average area burnt each year in Turkey was about 9000 ha, or 0.09% of the country's total forests. Forest fires are even more severe in Cyprus, with an average of about 1955 ha burnt each year, or about 1.1 % of the country's total forests over the same period. The little forest that remains in Syria - 2.4% of total land area - is being further degraded due to recurrent fires that increased from 59 annual fires in 1990 to 320 in 1999. In Lebanon, more than 300 fires were declared in less than 24 hours on 3 October 2007, destroying thousands of ha. of forests and other wooded lands (Asmar *et al.* 2009).

Agriculture changes also represent an important threat to the Near East forests. On one hand, out-migration to lowland urban agglomerations, and the abandonment of traditional agriculture systems, like mountain terraces, has caused significant problems of soil erosion and hydrologic disruption in many mountain forest areas (i.e. the High Atlas; Southern Anatolian ranges; Mount Lebanon; mountains of Yemen). On the other hand, the conversion of unsuitable mountain forest areas into subsistence agriculture, and the expansion of irrigation in wetlands and steppe-forest land are causing significant forest habitat loss, pollution from domestic sewage and agricultural effluents, and severe water and wind erosion problems. Moreover, the gathering of forest organic soil to supply tree nurseries can cause punctual erosion and regeneration problems in mature forest stands, like in the Atlas mountains.

Drug crops represent an important threat in some forest regions. In the Rif Mountains of northern Morocco, kif (marijuana) plantations are a serious cause of deforestation and soil erosion, which led to the eradication of 8,000 ha of cork oak forests in the Ketama region between 1984 and 1990. UNODC (2007) estimates that marijuana crops extended over approximately 72 500 ha in 2005, a reduction of 40% over the previous year due to a combination of factors, including unfavourable climate conditions, governmental eradication policies, and pressure on local farmers.

The combination of high population growth, poverty, and rapid urbanization is putting enormous pressure on the forests of the Near East. In 2002, the population of the Near East countries was about 459 million people, with relatively high, although uneven annual growth rates. In Iran population has doubled since 1979, and the demand for more agricultural and pastoral products has forced people to convert forest and rangelands into cultivated land, and to overuse wood and plants as fuel for household cooking and heating (Aminmansour 2004). The estimated growth rates for the period 2002-2015 indicate that Yemen is expected to hold the highest increase rates (3.4%), together with the highest records of rural population (69%) and population below 15 years age (47.2%)[5]. In most countries, the combination of high population growth rate and high population density in rural areas is the cause of the growing pressure on the scarce natural resources, especially on forests, trees and ranges.

[4] www.fire.uni-freiburg.de

[5] www.escwa.un.org/popin/publications/new/DemographicprofileArabCountries.pdf

Urban development and unsustainable tourism represent an important threat to coastal and mountain forests, and a cause of forest fragmentation and loss, pollution and wildlife disturbance. Rapid urbanization creates new pressures, such as forest fragmentation and clearance in the course of urban expansion, and overcutting in peri-urban areas to supply fuelwood to urban populations. The risk of accidental fires with dramatic environmental and socio-economic consequences is magnified by the fact that the seasonal increase of tourists often coincides with the warmest and driest periods, and by the fragmentation of the forestland caused by the sprawl of holiday resorts and secondary houses. Ski resorts and access roads are an important cause of forest and grassland degradation, soil erosion and pollution, and they have significant impacts on the local water cycle of certain regions, like the Troodos Mountains in Cyprus. On the other hand, skiing may become a completely economically unviable activity in many places, because of global warming.

Legal framework and forest-related policies

Government policies in the Near East countries often tend to favour agriculture over forestry and biodiversity. At the same time, the forestry sector suffers from marginalization, leading to the low priority in the national plans and financial allocations. Such policies discourage investments to improve forest productivity, while agricultural policies often promote land clearing for agricultural use, with no consideration for the value of the lost goods and services provided by the forest systems.

The actual situation in many countries of the Near East region calls for a thorough reform of the existing legislative body, in order to put in place a comprehensive law, which encompasses all the facets of forestry, and their links with existent other laws - agriculture, environment, land use, energy, etc. Several countries in the region have updated their forest legislation and regulations giving new emphasis to environmental protection, socio-economic roles of forestry and community involvement in forestry/agroforestry. These include, for example, the afforestation mobilization law in Turkey (1995), and the law for compulsory windbreak and tree plantations in farming systems in Iraq (1995). At the same time, heavier penalties are being introduced against forest offenses (e.g., the new forest law enacted in 1995 in Lebanon, and the proposed amended forest laws which are currently being debated in the parliaments of Jordan and Syria).

Turkey's forest laws have been in force since 1956 and the Government is currently preparing a complete reform package. Turkey's forest regulations are comprehensive, including measures for the protection and expansion of forests, and measures to secure cooperation between the State and the inhabitants of villages located within or near forests in order to ensure forest conservation while improving the living conditions of these people.

Iran's forest laws have also been in place for a long time (since 1968) and have been amended several times since.

Cyprus has formulated a forest policy and national forest programme, and started a process of updating its forest legislation, laying the stress on environmental services and recreation rather than wood production. The new strategy has two main thrusts: multiple use (protection, recreation and trade) and sustainability (ecological, economic and social). A participatory approach to forest management and its planning is introduced in the proposed new legislation.

Jordan, Lebanon and Syria view forests as important elements in their environmental conservation and rural development schemes. Forest conservation and management policies are part of agricultural policy in Jordan and Lebanon, and part of biodiversity strategy in Syria. Lebanon has launched a five-year national Reforestation Plan, while its long-term objective is for forest cover to reach 20 % in 30 years. In Jordan and Syria, the concern of the international community is an important factor determining the priority given to the forest sector and the amount of resources allocated to it. Laws regulating forest management in some countries, especially Jordan, focus mainly on prohibitions and limitations, ignoring planning, management and development issues. Jordanian law emphasizes forest protection, supports management aspects that regulate timber extraction from state and private forests, and authorizes the Ministry of Agriculture to permit and manage grazing in state forests.

The Gulf countries of Qatar, Saudi Arabia and the United Arab Emirates have allocated sufficient resources for greening activities. Saudi Arabia has already prepared its draft forest strategy and action plan. Qatar’s agricultural policy aims to protect trees and shrubs through administrative measures and the country also attributes importance to mangroves, declaring them nature reserves and encouraging

their expansion. Forest legislation is limited to general environmental protection laws (Bahrain, Kuwait, Qatar and the United Arab Emirates), grazing regulations (Kuwait and Oman) and the designation of protected areas for mangroves (Bahrain and Qatar). Saudi Arabia's forest and rangeland regulations have been in force since 1978, dealing with the protection of vegetation, forests and rangelands, and regulating their use. In addition, religious edicts play an important role in protecting forest resources. The Saudi Arabian legal, system regulates fuelwood collection and transportation, and charcoal production activities through licenses. The country's cabinet approved the establishment of rangeland affairs committees in 1999, an initiative to encourage the participation of local communities of pastoralists and breeders in the development and conservation of grazing resources. Oman is preparing a new law to control human and livestock utilization patterns for forest and rangeland resources by preventing illicit use and conversion to other land uses. The proposed law takes traditional protection customs into consideration and encompasses consultation with local administrators, technical units and local communities.

Owing to limited resources in Yemen and Afghanistan and the current security situation in Iraq, these countries are highly dependent on external assistance, which means that their policies are strongly affected by foreign aid agencies and the international community in general. Forest regulations do exist in Iraq, but the political situation in the country limits the ability of the authorities to enforce them. In Afghanistan and Yemen, the legislative framework for forests and related areas is very weak. Several versions of forest laws were drafted between 1970 and 1991, but none of them was ratified, because no agreements could be reached among the many stakeholders concerned.

2. Forests and climate change in the Near East

The Fourth Assessment Report (Solomon *et al.* 2007) of the Intergovernmental Panel on Climate Change (IPCC) concluded that there is very high confidence that the global average effect of human activity since 1750 has been one of warming of the climate system, with the industrial era seeing the highest increase rate of the last 10,000 years. Most of the observed increase in global average temperatures since the mid-20th century is very likely due to anthropogenic greenhouse concentrations. This change is already having a significant detrimental impact on species and habitats worldwide, and is likely to be the most profound threat to global biodiversity. Projected changes must take into account the impact of past, present and future human disturbances on the natural ecosystems, which have considerably reduced their resilience to climate change. Dryland ecosystems, like those of the Near East, are among the most vulnerable to this threat.

Past evidence of changes in climate and the consequences

Ecosystems are dynamic systems in a process of permanent adaptation to environmental changes. Over thousands of years, Near East forests have gone through several intense and abrupt changes in climate. The occurrence of numerous Tertiary relic and palaeo-endemic species is an evidence of these ecosystems' ability to adapt to sharp environmental changes. Studies from the Mediterranean region show that the current tree flora is made up of very resilient old taxa that have experienced many abrupt and intense climate changes in the past (Petit *et al.* 2005). Moreover, temperate trees and shrub species with southern range margins in North Africa and the Levant have the bulk of their genetic diversity in their so-called "rear-edge" southern populations, although these represent a small fraction of their distribution range. Therefore, it is expected that under a climate change scenario, the great stability and genetic diversity of the many relic tree species of the Near East may play a significant adaptation role, and become an important target for in-situ conservation strategies. Nevertheless, there are also evidences of the extinction of trees species and forest types at a local and regional scale, mainly due to the combination of sharp changes in climate and human impacts, such as the Neotithic intensification in the use of fire to convert forestland into agriculture and pastoral land (Carrion, 2003; Tinner *et al.* 2000 & 2005). Because of the high human impact in the region, the Near East forests will be especially sensitive to future environmental changes and their consequences.

Observed changes in climate and their effects

The WWF-sponsored study *Climate change impacts in the Mediterranean region resulting from a 2ºC global temperature rise* (Giannakopoulos *et al.* 2005) presents evidence for climate change during the last half of the 20th century, with winter and summer warming in large parts of the region (more significant summer warming trend in the western part), a statistically significant decrease in precipitation (up to 20%, mostly since 1970), the tendency towards a more intense concentration of rainfall, and an increase in day/night temperature differences. Alpert *et al.* (2008) obtained similar results, with an average increase of 1.5 - 4ºC in the temperature throughout the Mediterranean in the last 100 years, a dominant negative trend of rainfall reduction over the last 50 years, and a tendency towards the increase of extreme daily rainfall despite decreases in total values. These trends, however, differ across sub-regions and periods.

There is high confidence that a number of weather anomalies and environmental changes observed in the Near East in recent decades have been caused by global warming. The IPCC Fourth Assessment report highlights the major long-term changes observed, among which:

- Observed decreases in mountain snow and glacier cover in both hemispheres that are consistent with warming. As a consequence of this, some hydrological systems have been affected through increased runoff and earlier spring peak discharge.
    - Available data on Turkish glaciers point out that the most recent glacier retreat probably started at the beginning of the 20th century, and gained speed since the 1930's (Çiner 2003). This will have serious consequences in the reduction of the annual discharge of the Euphrates River that is predicted to be 29 - 70% less by the end of this century (Kitoh *et al.* 2008). In the Atlas Mountains, the main source of water for the entire western region in Morocco, some meteorological stations indicate

a trend of growing rainfall deficits and decrease of runoff, possibly related to climate change (Chaponniere & Smakhtin 2006)

- Widespread changes in the amount of precipitations, with a tendency for humid areas to become more humid and for dry and arid areas to become even drier (Lindner 2006).
    - From 1900 to 2005 precipitation has declined in dry regions like the Sahel and the Mediterranean Basin. Groundwater depletion has already occurred in regions with little groundwater recharge and large "fossil" or "non-renewable" groundwater resources, as is the case of the Nubian aquifer spanning through Libya, Egypt and Sudan.
    - Alpert *et al.* (2004) show that the frequencies of the mostly dry Red Sea trough systems have nearly doubled since the 1960s, from 50 to about 100 days per year, a fact that explains a dominant decreasing trend of rainfall in most of the eastern Mediterranean, with the increasing tendency towards heavier daily rainfall.
- In terrestrial ecosystems, earlier timing of spring events and poleward and upward shifts in plant and animal ranges are with very high confidence linked to recent warming.
    - In the High Atlas and Middle Atlas mountains of Morocco, the northward and upward spread of Saharan species such as *Fredolia aretioides* and *Zilla macropthera* has been observed (Medail & Quezel 2003). The same authors believe that the intensification of the summer drought period is the cause of the significant reduction of the populations of a number of relic species (*Laurus azorica, Betula fontqueri* and *Dracaena draco* subsp. *aigal*) in Morocco.
    - The temperature increase due to climate change is responsible for the northward and upward range expansion of several insect species and for the changes in the seasonal phenology, leading to faster development and higher feeding rate, as is the case of insect outbreaks in the Mediterranean region (Battisti, 2008). The insects show high performance and almost no mortality due to the absence of the main natural enemies in the new distribution areas at higher latitudes and altitudes, where many usual or potential host species grow. Extreme whether events, such as the exceptional summer of 2003, are facilitating higher attack rates in areas previously largely unaffected by insects like the pine processionary caterpillar (*Thaumetopoea pityocampa)* (Stastny *et al.* 2006). In the Atlas Mountains large attacks of pine processionary caterpillar were observed in cedar forest stands. The case deserves special interest for the implications it may have on the management of European forests and plantations, as well as on ornamental trees.
- Extreme weather changes including more intense and longer droughts over wider areas since 1970; more frequent heavy precipitation events over most land areas; more frequent heat waves; and increased intensity of tropical cyclones. Extreme events are the real challenge in climate change, and are probably the most important drivers of ecosystem change. Moreover, extreme climatic events also cause carbon flux anomalies with significant atmospheric CO_2 rises. Globally, the year 2003 is associated with one of the largest atmospheric carbon fluxes recorded since 1980.
    - Although drought is a natural phenomenon in the Near East, its frequency and intensity have increased in recent decades and it is projected that it will become even worse in the light of global climate change. For instance, extended meteorological droughts in the Middle Atlas Mountains of Morocco, namely the Oum er Rbia watershed, have strongly impacted the water availability (Chaponniere & Smakhtin 2006). The drought of 2005 was very severe in the Mediterranean region, and hit most of Syria, Egypt and Libya, as well as large areas of central Anatolia and eastern Morocco (Isendahl & Schmidt 2006). Terrestrial ecosystems seem to respond to droughts with an increased carbon flux to the atmosphere caused by a drop in the gross primary production (carbon sink) in comparison with ecosystem respiration (carbon source). A number of studies suggest that the effects of large-scale drought events can be detected in ecosystem carbon fluxes for at least 3-5 years after the occurrence of the event. Thus, understanding the response of ecosystems to large-scale drought events is a must, especially if we keep in mind they are likely to occur more frequently and with more intensity in the future, and that the periodicity of

large-scale droughts may become much shorter, and limit the recovery capacity of the ecosystems.

- Climate-induced drought and heat weaves have already caused forest mortality across a broad range of forest and woodland types around the world (Allen, 2009). Since the onset of severe droughts in North Africa from 1999 to 2002, including the most severe drought since at least the middle of the 15th century in 2000 (Touchan *et al.* 2008), cedar forests (*Cedrus atlantica*) have been hit by massive mortality in Morocco and Algeria (El Abidine, 2003; Bentouati, 2008). All Algerian cedar forests are affected, but the magnitude of mortality varies along a steep moisture gradient (Fig. 3), with die-off greatest (up to 100%) in the drier mountains nearest the Sahara Chenchouni *et al.* 2008). Substantial mortality caused by recent drought was reported in other tree species in North Africa (i.e. *Pinus halepensis, Quercus ilex, Quercus suber*, and *Juniperus thurifera*), central Turkey (oak, pine and fir species, Semerci *et al.* 2008) and Saudi Arabia (*Juniperus procera* mountain forests).
- More frequent and intense heat waves are behind the increased frequency and severity of savage forest fires since the last three decades, and have a perverse double negative effect: on one hand, they contribute to accelerate climate change due to the enormous emissions of CO_2 to the atmosphere, while on the other they significantly reduce the capacity of forest ecosystem to cope with climate change. In the Mediterranean Basin, for instance, about 50,000 fires sweep through 700,000 1,000,000 ha. of Mediterranean forest each year (Vélez, 1990). Of these, a few uncontrolled large-scale forest fires devastate large surfaces of forestland, with enormous economic costs and ecological damage as well as loss of human life. These fires have also caused air and water pollution and important health problems in major urban centres - some located at a considerable distance from the burned areas.

Climate change projections in the Near East

Man-originated greenhouse emissions are responsible for climate changes since the industrial revolution in the second half of the 19th century, and are expected to lead to an average global warming of 1.1 to 6.4ºC, in the period 1990 - 2100, depending on the volume of the global release (Kohler & Maselli 2009). The IPCC Fourth Assessment considers projected warming of about 0.2ºC per decade for the next two decades, and most scenarios show increases of more than 2ºC in annual temperature by 2080 compared with the average temperatures of 1960 - 1990 (Lindner 2006).

Ragab and Prudhomme (2000) concluded that by the year 2050, Northern Africa and some parts of Saudi Arabia, Iran, Syria, Jordan and Israel will experience reduced rainfall amounts up to 20% - 25% less than present mean values, while temperatures will rise between 2 – 2.75ºC inland, and about 1.5ºC in coastal areas. Similar results are obtained by Kunstmann *et al.* (2007) for the mountains of the upper Jordan catchment, with 25% decreases in mean annual precipitation and temperature increases of up to 4.5ºC, although in this case for the period 2070 - 2099. Total runoff is predicted to decrease by 23%, with a significant decrease of groundwater recharge. Giannakopoulos et al (2005) forecast that the Mediterranean will experience a global temperature rise of 2°C in the period 2031 - 2060, which will likely lead to a corresponding warming of 1 - 3°C. The warming will be higher inland than along the coast, with precipitation reductions all year round in North Africa and the Levant, and substantial decreases in the summer and more intense and strong rainfall events.

Nogués-Bravo *et al.* (2007) predict that the average amount of warming for global mountain systems in the 21st century (up to 2055) will be between two and three times greater than the average change recorded in the 20th century. According to the authors' results, based on four emission scenarios, most of the Near East mountains will warm up to 3 - 4ºC in the worst scenario, with the exception of Sudan and the southern part of the Arabian Peninsula where warming will average 2 - 3ºC, and the mountain of eastern Anatolia and central Iran that will warm the most, up to 4 - 5ºC. In the best scenario, the mountains of the region will warm up to 2 - 3ºC except for Sudan and the southern part of the Arabian Peninsula, with the lower rates between 0.75 - 2ºC.

Temperature changes

Giannakopoulos *et al.* (2005) summarize the following projections for the Near East countries of the Mediterranean region, based on two climate change scenarios:

- Mean and maximum temperatures will undergo a notably larger rise in summer (up to 4ºC) and a slightly larger rise in autumn (2 - 3ºC), with a rise of less than 2ºC in winter and spring.
- The number of hot days (Tmax > 30ºC) and summer days (Tmax > 25ºC) will increase differently, according to sub-regions: the highest rise will be inland, with one extra month of hot days and one extra month of summer days. The Middle East coastal areas will experience a slightly higher increase, with 1 - 3 additional weeks of hot days and 2 - 3 additional weeks of summer days. The coastal areas in the central part of North Africa will only have one additional month of summer days, while Cyprus will have about 2 additional weeks of summer days.
- The number of frosty nights (Tmin < 0ºC) will fall by 1 - 2 weeks along the coast and by up to one month inland, while the number of very cold nights (Tmin < -5ºC) will go through a slight decreasing trend. It seems there will be a 50% decrease in the number of coldest days, mainly in the south-eastern part of the region.
- When it comes to temperatures, the hottest regions will be Turkey and the Maghreb, while Cyprus will be the coolest place.

Precipitation changes

Although the projection in precipitation changes is less reliable, with considerable regional and seasonal variance between different model projections and a high degree of uncertainty, the inherent water constraints of most climate types in the region and the increase of temperatures will cause a significant increase in evapo-transpiration. The fragile water balance makes the whole region extremely sensitive to changes in rainfall or in the availability of water for the recharging of aquifers, the quantity and quality, and the flow variability of major rivers such as the Blue Nile, the White Nile, the Euphrates, the Tigris (Turkey, Syria and Iraq), the Jordan, and the Yarmuk River of Southern Lebanon (Trondalen 2008). According to this author, sudden 'hydrological shocks' as well as slow onset changes can increase the risk of conflict in unstable states and regions because of the governments' lack of capacity to respond, adapt, and recover.

Precipitation is the parameter that accounts for the largest differences between the two scenarios considered by Giannakopoulos *et al.* (2005):

- In the southern part of the region and Spain a drop in rainfall of 0 to 20% is predicted according to scenarios.
- Summer precipitation will decrease, except in the south-eastern part of the region (including southern Turkey) where a small increase is expected.
- Small decrease or no change in rainfall in the other seasons is expected, except in the south-eastern part of the region where a larger winter rainfall decrease is likely.
- An increase in the number of dry days (PP < 0.5mm) is expected almost everywhere, ranging from three weeks in inland Turkey, two to three weeks in the Maghreb (Morocco, Algeria and Tunisia), about two weeks along the coast, just a few extra dry days in the Middle East, Libya and Egypt, and a slight decrease in Cyprus.

Despite the considerable uncertainties about changes in precipitation, a substantial increase in water deficit is expected, driven more by increased temperatures than by reduced precipitation (Ohlemüller *et al.* 2006).

Increase of drought events

According to Giannakopoulos *et al.* (2005), longer dry spells will be common, with an increase of 2 - 4 weeks in Morocco and Libya, while in the south-eastern part of the region and Algeria no changes are expected. A two to four weeks extension of the dry season towards spring is expected in the Levant region, while incongruent patterns emerged in the scenarios for the Maghreb.

An increase in future drought events could turn the regional forest ecosystems into carbon sources, contributing to positive carbon-climate feed-backs. Water balance in the regional forest

ecosystems will be significantly affected by intense evapo-transpiration, caused by the combination of higher temperatures, lower precipitation rates, the increase of the periods with no rainfall over the year and the increase in the frequency and intensity of multi-annual drought events. Moreover, lower precipitation rates together with higher agriculture production needs due to population growth will exacerbate the competition between natural ecosystems and agriculture, with an extra-pressure in the use of water for irrigation.

Increase of heat waves and forest fire risk

According to Giannakopoulos *et al.* (2005) the largest increase in temperature is expected to take place in the summer, when extremely hot days and heat waves will increase substantially, especially in inland and southern Mediterranean locations. Fire risk is expected to increase nearly everywhere, especially in inland locations with projected additional 3 - 5 weeks of heat waves in the Middle East, Turkey and North Africa. The southern Mediterranean is at risk of forest fire all year round, except for the south-eastern tip that shows little change in fire risk.

Species migration and loss

Forest habitats and plant species growing at higher altitudes (i.e. mountain conifer tree species) have long-distance dispersal requirements that may be impossible without human support. The local or regional loss of significant numbers of species and habitat types is expected, because of climate change, especially in isolated mountain areas where species have limited options to find favourable conditions. In the mountains of the Mediterranean Basin, Thuiller *et al.* (2005) predict the extinction of approximately 60% of the total flora by 2080.

On the other hand, the upward dispersal of mountain tree species may be favoured by the fact that the current timberline appears at lower altitudes (up to 300 m) than the potential timberline, due to historical upland grazing practices. Moreover, many forest landscapes in the Near East are characterised by heterogeneous complex landforms with microclimate conditions that may provide shelter to many relic species, as it was the case in the past. In any case, changes in species interactions and succession mechanisms will work in parallel with pathogen population dynamics, with the latter being difficult to predict.

In the case of alien species, climate change may trigger rapid colonization events, as colonizers may temporarily escape from host-specific pathogens and behave like "superspecies" that experience a period of transient competitive advantage over the resident species (Regato, 2008). This pattern was observed already with a number of exotic species in all Mediterranean bio-geographic regions (e.g. *Pinus pinaster,* a native species from the western Mediterranean basin, has become a very invasive alien species in South Africa) due to multiple causes that are difficult to understand, including the absence of host- specific pathogens.

Sea-Level Rise

Sea-level rise (SLR) could lead to 1 to 3 m in the 21st century. A 1m SLR would affect 6 million people in Egypt and between 12% - 15% of agriculture land in the Nile delta will be lost (Medany 2008). According to a recent assessment done by the World Bank (Dasgupta *et al.* 2007), Qatar would experience a significant reduction of about 2.6% to 13% of its land area due to 1m and 5m SLR respectively; between 5% to 10% of the urban areas in Egypt, Libya, United Arab Emirates and Tunisia would be significantly impacted due to 1m and 5m SLR respectively.

