Journal of Environmental Science and Engineering A 2 (2013) 41-58
Formerly part of Journal of Environmental Science and Engineering, ISSN 1934-8932

Threats to Plant Diversity in the North Eastern Part of Libya (El-Jabal El-Akahdar and Marmarica Plateau)

Yacoub Mohamad Mohamad El-Barasi[1] and Manam Wafi Barrani Saaed[2]

1. Botany Department, Faculty of Science, Benghazi University (Previous Gar-Yunis University), Benghazi 25426, Libya

2. Range Department, High Institute of Agriculture Techniques, Al-Marj city 25426, Libya

Received: December 23, 2012 / Accepted: January 14, 2013 / Published: January 20, 2013.

Abstract: Little thought has been given to threats facing plant diversity in this area where many wild plants still exist in their refuge sites in valleys (wadis), the study area harboring most of the endemic species in the zone, and there are substantial maquis vegetation still remaining. Many plants species in this region have medicinal properties that give them scientific and commercial value. However, the wildlife species are gradually disappearing as a result of damaging and excessive resource exploitation the consistency of the irresponsible and inattentive activities, such as over grazing, ploughing, land reclamation, urbanization, mining, forest fires, over collecting and charcoal production cause damage to several habitats, communities disturbance as a result of that, hundreds of species are threatened with disappearance where many are at the brink of extinction. Also, the anthropogenic pressure accelerates Aeolian soil erosion and destroys the soil seed bank.

Key words: Biodiversity, human activities, El-Jabal El-Akhadar, Marmarica plateau.

1. Introduction

Libya occupies an area of 1.75954 million km^2. The desert is spread over more than 95% of the country, except for a narrow coastal strip which contains most of the country's inhabitants (6,310,434 inhabitants). The population density is about 1 inhabitant per km^2 in the southern region; meanwhile it is about 50 inhabitants per km^2 in the coastal strip.

The northern strip is characterized by a relative abundance of rainfall and soil fertility that make it suitable for the appearance of rich wildlife, thus differing from the rest of the country. El-Jabal El-Akhadar and Marmarica plateau have a unique relatively large biodiversity, particularly in valleys and depressions that act as a haven for many species.

The background of the area shows that it was free of any natural resource, other than the natural vegetation, as a result life of the local inhabitants relied upon. The main activities throughout history were grazing, gathering wood for fuel, production of bees honey, gathering medication species and wood products. Many plant species were a source of food for people, and at the same time, the natural vegetation is a haven for many kinds of birds and wild animals that are also a source of food and medication for the inhabitants.

In fact, the study area is rich in many medicinal and aromatic species such as *Ceratonia siliqua*, *Zizphus lotus*, *Cistus sps.*, *Thymus capitatus*, *Artemisia herba-alba*, *Globularia arabica*, *Teucrium polium*, *Juniperus phoenicea*, *Rosmarinus officinalis*, *Salvia fruticosa*, *Chamomilia pubescens*, *Pituranthos tortuousus*. El-Jabal El-Akhadar contains about 43 endemic plant species, meanwhile Marmarica plateau contains about 12 endemic plant species.

The human activities over the centuries have dramatically affected the biodiversity of this region. In recent decades, this effect has been intensified due to

Corresponding author: Yacoub Mohamad Mohamad El-Barasi, Ph.D., professor, main research field: ecology, plant ecology, phytosociology, seed ecology, range ecology and land uses. E-mail: Yammab54@yahoo.com.

the increase in the population and the import of modern mechanization which has caused an increase (in both density and area) of the destructive effects of human activities.

Although this region is one of the important areas for wildlife in Libya, it suffers from extreme biodiversity destruction and degradation and it is very important now to begin extensive environmental studies and conservation programs, including not only soil and biodiversity conservation but also beauty conservation and attention to local inhabitants because they play an important role in the ecological systems throughout the whole area.

2. The Biophysical Environment

The study area lies on the Mediterranean coast in north eastern Libya (Cyrenaica), at coordinates 20° to 25° east and 31°:30' to 33° north (Fig. 1), which include El-Jabal El-Akhadar (The Green Mountain), a three terraces hill which rise up gradually, the highest terrace reaches about 880 m above sea level. El-Jabal El-Akhadar extends from the city of Benghazi toward east reaching Gulf of Bomba with a length of about 350 km.

Moreover, the eastern part of the study area known as Marmarica plateau, a wide plateau which extends about 250 km from the Gulf of Bomba to reaches the Egyptian border, with an average height of 200 m above sea level [1].

In fact, the study area is a part of the great sprawling plateau that forms the Libyan land, which descends gradually from the south of the country to the north, but rises, near the coast to consist the study area, which is an elevated land. The north of the area abruptly descends to form steep slopes towards the sea, and it descends gradually towards the south until we reach the desert. The study area is divided by a large number of valleys that vary in depth and length; they are oriented towards the sea in the north, while many are oriented towards the south to end in the desert (Sahara).

Topography of the area has a great effect on the

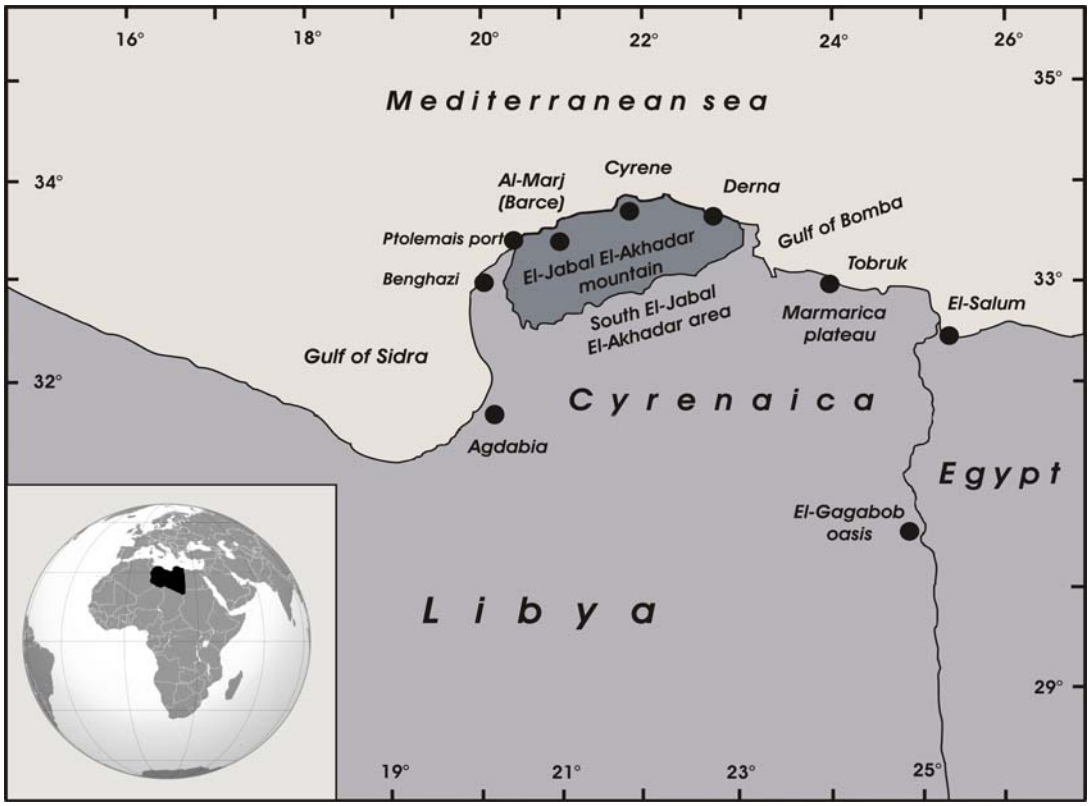

Fig. 1 Location map of the study area (by the authors).

distribution of natural vegetation because the low land receives more water through runoff after rainfall, and it has more prevention against wind and human activities, hence many valleys act as havens for many wildlife species that have disappeared completely from other parts in the region.

The soil in El-Jabal El-Akhadar area is characterized by the presence of red clay soil (Terra Rosa), it tends to be neutral or slightly alkaline (pH 7-8), the value of *TDS* (total dissolved salt) ranged between 190-624 ppm, *O.M*% (organic matter percentage) ranged between 1%-9% [2].