Population growth

Population growth and its consequences on land use, in addition to land degradation and price shocks, are already a major concern for sustained forest and agricultural productivity in the region. The trend of changes in temperature, precipitation and climatic extremes will add to this stress. The agriculture of the region is potentially vulnerable to environmental and climate changes, and this threat can severely affect food security. The predicted temperature increase beyond 3ºC in most regions (worst scenario in Nogués-Bravo *et al.* 2007) 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 agriculture land by the end

of the 21st century. The useful grazing period of most rangelands will also shrink because of the longer dry season, while shifting growing seasons due to altered precipitation patterns will force changes in cropping strategy or even crop types (Evans 2009).

Some scenarios predict a decrease of groundwater recharge of at least 10% by 2050, affecting the consumption needs of 16.1 to 19.3% of the global population. North Africa with be hit by a decrease of 70% of total water resources in 2090 - 2099, while West Asia will experience a decrease of 30% to 70% (Dröll 2009)

All countries of the Near East, except the Gulf countries, Iran, Iraq and Saudi Arabia, may be hardly hit by the raising prices of energy and energy-related commodities. This threat puts an additional pressure on forests, and may lead to the over-harvesting of trees and bush to obtain fuelwood for cooking and energy.

Climate Change forest hotspots in the Near East

Overall, the Near East forest ecosystems are considered globally outstanding for their biodiversity and critically endangered by the main international conservation organizations. From the ensemble of forest types in the region, researchers have identified those that are most vulnerable to the combined effect of climate and socio-economic changes, thus becoming priority targets for urgent adaptation efforts. On the basis of three criteria - sensitiveness to climate change impacts, adaptive capacity to cope with climate change and rarity of the habitat - the following forest types are considered the most threatened ones:

- *Conifer and mixed relic forests in the upper forest belt of the Near East high mountain ranges*. An increase of the annual mean temperature of about 3ºC will cause a shift of the altitudinal life-zones of approximately 545 m (Médail & Quézel 2003). Under these circumstances, the highest forest zones will be seriously affected (significant reduction of their ranges and local/regional loss of the entire populations), as upwards migration possibilities for tree species will be very limited. This is the case of all the cedar, fir, juniper and mountain pine forest types in North Africa (Rif, Middle Atlas and High Atlas in Morocco; Tellien Atlas and Saharan Atlas in Algeria), Lebanon and Anti-Lebanon mountain ranges; Troodos mountain in Cyprus; all Turkish high mountains, especially the Taurus and Amanus; all high mountains of Iran and Afghanistan; the high mountains of the southern part of the Arabian Peninsula (Jabal Al Akhdar in Oman; Jabal Hijaz in Saudi Arabia; the highlands of Yemen).
- *Refugial areas for threatened relic forest tree and shrub species*. A significant number of forest tree and shrub species in the Near East region are currently rare, vulnerable or threatened, in many cases consisting of very small populations or scattered individuals. These species may be endemic to the region (narrow paleo-endemics, like *Cupressus drupeziana*, and *Olea laperrini* in the Saharan mountains in Algeria), or may be populations of tree and shrub species from other bio-geographic regions with their southern range margins in the Near East. Several studies have demonstrated that these "rear-edge" populations have the bulk of the species genetic diversity, although they may represent a small fraction of their distribution range. Therefore, under a climate change scenario, the great stability and genetic diversity of the numerous "rear-edge" tree relic populations scattered along the Near East are extremely important for in-situ conservation strategies. Examples of refugial areas are: the fog oasis in the mountains of Saudi Arabia, Oman and Yemen; the island of Socotra; the Hoggar and Tassili mountains in Algeria; the Cyrenaica peninsula in Lybia; the Rif and Atlas mountains in Morocco; The Numidian coast in Algeria and Tunisia; The Pontic, Taurus and Amanus in Turkey; the Alborz in Iran; Mount Lebanon.
- *Wetland forests*. These forest types acquire a special significance in a region like the Near East, where extremely arid conditions prevail. According to recent IUCN research work on the status of freshwater biodiversity in North Africa (García *et al.* 2010), freshwater forest ecosystems are extremely threatened by the combined effect of climate and socio-economic changes. The accelerated trend of freshwater habitat loss and degradation in the region makes it very urgent the need to identify, protect and restore the remaining Near East natural wetland forests, including the oasis systems.

- *Coastal forests*. These habitats will be especially vulnerable to sea level rise and changes in the salinity conditions. Numerous coastal forests host very unique plant communities that will be especially vulnerable to climate change impacts. This is the case of the Liquidambar orientalis and Phoenix theophrasti forests in the south-western coast of Turkey (Médail & Quézel 2003); the scarce and fragmented coastal dune systems in the Mediterranean coast; the mangrove forests in the Red Sea and Persian Gulf.

3. Responses to climate change

Defining climate change adaptation and mitigation

The terms "adaptation" and "mitigation" are the two fundamental concepts in the climate change debate. Adaptation to climate change refers to adjustments in ecological, social, and economic systems in response to the effects of changes in climate (Spittlehouse & Stewart 2003) that moderates harm or exploits beneficial opportunities. Mitigation refers to any anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases (IPCC 2001). While mitigation tackles the causes of climate change, adaptation tackles the effects of the phenomenon.

On one hand, the more mitigation happens, the smaller will be the impact to which we will have to adjust our ecological, social and economic systems. On the other hand, the implementation of certain adaptation measures would lead to an appreciable increase in carbon sink and reduction in GHG emissions, which will eventually contribute to climate change mitigation. Climate mitigation and adaptation should not be seen as alternatives to each other, but rather as a combined set of actions within a comprehensive strategy to reduce greenhouse gas emissions and cope with the adverse effects that will inevitably occur due to past and current trend in anthropogenic greenhouse concentrations.

In general terms, all adaptive management practices in forestry, livestock and agriculture that are proposed in the following chapter contribute to store carbon in soil and vegetation, therefore have important mitigation role. Adaptive management aims to achieve sustainability in forest management, forest protection and people's livelihoods under current climate change forecasts, and it is intimately related to the mitigation efforts to reduce emissions from deforestation and forest degradation. Environmentally sound, social beneficial and economically viable afforestation and reforestation measures contribute both to adaptation and mitigation, so they should become a priority in any forest carbon project. Similarly, projects on the use of dry biomass for bio-energy and alternative energy to help reduce the overuse of wood for cooking and heating, contribute both to adaptation and mitigation efforts.

Adaptation of the Near East forest ecosystems to climate change

As a general rule, the different forest habitats and species will respond differently to climate change, through a number of biological changes:

- Tolerance to environmental changes and in-situ persistence;
- In-situ adaptation of species with high phenotypic plasticity that can evolve and genetically adapt to new conditions;
- More or less large-scale biome shifts, with the movement of species ranges northwards and upwards in elevation, following changes in the abiotic environment suitable for them:
- Reduced growth rate and regeneration success that can finally lead to extinction due to lack of ability to cope with the abiotic changes.

All these changes will certainly lead to new assemblages of species in space and time. Responses will also be influenced by changes in the competitiveness of different species, which will most probably encourage the expansion of invasive species.

The forest ecosystems of the Near East will adapt autonomously to climate change, as they have been doing for millennia. The forest species and habitats are made up of very resilient old taxa that have already experienced abrupt and intense climate changes in the past, and have been able to tolerate or in-situ adapt to new conditions (Petit *et al.* 2005). However, the combined effect of the intense alteration of forest ecosystems and climate change can prevent the adaptation of many forest species and habitats, and lead to unwanted irreversible changes, such as the loss of species and habitat diversity, and the transformation of large forest areas into scrublands. Paleobotanical data also demonstrate how the combined effects of climate change and human disturbances (i.e. human-caused fires) easily led to the local and regional extinction of species and forest habitat types in the Near East (Carrion 2003; Tinner *et al.* 2002 & 2005).

The interactions and adjustments between highly diverse forest ecosystems and culturally rich societies in the Near East have historically produced highly resilient socio-ecosystems, thereby reducing the likelihood of abrupt regional changes. The collapse of the traditional societies and communal management systems of forestland during the last decades is the root cause of intense forest degradation trends in many regions. In order to truly understand forest ecosystems' dynamics and avoid passing ecological thresholds that can lead to abrupt undesirable landscape changes, it is necessary to account for the human dimension, and avoid passing socio-cultural thresholds.

It can be reasonably argued that the first urgent step in adaptation will be to stop or reverse the existing "maladaptive processes and practices" which contribute to forest degradation and loss (Regato 2008). This will imply the need to enhance and restore the resilience of, and the links between the ecological and socio-cultural sub-systems of the Near East forest landscapes, through viable options for adaptive institutional arrangements and co-management systems, and healthy forest conditions.

When it comes to vulnerable socio-ecosystems, adaptation requires the adoption of flexible policies, governance and management systems which can enhance the adaptability of species and habitats, and reduce trends in human-induced pressures that increase vulnerability to climate change. Flexible approaches to policy design include:

- New governance patterns that enable meaningful stakeholder participation and guarantee secure land tenure, forest user rights and sufficient financial incentives (Seppälä *et al.* 2009). These factors represent the greatest impediment for sustainable forest management in the Near East countries. Governments should find viable solutions to devolve tenure rights to forest dwellers and they should introduce more flexible regulations in the forest and agriculture legislations to promote/strengthen the rights of forest dwellers on the exploitation of forest resources, while minimizing costs (i.e. through auctions with low or almost symbolic costs for local community groups).
- Formulation and implementation of appropriate policy tools and instruments, and development programmes in a permanent, open-ended process, through a permanent monitoring system to revise and adapt policies to new conditions and needs.
- Decentralization through the transfer of authority and responsibilities to local institutions. Adaptation is a inherently local process, therefore it is critical to help local institutions adopt effective adaptation approaches.

Current uncertainties in the climate change scenarios at regional and local levels, and in the modelling of species responses to climate change impacts, can lead decision makers and practitioners to the conclusion that adaptation interventions could be postponed. However, because of the magnitude and rate of predicted changes, planned adaptation interventions are urgently required before irreversible losses and changes towards undesirable conditions occur, or before the complete certainty about climate change-induced harms in forest ecosystems can be achieved. Moreover, planned adaptation may help influence the barriers, direction and timing of autonomous adaptation processes, and thus mitigate the socio-economic and environmental costs of climate change impacts, while maintaining the societal values of the current forest ecosystems and land uses. Nevertheless, a precautionary approach is also required to avoid undesirable consequences of planned adaptation options with high uncertainties and weak scientific basis.

A key adaptation strategy in a context of uncertainty is to maintain diversity, ecological structure and processes and reduce existing pressures on natural ecosystems (Markham & Malcolm 1996), incorporating compatible adaptation measures in all land use sectors and trade-offs to balance all demands. In fact, major impacts on forests often come from other land uses, such as agriculture (i.e. land conversion; competition for water resources; increased risk of fires from burning stubble), pasturage (i.e. overgrazing of forest understory, unsustainable forage collection, and soil erosion and compaction), road infrastructures (i.e. landslides), secondary houses and recreational uses (i.e. forest fragmentation, pollution, higher risk of fires).

Many authors agree on the fact that, as a general rule, preserving and enhancing ecological and cultural diversity is the best strategy to build resilience and secure the viability and sustainability of forest socio-ecosystems. A higher diversity at all levels implies a wider range of opportunities and options to cope with any environmental, social and economic change (Pagliani 2010a):

- A broader genetic pool in species populations will allow them to react to a wider range of environmental conditions and changes;
- Species-rich habitats and culture-rich societies can perform many different functions and have a higher number of adaptation options;
- More complex and structured ecosystems and social systems have more solid mechanisms to respond to changes;
- Multifunctional forest systems better meet society demands, not only for the provision of sufficient amount and quality of timber, fuelwood and NWFPs, but also for a wide range of ecosystem services, from carbon sequestration, biodiversity conservation, a sufficient supply and quality of water, to cultural services like recreation and spiritual needs.
- Mosaic landscapes offer a wider range of habitat requirements to species populations, and they provide more goods and services, diversified land use options and economic opportunities to rural societies.

Adaptation measures will necessarily involve the development of innovative solutions to fit into modern life conditions and face the higher environmental constraints caused by climate change. This will require:

- Higher certainties about temperature and precipitation changes based on regional climate models with higher spatial and temporal resolution in their predictions;
- More precise scenarios about how climate change will affect species, ecological processes and ecosystem services;
- Plans for "resilient landscapes", through stakeholders' consensus and participation and major efforts to reverse the human drivers of climate change, through the integration in land use, water management, disaster management, energy consumption, and human health policies.
- Innovative approaches and new technologies in adaptive conservation and land use management practices to maintain and restore resilient landscapes and socio-ecosystems;
- Enabling conditions (legislation, workable economic incentives, competent institutions, stakeholder participation, capacity building and awareness raising) to gain support and enable land managers and users to swift to resilient uses and management practices. These conditions will also allow rural economies to become highly self-sufficient and less dependent from subsidies.

Landscape adaptation measures

Both people and wildlife depend on the differential use of large territorial units or 'functional landscapes' in space and time. This is especially evident in most parts of the Near East, a region with sharp seasonal changes in the spatial distribution of resources due to environmental constraints. One such good example is the upland-lowland seasonal movements of people and wildlife to overcome the scarcity of seasonal resources and fulfil their needs in time and space. Through these movements, people, livestock and wildlife have influenced the structure, composition, distribution and dynamics of natural habitats in large territories, and contributed to the creation of very unique eco-cultural landscapes - a rich mosaic of forests and woodlands, scrub and pastureland, and herbaceous and tree crops often grown on sophisticated systems of terraces.

Healthy environmental conditions over large territories are required to maintain the functionality and sustainability of these socio-ecosystems - both in ecological and socio-economic terms - and to better respond to climate change impacts. Ensuring large-scale landscape connectivity is considered fundamental to help ecosystems and species respond to climate change (i.e. facilitating species migration needs) and avoid dramatic and abrupt transitions towards undesirable conditions (Halpin, 1997; Holling, 2001). Moreover, regaining landscape resilience will help reduce the risk of ignition and the spreading of large-scale harmful fires.

Because of this, climate change adaptation strategies will necessarily need to address rural development as a whole - not only forest ecosystems.

Building *fire-smart* forest landscapes

Fire can be both damaging and beneficial, and its use in ecosystem management can range from traditional burning practices to highly specialized techniques. The reduction of the damage caused by

fire and the promotion of the benefits it can bring can be achieved through *Integrated Fire Management* - a concept that employs social, economical, cultural and ecological evaluations with the objective of minimizing the damage and maximizing the benefits of fire (Rego *et al.* 2010).

The growing trend of large-scale, devastating fires with huge ecological, social and economic costs have pushed the authorities of several regional (i.e. Lebanon and Turkey) and neighbouring (i.e. Portugal, Greece, Spain) countries to revise the legislatives frameworks in order to improve fire management and fire disaster management. Under the current climate change scenario, the assessment of past successes and failures indicates that a comprehensive, integrated fire management strategy should have as a major focus on the prevention of harmful fires. It should also build on participative planning processes to regain fire-smart landscapes, promoting more resilient land uses and landscape patterns that help reduce the risk of uncontrolled fires. More and more societies in fire-prone regions will need to learn how to live with fire. In most cases, this means to regain traditional land uses and mosaic-like landscape patterns that appear to be more resilient against these environmental disturbances.

The new national fire strategy approved by the Lebanese government in May 2009 has the objective to reduce the risk of intense and frequent forest fires whilst allowing for fire regimes that are socially, economically and ecologically sustainable (Asmar *et al.* 2009). The strategy integrates five components with a climate change adaptation focus:

- Research, information and monitoring.
- Risk modification, including fire vulnerability reduction and prevention of harmful fires.
- Readiness, covering all provisions intended to improve interventions and safety in the event of fire.
- Response, including all means of intervention for fire suppression.
- Recovery, including the rehabilitation and ecological restoration of healthy forest conditions, and the support to individuals and communities in the short- and medium term aftermath of the fire.

The strategy also proposes mechanisms for participation and capacity building of all concerned stakeholders, and promotes incentives to restore healthy forests and adopt resilient land-uses.

Land owners, users and managers have a major role in fire risk reduction. Participatory spatial planning has the objective to actively engage all concerned stakeholders in the identification/mapping of high fire risk areas, and the adoption of resilient land use types and landscape patterns with a spatial distribution of uses and infrastructures which can better help reduce the risk of fire. Key measures include:

- Identify resilient traditional land uses based on the wide array of NWFPs from the Near East forests, estimate their economic value, and promote their use in areas that are highly sensitive to fire. The implementation of the new National Plan for the Protection of Forests against Wildfires in Portugal, for instance, has encouraged farmers to replace fire-prone eucalyptus plantations with cork oak (Quercus suber) and strawberry tree (Arbutus unedo) plantations in high fire risk areas, shifting from pulp production to a more diversified production of cork, Arbutus spirits and jam, honey, livestock, medicinal plants, etc (Regato, 2008).
- Maintain and restore the traditional mosaic-like landscape with forest stands alternating with pastureland and agriculture terraces. Crop terraces play very important anti-erosive, water regulation, fire-prevention roles, and their restoration is considered a climate change adaptation measure, as for instance in the National Adaptation Programme of Action of Yemen. Moreover, the EU-funded project INTERREG/ Mediterritage, carried out in various Mediterranean countries, has supported the recovery of the abandoned traditional mixed cultivation and breeding systems of irrigated terraces in Mugla (Turkey) and the High Atlas (Morocco) (Dubost *et al.* 2009). Among the positive outcomes of this experience is the restoration of terraces supporting viable farming systems based on high quality produce, and the set up of complementary touristic activities based on the cultural and landscape value of the terraces.
- Prevent the homogenization of the landscape caused by land use changes (conversion of marginal agriculture land and pastures into mono-specific tree plantations) and rural abandonment (colonization of abandoned agriculture and pastureland by dense scrublands and forests). The current trend of intensification of mono-specific stone pine plantations and

homogenization of the landscape in Mount Lebanon is increasing fire risk, and leading to a situation already experienced in Portugal, where forest subsidies have long supported the conversion of vast rural areas into dense eucalyptus and pine plantations, that have eventually been devastated by uncontrolled fires.

- Replace the traditional linear firebreaks with denuded soil and high erosion risk, with larger grassland areas, and promote livestock production. This is a general trend supported by public administrations in the high-fire risk regions of several Mediterranean countries, and appears to be more effective in preventing the spreading of fire (Gómez & Guzmán, 2008). Moreover, economic incentives for livestock production (i.e. for high quality livestock products in mountain areas) not only represent an important income generation opportunity for local communities, but also reduce the maintenance costs derived from the firebreak networks.
- Promote fuel load reduction measures like: a) Prescribed burning of biomass in high fire-risk areas, a management tool largely practiced in dryland regions (i.e. western USA and South Africa) that is being tested and introduced as a fire management tool in the Mediterranean region (i.e. the EU funded project FireParadox[6]); b) Promotion of livestock grazing in high fire risk areas (i.e. The "self-Prevention" initiative in the trans-boundary Duero river basin between Portugal and Spain supported with EU and governmental funds will promote goat grazing and production to reduce the accumulation of fuel in the landscape while benefiting 73 000 inhabitants; support bio-energy production using agriculture and forest waste products (i.e. from clearing stumps and roots of trees, pruning, and thinning) as well as dry biomass from shrub-land (i.e. in Lebanon, GTZ is currently supporting the NGO AFDC to implement a pilot bio-energy production initiative).
- Restore riparian forest corridors, not only to support the need of migratory species to adapt to climate change, but also for the role they play in reducing the capacity of fire to spread over the landscape. Riparian areas frequently differ from adjacent uplands in their vegetative composition and structure, geomorphology, hydrology, microclimate, and fuel characteristics. The adaptation of riparian plant species to fluvial disturbances can facilitate their survival and re-establishment after fires, and thus contribute to the rapid recovery of many streamside habitats (Dwire & Kauffman, 2003).

Although participatory planning processes can help raise the awareness of local actors on fire risk reduction options, trade off mechanisms (i.e. economic compensations and incentives) will eventually be needed to get the buy-in of individuals and communities and empower them to adopt resilient uses and management practices.

Post-fire restoration

Post-fire restoration and management should reduce future fire risk and increase ecosystem and landscape resilience to harmful fires. The development of a restoration action plan may be based on the Forest Landscape Restoration principles jointly developed by IUCN and WWF, and the guidelines of the Society of Ecological Restoration. The following key measures should be taken into consideration in post-fire restoration and management projects:

- Changes in the vegetation structure and species composition to reduce fire-prone conditions:
    - Post-fire vegetation may be dominated by dense scrublands of high-flammable species that generate fuel load continuity with a higher fire risk. Pilot experimental measures in Valencia (Spain) with a combination of selective clearing of high-flammable *Ulex parviflorus* scrubs and the planting of re-sprouting species seedling has transformed the scrubland into a landscape dominated by grasslands with sparse re-sprouting scrubs and a discontinuous fuel load in just 3 years (Valdecantos 2008). Moreover, the mulching of the soil surface with brush-chipping has greatly reduced the germination rates of fire-prone seeders.
    - Post-fire management measures to reduce biomass, speed up tree growth and create discontinuity between forest floor and tree crowns. This is especially relevant in forest ecosystems dominated by species with biological trails that increase the danger

[6] www.fireparadox.org

of canopy fires. This is the case of the Aleppo pine, which covers vast areas of North Africa and certain regions of the Middle East. Early thinning in the high density of pine saplings after fire is strongly advised to speed up tree growth, in order to create mature forest stands with high trees and wide crowns, and favour the percentage of non-serotinous cones with larger numbers of viable seeds (Verkaik & Espelta 2005)[7]. The increased production of viable seeds may create new economic opportunities to diversify production in Aleppo pine forests - i.e. the harvesting of pine seeds for tree-nurseries and for edible uses, like the traditional pastry production in Tunisia (Regato, 2007). Lower tree densities will also decrease canopy closure and reduce surface fuel, with the consequent reduction of fire risk.

- Post-fire snags and woody debris management. Management decisions may not only be based on the ecological effects on forest regeneration and soil stabilization, but also on socio-economic factors, such as the social opposition to standing post-fire snags due to aesthetical problems, the social demand for the economic use of snags and woody debris, security reasons, etc. It is recommended to test several options i.e. keep all standing dead trees; keep part of the standing dead trees and cut the rest, which may be left on the ground; cut all standing dead trees and leave them on the ground and remove part, or all the standing dead trees. In the case of pine trees with serotinous cones, the harvesting of standing dead trees should be postponed for at least three/four years, so as to allow the seed dispersal of this type of cones, which are known for the delayed opening. Pilot experimental measures in Sierra Nevada (Southern Spain) demonstrated that the best option for the area was to keep part of the standing dead trees and cut the rest, leaving them on the ground (Castro *et al.* 2010). This technique offered a number of benefits, such as: lower runoff erosion and higher soil nutrient incorporation, higher seed dispersal and regeneration, high protection of seeds against herbivores, microclimatic improvement, and lower management costs. The harvesting should be carried out with minimum mechanical activity, before the rainy season (Castro *et al.* 2010).
- The combination of species with different life strategies (i.e. re-sprouting species like *Quercus* spp, *Arbutus* spp, that regenerate well after fire; fruit trees which will attract seed dispersal fauna; nitrogen fixing shrubs; etc) in post-fire restoration work helps increase the resilience of forest stands and forest landscapes (Regato *et al.* 2010). A number of projects supported by WWF in Morocco and by IUCN in Lebanon have built the capacity of NGOs, local communities and the forest administration to diversify plant production in tree-nurseries, and grow a wider range of native tree, scrub and herbal species with different life strategies, for their use in post-fire restoration actions.

Integrating climate change adaptation in watershed management

The efficient management of climate change impacts on hydrologic regimes is a big challenge in the Near East forest landscapes, and it requires intelligent solutions for the sustainable use of all available water and land resources in an integrated fashion. Watershed management is an ideal framework for the sustainable use of natural resources and the protection of soil and water, as it uses river basins as functional landscape units that obey to natural and not political boundaries. It addresses the unbalanced flows between catchment mountain areas and lowlands, and provides an important policy tool to balance human development needs and natural resource use between lowland and upland areas.