On the other hand, the soil in southern parts of El-Jabal El-Akhadar and Marmarica plateau is mainly dry soil sediment over parent calcareous rocks, characterized by sandy loam texture and tends to be alkaline (pH 8-9), the value of *TDS* ranged between 208-5,311 ppm, *O.M*% ranged between 0.30%-1.10% [3].

In some coastal depressions and at the ends of some valleys, there are salt-marshes (sabkha) that have a high value of TDS which ranged between 6,769-14,471 ppm, and have a high value of alkalinity due to the accumulation of alkaline salt. Where the value of pH reached up to 10.6, it was occupied by Halophyte plant species [4].

El-Jabal El-Akhadar Mountain receives the greatest amount of rainfall in all Libya, where it has an average annual rainfall of about 400 mm/year, in Cyrene city area it is up to 600 mm/year. The rate of precipitation decreases as we head south, east or west, where as it is up to 270 mm/year in some areas south of El-Jabal El-Akhadar, and about 180 mm/year in Marmarica plateau, and it is about 270 mm/year in Benghazi plain. This rate will continue decreasing as we head south to reach the desert areas that receive rates of less than 50 mm/year.

About 75% of the rainfall falls during the winter season starting from October to February, while the dry period of the year starts from April to September. The average annual temperature in El-Jabal El-Akhadar is about 17 °C and in Marmarica plateau and parts of southern El-Jabal El-Akhadar it is 20 °C [5].

3. Natural Vegetation

According to Brullo and Furnari [6], the vegetation of this area represents in most of its aspects a pronounced autonomy, although there is less evidence to connect the west and east Mediterranean areas.

There are three main habitats that can be distinguished in the study area: The coastal zone is characterized by halophytic vegetation, the piedmont and mountain zone prevail with Mediterranean vegetation (Fig. 2) and the predesert south El-Jabal (mountain) zone is characterized by thermo-xerophilic vegetation. South El-Jabal El-Akhadar and Marmarica plateau are floristically and ecologically considered to be as a pasture zone (Fig. 5).

The flora of El-Jabal El-Akhadar is constituted of more than 1,350 species. About 70% of the total number of Libyan flora and the endemic species are about 43. While in Marmarica plateau, the flora is constituted of 407 species with about 12 endemic species. The total endemic plant species in the study area is estimated at 55 species which consists of about 78% of the endemic species in Libyan flora. According to Le Houerou [7], this zone (surrounded by Sahara desert) with monomodal rainfall regime is considered to be one of the main centers rich in endemic species.

Areas, like El-Jabal El-Akhadar and Marmarica plateau, with species concentration of endemism and unique habitats, that are facing risks, are considered to be hotspots.

As a matter of fact, in order to escape drought and survive, most of the vegetation exist where the prerequisite of life are available, such as in wadis (valleys) which harbour many wild species especially endemic and rare species. In these habitats, the spectrum of life is constituted of: therophytes 52.65%, phanerophytes 12%, chamaeophytes 7.5%,

cryptophytes 27.6% and hemicryptophytes 0.25%, with rainfall ranging between 63-576 mm/year, favoured by the monomodal rainfall regime. Important canopy species are met like: *Arbutus pavarii*, *Olea europea*, *Ceratonia siliqua*, *Pistacia lentiscus*, *Juniperus phoenicea*, *Rhamnus lycioides*, *Pinus halpensis*, *Cistus parviflorus*, *Quercus coccifera*, *Rhus tripartita* and others met like: *Sarcopoterium spinosum*, *Asphodelus ramosus*, *Nicotiana glauca*, *Arisarum vulgare*, *Rosmarinus officinalis*, *Micromeria nervosa*, *Bellis sylvestris*, *Androcymbium graminium*, *Trifolium tomemtosum*, *Silene Cyrenaica*, etc.. While in the drier predesertic southward zone, the therophytes constituted 56.75%, the phanerophytes 9.3%, chamaephytes 27.2%, cryptophytes 6.5% and hemicryptophytes 0.25%. Some of the species encountered in this area are *Ceratonia siliqua*, *Asphodulus ramosus*, *Sarcopoterium spinosum*, *Haloxylon scoparium*, *Thymeleae hirsuta*, *Artemisia herba-alba*, *Artemisia campestris*, *Thymus capitatus*, *Polygonum equisetiforme*, *Ononis reclinata*, *Onyza aegyptica*, *Emex spinosus*, *Nonea viviani*, *Pallenis spinosa*, *Anthemis taubertii*, *Noea mucronata*, *Plantago notata*, *Carduus argentatus*, *Atractylic serratuloides*, *Malva sylvestris*, *Hordeum morinum*, etc. The rainfall in these habitats ranged between 25-200 mm/year. The increased percentage of Therophytes reveals the effect of aridity in both zones causing the fragility and high sensitivity of these ecosystems.