The Water Framework Directive (WFD) of the European Union is a good example of an effective framework for participation in integrated watershed management. In the Near East, the WFD is

[7] *Serotiny* is described as the retention of mature seeds in a canopy-stored seed bank with synchronised delayed dispersal - Cone opening and seed release - in time of optimal conditions: fire and extreme dry weather (Enright et al., 1998). The percentage of serotinous cones is much higher in Aleppo pine young and small trees (up to 94%) than in adults (down to 6%) (Goubitz et al., 2004; Thanos & Daskalakou, 2000; Tapias et al, 2001). Moreover, with similar age/size, there is much higher serotiny in burned than in un-burned sites. Non-serotinous cones have a much larger number of viable seeds than serotinous cones.

implemented in the only country belonging to the EU – Cyprus - and in Turkey, a EU candidate member. Although the WFD does not explicitly mention the risks posed by climate change to the achievement of its environmental objectives, several articles provide good arguments for including climate change impacts into the planning process (Dworak & Leipprand 2007). Climatic variables are the root of many of the parameters that influence water resources, so climate change should be addressed when aiming to meet the WFD objectives – the good status of all waters. The European Union has established a Common Implementation Strategy (CIS) activity on "Climate Change and the EU Water Policy" with the aim to tackle climate change impacts in WFD river basin management planning, and ensure that today's decisions will still be viable in the future (Dworak & Leipprand 2007). The design of the WFD provides scope to adapt to climate change through the cyclical river basin planning process.

The EU Water Initiative is a participative multi-stakeholder dialogue process involving national governments, donors, the water industry, NGOs and other stakeholders in third countries, with the aim to improve coordination & cooperation and deliver more effective development assistance on sustainable river basin, and water governance and management. The WI pursues the transfer of the WFD principles in specific regions, including the neighbouring Mediterranean countries[8]. Pilot basin activities are under development to test the applicability of the WFD tools and principles and its potential use for f integrated water resource management in two pilot basins: the Sebou (Morocco) and the Litani (Lebanon). So far the test phase has produced assessments of pressures and impacts, the economic importance of water uses, water pricing and cost recovery. The cost-effectiveness of water management measures is currently under analysis.

Adaptive management practices

Adaptive forest management

All forest management actions undertaken to adapt to climate change should be consistent with sustainable forest management, so as to ensure that the ecosystem services provided by forests are maintained under future climate scenarios. Several research studies have modelled climate change impacts on different forest ecosystems, including Mediterranean and temperate forest types found in the Near East, and made recommendations on possible adaptive management responses tested in the field, aimed at increasing forest resilience while contributing to climate change mitigation through carbon storage.

- Changes in silvicultural practices
    - Adaptive thinning practices. In the context of increasing water scarcity and evapotranspiration caused by climate change, the influence of tree/scrub density on soil water availability remains crucial and it is related to dieback events. Successful experimental projects in Mediterranean evergreen oak woodlands and mountain conifer forests have demonstrated the effectiveness of thinning operations to help reduce water competition and improve water balance (Carreira *et al.* 2007; Gracia et al 1996; Kellomäki & Leinonen 2005). Forest plots where tree density was reduced were able to resist drought events, while a high percentage of trees died in the control plots. Moreover, the reduction of tree density and dry biomass reduces the risk of fire, eliminates growth stagnation in coppice forests, and favours better-structured and more mature forest stands that can store higher quantities of carbon.
    - Shrub cleaning operations: The opening of the forest canopy through thinning accelerates the growth of a high and dense shrub layer, with significant amount of dry biomass in the forest understory. A dense shrub layer may produce the opposite effect of the awaited one when reducing tree density, that is, to increase the risk of fire. Therefore, tree thinning should be combined with management measures to reduce and control shrub growth. This can be done through controlled grazing in the forest understory, once young trees have reached about 3m height (Ne'eman *et al*. 2004) and/or partial cleaning of the forest understory and reduction of the shrub height, in order to create a wide discontinuity between the forest floor and the tree crowns. The

[8] www.euwi.net/wg/mediterranean

control of shrub growth may be integrated as a second objective in the regulations for NWFP production (i.e. rosemary, myrtle and lentisk essence production by GFICs in Tunisia) and fuelwood collection. This will require the involvement of concerned GFIC actors in forestry planning, and the implementation of ad-hoc awareness raising and training activities to test adequate harvesting techniques (Regato 2007).

- The pruning of dead tree branches helps create discontinuity between forest floor and tree crowns, and reduces the risk of fire spreading. Regular pruning operations should be planned, and their costs can be absorbed through annual concessions to local community groups for fuelwood collection (Community-based fuelwood management) (Regato 2007).
- Changes in rotation intervals: longer rotation periods may be expected to compensate for growth rate reduction due to water constraints and the increased amount of carbon sequestered in tree biomass, forest soil and vegetation as a whole (Kellomäki & Leinonen 2005).
- Changes in harvesting periods: the collection of NWFP is often linked to climate conditions, as is the case of cork stripping, which takes place in the summer drought period. Because of the additional weeks of summer days and longer drought periods due to climate change, the harvesting periods should be well planned to prevent excessive evapotraspiration in the stripped cork oak trees that may cause tree mortality (Regato 2008).
- Increase species richness and close-to-nature forest management (Kellomäki & Leinonen 2005). Taking into account that multifunctional forest management is the central objective in most forest policies nowadays, and that timber production is often a marginal product in the Near East forests, it would be desirable to avoid the intensification of one single forest product, and manage a higher number of forest species – trees, scrub and herbs- with a balanced production of a wide range of products. Most researchers recommend the following changes in tree species composition in Mediterranean and temperate forests; the incorporation of indigenous tree species (especially those sensitive to drought) with a high potential for timber production, NWFP or carbon sequestration under climate change and increase the share of broadleaf species in mixed forests, as they might perform better under climate change (Regato 2008). Moreover, broadleaf trees such as evergreen oak species play a nursery role in mixed mountain forests, facilitating the regeneration of conifer trees.

- Enhancing forest resilience through restoration. Under the current climate change scenario, forest restoration should be oriented towards: increase the resilience of forest ecosystems, forest landscapes and watersheds to extreme weather events and disturbances such as heat waves and savage fires, torrential rainfall landslides and floods; reduce water constraints and facilitate species migration needs in the landscape. The Forest Landscape Restoration (FLR) approach and the ecological restoration principles and methodologies provide opportunities to regain ecological integrity while securing human wellbeing (Mansourian *et al.* 2007). FLR brings people together to identify, negotiate and implement practices that restore an agreed balance of ecological, social and economic benefits, promoting forest landscapes with a broader pattern of land uses and a higher resilience to climate change (Saint-Laurent 2008). The introduction of incentives and market opportunities for non-timber forest products not only facilitates the acceptance of forest owners and farmers to shift from mono-specific tree plantations to more diverse forest stands, but it also generates opportunities to diversify and increase local income. Key restoration measures are:
  - The diversification of tree and shrub species with different life strategies (i.e. re-sprouting species; fruit trees/shrubs which attract seed-dispersal fauna; nitrogen fixing trees and shrubs) at the landscape and forest stand level helps to diversify the forest responses to climate stressors and disturbances (Regato *et al.* 2010). This measure implies an understanding of the ecological function of the wide array of species (trees, shrubs and herbs) than used to characterise the Near East forest ecosystems, an assessment of their economic and social values, and the development

of production techniques in the forest administration and in community-run tree-nurseries. A number of pilot initiatives supported by WWF and IUCN in partnership with local NGOs in Morocco and Lebanon have raised awareness about the need to change the old-fashioned strategies based on few native pines and exotic trees (Eucalyptus and Acacia) in favour of a wider range of native forest species. Among the results achieved so far are the increased capacity of NGOs, members of the forest administration and local community groups in the production of a significant number of native species, the establishment of nurseries with important stocks of seeds and saplings from native species, and the testing in the field of different plantation methods (Regato *et al.* 2009). The Lebanese project is also looking at the economic potential of native species for the production of essences and dry aromatic and medicinal herbs, to be sold by women in their villages and in information centres of natural reserves, in the framework of eco-tourism packages.

- In the Near East, the use of runoff and fog water produced upslope has been an efficient, traditional agriculture practice, which may play an important role in the restoration of degraded areas. The need for managing water scarcity in forest restoration initiatives (especially during the first 2 - 3 years after plantation) can benefit from this traditional knowledge. In the degraded mountains around Valencia (Spain), researchers have tried to secure the long-term survival of seedlings (Valdecantos 2008) through the use of lateral channels that deviate surface runoff water towards the hole where the seedlings are planted. The survival rate of *Quercus ilex* planted with this technique increased by 25% as compared to control holes. At the same time, the application of 3 - 5 litres of water gathered in fog collectors to *Quercus ilex* seedlings once or twice during the first summer after planting raised survival rates to close to 100% (Estrela 2004).
- The natural regeneration and spreading of forest species into secondary forest is often facilitated by "nurse" plants that create favourable soil conditions and improve the microclimate. In the Near East, this is the case of numerous shrubs (i.e. *Lavandula* spp. and *Thymus satureioides* facilitate the early growth of the Atlas Cypress in Morocco, Ouahmane *et al.* 2006), herbs (i.e. the halfa grass facilitates the regeneration of shrubs and Aleppo pine in the steppe-forest ecotonal zone in North Africa) and trees (i.e. evergreen oaks facilitate the regeneration of fir and cedar trees in mountain areas of North Africa and the Middle East). The use of shrubs as nurse-plants for reforestation has proved a viable technique to increase reforestation success in the Near East, mainly due to the reduction of solar radiation, the improvement of soil water retention, and the protection from herbivore damage (Castro *et al.* 2004). In addition, this technique offers the advantage of following natural succession, and thus minimizes the impact of afforestation on the natural vegetation. Experimental studies in Sierra Nevada (Southern Spain) demonstrate that shrubs clearly enhanced seedling establishment. After 4 years, the survival for Pinus sylvestris and Pinus nigra under the canopy of Salvia was significantly higher than the values reported for the traditional technique in areas of bare soil (Castro el al. 2004). The use of nurse-plants in reforestation has also been tested in the olive-juniper forests types of the southern Arabian Peninsula and Ethiopian Highlands, where planting under shrubs during above-average rainy summers favours forest regeneration, keeps levels of indigenous biodiversity high, limits livestock damage to olive saplings, and reduces the risk of soil erosion (Aerts *et al.* 2007).
- Healthy organic soil conditions can play a critical role in building the resilience of Near East forests ecosystems. The conservation and restoration of organic soil responds to important adaptation and mitigation objectives, such as improving site productivity (water retention and nutrient availability), improving soil structure (less vulnerable to runoff erosion and higher capacity to store and regulate water supply), increasing carbon storage, etc. Plant production in tree nurseries should have a special focus on organic soil restoration in degraded forestland through compost production (i.e. organic waste and tree pruning residues, residues from pine nut production) and

the use of mycorrhiza fungi (improvement of soil structure, and water and mineral uptake in plants) in native species production and plantation (i.e. the experience of the EU funded project RedMed in the Mediterranean region[9]. The use of forest dry biomass and pruning residues from tree crops will also help reduce fire risk, as the burning of waste is a major cause of forest fires in many areas. Moreover, the use of mycorrhiza fungi not only will improve plant growth and productivity, but it can also enhance the growth of edible mushrooms as an alternative source of revenue.

- Give priority to forest restoration in the Near East coastal mountains, especially in the Southern Arabian peninsula, is an important adaptation measure due to the climate regulation role (intercept fog water and perhaps triggers rainfall) that such mountain forests play in an otherwise arid landscape. Regaining healthy forest conditions in these areas will increase water availability, and allow fog water collection thanks to the existing, promising and low-cost water harvesting technologies for drinking water, crop irrigation, livestock beverage and forest restoration (Nef 2001). Experimental projects have been implemented in a number of countries, including the Near East (Oman) and the Mediterranean region (Spain).
- Facilitate species migration needs in the landscape. On the basis of climate change scenarios and models with projections on species range shifts, it will be possible to identify the future suitable areas for forest species in the landscape. We can thus anticipate migration needs by planting in suitable areas new tree species that are better adapted to the predicted conditions, although this option may have risks due to uncertainties in over-simplified species-based models and climate change scenarios (Regato 2008).
- A more precautionary option will be to facilitate long-distance dispersal needs by restoring scattered forest stands and riparian corridors in strongly converted landscapes with native species. This technique will reduce the dispersal distance required by seeds to reach suitable habitat conditions to grow. The restoration of riparian forests will play an outstanding multiple function, as they will act as corridors in the migration of species, and will help improve water infiltration and groundwater recharge, the filtration of pollutants. Riparian forests can also reduce the temperature of watercourses, and they can act as barriers that prevent the spreading of fire over the landscape.

Adaptation measures in forest conservation

Forests in most Near East have a direct or indirect (through multipurpose use) primary protection function. Forest protection in watersheds should be strengthened to take into account future changes in climate conditions, and it should be oriented to reduce impacts. Undisturbed forests are generally assumed to be the most efficient land cover type in mountain watersheds, as they guarantee best water flow regulation, better water quality, and minimise the occurrence and damage of fast-flood risk. This is especially true in the dryland regions with torrential watersheds and a high risk of erosion and flash flood (Vallejo 2008). Although deforested catchments might increase stream flow and aquifer recharge (Calder 2000), the temporal or permanent elimination of forest cover often leads to an important reduction of water quality, and to an increase of pollutants like nitrates, flash-floods and erosion.

Gene resources conservation

The central task of gene resource conservation is, beyond any economic thinking, the maintenance of the evolutionary-adaptive potential of species, communities and ecosystems (Mátyás 1997). Strategies for adaptive conservation and management of Near East forests can take place *in situ* and *ex situ*.

Forest species and populations with higher phenotypic plasticity and genotypic diversity can better tolerate changes in the environment. Forest ecosystems in the Near East are often characterised by high species and genetic diversity, including highly resilient, old taxa that have experienced many abrupt and intense climate changes in the past (Petit *et al.* 2005). The inventory and conservation of

[9] www.ceam.es/redmed

genetic reserves in dry mountain forests will help preserve the genetic diversity of forest species and ecotypes, ensure higher forest adaptive capacity, and provide genetic material for the translocation of drought-tolerant provenances and genotypes to help species adapt to changes in the climate conditions.

Pollen and seed movement is key in the maintenance and conservation of high forest genetic diversity. Therefore adaptation measures to avoid the disruption of the genetic system of forest populations should prevent forest fragmentation and low forest densities (Papageorgiou 2008). Moreover, the enhancement of gene flow (hybridation) will facilitate the selection of drought-tolerant provenances and genotypes to plan and adapt forestry in dryland mountain regions (Fady 2008).

Resistance to environmental changes through phenotypic plasticity, in-situ genetic adaptation to new conditions, and short distance migration northwards and upwards, are all possible short-term responses to climate change for tree populations to avoid extinction. Therefore, in order to define conservation strategies, it is essential to assess the genetic risk that could threaten the different forest habitats and tree species populations in addition to global change risks. A good example to address this issue is provided by the Near East cedar forests, which will experience fast and severe climate change in the near future (Hoerling & Kumar 2004). Three of the four cedar species (*Cedrus libani* in Lebanon, Syria and Turkey; *C. brevifolia* in Cyprus*; C. atlantica* in Morocco and Algeria*)* are endemic to the Near East, while the fourth (*C. deodara* in Afganistan) is more widely distributed in the Himalayas. Experimental studies on the genetics of the cedar species conclude that:

- The Atlas and Himalayan cedar species populations harbour significantly lower genetic diversity values than *C. libani* and *C. brevifolia* populations (Bou Dagher-Kharrat *et al.* 2007). *Cedrus deodara* seems to be a genetically endangered species, as it suffers of a lack of overall genetic diversity, that is, low genetic diversity within populations and low differentiation among populations, as well as from geographical and reproductive isolation from other cedar species. Therefore, it would be important to focus adaptation measures on better understanding the existent genetic erosion in the Himalayan cedar populations, and assess the species' capacity to withstand climate change.
- In spite of its low genetic diversity, the absence of genetic erosion in the Atlas cedar populations (Lefèvre *et al.* 2004; Fady *et al.* 2008) indicates that this taxon does not appear at genetic risk as a whole. Nevertheless, it is definitively urgent to implement adaptive management measures to stop and reverse the accelerated trend of dieback events in the Atlas cedar populations, such as restore healthy forest conditions with a more diversified species composition and forest structure; plant *nurse* species (i.e. several shrub species and *Quercus ilex*) in degraded areas to facilitate cedar regeneration; prevent organic soil destruction, such as subsistence agriculture, overgrazing and the gathering of soil for tree nurseries, in cedar forest stands and prevent savage wood collection and monitor pests to better understand the interacting effect of maladaptive management practices and climate change in dieback events.
- *Cedrus libani* forests from Lebanon and Turkey constitute two genetically isolated groups that probably arose from distinct refugia after the last Quaternary glacial cycle (Fady *et al.* 2008). While the genetic diversity was high in most of the natural Turkish populations, with relatively low inter-population differentiation and no overall indication of serious genetic threat, most Lebanese populations are currently under threat, either because of low gene diversity and genetic erosion, small size or low natural regeneration. All cedar forest stands in Lebanon deserve high conservation priority, as they are the remnants of what was once a large continuous forest (Alptekin *et al.* 1997) with high genetic differentiation among populations as a result of fragmentation. In populations where gene diversity has been seriously reduced, introducing some level of gene flow from high gene diversity populations might reduce the risk of future maladaptation (Fady *et al.* 2008). As a general rule, maintaining population dynamics and regeneration is a priority for the conservation of *C. libani*. In degraded forestland, restoration actions with nurse plants (i.e. *Quercus brantii* subsp. *look* in Mount Lebanon) can facilitate natural cedar regeneration, as well as the growth of planted cedar saplings.
- The declining, small, and fragmented populations of *C. brevifolia* in Cyprus (only 20,000 trees currently remain) are under threat, and this cedar taxon is mentioned in the IUCN red list (Khuri and Talhouk 1999). Thanks to the high genetic diversity of this species, adequate

measures for habitat preservation and continuous regeneration, such as those currently carried out by the Cyprus forest administration, should be enough to allow in situ persistence of the species. Moreover, the small genetic distance with *C. libani* and the remarkable adaptive traits of *C. brevifolia*, - including drought tolerance - make this species a valuable resource for improving drought tolerance within the *C. libani* complex in the perspective of climate change (Bou Dagher-Kharrat *et al.* 2007).

When species or populations are unable to adapt and in situ conservation efforts can't prevent species loss, ex situ measures are needed for the maintenance of genetic diversity. Frequent and representative collections of seeds for the different provenances and genotypes of threatened forest tree species should be a priority in the Near East region. In the Mediterranean countries of the region, about 40 threatened conifer and broadleaf tree species are included in the IUCN global and national red lists of plants (Quézel & Médail 2003). The seeds can be stored in gene banks and seed orchards that will eventually provide genetic material for restoration activities (Papageorgiou 2008).

Adaptive management in forest protection

Strict conservation measures in the absence of a natural perturbation regime may lead to increased vulnerability of mountain forests to climate change (Regato, 2008). This is especially likely in the case of the many Near East relic forest types that are nowadays concentrated in climate change-vulnerable mountainous areas, with more or less isolated populations of endemic and relict conifer tree species and subspecies.

Experimental studies in Mediterranean relic forest types found in southern Europe and North Africa demonstrate that adaptive conservation measures may demand a shift from strict protection to proactive management. For instance, strict protection measures that encourage natural regeneration and/or reforestation, prevent any natural or human-induced perturbation regime, and entail the abandonment of traditional land use practices, have led to the densification of *Abies pinsapo* relic forests in southern Spain, and have diminished the ability of trees to cope with climatic stress, especially drought (Valladares, 2008). After the intense drought at the end of the 20th century, symptoms of acute decline and dieback episodes were observed in the Spanish *pinsapo* fir populations, while no such symptoms appeared in the Moroccan populations (Carreira *et al.* 2008).

This contrasting behaviour and the fact that traditional land uses still occur in the Rif mountains, suggests the hypothesis that the higher vulnerability of the Spanish populations might be related to the predisposing effect of excessive stand densification obtained through the severe protection measures. On the contrary, the maintenance of low-intensity traditional uses (grazing and scattered logging) in the Moroccan forests may have promoted greater structural diversity, which might explain the higher resilience to recent climate change. Successful results in experimental plots suggest that adaptation option that enhance structural diversity at the stand level, and the implementation of a minor perturbation regime through low-intensity thinning practices, help reduce the severity and degree of incidence of possible mortality, and increase forest resilience to climate change (Carreira *et al.* 2008).

Rethinking protected area networks

Forest protected areas will become increasingly important in a climate change context, but only if well planned, efficiently managed and with adequate staff and resources. Forest protected areas can serve for both adaptation and mitigation to climate change (Regato 2008):

- Methodologies and criteria based on biodiversity adaptation needs can help design more effective protected areas boundaries and networks -including buffer zones and corridors- to enhance connectivity and secure provisions for *in situ* conservation of representative examples of all species and habitat types, for protecting forest genetic reserves, and for the facilitation of species migration needs.
- The assessment of high carbon storage and sequestration potential in forestland can be used as an additional filter in selecting protected areas.

Adaptation measures may include (Dudley *et al.* 2010):

- Increase the area of forest protected areas and landscape connectivity through protected areas networks;

- Increase the efficiency of management in forest protected areas (i.e. by further application of assessment drawing on the IUCN-WCPA management effectiveness assessment framework);
- Restore forests in protected areas in logged-over areas, abandoned farmland, and in places where climate changes make unviable other land uses and building management capacities.
- Build capacity of protected areas managers and local communities to monitor climate impacts on biodiversity.
- Integrate nature conservation into broader landscape level spatial planning objectives and adopt adaptation measures in other economic sectors, which are compatible with nature conservation needs.

Adaptation measures in coastal forest ecosystems

Coastal dune systems

Coastal dunes are extremely fragile ecosystems located in the transitional zone between continental and marine habitats. They regulate the hydrodynamics of estuaries, marshes and coastal lagoons. The environmental function of coastal dune systems becomes even more relevant under current climate change scenario, with a predicted rise of the sea level, and increase in the frequency and intensity of storms.

Bad management practices (i.e. deforestation, overgrazing, mining of sand dunes, urbanization) have degraded the coastal vegetation in many Near East countries, and caused important erosion problems, the mobilization of sand into urban and industrial areas, and the loss of dune ecosystems in large parts of the coast.

Adaptive management of coastal sand dunes urgently require the implementation of good restoration practices to regain the functionality of the system, stabilize sandy soils, reduce vulnerability against extreme weather events, and protect the coastal vegetation and settlements established behind the dune systems. Restoration should take advantage of the high diversity of plant species that characterizes the Near East sand dune ecosystems. It is important to change the approach followed in the past decades, and still is in force in the North African countries, which makes use of exotic species such as acacias for dune fixation, and thus prevents the system from regaining natural conditions. Moreover, exotic species may become invasive under climate change conditions (i.e. a number of South African *Carpobrotus* species became already invasive in a number of coastal areas in the Mediterranean) and cause the disappearance of endemic species and ecosystems (Médail & Quézel 2003).

Mangroves

Mangroves are found in the Gulf countries, Yemen, Egypt and Sudan. They cover about 47 266 ha, with the greatest extent in Saudi Arabia (20 400 ha) and Iran (19 234 ha) (FAO 2007). Although the extension of mangroves has remained quite stable during the last decade, the combined effect of unsustainable management practices (i.e. overgrazing and wood collection) and climate change (i.e. sea level rise; more frequent and intense storms; indirect effect of increased temperature and CO_2 damaging coral reefs, that provide shelter from wave action) represent a major threat t the survival of these ecosystems.

Some general adaptation measures to strengthen mangrove resilience to climate change include the following (McLeod & Rodney 2006):

- Reduce human stressors and restore degraded areas. This implies trade offs to identify alternative livelihoods for mangrove-dependent communities.
- Rehabilitation of high-tide habitats to enhance capacity for the inland retreat of mangroves in response to sea level rise, and reduce impacts from adjacent land-use practices.
- Understand and preserve the connectivity between mangroves and sources of freshwater and sediment, and between mangroves and their associated habitats like coral reefs and sea-grasses.
- Establish baseline data and monitor the response of mangroves to climate change.

Adaptation measures under other land uses

Planning the location of resilient land uses in forest landscapes and managing them in order to optimise water balance, water supply, reduction of hazards, and ecosystem conservation are key aspects of adaptation to climate change (Vallejo 2008).

Reducing water competition between agriculture and forestland

The expected greater water stress and reduction of groundwater recharge will have a negative impact on crops and water availability, and it will critically influence the patterns of future agricultural production. Higher irrigation needs will increase the competition for water between agriculture and forestland, and they will likely favour dieback processes, as it has already happened in several areas of the Mediterranean region (i.e. cork oak dieback in the coastal lowlands around Mamora in Morocco; riparian forest dieback in the Tablas de Daimiel National Park in southern Spain). This implies the need for improving water productivity and water use efficiency in agriculture, as an adaptation measure to reduce the vulnerability of the Near East forest ecosystems to climate change. Measures like the modification of soil management practices in agriculture (e.g. low tillage and the maintenance of permanent soil to reduce erosion rates and downstream flooding and increase water absorption and retention), the adoption of new irrigation technologies, the development of participatory water resource allocation tools to facilitate decision-making, and the adoption of co-management systems involving local communities, researchers, government extension and NGOs, are all likely to improve the adaptation capacity of mountain farmers.

The work of ICARDA in Syria and Central Asia shows the benefits of minimum- and zero-tillage over deep-tillage systems, especially if combined with cereal-legume crop rotations, and the beneficial effect on crop yields, soil quality, water use efficiency and net revenue (Thomas *et al.* 2007). A study of ICARDA on on-farm water use efficiency shows that farmers actually over-irrigate their crops by 20 - 60%, while the results of a field research work on Syrian farmers demonstrates that they could produce 33% more grain from 50% full supplemental irrigation practice compared with full irrigation

A number of low cost, simple irrigation methods which require much less water and labour (i.e. deep pipes, buried clay pots, porous capsules, wicks, porous hose, and sub-irrigation with perforated pie) and that were traditionally widespread (Bainbridge 2008), in combination with new technologies (i.e. decision-making tools to calculate the real water demand of crops) can help save a significant amount of water and increase yields in agriculture, agro-forestry and land restoration in the region (Thomas *et al.* 2007; Isendahl & Schmidt 2006).

Agro-forestry adaptation measures

Traditional agro-forestry systems are found in most Near East countries. They combine the use of profitable trees (i.e. wood, fodder, fuelwood, resins, edible fruits), agriculture crops and grazing, and provide a wider range of products and revenues for local people. They represent an effective adaptation strategy to help mitigate the consequences of irregular and unforeseen rainfall in annual crops, and of economic fluctuations through regular and reliable supply of complementary products for people and livestock (Berthe 1997).

Farm trees and shrubs are found scattered or in small stands throughout cultivated areas or surrounding crop fields (i.e. hedges, windbreaks and shelterbelts) and provide important environmental services to the system - i.e. they provide shadow that helps reduce evapo-transpiration and maintain over longer periods green pasture under the trees during summer drought; they increase soil fertility and nutrient cycling; they regulate runoff and water infiltration. The promotion of agro-forestry practices with the introduction or increase of trees in agriculture land represents an important adaptation measures in the Near East region.

Green shelterbelts : Green shelterbelts are an important element on agricultural land in most countries of the region. Farmers are well aware of the importance of windbreaks and shelterbelts in protecting croplands against drying winds and sand deposition, and runoff erosion. In Yemen, farmers plant forest trees around farms, on terraces and along water courses. Agroforestry areas supply building materials, fuelwood, fodder and habitat for honey production (FAO 2004a). In Syria, windbreaks composed of several tree species cover 4600 ha, and it is estimated that they increase crop production by 15 to 40%. In Oman, shelterbelts and windbreaks are beneficial in increasing

agricultural production and stabilizing canal banks. They are mainly made of tree species such as *Ziziphus* spp., *Prosopis cineraria* and *Phoenix dactylifera,* which also produce cash crops. Farmers in Iraq plant poplars or other woody shrubs in hedges or shelterbelts around agricultural land and along irrigation channels. In the Mediterranean area of North Africa, substantial tree resources exist outside forests, especially olive and fruit trees in agricultural fields. The establishment of windbreaks and shelterbelts around farmlands is a standard farming practice in most of North Africa.

Fruit orchards : Fruit orchards are an important system in most Near East countries, and they generate considerable economic benefits by producing fruit, while protecting farmland and supplying wood and other environmental services. In the Mediterranean zone, substantial numbers of olive and fruit trees are found in agricultural fields, while date palms are common in arid areas.

In the United Arab Emirates, date palm cultivation plays a key role in turning large tracts of desert into green oases (UAE, 2006). Over 40 million date palms were grown, and 4 000 tonnes of dates were sold for a value of US$8 million in 2003. An existing regulation stipulates that every 4-hectare farm must have at least 200 date palms. Fruit orchards in Oman cover 100 886 ha, accounting for 57.7% of the country's agricultural land. There are also 179 000 coconut palms in fruit orchards (FAO, 2004a). Coconut and date palms are the main components of orchards in Iran. Significant projects have been implemented for the development and modernization of orchards over the past decade, and it is estimated that their area increased by 38.8% between 1990 and 2000, rising to 1.7 million ha.

Avoiding large-scale land use changes in non-forested natural ecosystems

Non-forested dryland ecosystems, namely deserts and steppes, characterise large parts of the Near East region. In spite of the critical role against desertification played by the Near East non-forested drylands, the society hardly values them, and tends to view them as wastelands. These habitats are thus being exposed to severe degradation (overgrazing, over-harvesting of wood and plants, land conversion into agriculture, etc) and large-scale development plans.

The synergetic combination of climate change associated with too intense and/or rapid anthropogenic changes is leading to irreversible changes (i.e. vegetation loss, soil alteration by aeolian sand mobilization, and encroachment of inhabited areas) and the impoverishment of the natural and social capital of the Near East steppes. Major afforestation and agriculture irrigation plans have converted huge steppe areas in North Africa (i.e. more than 50% - about 3 million ha - of the Halfa-Steppes in Algeria were lost during the last century; Dalila & Slimane 2008), and caused significant ecological and social problems, especially in terms of species and habitat loss, soil erosion and sand mobilization invading human settlements, agriculture and forestland.

Steppe species and ecosystems have developed very effective strategies to cope with environmental constraints such as water scarcity, extreme hot and cold temperatures, and un-predictable long drought periods with sporadic rainfall. They are highly resilient to extreme weather events and disturbances, and hold great significance in the context of climate change. For instance, steppe grass species, like halfa (*Stipa tenacissima*) tussocks, positively modify the availability of resources such as light, nutrients and water in semi-arid steppes through the amelioration of the microclimate, the improvement in the soil structure and depth, the increase in soil moisture and water infiltration, and carbon and nitrogen storage (Maestre *et al.* 2003 & 2007). Halfa creates “hotspots” of favourable soil conditions and microclimate, the so-called “resource islands” or “islands of fertility” (Maestre *et al.* 2001) facilitating the establishment of shrubs and tree species in the steppe-forest ecotonal zone in semi-arid regions, a very important feature when planning restoration actions in degraded steppe land.

A good adaptation strategy will entail the prevention of steppe land conversion, the restoration of steppe vegetation, the valorisation of the ecological role of steppe grasses and shrubs, and the growth of tree saplings to restore forestland.

Adaptation in urban forestry practices

Urban and peri-urban forests play important climate regulation, protection (i.e. protecting human settlements from sand and dust storms) and cultural services (i.e. for recreational and other amenities) (Knuth 2006). Parks and gardens have been established at high cost to enhance major urban centres in the United Arab Emirates, Kuwait, Oman, Bahrain and Saudi Arabia. Green spaces in Iran have

expanded from 6 000 ha in 1987 to about 14 000 ha today to compensate for private orchards removed during the urbanization process. Syria has also undertaken a vigorous urban forestry program and forest plantations near cities have been turned into recreational sites. In Turkey, the establishment of greenbelts around urban areas has been gaining increasing importance since the mid-1980s and a total of 132 000 ha of greenbelts has been established around cities in 32 provinces.

Almost all urban and peri-urban forests need to be heavily irrigated in the Near East, especially in their early stages. An increasing number of countries, including Jordan, Oman, Cyprus, Turkey, Iran, Egypt and Saudi Arabia have developed and improved irrigation systems and are using treated sewage water to irrigate forest plantations and greenbelts. As the shortage of freshwater is a major constraint, the expansion and maintenance of urban forests will become increasingly dependent on the use of treated wastewater. In addition, drip-irrigation techniques have been developed and are widely used to irrigate urban forests.

In most countries, urban forestry requires high investments for establishment and maintenance, and almost all of these come from national budgets. However, the financial commitment of governments is not always assured, because priorities are set at different levels. Cyprus appears to have a more stable system for financing its urban forestry, with special taxes intended to finance the management of urban green spaces, while the greening of urban areas is one of the main tasks of the country's municipal administrations. With tourism becoming a major source of income, improving the urban environment has become all the more important. In countries where the government has insufficient resources, urban forestry is mainly dependent on international support.

Estimations of adaptation costs

All countries need to adapt to climate change, and this will be costly. The lack of funds available for adaptation is an obstacle for the implementation of adaptation plans. Without sustained funding, adaptation will not be effectively addressed, as short-term emergency relief and will be unsupportive of sustainable development.

There is no information on the estimated costs for adaptation to climate change in any of the countries of the Near East. The overall picture emerges from the recent IPCC projections. By 2100, under a baseline climate change scenario, the average cost of adaptation in parts of the Near East Region - especially the Middle East - is predicted to be equivalent to around a 2.5 % and 1.9 % loss in GDP respectively, compared with what could have been achieved in a world without climate change (FAO 2008). Under an extreme climate change scenario, the average cost is predicted to be 3.5% of GDP in Africa and the Middle East, due to loss of agricultural land and/or threats to coastal cities.

According to the Stern 2006 review, there are reasons to assume that some of the worst projections might materialize. The poorest people would be hit the hardest, and the cumulative effects of extreme weather could be worse than anticipated. If emissions continue unabated, temperatures could reach much higher levels in the next century, and the region would experience far greater impact, including mass migration and conflict. The earmarking of additional funds is vital for the Near East countries, in order to plan for, and implement adaptation plans and projects. A basic conclusion of the Stern Review is that the costs of inaction far outweigh the costs of strong and urgent action by at least five to one. The study undertaken for the UNFCCC estimates that in 2030 the adaptation funds required will be: US$ 14 billion for agriculture, forestry and fisheries; US$ 11 billion for water resources; US$ 5 billion for human health; US$ 11 billion for coastal zones; and US$ 8 – 130 billion for infrastructure (see UNFCCC 2007). The investment and financial flows needed for adaptation are likely to be tens of billions of dollars per year several decades from now and could be more than US$ 100 billion/year. Other studies also estimate adaptation costs at tens of billions of dollars/year.

Recent top-down approaches have looked at the necessary additional financing needed on current investment to include an adaptation component. One estimate of the global cost of ‘climate-proofing’ new investments in developing countries is US$10–40 billion per year, and using a similar approach, the World Bank and UNECA estimate an annual cost of US$ 2–7 billion for Africa alone (around 0.5% of Africa’s GDP). The AfDB also estimates the need for additional resources of US$300 million/year just to safeguard the effectiveness of new AfDB/African Development Fund (ADF) investments (Watkiss 2009).

Mitigation measures

Climate change mitigation is achieved by storing carbon that would otherwise be released into, or retained within the atmosphere. Forest mitigation options include reducing emissions from deforestation and forest degradation, enhancing the sequestration rate in existing and new forests, using wood fuels as substitutes for fossil fuels, and using wood products to replace more energy intensive materials. If properly designed and implemented, forestry mitigation options will have substantial co-benefits in terms of employment and income generation opportunities, biodiversity and watershed conservation, provision of timber and fibre, as well as aesthetic and recreational services.

Although the Kyoto Protocol aims to increase carbon dioxide sequestration worldwide, until recently, the potential of drylands to sequester atmospheric carbon was not highly valued because of their relatively low plant biomass stocks, especially where land is degraded (Dobie & Goumandakoya 2005). This is the reason why the largely degraded soils of dryland ecosystems and agriculture land are still far from saturated with carbon and their potential to sequester carbon may be very high (Farage *et al.* 2003). Moreover, the sheer size of the drylands has drawn attention on the fact that a very small overall increment in plant biomass through better management could make a significant contribution to the global carbon budget. Globally, 36% of the carbon stored is terrestrial ecosystems is stored in drylands, mostly in dryland soils (MEA 2005).

Increasing carbon stocks through reduced forest degradation and deforestation

The 2005 Global Forest Resources Assessment (FRA 2005) defines deforestation as the conversion of forestland to other land uses or a long-term reduction in crown cover to less than the minimum 10% threshold. According to the IPCC, the forest sector accounts for 17.4% of global greenhouse gas emissions. Forest degradation and the gradual reduction of biomass within forests in the absence of land-use change represent at least 30% of total forest emissions – mostly the consequence of timber or fuelwood collection, and fires often associated with agricultural clearing.

The causes of deforestation and forest degradation are complex and often related to a lack of proper forest management and regeneration activities. Sustainable forest management provides a method for balancing diverging priorities of sustainable economic and social development on the one hand, and ecological sustainability on the other. When following the principles of sustainable forest management, forest resources are managed and extracted at a rate that meets the needs of the society while ensuring forest regeneration, health and vitality.

Forest cover in the Near East region has been relatively stable over the past 15 years, with slight increases in most countries, mainly due to tree plantations and - in cases like those of Cyprus and Lebanon - to forest colonization of abandoned agriculture land (FRA 2005). Afghanistan and Mauritania are the only countries of the region where forest cover has decreased quite significantly. However, there is a fundamental problem with the reliability and availability of information, as most countries only have limited capacities for regular monitoring and reporting of changes in forest cover. Available figures seldom provide an indication of degradation, which is often a slow and less obvious process. For instance, there is an important loss of cedar forests in North Africa, which often entails the loss of the upper tree layer without changes in forest cover, and eventually leads to the forests being only composed of holm oak (*Quercus ilex*). Moreover, the significant forest fragmentation caused by subsistence agriculture and grazing in mountain areas is hardly captured in the statistics.

Initiatives to reduce emissions from deforestation and degradation may draw financial support for sustainable forest management (SFM). The wealth of experience, tools, approaches and partnerships that already exists in SFM should be applied to the climate change challenge. As the IPCC puts it, "comprehensive intersectoral programs that combine measures to control deforestation and forest degradation with measures to increase agricultural productivity and sustainability will likely contribute more to reducing vulnerability of forests to climate change, land use change and other stress factors than independent sectoral initiatives".

Effective strategies for reducing emissions from forest degradation exist and many have been employed for years to protect standing forests. In addition to the adaptive management practices already mentioned in the previous chapter, strategies that are currently available to address degradation on the ground include:

Fire Management

Many countries in the region lack policy measures and the institutional capacity for effective fire management, including monitoring, early warning, preparedness, prevention, suppression and restoration. The national fire strategy approved in May 2009 by the government in Lebanon is a good example of integrated fire management approach to reduce the risk of harmful forest fires, allowing for fire regimes that are socially, economically and ecologically sustainable, increasing ecological and social resilience in forested rural landscapes, and reducing carbon emissions (Asmar *et al.* 2009). The strategy takes into accounts the essential need of engaging all concerned actors in fire management, especially local communities. The Lebanese fire strategy could be used as an example for the revision or development of other fire management strategies in the region.

Owing to the trans-boundary nature of forest fires, the planning for their prevention should be addressed from a regional perspective. Jordan and Cyprus have already provided assistance in fire suppression to other regional countries, and informal cooperation is taking place between Cyprus and Lebanon. The Mediterranean countries that are part of the European Union are more advanced in terms of cooperation on forest fires. Significant prevention efforts made by the EU and its member states have been focused on training, investigation, awareness and structural prevention, although efforts need to be intensified to deal with the consequences of climate change (Gómez del Álamo 2010). Among the recommendations proposed at the 2010 workshop on *The Assessment of Forest Fires Risks and Innovative Strategies for Fire Prevention*[10] (Rhodes, Greece) to review current prevention systems in European countries and identify new strategies and policies needed in this area, are: the establishment of a European Sustainable Fund for Forest Fire Prevention, the inclusion of awareness and education on forests in all the educational programmes, and the promotion of the economic dimension of forests. In fact, the correlation between active forest management in an integrated rural development context and the reduction of fires is crucial. The promotion of resilient land uses –forest, agriculture and pasturage- requires good economic valuation and incentives to gain the acceptance from landowners and users, and help them adopt resilient practices and uses.

Fuelwood Management

Wood is the fourth-largest source of energy - after petroleum, coal, and gas - and it is the largest renewable source. Fuelwood and charcoal are a major source of energy in rural households throughout the Near East. In fact, between 66% and 99% of all wood removals in the region is used for fuel, compared with a global average of 40% (FRA 2005). With international prices of fossil fuel rising, it can be expected that fuelwood use will also increase in the region, leading to additional deforestation and forest degradation. By providing renewable materials and fuels - thereby reducing reliance on fossil fuels - and still maintaining their role as carbon reservoirs, forests can make a long-term contribution to mitigating climate change. The use of sustainably harvested biofuels produces a CO_2 benefit when the emissions from biomass combustion are offset by biomass growth, and emissions from fossil fuel combustion are avoided.

The use of surplus wood from unutilized wood wastes in all wood related industries, agriculture based on fruit tree crops, and logging residues, and from improved forest management (pruning and thinning residues from underutilised species) can actually increase forest productivity, and thus contribute to the overall economic viability of the concept. The proper removal of these materials - a need already recognised by most forest experts - will make the forests healthier, more productive and will simultaneously add to energy supply. As a renewable fuel resource, biomass residue is increasingly being recognized for its potential value to industry, rather than merely waste. When used as an industrial fuel, biomass is a substitute for fossil fuels, and adds to the saving of non-renewable resources.

Several strategies can be employed to alleviate the pressure of fuelwood collection - a major driver of degradation and deforestation in most of the Near East. The negative impact can be mitigated through a variety of land management and improved cooking regimes, including:

- Employ systems that combine trees and shrubs with crops and/or livestock to create more diverse and productive agro-forestry landscapes, and adopt sustainable tree pruning systems and biomass reduction shrub clearing that can supply fuelwood.

[10] www.foresteurope.org/eng/Commitments/Documents/Meetings_2010

- Assess biomass contents in all wooded areas and test biomass collection options for bio-energy production that are compatible with nature conservation and ecosystem functionality.
- Restore cleared or degraded lands to provide a new source of fuelwood for communities.
- Assess the potential use of agriculture and forest waste materials for bio-energy production, with the added value of reducing fire risk. Biomass resources for energy include residues from forest management and forest industries (i.e. from the processing of wood, paper pulp and pine nuts), together with significant quantities of residues derived from agriculture (i.e. residues from olive tree pruning, grape molasses, cotton stalks) are available for energy production. They are a cost-effective source of energy at the present fuel prices.
- Replace wood-burning stoves with models that burn other fuels, such as methane from agricultural waste. Use economical, easy to use stoves that improve the efficiency of fuelwood or charcoal, meet the needs of rural women, and promote behavioural changes, like drying fuel wood before use, or using a lid during cooking. Cook stoves are the most common way of cooking and heating food in developing countries, where the average rural family spends 20% or more of its income to purchase wood or charcoal for cooking. If most cooking stoves were improved to be heat-efficient and produce less smoke, the change would be highly beneficial for rural communities in the region. In Sudan, an efficient stove program was carried out In Darfur in 2006 (ProAct Network 2008). The goal of the program was to develop new, more efficient kinds of stoves. Of the tested improved stoves, a local made modified stove was accepted, which used 67% of the fuel needed for the conventional three-stone fire stove. It is believed that with appropriate modifications, the fuel consumed by a three-stone fire stove can be lowered by 50% - with an annual saving of over 900kg of fuelwood per household.

Forest certification

Forest certification is a labelling system used to encourage sustainable forest management by providing added value to forest products from well-managed forests (Robson *et al.* 2004). Effective forest certification schemes have sets of principles and criteria on environmental, social and economic requirements so as to ensure sustainable forest management. The market demand for certified forest products puts pressure on forest owners, which in the Near East is mainly the public administration, to secure good and efficient governance of forest resources and fair distribution of benefits. Forest certification represents an effective tool to ensure sustainable forest management and create the necessary conditions for the reduction of forest degradation and deforestation. Moreover, forest certification can open new market opportunities, and bring a tangible contribution to the improvement of people's livelihoods.

Certain certification schemes, such as FSC (Forest Stewardship Council), are more effective in achieving sustainable forest management, namely that forests are managed in an environmentally appropriate, socially beneficial and economically viable way, based on a set of principles and open, multi-stakeholder participatory processes and governance mechanisms.

Throughout the Near East, there is a clear need to develop national certification standards which can help solve major environmental and social issues, while remaining competitive in the market. The FSC cork oak certification programme led by WWF, for instance adopted a step-wise approach as follows (Berrahmouni 2008):

- Raise awareness to increase consumers demand for wine with cork stoppers, and lobby the wine industry to reduce the substitution of cork with non-natural substitutes (plastic or screw tops).
- Lobby the cork processing industry to adopt FSC certification, as the best way to meet the wine industry demand for good quality cork stoppers. The processing industry demand for certified raw cork puts pressure on landowners to apply for FSC certification of their forestland.
- Raise awareness and building capacity of forest owners and the public administration to adopt forest certification and develop FSC national certification standards.

All this implies a number of obligations for the public administration (e.g. improving legislation and governance mechanisms, granting access rights to local communities and developing co-management frameworks) that have a positive effect on the forest ecosystems and inhabitants. The WWF programme has produced the following results so far: The first ever FSC-certified wine

producers and traders using FSC cork stoppers; the certification of the chain of custody of major cork producers in Portugal and Spain making FSC cork stoppers available in the market; pilot certification of 30 000 ha (50 000 ha more are under progress) of cork oak forests in Portugal, Spain and Italy; the establishment of national working groups for the development of FSC standards for responsible forest management in Portugal and Morocco. Moreover, the programme is working with local community groups in Morocco and Tunisia to support the diversification of their economies, based on a wide range of cork oak forest products and services, including ecotourism activities.

The United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD)

At the 2007 UNFCCC Conference of Parties (COP) in Bali, it was agreed to develop a mechanism to compensate reduced emissions from avoided deforestation and degradation. Reducing emissions from deforestation and forest degradation (REDD) became REDD Plus after conservation, sustainable management and enhancement of carbon stocks were added to the original concept at Bali. A report prepared for the UNFCCC Secretariat quantified the mitigation potential of REDD based on an analysis of the opportunity costs of different use alternatives (Blaser & Robledo 2007). This analysis considered a simplified approach to characterize the following direct drivers of deforestation and forest degradation: commercial agriculture; commercial crops; cattle ranching (large scale); subsistence farming; small scale agriculture/shifting cultivation/slash and burn agriculture; wood and non wood forest products gathering for local use, mostly family-based; commercial timber (legal and illegal) for national and international markets.

Although most discussions about REDD focus on avoiding forest loss from multiple-use landscapes, it is possible that the maintenance of carbon stored in other ecosystems such as grasslands and wetlands could be eligible for funding (Dudley *et al.* 2010). Methods to measure and verify reductions originating from changes in land-use and land management are currently being developed under the UNFCCC (Pistorius *et al.* 2008).

Near East countries should investigate where the carbon storage potential is great enough to attract finance. In this sense, interventions that increase the amount of carbon stored in drylands, particularly those that are relatively low cost, may be attractive to carbon markets (Trumper *et al.* 2008). Moreover, countries should consider whether REDD and other mechanisms could prioritise schemes that also deliver co-benefits such as watershed or erosion protection. It is clear that dryland carbon sequestration, particularly in soils, can provide other ecosystem and social benefits, and actions for soil improvement through carbon sequestration are a win-win situation where increases in agronomic productivity may help mitigate global warming (FAO 2004b).

Three aspects are of paramount importance for the effective implementation of REDD; the amount of money made available must be adequate and timely, the funds must reach the people who are expected to make sacrifices for preventing deforestation and the funds must be spent on activities that ensure, indirectly and directly, the conservation and enhancement of carbon stocks (Kant 2010). In addition to this, deforestation and forest degradation will only be avoided with fundamental policy reforms to achieve good governance - not only through improvements in the forestry administration and management, but mostly with the establishment of collaborative management systems and fair tenure rights for local communities, and the assessment of the economic value of the wide range of goods and services provided by the Near East forests.

Enhancing carbon sequestration through afforestation/reforestation

Although forests and woodlands can play an import role as carbon sinks, the scope for adopting this approach in the Near East is limited by a number of reasons. CO_2 sequestration projects in the region tend to be outside the CDM framework of the Kyoto Protocol, and most are externally funded afforestation/reforestation projects where CO_2 sequestration is accomplished incidentally. Inherent low biomass productivity and the rigorous requirements limit the capacity of the countries to implement afforestation/reforestation projects within the CDM framework. CDM is a market-based mechanism, with most resources flowing to those countries that are able to sequester carbon competitively. This may limit the ability of the region to take advantage of this scheme.

The fact that most countries in the region have low natural forest cover has encouraged considerable afforestation and reforestation efforts, mostly focusing on the protective functions of

forests and trees. Forest plantations account for about 5.6% of the total forests in the Near East, with Sudan (5.4 million ha) and Turkey (2.5 million ha) having the largest share (FRA 2005). During 2000 - 2005, tree plantations significantly increased in Algeria, Morocco and Israel.

Almost all forestland in Egypt, Bahrain, Kuwait, Oman and the United Arab Emirates are considered plantations. About half of Oman's very limited forest plantations are for rangeland rehabilitation while the other half are intended for the rehabilitation of degraded forest areas. In Saudi Arabia, a sand barrier project implemented in 1962 in the Al Ahsaa Governorate brought to the afforestation of an area of 1560 ha, while reforestation in deteriorated forests was also carried out since 1966.

Tree plantations in North Africa are mainly done with few exotics (i.e. eucalyptus and acacia) and native pine species. In Tunisia, a decree encouraging tree planting dates back to 1886; reforestation has been in full swing since 1956, and 202 000 ha of trees have so far been planted. Algeria has planted the largest area, with 718 000 ha, of which 40 000 are eucalyptus and 48 000 ha are pine. The Green Barrier is a testimony to these efforts. In Sudan, *Acacia senegal*, the source of Arabic gum, is one of the main species planted.

Turkey and Iran are the main producers of wood products in the region and have established considerable plantations in areas with higher wood productivity for production purposes. In Turkey, poplar plantations cover about 130 000 ha and provide 3.3 million m^3 of industrial wood per year, accounting for 25% of total domestic industrial wood supplies. In 1999, Iran had 204 000 ha of industrial plantations, composed mainly of poplar and eucalyptus, and covering more than half the total consumption of the domestic wood industry. Poplar plantations are also found in Afghanistan and Lebanon, where they are intended for small local industries and fuelwood production.

Some plantations in certain Near East countries are intended for NWFP production - i.e. pine nuts, carob molasses – and most are privately owned. The involvement of the private sector in plantations has been slight to date, although various incentives have been offered to encourage private planting, as in the case of Turkey, Lebanon and Iran. The prolonged dry conditions of most countries require irrigation in the early years of establishment. For example, all the plantations in the United Arab Emirates have been set up through irrigation, as have half of those of Iraq. Obviously the high investment required for irrigation is an important constraint in expanding plantations. In addition, the predominant public ownership of forestland limits the private sector's participation.

In spite of the substantial investment, these plantations have not always yielded the expected result, often as a result of old-fashion planting techniques, unsuitable sites (soil and climate conditions) for the species selected, or poor maintenance. Overall, Near East country would benefit of a trend similar to that experienced the northern Mediterranean countries, towards ecologically sound and social beneficial plantations, mainly based on a wider range of multi-purpose native tree species. In recent years, efforts have been made to increase community participation in ecologically sound tree planting schemes. For instance, in Turkey NGOs have initiated tree-planting campaigns in partnership with the Government and with the involvement of local community groups. International organisations (i.e. IUCN and WWF) have supported capacity building and pilot actions to demonstrate good practices in multi-species plantations with native species.

Forest plantations, except those on farmlands, were mainly established by the public sector. As yet, there are no real incentives to attract private sector interest in establishing commercial plantations, on account of the high costs and the inherent low productivity. An exception to this general trend, however, can be seen in the Sudan, where conditions are more favourable for growing trees.

Enhancing landscape-level carbon sink through forest conservation

The IPCC clearly identifies the mitigation role of effective forest protection measures - i.e. well managed protected areas, indigenous reserves, non-timber forest reserves and community reserves - that lead to carbon sequestration. Protected areas, if effectively managed, have proven to be powerful vehicles for reducing deforestation and forest degradation, and they have the potential to be an important building block of national REDD. New protected areas may be eligible under some proposed REDD crediting mechanisms within the context of national programmes that address potential emissions leakages. Beyond reducing forest loss and degradation, such areas would secure ecosystem services vital to climate change adaptation and safeguard threatened species ($REDD^+$) (Dudley *et al.* 2010).

There has been significant progress in the formulation and amendment of laws for the protection

of forests. Some countries of the region, including Turkey, Saudi Arabia, Cyprus, Lebanon, Tunisia and Morocco, have recently adopted policies and taken steps to expand and improve the management of protected areas. However, the percentage of forestland included in the parks and protected area systems of the Near East is still to be calculated. A number of new public and private protected areas have been established in recent years. Saudi Arabia, Iran, Israel, Oman and Turkey have extensive parks and protected area systems. Morocco has identified an important number of terrestrial, freshwater and marine sites of biological and ecological significance (*SIBEs*), which well represent the biodiversity of the country and are candidate protected areas for the forthcoming years. Of Jordan's registered forestlands, 30,000 ha are located in rangeland, and the Directorate of Forests has established 22 pasture reserves with an area of 72,000 ha.

The CBD Programme of Work on Protected Areas (PoWPA) supports the elaboration of national gap analysis exercises to complete ecologically representative networks of protected areas. Currently, the UNDP GEF is supporting ongoing gap analysis in 20 countries (Mauritania and Afghanistan included) to provide mapping data and tools for the identification of areas in need of protection with high biodiversity value and livelihood significance, that are carbon-rich natural ecosystems (Dudley *et al.* 2010).
Although the inclusion of protected areas in REDD programmes has several advantages (i.e. REDD can fit into an existing framework without long political and legal delays; protected areas usually have systems for land tenure agreements, an issue that has already been identified as a key requirement of REDD), a number of issues are still to be worked out, if potential REDD projects are to be really effective and socially equitable (Rietbergen-McCracken 2008)

Enabling conditions

The need for more management will require considerable investments in infrastructure (communications and fire detection), training and equipment. It is expected that the frequency and intensity of fire, insect attack and disease will increase. It is important that the countries of the region cover these costs through projects for the climate change mitigation services provided by forests (CDM projects).

Governments typically have less authority to regulate land use on private lands and so have relied upon incentives to maintain forest cover, or to improve management. These incentives can take the form of tax credits, subsidies, cost sharing, contracts, technical assistance and environmental service payments. The lack of robust institutional and regulatory frameworks, trained personnel, and secure land tenure has constrained the effectiveness of forest management in many developing countries.

Despite these problems, there are several examples where large investments in building technical and institutional capacity have dramatically improved forestry practices. Policies aimed at liberalizing trade in forest products have mixed impacts on forest management practices. Trade liberalization in forest products can enhance competition, and it can turn improved forest management practices more economically attractive in mature markets.

The voluntary certification to sustainable forest management standards aims to improve forest management by providing incentives such as increased market access or price premiums to certified producers who meet these standards. Certification can result in measurable improvements in management practices.

Adaptive governance

In the Near East, deforestation and forest degradation are often caused by factors stemming from poor forest governance. Solutions to these complex challenges include:

- Simplify decision-making and improve the resources of the concerned authorities to ensure compliance with forest policies.
- Provide government agencies with the manpower, skills, equipment and financial resources to implement and enforce laws.
- Set up mechanisms for inter-agency policy-making, planning and implementation, as many land use sectors have direct impacts on each other (e.g. forestry and agriculture).

- Make use of new technologies to generate accurate and timely information on forest resources and incorporate a more comprehensive suite of forest values.
- Employ open decision-making processes and circulate information among stakeholders on use rights, management planning and harvest.

The different co-management systems and flexible institutional agreements adopted by forest users (farmers and herders) in the Near East through the centuries have often proved an effective response to extreme environmental conditions, unpredictable disturbances and limited resources. The annulment or weakening of communal property rights and management systems in the Near East is directly related to the intense degradation trend in many forest areas. Climate change adaptation will necessarily require decentralized governance patterns, the devolution of power (authority and responsibility) from centralised states to local community groups (Murphree 1997), the identification of new forms of dialogue to help broaden participation in decision-making, and adequate policy incentives and innovative technologies to facilitate the integration of traditional systems into the current socio-economic and political contexts. One could say that contemporary communal management systems will necessarily become puzzles of old and new knowledge, practices, tools and values of different cultural origin (Borrini-F *et al.* 2007) representing compromises between formal and informal institutions, and the attempts of local communities to adapt their management systems to the new environmental conditions, the requirements of the market economy, and tenure regulations imposed by the state.

After a long period during which centralised states have prevented local communities to make an adequate use of the traditional communal rights, important lobbying efforts from local communities and NGOs have achieved increased governmental recognition of the value of the commons, and the restoration of the common use of resources in some dryland mountain regions. Recent agreements between the Iranian government and the Centre for Sustainable Development, a national NGO, has set the ground for the restoration of the ancient Qashqai nomadic pastoral system which defined migratory routes over hundreds of kilometres, and shaped a common property regime which supported a thriving economy based on wool, meat and dairy products. Two GEF projects supported by UNDP in the Middle Atlas and High Atlas mountains in Morocco are currently looking at good governance options for mountain dwellers, and testing effective collaborative management systems of rangelands and forestlands. The Islamic form of communal management and protection for rangelands, forests, watersheds and wildlife (Hima) is being promoted by NGOs and international organizations like IUCN as an opportunity to restore good governance and sustainable management in the Middle East drylands.

Knowledge and Research

Regional awareness on climate change

Societal responses to the impacts of climate change require the necessary awareness and understanding of all social groups. A comprehensive survey on public attitudes towards climate change was carried out by the Arab Forum for Environment and Development (AFED), as part of its 2009 annual report on the impact of climate change on the Arab region (Saab 2009). The results reveal outright recognition of the problem at all levels and in all countries of the region:

- 98% of respondents believe that climate is changing and 89% is convinced that human activity is its primary cause. The majority thought that changing consumption patterns is the prime measure needed to mitigate to the threat.
- 84% of the respondents thought that climate change posed a real threat to their countries, with the highest numbers in Tunisia (100%) and Morocco (94%), while the lowest was in Syria (67%). This reveals a sharp increase compared to previous pan-Arab surveys (Arab Public Opinion and the Environment 2000, EDM, UNEP, CAMRE).
- Health was the sector considered more likely to be affected by climate change (78%) followed by drinking water (72%), food (69%), coastal areas (53%), forests (47%), and tourism (39%). Forests scored higher in Lebanon, but also in Morocco, Syria and Jordan.

- The majority of the respondents thought that their governments were not doing enough to address climate change (51%) and 94% agreed that their country should participate in worldwide action to deal with climate change challenges.

Raising awareness through well-orchestrated campaigns, school curriculum and university syllabus should be an important component of any response to climate change impacts in the Near East. The adaptive knowledge and skill historically developed by forest dwellers in the region should be recognised and incorporated in climate change educational and research programmes. Scientists and practitioners should be brought together to facilitate cross-fertilisation between scientific and local knowledge, achieve a common understanding, and present the scientific projections of climate change effects in a transparent way. Such approach would also facilitate the participation of the most vulnerable segments of the population, including women and the poor, in the formulation and implementation of responses (Gregoire 2008).

Research

Although climate change is projected to have serious impacts on natural and human systems in the Near East, only modest efforts are being made in the field of scientific research related to adaptation and mitigation. According to Medany (2008) climate change studies in the Arab countries are mostly based on modelling, remote sensing and projection techniques. Because of the lack of facilities and funds available to most for the research institutions, empirical and experimental techniques are still applied. There is a clear need for a new set of harmonized projections (models used, baselines, timeframe, etc.) for the region, sub-region and countries under IPCC 4 scenarios, which could be updated and calibrated on demand, to help formulate better responses based on more robust results (Gregoire 2008).

So far, few and limited research studies on mitigation and adaptation have been published, including a number of papers addressing climate change impacts, vulnerability and adaptation needs for several forest types (Linares & Tíscar 2010; Fady *et al.* 2008; Garzón *et al.* 2008; Bou Dagher-Kharrat *et al.* 2007; McLeod & Salm 2006). Many gaps still need to be filled in the future, especially on Near East forest ecosystems. The cooperation among researchers and institutions from Near East countries should be enhanced to share knowledge and increase efficiency in addressing common challenges. The IUCN Centre for Mediterranean Cooperation has supported regional members and partners, representing the research, public administration and NGO communities, in sharing know-how and agreeing on a common vision on forest adaptation to global change (Regato 2008). The Mediterranean Regional Office of the European Forest Institute has launched a Mediterranean Forest Research Agenda (EFIMED 2009), based on a series of workshops with its regional members and partners, with the objective of sharing knowledge and developing new tools for forest management and governance in four strategic fields relevant to global change: climate and land use changes, wildfires, goods and services and multifunctional management.

Pilot Projects

Within the region, a few projects are currently testing climate change adaptation options for rural development, focusing on water use, agriculture, and forest management. The Eco-Park project of the NGO Friends of the Earth Middle East in the Jordan river basin is a successful example of adaptation to climate change on water saving, environmental awareness, and adapting biodiversity to new climate conditions (Hussein 2010).

The World Bank and its MENA (Middle East and North Africa) counterparts are jointly implementing adaptation projects on infrastructure investment in key sectors such as water resources and urban development, knowledge strengthening, and policy reform (Dobardzic & Cervigni 2007):

- The Moroccan government is working with the World Bank to improve the sustainability of irrigation in the Oum Er Rbia river basin. The authorities will commit to provide a fixed amount of water to the farmers on a demand basis, while the farmers will have to commit to not exceed a fixed quantity of water consumption. The project will subsidize localized irrigation equipment (drip, micro-sprinklers, etc.), promote private investment in post-harvest infrastructure, and help farmers link to domestic and international markets.

- In Yemen, the World Bank is supporting the identification and implementation of coping strategies for adaptation to climate change for highland farmers who rely on rainfed agriculture. These include the conservation and utilization of agro-biodiversity (particularly the local land races and their wild relatives) and associated local traditional knowledge. The project will emphasize the conservation of agro-biodiversity.

Several Near East countries have included a list of climate change mitigation projects in their national communications to the UNFCCC (Gelil 2007). Among these, the following themes are related to land use change and forestry: several reforestation projects in Morocco, Sudan and Mauritania; an agro-forestry project in Morocco; several composting projects in Mauritania, Morocco and Lebanon; a project to improve timber harvesting techniques and one to restore and improve management in rangelands in Sudan; several projects on improved use of stoves (Mauritania), solar cookers (Sudan), sustainable use of biomass in rural areas (Morocco) and for fuel in households, bakeries and brick-making industry (Sudan).

Monitoring

Many countries of the region have outdated or partial national forest surveys (FRA 2010). Forestry departments need to initiate or intensify forest monitoring and the assessment of the productive and protective functions of forests at specific time scale. Forest assessments should be comprehensive, at the national and sub-national level, so as to improve the capacity of decision-makers to manage uncertainties, coordinate early actions, minimize damage, and assist in adaptation to climate change.

The monitoring of ecological changes due to climate and land use changes, and the effectiveness of adaptation and mitigation responses are major gaps that will require significant efforts and investments. Many countries in the Near East are aware of the need to establish strong and effective institutions to manage national observation systems, rehabilitate, modernize and extend the coverage of observation networks, and develop, use and access databases (Gelil 2007). The extension of existing international monitoring programmes to the Near East and the development of regional networking could facilitate the transfer of know-how, and foster a permanent cooperation to exchange experiences and compare results on environmental changes.

Capacity Building

Most of the Near East countries have limited institutional capacity to respond to the challenge of modern forestry. The critical challenges that need be addressed to fill the gaps include:

- Weak capacity of assessment and monitoring.
- Weak intersectoral cooperation between stakeholders.
- Low professional capacity due to limited qualified training on specific subjects.
- Low public awareness.
- Lack of funds for implementing the national action plans measurements.

The National Capacity Self-Assessment (NCSA) is a GEF Enabling Activity, and an opportunity for countries to determine underlying capacity needs to strengthen the management of environmental issues in accordance with MEA (Multilateral Environmental Agreements) guidance and obligations. In the Arab region, 12 countries are currently undertaking their NCSA: Two of them (Jordan and Morocco) are finalizing their NCSA Reports and Action Plans; four countries (Algeria, Lebanon, Egypt and Tunisia) are at the assessment stages; three countries (Sudan, Syria and Yemen) are in the stocktaking phase, and the three more countries (Djibouti, Libya and Oman) are at an earlier stage of the process[11].

Forest dwellers in the Near East are severely affected, and hardly able to cope with the impacts of climate change. In view of this, the Global Environmental Facility (GEF) council proposed to channel 10% of the resources under the Strategic Priority on Adaptation need to community-based activities through the mechanism of the GEF Small Grants Programme (SGP)[12]. UNDP, in collaboration with the GEF SGP, has designed the Community-Based Adaptation (CBA) programme to reduce

[11] For further information, see: ncsa.undp.org/docs/140.pdf
[12] Document GEF/C.23/Inf.8/Rev.1, May 11, 2004

vulnerability and increase adaptive capacity to the adverse effects of climate change in the focal areas in which the GEF works, building the resilience of communities, ecosystems, and resource-dependant livelihoods. A number of pilot projects under the CBA framework addressing community-based adaptation directly or indirectly related to forest ecosystems are being implemented in Morocco, Sudan and Tunisia[13].

Capacity-building programmes should take place at the local, national and regional levels. It is important for stakeholders and donor agencies to recognize both the role that research institutions may play as centres of excellence, and the value that traditional knowledge may have in developing innovative adaptation options (Regato 2008). Enhanced support is needed for a capacity-building plan including the following package of options: build up regional networks and exchange programmes to establish and strengthen centres of excellence on forests and climate change adaptation; enhance integrated research to understand and model the effects of climate change on forests ecosystems and inhabitants, and to prioritize conservation and rural development efforts; conduct regional workshops and training programmes, following the "learning by doing" approach; revise education curricula to introduce climate change adaptation in all relevant studies.

In 2008, the Global Environment Facility (GEF) launched a three-year Adaptation Learning Mechanism (ALM) project worth US$1 million, with co-financing from the Swiss Agency for Development and Cooperation and the Institut de l'Énergie et de l'Environnement de la Francophonie[14]. The project, which is implemented by UNDP/GEF in partnership with the WB, the UNFCCC Secretariat and UNEP, is aimed to empower local communities in the implementation of adaptation practices on the ground, and to integrate climate change risks and adaptation into development policies and plans. The project also seeks to provide stakeholders with a common platform for sharing and learning. The ALM complements the wide range of adaptation knowledge networks and initiatives already underway.

So far, ALM projects are implemented only in few Near East countries, and they mainly address agriculture and water management issues:

- Tunisia: a project to increase capacity of farmers to adapt Sustainable Land Management (SLM) practices and enhance resilience to climate change;
- Morocco: a specific project to enhance resilience of oasis socio-ecosystems, and a more general project to help integrate climate change into sectoral policies, and enhance resilience in agriculture and water management and planning;
- Yemen: a project to build farmers capacity in the use of agro-biodiversity resources in the rain fed Highlands;
- Jordan: a project to support Jordan's in the achievement of the MDG's, strengthening adaptation capacity on food security, water management and health protection;
- Turkey: a project to develop national capacities to manage climate change risks, through the mainstreaming of climate change issues into national development framework, local pilot actions and the UN country programmatic framework. In the midway of project implementation, a participatory assessment of climate change vulnerability was undertaken in 11 provinces, where needs and gaps for early warning mechanisms to drought and floods were identified. Furthermore, 18 community-based pilot adaptation projects were initiated in the Seyhan river basin.

A new capacity building project was launched by GTZ in 2010 to enable concerned stakeholders (i.e. decision makers, governmental staff, NGOs, and representatives from research and the private sector) to specifically address climate change adaptation needs in forest conservation and management in the Near East region, and incorporate appropriate cross-sectoral responses in relevant policy frameworks. The project, with €4 million funding for 4 years, will be implemented by GTZ in Morocco, Algeria, Tunisia, Egypt, Lebanon, Jordan, Syria and Turkey, in cooperation with Silva Mediterranea (SilvaMed) of FAO and in close coordination with other regional and international institutions and initiatives, including the Barcelona-based European Forest Institute/ Mediterranean Regional Office (EFIMED); the Centre for Environment and Development for the Arab Region and Europe

[13] www.undp-adaptation.org/portfolio
[14] www.adaptationlearning.net

(CEDARE) in Cairo; EUWI-MED (the Mediterranean component of the EU Water Initiative), IUCN and WWF. The project interventions will follow a "regional" approach through the concentration on issues of regional or border-crossing importance. The project will also contribute to the mobilisation of other financial partners in order to make sure that investment will be available once adaptation activities are ready for implementation.

Financial Opportunities

Adaptation and mitigation options to avoid forest degradation and increase ecological and social resilience will require trade-offs, in order to balance all demands and replace maladaptive practices with resilient land uses. Most Near East forests have low economic value for timber export, but high value for in-situ preservation of a wide range of goods and environmental services (Regato & Salman, 2008). Forest landowners and users should be compensated and the role they play in providing environmental services should be recognised. Governmental policies, intergovernmental organisations and aid agencies should give priority to measures like:

- Agri-environmental incentives and compensations supporting land uses linked to healthy forest conditions (e.g. transhumance and high-mountain pasturing) and to environmental risk reduction (e.g. livestock production in high fire risk areas);
- Investment aid to diversify, innovate and strengthen the forest sector, with special focus on the economic value and production of high quality NWFPs, as part of diversified agro-forestry production system or coupled with tourism;
- Development of new marketing opportunities, including certification and labelling, to promote the advantages of forest landscapes, and their ability to supply high-quality products linked to cultural values and attractive to urban dwellers.

Besides the development of economic incentives for sustainable agro-forestry practices, political and economic measures should be put in place to remove environmentally perverse subsidies and to discourage activities that degrade forest ecosystem services (Dudley *et al.* 2010).

Over the past two years, more than 16 international funds for climate change mitigation and adaptation— mainly multilateral and bilateral—have been established, of which no fewer than six focus on avoiding deforestation and forest degradation in developing countries (Gaul *et al.* 2010). In spite of this, only few projects address forest adaptation and mitigation in the Near East region.

The Adaptation Fund under the Kyoto Protocol was specifically initiated to assist developing country parties that are particularly vulnerable to climate change impacts in meeting the costs of adaptation, and to finance concrete adaptation projects and programmes[15]. A key innovative feature of this Fund is the direct access for developing countries. They can nominate domestic institutions for accreditation as National Implementing Entities (NIEs), which will be responsible for endorsing the country proposals. Every country has to determine its own adaptation priorities due to the very site- and content-specific adaptation needs. Nevertheless, there are some guiding criteria agreed by the Kyoto Protocol parties, which are important in order to make the Fund and effective and targeted tool. In April 2010, the Fund has started up inviting countries to submit projects and programme proposals for funding.

Payments for Environmental Services

Payments for Environmental Services (PES) are thought to be an effective financing instrument for climate change adaptation and mitigation, namely for REDD and REDD + implementation (Bond *et al.* 2009). Under PES, payments are conditional, and only made if the service – i.e. the conservation of the forest - is delivered. Important preconditions for success include supporting improved forest governance, land tenure and rights for forest dependent communities. If preconditions are not fulfilled, the risk is that forest-dependent communities will not benefit or, worse, they might be harmed by PES projects. Good governance is a major challenge in the Near East countries, and it may be a major constraint for the effective implementation of PES schemes. Nevertheless, some good results to restore communal management systems in Iran and Morocco pave the way to an optimistic approach to the use of PES in the near future.

[15] www.adaptation-fund.org

Securing the wide range of important ecosystem services provided by forest landscapes in the Near East region should be part of any national and regional strategy on climate change adaptation and mitigation. This will only be possible through a combined use of different payment mechanisms and markets for carbon, water, biodiversity, NWFPs and cultural services.

Water services

Many forests and plantations in the Near East countries have the main function of watershed protection (i.e. soil erosion control; flood prevention; water storage and regulation). The potential for developing markets for watershed services in the region is a very promising one, especially when considering the critical role played by mountain forests in the Near East – often known as water castles – in securing the water supply for millions of people. Watershed PES schemes have provided successful results in economically compensating local communities to protect and sustainably manage forestland in different parts of the world, namely Latin America (Stanton *et al.* 2010). However, watershed PES's are still in their infancy in the Near East region, with only a few being currently implemented, such as a WWF-led initiative in the Sebou river basin in Morocco.

Provisioning and cultural services

Among the best emerging practices, the diversification of revenues for communities involved in PES schemes through the creation of new markets for environmental goods and services (non-timber forest products, organic food, ecotourism) appears to be the most promising ones (Mayrand & Paquin 2004), with an additional substantial contribution to climate change adaptation and mitigation measures. PES schemes can play a significant role in strengthening the resilience of forest dwellers to climate change, by including specific support measures for the diversification of forest goods and services, and for small-scale community forest enterprises, market development and income generation in their compensation packages.

A good example is represented by the steady increase of the economic value of argan oil (Argania spinosa) in Morocco that has opened up new opportunities to increase ecological resilience and reduce the vulnerability of forest dwellers, namely women, through community-run forest enterprises, international and domestic markets, and a boost of the tourism sector. Since the UNESCO declaration of the "Arganerie Biosphere Reserve" in 1998, covering more than 850 000 ha of argan woodlands, Aid Agencies and NGOs have supported a number of projects to build ecological and social resilience to global change. Several recently established women cooperatives organised under the Union of Women's Cooperatives for the Arganerie, have gained new employment opportunities, and 13 extraction and trading companies –some organic certified- have emerged and are involved in local and international trade (Lybbert *et al.* 2010). Although the women`s share of benefits still remains limited, these initiatives created new employment alternatives and paved the way to community-based forest management. Moreover, organic certification has improved the documentation of collection of argan seeds and the quality of the product.

Morocco is the only country in the Near East where the GEF has funded projects in which PES is the core objective of the project or there is an explicit PES component in the project design (Cavalier 2010). The recently approved IFAD/GEF project on agro-biodiversity conservation in the argan woodlands of the Souss-Massa Draa region in Morocco is one of the 42 PES projects funded by the GEF, aiming at scaling-up previous experiences on integrated community-based agro-forestry management by harnessing innovative financing mechanisms.

Another good example from the Middle East is the Shouf Cedar Biosphere Reserve of Lebanon, where aid agencies and governmental funds support the authority in charge of the management of the protected area on initiatives aimed at improving the livelihoods of the local communities, and the creation of a new economy based on the sustainable exploitation of the natural resources. The strategy focuses on two promising lines of work: nature tourism and NWFPs. The Rural Development Programme launched in 1999 encouraged the members of the local community – especially women – to make use of raw materials and produce a wide array of goods, such as marmalades and jams, dried herbs, beverages, distilled waters, oils and craftwork. So far, the programme has granted aid to 40 families, facilitating the set up of several small family-based enterprises and the commercialisation of more than 70 products that are available on sale at the main entrances of the Reserve (Pagliani 2010b).

Carbon sequestration services

The different options for carbon sequestration in forest management include soil erosion control, afforestation and reforestation, forest restoration, sustainable forest management and conservation, maintaining and increasing trees in agriculture land, incorporating composting and micorrhyzation in tree nurseries, sustainable livestock densities in forest land, etc. Such options are in harmony with the improvement of the livelihoods of forest dwellers and agro-pastoralists.

Carbon markets exist both under compliance schemes created and regulated by mandatory regional, national, and international carbon reduction regimes (i.e. the UNFCCC Kyoto Protocol and the European Union's Emissions Trading Scheme), and as voluntary programs outside of the compliance markets, enabling companies and individuals to purchase carbon offsets on a voluntary basis. Payment mechanisms for carbon sequestration through afforestation and reforestation were initially established at the Kyoto Protocol's Clean Development Mechanism, allowing industrialized countries to set up carbon offset projects in developing countries. However, until now, less than 1% of all approved CDM projects have dealt with afforestation or reforestation (Gaul *et al.* 2010). In the Near East, 12 countries[16] have submitted projects under the CDM, none of them on forest carbon.

In the case of the voluntary carbon market, in 2009, the Afforestation/Reforestation sector comprised 10% of all transactions (4.3 million tCO_2-eq), corresponding to 75% of all forest carbon transactions (Hamilton *et al.* 2010). The major reasons for the steady but slow growth of the forestry sector were the criticism and difficulties surrounding land-based projects - the complexity of such projects, the non-permanence of forests, and the perceived high risks.

Turkey is the only country in the Near East that has participated in the voluntary carbon market. Although Turkey ratified the Kyoto Protocol, it is ineligible to generate CDM credits, and the voluntary markets therefore remain its main niche until 2013, the expiry date of the Kyoto Protocol (Hamilton *et al.* 2010). The majority of credits were from renewable energy projects (72%), with no forest carbon projects. The market has fell since 2008 (6% market share, down from 15% in 2008), mainly due to local barriers —unclear position of the Turkish administration towards the Kyoto Protocol or future agreements to replace the Kyoto Protocol; insufficient incentives to project developers (Hamilton *et al.* 2010). According to these authors, survey respondents are very optimistic about the prospects for the global voluntary markets, with an average estimated increase to approximately 400 $MtCO_2e$ in 2012, 800 $MtCO_2e$ in 2015 and 1,200 $MtCO_2e$ in 2020. The Near East countries could benefit from buyer demand for offsets with sustainable development benefits along with NGO and international agency investments, as was the case in a number of countries in Africa that have managed a slight gain in volume and market share since 2006 to protect valuable forest ecosystems. Africa's growth has coincided with increased volumes from African CDM projects, which doubled their market share.

At the 2007 UNFCCC Conference of Parties (COP) in Bali, it was agreed to develop a mechanism to compensate reduced emissions from avoided deforestation and degradation. Reducing emissions from deforestation and forest degradation (REDD) became REDD + when conservation, sustainable management and enhancement of carbon stocks were added to the original concept at Bali.

A UNREDD Programme recently emerged as a collaboration between FAO, UNEP and UNDP, and with international finance to support REDD+ readiness in nine pilot countries[17]. In order to respond to the high interest expressed by a number of REDD countries, the programme foresees an option to welcome new countries as partners. Since October 2009, 13 new partner countries have joined in and more have formally expressed interest. The Near East region is only represented by Sudan, as a partner country.

With funding of US$48 million, the UN-REDD Programme has already begun its support to pilot countries starting to establish governance systems for REDD+, through national UN-REDD programmes. The programme is supporting priority governance interventions identified by governments and national stakeholders, such as stakeholder consultation and participation and cross-sectoral coordination in REDD+ planning and implementation, and legislative review towards reform and enforcement. Further US$3.8 million were allocated for carbon monitoring, reporting and verification (MRV) systems. Although at this stage money is flowing only to the nine pilot countries,

[16] Cyprus, Egypt, Iran, Israel, Jordan, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, UAM.
[17] Bolivia, DR Congo, Indonesia, Panama, Papua New Guinea, Paraguay, Tanzania, Vietnam and Zambia.

partner countries can participate through networking, knowledge sharing, access to the satellite imagery archives, attendance to global and regional workshops and with official observer status at UNREDD Policy Board meetings.

Efforts to support a global REDD pilot activities are not confined to the UN's programme. The World Bank's Forest Carbon Partnership Facility (FCPF) and the GEF climate change and sustainable forest management focal areas of its fifth replenishment, are multilateral funding windows addressing activities around LULUCF, including REDD frameworks. The International Climate Initiative of the German government receives funding from emissions trading and thus represents an innovative financing mechanism to support partner developing countries in the area of climate protection. Norway has launched an International Climate and Forest Initiative, pledging up to US$600 million annually to selected countries for performance-based compensation schemes associated with deforestation reduction targets. Australia, in turn, announced a Global Initiative on Forests and Climate, and the United Kingdom established the international window of the Environmental Transformation Fund, which, to some degree, is also poised to provide resources for REDD-related activities.

GEF funding mechanisms

Established in 1991, The Global Environmental Facility (GEF) is the largest funder of projects to improve the global environment The GEF provides grants to developing countries, and countries with economies in transition, linking local, national and global environmental challenges, and promoting sustainable livelihoods. It also operates as a financial mechanism for implementing international conventions, such as UNFCCC, CBD and UNCCD.

Adaptation

In 2001, the GEF received the mandate to finance adaptation projects on the ground, and since then has piloted adaptation action under four financing avenues:

- Strategic Priority on Adaptation (SPA), a US$50 million programme within the GEF Trust Fund, to finance concrete adaptation projects on the ground, implementing measures for the specific purpose of reducing vulnerability and increasing the adaptive capacity of vulnerable communities and the ecosystems on which their lives depend. The Near East countries are underrepresented in this programme, with only few projects addressing adaptive land management issues, basically in agriculture and water uses:
    - The Community-Based Adaptation (CBA) initiative, designed by UNDP and the GEF Small Grants Programme (SGP), is a portfolio of 8 to 20 small-scale "project/policy laboratories" in each of the 10 participating countries. The aim of the initiative is to enhance adaptive capacity of local communities and reduce vulnerability to climate change impacts, through cooperation among member countries, replication of best practices and integration of lessons learned into policies. Morocco is the only Near East country participating in this initiative, with the specific goal to enhance the resilience of oasis socio-ecosystems - Iguiwaz and Tarmkiste, in southern Morocco.
    - The project on adaptation to climate change using agro-biodiversity resources in the rainfed Highlands of Yemen.
    - The land and water optimization project in Tunisia.

Even though these projects do not address specific aspects of adaptation in forest, they indirectly contribute to build ecological resilience - i.e. improve water balance between land uses; improve soil conditions - and the adaptive capacity of forest dwellers.

- The Least Developed Countries Fund (LDCF), is the only accessible to the 48 Less Developed Countries (LDCs) that have ratified the UNFCCC, including 4 Near East countries - Afghanistan, Mauritania, Sudan and Yemen. The aim of this fund is to finance the special needs of the LDCs under the Climate Convention, with the priority of preparation and implementation of the National Adaptation Programmes of Action (NAPAs). All the four LDCs in the Near East have already developed and submitted their NAPAs.

  The LDCF is funding a project for the implementation of the NAPA priority interventions in Sudan, to enhance the capacity of small-scale farmers and pastoralists to improve water

harvesting and small-scale irrigation techniques; to use heat-resistant plant varieties and new commercial crops; to intensify tree planting along irrigation channels; and to rehabilitate vegetation cover and communal rangelands. The LDCF is also funding a project to build adaptive capacity and resilience to climate change in Afghanistan.

- The Special Climate Change Fund (SCCF) is a separated fund of about US$ 100 million established by the UNFCCC in 2001, whose resources are accessible to all developing countries. The fund includes 4 avenues of financing: adaptation, which is the top priority; technology transfer; energy, transport, industry, agriculture, forestry and waste management; and economic diversification. So far, the SCCF is not funding any adaptation project on forest related issues in the Near East region.
- The GEF Trust Fund, which is replenished every 4 years based on donor pledges, has received US$ 10.9 billion during its four replenishments. The funding is available for activities under the GEF Focal Areas, defined during the replenishment discussions. The GEF Trust Fund has contributed to a number of climate change adaptation and mitigation projects in the region: Bio-energy for sustainable rural development in Egypt; Adaptation of vulnerable agriculture production systems in Mauritania; Integration of climate change in development planning and disaster prevention to increase resilience in the agriculture and water sectors in Morocco; Integrated carbon sequestration project in Sudan; Investment scale-up and biomass pilot in Tunisia; Institutional strengthening for natural resource management in Iran, supporting community-driven resilience approaches and techniques for land and water management.

Mitigation

The GEF has financed sustainable forest management since its inception in 1991. As such, GEF initiatives on forest conservation have contributed to reduce greenhouse gas emissions from deforestation and forest degradation in the past.

For the first time, the Global Environment Facility (GEF) will make available a separate funding envelope for SFM/REDD+ for countries willing to invest portions of their allocations from biodiversity, climate change and land degradation toward more far reaching Sustainable Forest Management/REDD+ projects. Altogether, the GEF may provide up to US$1 billion for SFM/REDD+ funding throughout the course of GEF-5. All types of forests, ranging from tropical and sub-tropical forests to woodlands, will be eligible for funding and a wide spectrum of options for countries will be available, including forest policy (re-)formulation, forest protected area creation and management, forest inventory and carbon measurement and monitoring, reduced-impact logging, certification of timber and NWFPs, and payment for ecosystem services, among others. In addition, the GEF will strongly support work with local communities to develop alternative livelihood methods to reduce emissions and sequester carbon. Under special circumstances, the GEF may also finance REDD+ Readiness activities.

Legal Framework

In the Near East, Integrated land-use management strategies are still at their infancy. Governmental policies and laws often are sector-specific - covering topics such as such as agriculture, forestry, and environmental protection - and they directly and negatively impact the health, integrity, and sustainable management of forest resources. This model represents a significant barrier to adaptation, as it constrains the potential for altering or supplementing current management practices to enable adaptation to climate change.

While stronger environmental commitments have translated into the establishment of new environmental institutions, in most cases a significant gap remains with respect to their ability to effectively manage the sustainable development process (Gelil 2007). Moreover, the enforcement of laws and regulations is still a big challenge in many parts of the Near East.

A major challenge for the countries of the region is the adoption of an integrated, multi-sectoral, process-oriented and participatory approach to sustainable development, which can move towards an effective governance system, and address economic and social issues alongside and in line with environmental priorities (Gelil 2007). Multiple agency collaboration can be difficult in many Near East countries because of conflicting legislation, mandates, and cultures, but such collaboration is

likely to be a hallmark of successful adaptation to climate change. Few regional countries have established a national interagency committee on climate change, such as that of Egypt, where the committee members represent a wide range of governmental and non-governmental actors, including private, scientific and international organisations (Gelil 2007). Another good example is Morocco, that has established the following administrative bodies; a CC Unit in charge of coordination and follow up of Morocco's commitment vis-à-vis the Convention; A National Committee for Climatic Change (CNCC) with representatives of ministerial Departments and national institutions involved in CC issues; an Information Centre on Sustainable Energy and Environment (CIEDE); a National Scientific and Technical Committee (CNST) involving national experts and set up as a national equivalent to IPCC; and a Unit in charge of CDM[18].

The environmental ministries, agencies and councils in the Gulf countries are still fairly new, and have limited capacity to play a significant role in the decision-making processes to address the priority environmental challenges posed by climate change (Raouf 2008). In recognition of the impact of climate change, in 2007 Oman changed the name of the Ministry of Environment and Regional Municipalities to the Ministry of Environment and Climate Change. The same year, the UAE have launched an initiative (The Abu Dhabi Global Environmental Data Initiative) with WWF to cut down its ecological footprint and to ensure a sustainable future.

A decentralization of land administration and management is much needed in the region, while strong law enforcement agencies for the monitoring and implementation of land regulations should be set up. Land laws are crucial instruments towards the achievements of a more sustainable land use. Sustainability in this field will eventually, largely depend on the degree of harmonisation between land laws, environmental laws, agricultural laws and other land-use laws. Unfortunately, most countries are still lacking the institutional capacity, technology, and trained human resource needed to adopt sustainable land use policies, laws and regulations.

In the 9th National Development Plan of Turkey (2007-2013) it was decided that a climate change action plan strategy shall be prepared as national policy. The UNDP country office in Turkey is funding a GEF project, under the Adaptation Learning Initiative, to enhance the capacity of Turkey to adapt to climate change, targeting the key strategic planning frameworks to mainstream climate change adaptation[19]. A new and revised legal framework will be developed to introduce clear rules and procedures for mainstreaming climate change risks into development and regional planning.

Cyprus is the only EU country in the region. The EU cohesion policy has as an investment priority in Cyprus to support climate change mitigation and to encourage the use of renewable energies. For the mitigation of climate change, Cyprus has set up an Ad-Hoc Committee on Climate Change and is now active in the selection of the measures to reduce/stabilize the emission of the Greenhouse gases to the atmosphere (Tsiourtis 2002). However the Committee is not concerned with climate change adaptation measures. Due to climate change and the immediate impact on the reduction in the availability of the natural water resources, the Government of Cyprus has set up a Drought Management Committee with the responsibility of implementing measures to mitigate the adverse effects of drought, especially water scarcity. The Drought Management Committee is not a permanent committee but ad-hoc and is energized when drought occurs.

The second annual conference of the Arab Forum for Environment and Development (AFED) (Beirut, November 2009), endorsed the following recommendations to strengthen climate change issues in national policies and promote a concerted regional effort to make countries better prepared to address the climate change challenges[20]:

- Create a strong national body, a Ministerial Committee or High Council, presided over by the Head of State or the Prime Minister, to endorse policies, ensure follow-up, and make course corrections, and a technical council with qualified teams to regularly update information and provide climate change assessments and possible responses to the national body.
- Make climate change a public policy issue to be addressed not only by environmental ministries and councils, but also by all relevant government ministries (i.e. agriculture, water resources, energy, electricity, planning, economy, public health, and tourism.) and ensure that

[18] First National Communication to the UNFCCC, Morocco.
[19] First National Communication to the UNFCCC, Turkey.
[20] www.afedonline.org

development plans take fully into account the impacts of climate change, with the participation of the civil society and private sector.

- Formulate a clear Arab position at the international climate change negotiations to reach an effective post-Kyoto agreement.

International Policy Frameworks

The Near East countries have already signed a number of multilateral environmental agreements (MEA) that set a relevant policy framework for the sustainable management of forests and their resources. Amongst them, the United Nations Convention to Combat Desertification (UNCCD), the Convention on Biological Diversity (CBD), the Convention on Climate Change (UNFCCC), and the United Forum on Forests (UNFF) deserve a special mention due to their high impact on forests and forestry.

Recently, the three conventions have identified synergies and developed joint programmes of work to address the interacting effects of desertification, biodiversity loss and climate change impacts. The interlink between desertification and biodiversity loss in the world's drylands has induced the Secretariats of the CBD and UNCCD to agree a Joint Work Programme (JWP) in 2003, focusing on the biological diversity of dry and sub-humid lands. Moreover, the CBD renewed the Programme of Work on Protected Areas at COP10 to address more specifically the role of protected areas in responses to climate change, in liaison with other CBD programmes. The UNFCCC has also recognised protected areas as tools for mitigation and adaptation to climate change, and has opened up key climate change related funding mechanisms, including REDD and adaptation funds, to the creation, enhancement and effective management of protected area systems.

The Convention on Climate Change: national adaptation and mitigation measures in the forest sector[21]

All Near East countries except Iraq have ratified or acceded to the UNFCCC. All countries but Turkey are non-Annex 1 Parties, that is developing countries especially vulnerable to the adverse impacts of climate change, with no emissions reduction commitments and eligible for CDM. Turkey is the only Annex 1 country, ineligible to generate CDM credits, although with a special status in recognition of its particular circumstances[22].

Only 15 of them have submitted their first national communication. Of these, Egypt, Jordan and the United Arab Emirates have also submitted the second national communication. Countries that have not submitted any national communication report include Afghanistan, Cyprus, Iraq, Kuwait, Libya, Oman, Qatar, and Syria.

NAPAs (National Adaptation Programmes of Action) provide a process to identify priority activities that respond to the urgent and immediate needs for climate change adaptation. In the NAPA process, prominence is given to community-level input as an important source of information, recognizing that grassroots communities are the main stakeholders (UNFCC website). The three Arab countries from the region featured in the "least developed" list - Mauritania, Yemen and Sudan- have developed their NAPAs.

Overall, all countries mention the need to improve knowledge about climate change impacts and scenarios, complete data gaps, raise awareness and build the capacity of all stakeholders - from grassroots organisations to decision-makers and the general public - to mainstream adaptation into national policy-making and harmonise adaptation options in all development sectors, and to facilitate the release of funds needed for the implementation of all necessary adaptation and mitigation measures.

[21] The information of this chapter is extracted from the National Communications to the UNFCCC and the NAPAs prepared to date in the Near East Countries.

[22] Turkey possesses the lowest per capita fossil-fuel-based CO2 emissions amongst OECD countries (3.3 tonnes per capita, against the OECD average of 11.1, and the EU 25 average of 9.0) mainly due to the optimum use of domestic resources as one of the main components of the national energy strategy.

National adaptation measures in the forest sector

All countries except Tunisia propose adaptation measures in the forest sector. These can be summarised as follows:

- Forest management: Few Near East countries (Algeria, Iran, Mauritania, Sudan and Turkey) specifically mention the urgent need to adopt silvicultural practices and develop forest management plans as a prerequisite to stop and reverse forest degradation. The restoration of community-based forest and rangeland management systems is also considered a prerequisite in Mauritania, Sudan and Turkey. There is no specific reference to adaptive forest management except for Turkey, which is the only country mentioning ecosystem-based management at the watershed level.
- Afforestation and forest restoration measures to restore degraded forestlands, prevent soil erosion (including sand mobilization) and increase forest surface are mentioned in most countries. Israel makes specific reference to the role of plantations to trigger rainfall and produce humid microclimates at meso-scales, and proposes the use of tree species that have proved resistant to severe drought. Coastal dunes and mangroves restoration is seen as an important adaptation measure to cope with sea level rise impacts in Mauritania, Egypt, Yemen, Saudi Arabia, Bahrain and UAE. The establishment of peri-urban forest belts is mentioned in Algeria and Mauritania. Sudan and Turkey make specific reference to stakeholder's participation in forest restoration, with the concrete example of the positive results already achieved with the governmental-NGO partnership on forest restoration in Turkey.
- Environmental risk reduction measures are only mentioned in three countries: a) Fire risk reduction through prescribed and controlled grazing and herbivore reintroduction in Israel; b) the establishment of firebreaks and enabling herders on fire management in Mauritania; c) management plans to reverse dieback in juniper forests in Saudi Arabia.
- A range of alternative sources of energy to reduce forest degradation, and the excessive collection of fuelwood, are proposed in Sudan and Yemen.
- The conservation of forest gene resources and the use of drought-tolerant ecotypes are only mentioned in Lebanon.
- Good rangeland management practices and restoration of grasslands, including marginal agriculture land, are mentioned in Iran, Sudan and Turkey. In the case of Iran, some proposed adaptation measures can be counterproductive: the permanent settlement of nomads may lead to the loss of traditional knowledge in adapting to a changing climate, while the proposed measures to remove livestock from forestland can prevent the role that grazing plays in reducing dry biomass and fire risk.
- Agro-forestry is seen as a resilient land use system in Iran, Mauritania, Morocco and Sudan. This measure contributes to the diversification of land uses, tree species, NWFPs and sources of revenue.
- Agriculture measures to reduce water stress (and indirectly improve water balance between different land uses) and reduce the risk of fire (burning of agriculture residues is a major cause of forest fires) are proposed in Iran, Israel, Jordan, and Turkey. Yemen proposes watershed management measures through the restoration of agriculture terraces. The value of traditional knowledge on drought mitigation and water management and, the importance of reviving it and complementing it with new technologies, is highlighted in Jordan and Yemen.
- The adaptation role of well-designed forest protected areas networks is mentioned in Algeria, Israel, Lebanon, Saudi Arabia and Turkey. There are specific references to the need to create landscape connectivity (i.e. two north-south corridors in Israel) and protected areas' boundaries that are large enough to represent the climate diversity and facilitate the species migration needs, and to the need to protect representative areas of all sensitive species and habitat types.

National mitigation measures in the forest sector

Only seven countries propose mitigation measures in the forest sector. We can summarise them as follows:

- Sustainable forest management plans to increase the potential of carbon storage in forestland are mentioned in Iran, Lebanon, Sudan and Turkey. Specific measures are mentioned in Lebanon, such as an increased rotation length and the quality of wood produced for long-life products.
- Amend, revise and update forest policies and legislation to allow a broader participation in forest management and restoration is only mentioned in Lebanon, Sudan and Turkey. Sudan mentions the need to clearly establish communal, private and state property rights, through legislation changes and the establishment of a coordination body. The need for a forest cadastre is also mentioned in Algeria.
- Expand forestland through afforestation to increase carbon sinks is mentioned in Iran, Israel, Lebanon, Morocco, Sudan, Tunisia and Turkey. Specific recommendations for the use of native/appropriate species are proposed in all cases except for Morocco, and adaptive watering techniques for tree plantations are mentioned in Israel. In the case of Tunisia, afforestation in steppe areas is proposed, in spite of the past negative experiences and the high risk of land degradation and mobilization of sandy soils.
- The mitigation role of sound firefighting and pest prevention measures are only mentioned in Lebanon. In this country, the new national fire strategy has been designed with a clear and innovative climate change adaptation and mitigation focus.
- The carbon storage role of agroforestry, through the planting of fruit and multipurpose trees in agriculture and rangeland, is mentioned in Iran, Morocco, Sudan and Tunisia.
- Alternative energy sources to reduce forest degradation from excessive collection of fuelwood are proposed in Mauritania, Morocco and Sudan.
- The importance of rangelands as carbon sinks is mentioned in Iran and Turkey. The sustainable management of grazing and the restoration of grasslands are also proposed in Lebanon, Sudan and Tunisia. These measures require strong extension programmes and bottom-up approaches to restore communal management systems.
- The role of forest protected areas for carbon storage is proposed in Lebanon (up to 75,000 ha of protected forests by 2040), Sudan and Turkey.

4.Recommendations

In view of the alarming increase in forest loss and degradation caused by the combined effect of climate and socio-economic changes in the Near East, governments, intergovernmental organisations and aid agencies should give priority and earmark the necessary funding to the implementation of regional research programmes, engaging all concerned stakeholders and aimed at filling major information gaps, exchanging know-how and monitoring global change effects on forest ecosystems and dwellers.

Research organizations working on ecological, social and climate sciences should join forces to develop more accurate scenarios and predictions about climate change impacts on forest ecosystems and communities at the regional and local levels. Research programmes should encourage the participation of scientists, forest managers, NGOs and local community groups from regional and neighbouring countries. Trans-national cooperation programmes addressing climate change impacts and adaptation measures should become a priority in the whole Near East region. The recommended approach is that of learning by doing, sharing experience, and exchanging traditional and scientific know-how between 'nodes of expertise' and less-favoured areas.

The governments of the region should seek the assistance of intergovernmental organizations and aid agencies to develop and implement effective monitoring programmes based on modern methodologies, a representative number of pilot sites and stakeholders' participation. Concerned 'climate change watchers'— including foresters, farmers, shepherds, etc.— should play a key role in the implementation and monitoring of such programmes.

Local community groups should be enabled to take the lead in developing locally adapted solutions. International cooperation programmes and aid agencies should provide direct support to community groups and encourage cooperation among grass-root organisations on how to adapt traditional know-how to the challenges posed by climate change. These programmes should strive to bring together scientists and practitioners, facilitating the cross-fertilisation between scientific and local knowledge, and trying to achieve a common understanding and working language.

Governments and research organizations from the region should give priority to the establishment of representative collections of seed for the main and most threatened forest tree species. These can be maintained in gene banks or plantations, and can contribute to the increase of the genetic base of natural populations through the creation of seed orchards that will supply variable seed for restoration activities. Existing national (i.e. National Tree Seed Centre in Sudan) and regional banks for plant genetic resources (i.e. the ICARDA's gene-bank) should be extended, including the collection of all the vulnerable tree species in the region.

Intergovernmental organisations and aid agencies should foster the establishment of a regional network of pilot projects on forest adaptation measures, representing all forest ecosystem types, and prioritizing those sensitive areas that are mostly hit by climate change.

- Results from applied research in forest ecosystems found in the Near East demonstrate that management practices that promote diversity at all levels (genetic, species, forest stand, landscape) are the best approach to increase ecological and social resilience to climate change.
- Those forest species and ecotypes that have proved to be highly resilient to changeable climate conditions and water stress in the region, should be better known and further investigated, because of the effective role they can play in adaptation strategies inside and outside the region.
- Forest management practices aiming to improve water balances, reduce dry biomass, and obtain more mature, diverse and structured forest stands should be encouraged, as they appear to be very effective in the prevention of the impacts caused by extreme weather events (i.e. harmful fires and forest dieback).
- Inter-governmental organizations, aid agencies, and NGOs should support grassroots organisations in the assessment of local knowledge and experiences on adaptation to

environmental changes. Applied research that combines traditional knowledge and technological development should be promoted.

Effective solutions to stop and reverse the combined impact of climate and socio-economic changes on Near East forest ecosystems will only be possible if governments develop more flexible policies and legal frameworks that provide the necessary means to restore and adapt communal management systems and property regimes of forest and rangelands to current socio-economic and political contexts.

Intergovernmental organizations and aid agencies should prioritise development programmes to revive past experiences of flexible policies and institutional arrangements, identifying new forms of dialogue and participation in decision-making, innovative technologies, and adequate policy incentives to effectively support adaptation measures.

Communal institutions need the collaboration of external agents (NGOs, international research and development organisations) not only for the information they can provide on comparative experiences from other regions, but also as allies with privileged access to policy processes which can improve the enabling conditions frameworks.

Intergovernmental organisations and aid agencies should collaborate with the governments and civil societies of the region to develop effective forest landscape restoration and afforestation plans, which can effectively and simultaneously address climate change adaptation and mitigation needs. The following measures are especially recommended:

- The organisation of regional and national workshops open to all concerned stakeholders to assess current afforestation polices, and the promotion of field missions and exchanges among experts and managers from regional and neighbouring countries sharing similar forest ecosystem types.
- National reports to the UNFCCC should be carefully weighted, in order to avoid the delivery of incoherent messages, such as the conversion of natural habitat types (i.e. steppes, grasslands and desert land) into forest plantations, which may exacerbate climate change impacts.

The impacts of climate change on Near East forest ecosystems are often exacerbated by the effect of maladaptive processes and practices from other development sectors. Regional governments should increase efforts to integrate climate change mitigation and adaptation in all development strategies and policies, and design measures that are coherent and consistent with all economic sectors. All the countries of the region should follow the example of Egypt - which has established a national interagency committee on climate change.

- Central governments should support landscape adaptation options, facilitating participatory land use planning processes to identify resilient land uses and landscape patterns, and adopting measures to facilitate their adoption by land owners and users.
- Mosaic landscape patters with a high diversity of habitat types and land uses appear to be the most resilient ones. The adoption of agro-forestry systems that promote such mosaic patters in the national adaptation and mitigation strategies will have multiple positive effects to reduce climate change impacts.
- Low cost, simple techniques on adaptive management of soil and water in agriculture and pasturage have demonstrated to be very effective to cope with climate change impacts in forest landscapes. The governments of the region should better integrate the forest and agriculture sectors in rural development policies, and identify synergies among adaptation measures.

Economic incentives are an important tool to cover the cost of adaptation and mitigation measures, and to obtain the buy-in of forest owners and users. Governmental policies and intergovernmental organisations and aid agencies should prioritise financial support to:

- Valuing forest goods and indentifying new economic opportunities for a wider range of NWFP through the sale of products and tourism services, on both domestic and international markets.

- Agri-environmental incentives and compensations that favour the preservation of forest environmental services (e.g. provision of water) and that help reduce environmental risk (e.g. livestock production in high fire risk areas). Priority should be given to pilot initiatives that can pave the way for the introduction of payments for environmental services in the region.
- Investment aid to innovate, diversify and strengthen the forest sector, with a special focus on: the production of high quality NWFP products, as an environmentally friendly production sector on its own or coupled with tourism; the creation of locally-based enterprises on bio-energy using dry biomass and residues from forest and agriculture.
- Development of new marketing opportunities, including certification and labelling, to promote the advantages of well preserved forest landscapes, and their ability to supply high-quality products linked to cultural values and attractive to urban dwellers.

The use of protected areas in climate response strategies need be prioritised at the international level and by national and local governments. Protected forests should become eligible under some proposed REDD crediting mechanisms within the context of national programmes that address potential emissions leakages. Regional governments should incorporate protected area systems into national climate change strategies and action plans, and ensure their effective management, in order to ensure their role as providers of benefits related to biodiversity and climate change.

- In view of the significant role that protected areas may play in climate change adaptation and mitigation, Near East countries should assess their national protected areas systems, so as to: secure adequate representation of all forest types, species and genotypes; increase landscape connectivity and facilitate species migration needs; design protected areas boundaries that can effectively maintain essential ecosystem services and avoid forest conversion and secure carbon storage in key forest areas.

The national reports to the UNFCCC should be more accurate when defining adaptation and mitigation measures, and clearly explain the interacting effects of each measure in the various development sectors.

- The GEF agencies (UN programmes, FAO, IFAD, the WB and other development banks) should encourage a more representative participation of the Near East countries in the different existing funding mechanisms for climate change adaptation and mitigation.

Regional governments, intergovernmental organisations and aid agencies should identify synergies in addressing climate change, biodiversity loss and desertification. All projects tackling climate change adaptation and mitigation should include measures to enhance biodiversity and combat desertification.

5. References

Aerts, R., A. Negussie, W. Maes, E. November, M. Hermy, B. Muys (2007) Restoration of Dry Afromontane Forest Using Pioneer Shrubs as Nurse-Plants for Olea europaea ssp. Cuspidata. Restoration Ecology Vol. 15, No. 1, pp. 129–138.

Allen C.D., A. Macalady, H. Chenchouni, D. Bachelet, N. McDowell, M. Vennetier, P. Gonzales, T. Hogg, A. Rigling, D. Breshears, R. Fensham, Z. Zhang, T. Kitzberger, J. Lim, J. Castro, G. Allard, S. Running, A. Semerci, and N. Cobb (2009) Climate-induced forest mortality: a global overview of emerging risks. Forest Ecology and Management (in press).

Alpert, P., I. Osetinsky, B. Ziv and H. Shafir (2004) Semi-Objective Classification for Daily Synoptic Systems: Application to the Eastern Mediterranean Climate Change, International Journal of Climatology, 24, 1001-1011.

Alpert, P., S.O. Krichak, H. Shafir, D. Haim, I. Osetinsky (2008) Climatic trends to extremes employing regional modeling and statistical interpretation over the E. Mediterranean. Global and Planetary Change, v. 63, iss. 2-3, p. 163-170.

Alptekin CU, M. Bariteau, J.P. Fabre (1997) Le cédre de Turquie: aire naturelle, insectes ravageurs, perspectives d'utilisation pour le reboisement en France. Rev For Fr 49:19–31

Aminmansour M. (2004) Drought and desertification in Iran. Iran & Iranian Latest News Persian Journal, Aug 30, 2004. www.iranian.ws/cgi-bin/iran_news/exec/view.cgi/2/35590.

Anderson, D.M.W. (1989) NFT Gums, Ancient and Modern Commercial Products. – NFT highlights, 89-1-01. Nitrogen Fixing Association. Hawaii.

Asmar, F., S. Bou Fakhreddine, G. Mitri, R. Bou Selman, P. Regato, T. O'Connell, G. Aakl, N. Assaf, L. Samaha, J. Stephan, Z. Tamim, Z. El Natour (2009) Lebanon's National Forest Fire Management Strategy. Ministry of Environment, Lebanon.

Atay, S. (2000) Trade in wild medicinal plants and bulbous plants of Turkey and the involvement of local people. In: Seminar Proceedings Harvesting of Non-wood Forest Products. FAO.

Battisti A. (2008) Forests and climate change - lessons from insects. iForest 1: 1-5; online: Feb 28, 2008. www.sisef.it/iforest/

Benito Garzón M., R. Sánchez de Dios, H. Sainz Ollero (2008) Effects of climate change on the distribution of Iberian tree species. Applied Vegetation Science doi: 10.3170/2008-7-18348, published online 6 February 2008 © IAVS

Bentouati, A. (2008) La situation du cèdre de l'Atlas en Algérie. Forêt Méditerranéenne 29, 203–209.

Berrahmouni, N. (2008) The value of certification in safeguarding natural capital and improving living standards in mountain landscapes: the WWF Cork Oak Landscapes Programme. In: Regato, P. & R. Salman (2008) Mediterranean Mountains in a Changing World: Guidelines for developing action plans. Malaga, Spain: IUCN.

Berthe, Y. (1997) The role of forestry in combating desertification. XI WORLD FORESTRY CONGRESS. Antalya, Turkey.

Blaser, J & C. Robledo (2007) Initial Analysis of the Mitigation Potential in the Forestry Sector. Prepared for the UNFCCC Secretariat, Intercooperation, Bern 1. August, 2007

Bond, I., M. Grieg-Gran, S. Wertz-Kanounnikoff, P. Hazlewood, S. Wunder, A. Angelsen (2009) Incentives to sustain forest ecosystem services: A review and lessons for REDD. IIED, 62 pages.

Borrini-Feyerabend, G., M. Pimbert, M.T. Farvar, A. Kothari, Y. Renard (2007). Sharing Power. Learning-by-doing in co-management of natural resources throughout the world. Earthscan

Bou Dagher-Kharrat, M., S. Mariette; F. Lefèvre, B. Fady, G. Grenierde March, C. Plomion, A. Savoure (2007) Geographical diversity and genetic relationships among Cedrus species estimated by AFLP. Tree Genetics & Genomes (2007) 3:275–285

Bou-Zeid, E. & M. El-Fadel (2002) Climate Change and Water Resources in Lebanon and the Middle East. Journal of Water Resources Planning and Management, Sept/Oct 2002.

Calder, I.R. (2000) Forests and hydrological services: reconciling public and science perceptions. Land Use and Water Resources Research 2(2): 1-12.

Carrión J.S. (2003) Sobresaltos en el bosque mediterráneo: incidencia de las perturbaciones observables en una escala paleoecológica. Ecosistemas 2003. www.aeet.org/ecosistemas/033/revision1.htm

Castro, J., R. Zamora, J.A. Hódar, J.M. Gómez, L. Gómez-Aparicio (2004) Benefits of Using Shrubs as Nurse Plants for Reforestation in Mediterranean Mountains: A 4-Year Study. Restoration Ecology, Vol. 12 No. 3.

Castro, J., G. Moreno-Rueda, J.A. Hódar (2010) Experimental Test of Postfire Management in Pine Forests: Impact of Salvage Logging versus Partial Cutting and Nonintervention on Bird–Species Assemblages. Conservation Biology, Volume 24, Issue 3, pages 810–819, June 2010

Cavelier, J. (2010) Payments for Ecosystem Services. GEF

Chaponniere, A. & V. Smakhtin (2006) A review of climate change scenarios and preliminary rainfall trend analysis in the Oum er Rbia Basin, Morocco. Working Paper 110 (Drought Series: Paper 8) Colombo, Sri Lanka: International Water Management Institute (IWMI).

Chenchouni, H., S.B. Abdelkrim, B. Athmane (2008) The deterioration of the Atlas Cedar (Cedrus atlantica) in Algeria. Oral presentation at: International Conference 'Adaptation of Forests and Forest Management to Changing Climate withEmphasis on Forest Health: A Review of Science, Policies, and Practices', Umea, Sweden: FAO/IUFRO, 25–28 August 2008.

Christensen, I. & B. Veillerette (2007) The status of rural poverty in the Near East and North Africa. FAO and IFAD.

Ciner A. (2003) Glaciers and Late Quaternary Glacial Deposits of Turkey. Geophysical Research Abstracts 5, 04888. European Geophysical Society 2003.

Croitoru, L. (2008) Value of Mediterranean forests. In: Encyclopedia of Earth. Eds. Cutler J. Cleveland (Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment).

Dalila, N. & B. Slimane (2008) La désertification dans les steppes algériennes : causes, impacts et actions de lutte. Vertigo - la revue électronique en sciences de l'environnement, Vol. 8 Nº 1.

Dasgupta, S., B. Laplante, C. Meisner and J. Yan (2007) The impact of Sea Level Rise on Developing Countries: A Comparative Study. World Bank Policy Research Working Paper 4136, February 2007.

De Lillis, M., L. Costanzo, P.M. Bianco, and A. Tinelli (2004) Sustainability of sand dune restoration along the coast of the Tyrrhenian sea. Journal of Coastal Conservation, Vol. 10, Nº 1: 93-100.

DGF (1995) Résultats du Premier Inventaire Forestier National en Tunisie. Ministère de l'Agriculture, Tunis.

Dobardzic, S. & R. Cervigni (2007). Middle East and North Africa Region. Environmental Matters, 2007. World Bank.

Dobie, P. & M. Goumandakoya (2005) The Global Drylands Imperative. Implementing the Millennium Development Goals in the Drylands of the World. UNDP & the Canadian International Development Agency.

Dröll, P. (2009) Vulnerability to the impact of climate change on renewable groundwater resources: a globa- scale assessment. Env. Res. Lett. 4.

Dubost, M., L. Girard, D. Camacho *Eds*, with contribution of **A. Biomonti, A. Messina, K. Burini, G. Karagoz. A. Hanafi** (2009). TERRAMED. Valorization of terrace cultivation systems. MEDITERRITAGE Project, INTERREG III C South Zone.

Dudley, N., S. Stolton, A. Belokurov, L. Krueger, N. Lopoukhine, K. MacKinnon, T. Sandwith and N. Sekhran *Eds* (2010); Natural Solutions: Protected areas helping people cope with climate

change, IUCN- WCPA, TNC, UNDP, WCS, The World Bank and WWF, Gland, Switzerland, Washington DC and New York, USA

Dworak, T. & A. Leipprand (2007) Climate Change and the EU Water Policy Including Climate Change in River Basin Planning. Support to the CIS working group on Climate change and Water. Ecologic

Dwire, K.A. & J. B. Kauffman (2003) Fire and riparian ecosystems in landscapes of the western USA. Forest Ecology and Management 178 (2003) 61–74

EFIMED (2009) A Mediterranean Forest Research Agenda – MFRA 2010-2020.

El Abidine, A.Z. (2003) Forest decline in Morocco: causes and control strategy. Science et changements planétaires/Sécheresse 14, 209–218.

Enright, N.J., R. Marsula, B. Lamont, C. Wissel (1998) The ecological significance of canopy seed storage in fire-prone environments: a model for non-sprouting shrubs. Journal of Ecology 86.

Estrela M.J., J.A. Valiente, D. Corell, M.M. Millán (2004) Fog collection in a region of the Western Mediterranean basin: evaluation of the use of fog water for the restoration of wildfire burnt areas. In : The Third International Conference on Fog, Fog Collection and Dew, 11-15 oct, Cape Town, Afrique du Sud.

Evans, J.P. (2009) 21st century climate change in the Middle East. Climatic Change (2009) 92:417–432 DOI 10.1007/s10584-008-9438-5

Fady B. (2008) Influence of climate change on the natural distribution of tree species. In : Regato, P. (2008) Adapting to global change, Mediterranean Forests. IUCN Centre for Mediterranean Cooperation.

Fady, B., F. Lefèvre, G.G. Vendramin, A. Ambert, C. Régnier, M. Bariteau (2008) Genetic consequences of past climate and human impact on eastern Mediterranean Cedrus libani forests. Implications for their conservation. Conserv Genet (2008) 9:85–95

FAO (2004a) Forestry Outlook Study for West and Central Asia (FOWECA). 1st Sub-regional Workshop for Central Asia and the Caucasus 20-26 May 2004, Beirut, Lebanon

FAO (2004b) Carbon sequestration in drylands. World Soil Resources Reports, 102. FAO, Rome.

FAO (2007) The World's Mangroves 1980-2005. FAO Forestry Papers, 153.

FAO (2008) Climate Change implications for agriculture in the Near East. 20th FAO Regional Conference for the Near East, Cairo 1-5 March 2008.

Farage P., J. Pretty, and A. Ball (2003) Biophysical Aspects of Carbon Sequestration in Drylands. University of Essex.

Fé d'Ostiani, L. (2004) Watershed management: a key component of rural development in the Mediterranean region. Watershed Management and Sustainable Development Working Paper Nº 4. FAO, Rome.

FRA (2005) Global Forest Resources Assessment 2005. FAO

FRA (2010) Global Forest Resource Assessment 2010. FAO

Garcia, N., A. Cuttelod, D. Abdul Malak *Eds.* (2010) The status and distribution of freshwater biodiversity in Northern Africa. IUCN.

Gaul, D, A. Kutter, G.A.B. da Fonseca (2010) A New Climate for Forests. GEF action on sustainable forest management. GEF

Gebrehiwot, K., B. Muys, M. Haile and R. Mitloehner (2003) Introducing Boswellia papyrifera (Del.) Hochst and its non-timber forest product, frankincense. International Forestry Review 5(4),

Gelil, I.A. (2007) Arab Region State of Implementation on Climate Change. League of Arab States, Technical Secretariat Council of Arab Ministers Responsible for the Environment. www.un.org/esa/sustdev/csd/csd14/

Giannakopoulos C, Bindi M, Moriondo M, LeSager P, Tin T. (2005) Climate change impacts in the Mediterranean resulting from a _oC global temperature rise. Report for WWF. Observatoire national d'Athènes, Grèce.

Gómez, J. & A. Gúzman (2008) Planificación Integral para la Protección contra Incendios Forestales en España, el Caso de la Comunidad Valenciana. Segundo Simposio internacional sobre políticas, planificación y economía de los programas de protección contra incendios forestales: una visión global. USDA

Gómez del Álamo, R (2010) Editorial Silva Mediterranea. Silva Mediterranea Newsletter n0 4 - August 2010. www.fao.org/forestry/

Gommes, R., T. El Hairech, D. Rosillon, R. Balaghi, H. Kanamaru (2009) Impact of climate change on agricultural yields in Morocco. WB Morocco & FAO Climate Change Study.

Gracia C, Bellot J, Sabaté S, Albeza E, Djema A, Leon B, Martínez J M, Ruiz I, Tello E (1996) Respuesta del encinar a tratamientos de aclareo selectivo. In: Vallejo R (ed) La restauración de la cubierta vegetal en la Comunidad Valenciana. Fundación CEAM, Valencia, pp 547-601

Gregoire, G. (2008) Climate Change Adaptation in the Water Sector in the Middle East and North Africa: A Review of Main Issues. Technical Note prepared by METAP under the EC-funded SMAP III project "Promoting awareness and enabling a policy framework for environment and development integration in the Mediterranean with a focus on Integrated coastal Zone Management".

Goubitz S., R. Nathan, R. Roitemberg, A. Shmida, G. Ne'eman (2004) Canopy seed bank structure in relation to fire, tree size and density. Plant Ecology 173. Kluwer Acad. Publishers. Netherlands

Hamilton, K., U. Chokkalingam, & M. Bendana (2010) State of the Forest Carbon Markets 2009: Taking Root & Branching Out. (ecosystemmarketplace.com/documents/).

Halpin, P.N. (1997) Global climate change and natural-area protection: Management responses and research directions. Ecol. App. 7, 828-843.

Hertel, T.W. & S. D. Rosch (2010) Climate Change, Agriculture, and Poverty. Appl. Econ. Perspect. Pol. (2010) doi: 10.1093/aepp/ppq016

Hitz S. & J. Smith (2004) Estimating global impacts of climate change. Glob Environ Ch 14:201–218

Hoerling M. & A. Kumar (2004) The perfect ocean for drought. Science 299:691–694

Holling, C.S. (2001) Understanding the complexity of economic, ecological, and social systems. Ecosystems 4:390–405.

Hussein, H. (2010) Adaptation to Climate Change in the Jordan River Valley: the Case of the Sharhabil Bin Hassneh Eco-Park. College of Europe Natolin (Warsaw) Thesis for the Degree of Master in Arts in European Interdisciplinary Studies.

Insall, D. (1999) A review of the ecology and conservation status of Arabian Tahr. Pages 129-146 in M. Fisher, S. A. Ghazanfar, and J. A. Spalton, editors. The natural history of Oman: A festschrift for Michael Gallagher. Backhuys Publishers, Leiden.

Iqbal, F. (2006) Sustaining Gains in Poverty Reduction and Human Development in the Middle East and North Africa. The World Bank.

Isendahl N, Schmidt G. (2006) Drought in the Mediterranean: WWF Policy Proposals. WWF.

Kameri-Mbote, P. (2005) Achieving the Millennium Development Goals in the Drylands Gender Considerations. IELRC WORKING PAPER 2005 – 8.

Kant , P. (2010) A Fresh Look at REDD. IGREC Web Publication No.01.

Kellomäki, S. & S. Leinonen *Eds.* (2005). Management of European Forests Under Changing Climatic Conditions. SilviStrat Final Project Report, Tiedonantoja/Research Notes No. 163. University of Joensuu, Faculty of Forestry. ISBN: 952-458-652-5. 427 p.

Kharazipour, A.R., C. Schöpper and C. Müller *Ed.* (2008) Review of Forests, Wood Products and Wood Biotechnology of Iran and Germany – Part II. Universitätsverlag Göttingen.

Khalil A.E.E. (1982) Influence of windbreaks on field and forage crops in West Nubariah region. M.Sc. Thesis, Alexandria University.

Khuri S. & Talhouk S.N. (1999) Cedars of Lebanon Cedrus libani A. Rich. In: Farjon A, Page CN (eds) Conifers: status survey and conservation action plan, IUCN, Gland, Switzerland, pp 108– 111

Kitoh A., A. Yatagai, and P. Alpert (2008) First super-high- resolution model projection that the ancient 'Fertile Crescent' will disappear in this century. Hydrological Research Letters, 2, 1–4. The Japan Society of Hydrology and Water Resources

Knuth, L., T.B. Randrup, J. Schipperijn (2006) Urban and peri-urban forestry and greening in West and Central Asia. Experiences, constraints and prospects. FAO

Kohler, T. & D. Maselli (2009) Mountains and Climate Change: From Understanding to Action. Geographica Bernensia and SDC Pub.

Kunstmann, H., P. Suppan, A. Heckl, and A. Rimmer (2007) Regional climate change in the Middle East and impact on hydrology in the Upper Jordan catchment. In IAHS publication, Quantification and Reduction of Predictive Uncertainty for Sustainable Water Resources Management. Wallingford, UK, HR Wallingford, pp. 141–49.

Lagrot, I. & J. F. Lagrot (1999) Report on the status of the Arabian leopard in the Arabian Peninsula. Unpublished report to the Arabian Leopard Trust, United Arab Emirates. In: Llewellyn-Smith, R. (2001) Southwestern Arabian montane woodlands (AT1321). www.worldwidelife.org.

Lange, D. & U. Schippman (1997). Trade survey of medicinal plants in Germany. A contribution to international plant species conservation.- Bundesamt für Naturschutz. Bonn-Bad Godesberg.

Lefèvre F., B. Fady, D. Fallour-Rubio, D. Ghosn, M. Bariteau (2004) Impact of founder population, drift and selection on the genetic diversity of a recently translocated tree population. Heredity 93:542–550

Linares, J.C. & P.A. Tíscar (2010) Climate change impacts and vulnerability of the southern populations of Pinus nigra subsp. salzmannii. Tree Physiology.

Lindner M. (2006) How to adapt forest management in response to the challenges of climate change? In : IPGRI-IUFRO Workshop, Climate Change and forest genetic diversity: implications for sustainable forest management in Europe. Paris, France, 15-16 mars 2006.

Lybbert, J.T., C.B. Travis, H. Narjisse (2010) Commercializing Argan Oil in Southwestern Morocco: Pitfalls on the Pathway to Sustainable Development. In: S. Pagiola, J. Bishop and S. Wunder (Eds.) Buying Biodiversity: Financing Conservation For Sustainable Development (Washington: World Bank).

Maestre, F. T., S. Bautista, J. Cortina and J. Bellot (2001). Potential of using facilitation by grasses to establish shrubs on a semiarid degraded steppe. Ecological Applications 11: 1641-1655.

Maestre, F. T., S. Bautista, J. Cortina, C. Bladé, J. Bellot and V.R. Vallejo (2003) Bases ecológicas para la restauración de los espartales semiáridos degradados. Ecosistemas 2003/1.

Maestre F.T., D.A. Ramírez, and J. Cortina (2007) Ecología del esparto (Stipa tenacissima L.) y los espartales de la Península Ibérica . Ecosistemas. 2007/2.

Mansourian, S., D. Vallauri, N. Dudley (2007). Forest Landscape Restoration. Beyond Planting Trees. Springer.

Markham, A. and J. Malcolm (1996) Biodiversity and wildlife: adaptation to climate change. Pages 384-401. In Smith, J., N. Bhatti, G. Menzhulin, R. Benioff, M. Campos, B. Jallow, and F. Rijsberman *Eds.* Adap- tation to climate change: assessment and issues. Springer-Verlag, New York.

Mátyás, C. (1997) Conservation of genetic resources in a changing world – strategy considerations for temperate forest tree species. XI WORLD FORESTRY CONGRESS. Antalya, Turkey.

Mayrand, K. & M. Paquin (2004) Payments for Environmental Services: A Survey and Assessment of Current Schemes. Unisféra International Centre, For the Commission for Environmental Cooperation of North America. Montreal.

McLeod, Elizabeth and Salm, Rodney V. (2006). Managing Mangroves for Resilience to Climate Change. IUCN, Gland, Switzerland. 64pp.

MEA (2005) Millennium Ecosystem Assessment. Ecosystems and Human Well-being: Desertification Synthesis. World Resources Institute, Washington, DC.

Médail, F. & P. Quézel (1997) Hot-spots analysis for conservation of plant biodiversity in the Mediterranean basin. Annals of the Missouri Botanical Garden 84:112-127.

Medail, F. & P. Quezel (2003) Conséquences écologiques possibles des changements climatiques sur la flore et la végétation du bassin méditerranéen. Bocconea 16(1).

Medany, M. (2008) Impact of Climate Change on Arab Countries. In: Tolba, M.K. & N.W. Saab Eds. Arab Environment: Future Challenges. 2008 Report of the Arab Forum for Environment and Development. AFED.

Merger, E. (2010) Status and Future of the Afforestation and Reforestation (A/R) Carbon Sector. Carbon Positive Ed.

Merlo, M. & L. Croitoru *Eds.* (2005) Valuing Mediterranean Forests: Towards Total Economic Value, CABI International, Wallingford UK/Cambridge.

Moussouris, Y & P. Regato (2002) Mastic gum (Pistacia lentiscus), cork oak (Quercus suber), argan (Argania spinosa), pine nut (Pinus pinea), pine resin (Pinus spp.) and chestnut (Castanea sativa). In: Shanley, P., A.R. Pierce, S.A. Laird & A. Guillén Eds. Tapping the Green Market. People and Plants Conservation Series. Earthscan.

Murphree M. (1997). Common property, communal property and open access regimes. In: Borrini-Feyerabend. Gracia, ed. 1997. Beyond Fences. Seeking Social Sustainability in Conservation. Vol. 2: A Resource Book, Gracia, ed. Gland, Suiza: IUCN.

Myers, N., A.R. Mittermeier, C. G. Mittermeier, G. A. B. da Fonseca, J. Kent (2000) Biodiversity hotspots for conservation priorities. Nature, Vol. 403

Ne'eman G., S. Goubitz, R. Nathan (2004) Reproductive traits of Pinus halepensis in the light of fire – a critical review. Plant Ecology 171. Kluwer Acad. Publisher. Netherlands.

Nef, J. (2001) An assessment of the state of the fog-collecting project in Chungungo, Chile. University of Guelph, Guelph, ON, CA.

Nogués-Bravo, D., M.B. Araujo, M.P. Errea, J.P. Martínez-Rica (2007) Exposure of global mountain systems to climate warming during the 21st Century. Global Environmental Change 17 (2007) 420–428

Ohlemüller R, Gritti ES, Sykes MT, Thomas CD. (2006) Towards European climate risk surfaces: the extent and distribution of analogous and non-analogous climates 1931-2100. Global Ecology and Biogeography, 15.

Olson, D. & E. Dinerstein (2002) The Global 200: Priority Ecoregions for Global Conservation. Ann. Missouri Bot. Gard. 89: 199–224. 2002.

OTDA (2000) La gestión de l'Albufera de Valencia y su Devesa (unpublished document).

OTDA (2008) Restauración de las dunas litorales de la Devesa de la Albufera de Valencia. Ayuntamiento de Valencia

Ouahmane, L., R. Duponnois, M. Hafidi, M. Kisa, A. Boumezouch, J. Thioulouse and C. Plenchette (2006) Some Mediterranean plant species (Lavandula spp. and Thymus satureioides) act as potential 'plant nurses' for the early growth of Cupressus atlantica. Plant Ecology (2006). Springer

Özkan, Z.C. & H. H. Acar (2000) Production, transport and storage of chestnuts in Turkey. In: Seminar Proceedings Harvesting of Non-wood Forest Products. FAO.

Pagliani, M. *Ed.* (2010a) Mediterranean Mosaics. Cogecstre Ed.

Pagliani, M. (2010b) Using Tourism and Non Wood Forest Products to Build a Sustainable Economy in the Shouf Biosphere Reserve (Lebanon). In: Regato, P. Dryland Mountains. FAO (in print).

Papageorgiou AC. (2008) Mediterranean forest genetic diversity and adaptive conservation strategies. In: Compte-rendu présenté lors de l'atelier international UICN-WWF « Adaptation au changement climatique dans la gestion et la conservation des forêts méditerranéennes » Athènes, 2008. www.uicnmed. org.

Papanastasis, V.P. (2009) Grazing Value of Mediterranean Forests. In: Palahí, M., Y. Birot, F. Bravo, E. Gorriz (eds.) Modelling, Valuing and Managing Mediterranean Forest Ecosystems for Non-Timber Goods and Services. EFI Proceedings No. 57

Petit JP, Hampe A, Cheddadi R. (2005) Climate changes and tree phylogeography in the Mediterranean. TAXON, 54(4): 877-885.

Pistorius, T., C. Schmitt and G. Winkel (2008); A Global Network of Forest Protected Areas under the CBD, University of Freiburg, Faculty of Forest and Environmental Sciences.

Porter, G., N. Bird, N. Kaur, L. Peskett (2008) New Finance for Climate Change and the Environment. WWF and Heinrich Böll Foundation.

ProAct Network (2008) Assessing the effectiveness of fuel-efficient stove programming. A Darfur-wide-review. www.proactnetwork.org

Quézel P. and F. Médail (2003) Ecologie et biogéographie des forêts du bassin Méditerranéen. Elsevier, Collection Environnement, Paris

Ragab R., and C. Prudhomme (2000) Climate change and water resources management in the southern Mediterranean and Middle East countries. The Second World Water Forum, 17–22, March 2000, The Hague.

Raouf, M.A. (2008) Climate Change Threats, Opportunities, and the GCC Countries. Middle East Institute Policy Briefs Nº 12.

Regato, P. (2001) The Mediterranean Forests, a New Conservation Strategy. WWF-MedPO Ed, Rome.

Regato, P. (2007) Management recommendations for Pinus halepensis seeds production in Gouria region (Tunisia). Unpublished report produced for the AECID Project: Programa Aumento de la sostenibilidad de los medios de vida de Poblaciones Rurales Vulnerables en Marruecos, Mauritania y Túnez. Spain.

Regato, P. & R. Salman (2008) Mediterranean Mountains in a Changing World: Guidelines for developing action plans. Malaga, Spain: IUCN Centre for Mediterranean Cooperation. xii+88 pp.

Regato, P., R. Colomer, N. Berrahmouni, A. Badalotti, & A.O. Dia (2009) Forest Landscape Restoration in Morocco. Handbook on Good Practices. WWF.

Regato, P., R. Murti, M. Valderrabano, C. Danielutti (2010) Reducing Fire Disasters through Ecosystem Management in Lebanon (IUCN). In: Demonstrating the Role of Ecosystems-based Management for Disaster Risk Reduction. Prepared for the Partnership for Environment and Disaster Risk Reduction (PEDRR) Workshop, September 2010 UNU Campus in Bonn.

Rego, F., E. Rigolot, P.Fernandes, C. Montiel, J.S. Silva (2010) Towards Integrated Fire Management. EFI Policy Brief 4

Rietbergen-McCracken, J. *Ed*. (2008) Green Carbon Guidebook, WWF US, Washington DC.

Robson, M., N. Berrahmouni, P. Regato (2004) La certification forestière, environnement et développement. Beacon Press.

Saab, N. (2008) The Environment in Arab Media. In: Tolba, M.K. & N.W. Saab Eds. Arab Environment: Future Challenges. 2008 Report of the Arab Forum for Environment and Development. AFED.

Saint-Laurent C. (2008) International Policy Context for Adaptation Within An Integrated Forest Sector Response. In : Compte-rendu présenté lors de l'atelier international UICN-WWF « Adaptation au changement climatique dans la gestion et la conservation des forêts méditerranéennes » Athènes, 2008 www. uicnmed.org.

Saliha Dobardzic, S. & R. Cervigni (2007) Middle East and North Africa Region. Environmental Matters, WB www.worldbank.org/mna.

Schlecht, E., C. Hülsebusch, F. Mahler, K. Becker (2004) The use of differentially corrected global positioning system to monitor activities of cattle at pasture. Appl. Anim. Behav. Sci. 85, 185–202.

Semerci, A., B.N. Sanlı, O. Sahin, O. Celik, G.B. Balkız, S. Ceylan, N. Argun (2008) Examination of tree mortalities in semi-arid central Anatolian region of Turkey during last six-year period (2002–2007). Poster presentation at: International Conference ‘‘Adaptation of Forests and Forest Management to Changing Climate with Emphasis on Forest Health: A Review of Science, Policies, and Practices’’. Sweden, FAO/IUFRO, 25–28 August 2008.

Seppälä, R., A. Buck and P. Katila. (*Eds.*) (2009) Adaptation of Forests and People to Climate Change. A Global Assessment Report. IUFRO World Series Volume 22. Helsinki. 224 p.

Solomon S. *et al.* (2007) Technical Summary. In : Solomon S, Qin D, Manning M, Chen Z, Marquis M, Averyt KB, Tignor M, Miller HL (Eds.) Climate Change _007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, Royaume-Uni et New York, NY, Etats- Unis.

Spittlehouse DL, Stewart RB. (2003) Adaptation to Climate Change in Forest Management. BC Journal of Ecosystems and Management, 4(1). FORREX.

Stanton, T., M. Echavarria, K. Hamilton, and C. Ott (2010) State of Watershed Payments: An Emerging Marketplace. Ecosystem Marketplace. www.forest-trends.org/documents/files/doc_2438.pdf.

Stastny M, Battisti A, Petrucco Toffolo E, Schlyter F, Larsson S. (2006). Host plant use in the range expansion of the pine processionary moth, Thaumetopoea pityocampa. Ecological Entomology31: 481-490.

Tapias, R., L. Gil, P. Fuentes-Utrilla, J. Pardos (2001) Canopy seed banks in Mediterranean pines of South-eastern Spain: a comparison between Pinus halepensis, P. pinaster, P. nigra and P. pinea. Journal of Ecology 89.

Thanos, C.A., E.N. Daskalakou (2000) Reproduction in Pinus halepensis and Pinus brutia. In: Ne’eman & Trabaud (eds): Ecology, Biogeography and Management of Pinus halepensis and Pinus brutia Forest Ecosystems in the Mediterranean Basin. Backhuys Pub.

Thomas, R.J., E. de Pauw, M. Qadir, A. Amri, M. Pala, A. Yahyaoui, M. El-Bouhssini, M. Baum, L. Iñiguez, K. Shideed (2007) Increasing the Resilience of Dryland Agro-ecosystems to Climate Change. International Centre for Agricultural Research in the Dry Areas (ICARDA).

Thuiller W., S. Lavorel, M-B. Araujo, M.T. Sykes, and I.C. Prentice (2005) Climate change threats to plant diversity in Europe. PNAS, 102, 23: 8245-8250.

Tinner W, Conedera M, Gobet E, Hubschmid P, Wehrli M, Ammann B. (2000) A palaeoecological attempt to classify fire sensitivity of trees in the southern Alps. The Holocene, 10, 565-574.

Tinner W, Conedera M, Ammann B, Lotter AF. (2005) Fire ecology north and south of the Alps since the last ice age. The Holocene, 15, 1214-1226.

Torres, E., P. Regato, X. Escuté (2008) Mediterranean Conifer Forest Products: pine nuts. In: Berrahmouni, N., X. Escuté, P. Regato & C. Stein (Eds.) Beyond Cork—a wealth of resources for people and Nature. WWF

Touchan, R., K.J. Anchukaitis, D.M. Meko, S. Attalah, C. Baisan, A. Aloui (2008) Long term context for recent drought in northwestern Africa. Geophysical Research Letters 35, L13705.

Trondalen, J.M. (2008) Water and Peace for the People – Proposed Solutions to Water Disputes in the Middle East. Paris, UNESCO International Hydrological Programme (IHP).

Trumper, K., C. Ravillious, B. Dickson (2008) Carbon in Drylands: Desertification, climate change and carbon finance. A UNEP-UNDP-UNCCD Technical Note for Discussion at CRIC 7, Istanbul.

Tsiourtis, N.X. (2002) CYPRUS-Water Resources Planning and Climate Change Adaptation. Mediterranean Regional Roundtable Athens, Greece, December 10-11, 2002. IUCN

UAE (2006) Economic Development. United Arab Emirates Yearbook 2006.

UNODC (2007) Enquête sur le cannabis au Maroc 2005

Valdecantos A. (2008) Post-fire restoration strategies/interventions to increase forest resilience against large forest fires exacerbated by climate change: The case of Valencia (Spain). In : Regato, P. (2008) Adapting to global change, Mediterranean Forests. IUCN Centre for Mediterranean Cooperation.

Valladares, F. (2008). A mechanistic view of the capacity of forest to cope with climate change. In F. Bravo, V. Le May, R. Jandl and K. von Gadow (eds). Managing Forest Ecosystems: the challenge of climate change, pp. 11–35. Berlin: Springer Verlag.

Vallejo, V.R. (2008) Rural landscape and water: the role of forests. Fundación CEAM, Expo Zaragoza.

Vélez, R. (1990) Mediterranean Forest Fires: A regional perspective. In: Unasylva Nº 162, Fire!. FAO

Verkaik, I, J.M. Espelta (2005) Effect of thinning and post-fire regeneration age on the reproductive characteristics of Pinus halepensis Mill. Forests. II International Conference on prevention strategies of fires in Southern Europe. CREAF.

Walter, K.S. & H.J. Gillett *Eds.* (1998) 1997 IUCN Red List of Threatened Plants. Compiled by WCMC. IUCN

Watkiss, P. (2009) The Economics of Adapting to Climate Change in Africa: Linking experience, ensembles and entitlement. African finance ministers meeting: Financing for Development, Conference on Climate Change, Kigali, 21/22 May 2009.

Yano, T., M. Aydin, T. Haraguchi (2007) Impact of Climate Change on Irrigation Demand and Crop Growth in a Mediterranean Environment of Turkey. Sensors 2007, 7, 2297-2315.

Zaroug, M. (1984) Importance of fodder trees and shrubs for the productivity of rangelands and agriculture Systems in the Near East. In: The Current State of Knowledge on Prosopis tamarugo Papers presented at the International Round Table on Prosopis tamarugo Phil.Arica, Chile.

Annex 1. Forest and wood land cover, designated functions and tree plantations in the Near East (FRA 2005)

Country	Total Forest Land (1000ha)	% Forest	% Change 2000-2005	Designated Forest Functions						Other Wood Land	PD/PL (ha x 1000)	PT/PL (ha x 1000)	PL Rate (ha) 1990-2000	PL Rate (ha) 2000-2005
				PR	PT	Con	SS	MP	N/U					
ALG	2277	1	1.2	32.9	63	4	0.1	-	-	1595	12	742	3200	20400
EGY	67	0.1	2.6	1.9	50	-	-	48.1	-	20	1	66	1500	1600
LIB	217	0.1	0	-	100	-	-	-	-	330	-	217	0	-
MAU	267		-3.4	-	-	-	-	-	100	3110	-	-		
MOR	4764	9.8	0.2	-	-	-	-	-	-	406	563	-	4500	8000
SUD	67546	28.4	-0.8	44.9	2.6	12.7	-	-	39.9	-	4728	675	-47123	-47123
TUN	1056	6.8	1.9	23	42	3.7	-	31.3	-	170	150	348	19700	15000
AFG	867		-3.1	-	-	-	-	100	-	-	-	-		
BAH	n.s.	0.6	3.8	-	100	-	-	-	-	-	-	-	16	15
CYP	174	18.9	-	24.7	-	2.9	10.3	55.6	5.7	214	-	5	0	400
IRAN	11075	6.8	0	13.5	-	1.4	-	85.1	-	5340	616	-	0	0
IRAQ	822	1.9	0.1	-	80	20	-	-	-	927	-	13	0	-400
ISR	171	8.3	0.8	-	12.9	4.1	-	83	-	85	-	101	1000	1400
JOR	83	0.9	0	-	6	1.2	1.2	91.6	-	52	-	40	0	0
KUW	6	0.3	2.7	-	100	-	-	-	-	0	-	6	140	140
LEB	136	13.3	0.8	97.4	-	2.6	-	-	-	106	8	-	-	-
PAL	9	1.5	0	-	-	-	-	-	-	-	-	-	-	-
OMAN	2	-	0	100	-	-	-	-	-	1303	-	2	0	0
QATAR	n.s.	-	0	-	-	-	-	-	-	n.s.	-	-	-	-
SAUD A	2728	1.3	0	-	-	-	-	100	-	34155	-	-	-	-
SYR	461	2.5	1.3	-	-	-	-	100	-	35	-	264	5950	5960
TUR	10175	13.2	0.2	78.3	13.9	7.6	0.2	-	-	10689	1911	621	-1000	0
UAE	312	3.7	0.1	-	-	-	-	100	-	4	-	-	6500	400
YEM	549	1	0	-	-	-	-	100	-	1406	-	-	-	-
TOTAL	194630									59947	7989	3100		

PR: Production; PT: Protection; SS: Social Service; MP: Multipurpose; N/U: None/Unknown; PL: Plantations; PD: Productive; n.s.= not significant

Annex 2. Total Economic Value of Forests in Near East countries

	Direct use values					*Indirect use values*	
2007 US$	WFPs[1]	NWFPs[2]	Grazing	Recreation	Hunting	Watershed protection[3]	Carbon sequestration
Morocco	27	5	36	n.a.	-5	27	-3
Algeria	-6	1	42	n.a.	n.a.	29	-3
Tunisia	1	29	95	n.a.	3	33	6
Egypt	8	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
South:	***15***	***5***	***41***	***n.c.***	***-3***	***28***	***-3***
Palestine	10	32	28	n.a.	n.a.	n.a.	n.a.
Israel	6	38	n.a.	215	n.a.	n.a.	n.a.
Lebanon	-9	165	9	3	114	n.a.	-14
Syria	4	9	n.a.	n.a.	n.a.	94	8
Turkey	29	5	14	n.a.	1	-8	10
Cyprus	3	18	n.a.	6	4	n.a.	8
East:	***28***	***6***	***13***	***1***	***1***	***-5***	***10***

Table 2[23]. *TEV= Total Economic Value; WFP= Wood Forest Products; NWFP= Non-Wood Forest Products*

[23] In: Croitoru, 2008

Annex 3. Mangrove Forest cover in the Near East Countries

Country	1980	Recent data		Changes		
		Ha	Yr	1980 - 1990	1990 - 2000	2000 - 2005
Bahrain	150	100	92	-4	-1	0
Iran	27500	19234	97	-2	-1.6	-0.1
Kuwait	n.s.	5	04	n/a	n/a	n/a
Oman	2000	1088	95	0	-6.7	0
Qatar	500	500	92	0	0	0
Saudi Arabia	21000	20400	85	-0.5	0	0
UAE	3500	4000	99	0.8	0.5	0.5
Yemen	1000	927	93	-0.5	-0.5	0
Egypt	500	512	02	0	0	0
Sudan	500	500	95	0	0	0
TOTAL	56650	47266				

FAO 2007: The World's Mangroves 1980-2005 n.s.= not significant; n/a: not available

FAO FORESTS AND CLIMATE CHANGE WORKING PAPER SERIES

1. Forests and climate change - Instruments related to the United Nations framework convention on climate change and their potential for sustainable forest management in Africa. 2003 (E, F)
2. Adaptation of forest ecosystems and the forest sector to climate change. 2005 (E)
3. Forestry projects under the CDM: Procedures, experiences and lessons learned. 2005 (E)
4. Choosing a forest definition for the Clean Development Mechanism. 2006 (E)
5. Definitional issues related to reducing emissions from deforestation in developing countries. 2007 (E)
6. Woodfuels and climate change mitigation - case studies from Brazil, India and Mexico 2010 (E)
7. Forests and climate change in the Asia-Pacific Region. 2010 (E)
8. Forests and climate change in Eastern Europe and Central Asia. 2010 (E, R)
9. Forests and climate change in the Near East Region. 2010 (E)

E – English, F – French, R – Russian

The FAO Forests and Climate change Working Papers are available on the website www.fao.org/climatechange/61880/en/