The area suffers from retrogressive succession and the driving forces for this are: cutting of wood, over collection, fire, overstocking, clearing (the main anthropogenic pressure) and droughts. Vegetation of the area is very heterogeneous in distribution and closely associated with landscape features, geological formation and topography which control water availability. Ephemeral waves of short-lived plant growth appear during spells of rain and last as long as water is available. However, water availability is still the main factor affecting the distribution of plant species in the region.

Beside topography, rain water controls vegetation distribution in the region as follow:

(1) At isohyets 50-200 mm/year: This zone represents south Al-Jabal Al-Akhadar and the whole of Marmarica plateau zone, and many species are distributed there such as: *Artemisia herba-alba*, *Pituranthos tortuousus*, *Thymus capitatus*, *Anabasis articulata*, *Haloxylon scoparium*, *Thymelaea hirsuta*, *Zilla spinosa*. At wadis beds, we encounter species like: *Rhus tripartita*, *Retama raetam*, *Ziziphus lotus*, *Lycium europaeum*, *Atriplex halimus*, but in coastal salt marshes and wet lands, many species are existing, such as: *Mesembryanthemum sps.*, *Silene succulenta*, *Arthrocnemum sps.*, *Atriplex mollis*, *Salsola kali*, *Juncus maritimus*, *Arundo donax*, *Tamarix aphylla*, *Nitraria retusa*, *Zygophyllum album*, *Suaeda vera*, most of these areas are subjected to degradation and desertification particularly those which are on the fringe of the Sahara;

(2) At isohyets 200-300 mm/year: It is located north of the previous zones, and many species are distributed there such as: *Centaurea alexandrina*, *Carthamus lanatus*, *Sarcopoterium spinosum*, *Ballota pseudo dictamnus*, *Marrubium alysson*, *Phlomis floccose*, *Eryngium compestre*, moreover *Juniperus communs* is found, but in small pockets on the coast due to degradation of an ancient open forest;

(3) At isohyets 300-450 mm/year: This zone represents the whole part of El-Jabal El-Akhadar. The main distributed species are: *Juniperus phoenicea*, *Arbutus pavarii*, *Ceratonia siliqua*, *Pistacia lentiscus*, *Quercus coccifera*, *Pinus halepensis*, *Olea europaea*, *Rosmarinus officinalis* and *Rhamnus oleoides*;

(4) At isohyets 450-600 mm/year: This is represented by small areas in some wadis in parts of Cyrene city area and Wadi El-Kouf near El-Bayda city, in places considered being the last refugial sites for: *Cupressus sempervirens.*

The main endangered species in the study area are: *Juniperus phoenicea*, *Juniperus communs*, *Myrtus*

communis, *Cupressus sempervirens*, *Rosmarinus officinalis*, *Salvia officinalis*, *Ziziphus lotus*, *Thymus capitatus*, *Olea europea*, *Artemisia herba alba*, *Ceratonia siliqua*, *Arbutus pavarii* and *Urgenea marittima*.

4. Soil Seed Bank

Climatic factors play an important role in forming soil seed banks in these zones, which are mainly composed of ephemeral and annual seeds (therophytes) forming the transient soil seed bank. They have the ability to complete their life cycle, producing considerable quantities of seeds, in just a few weeks in the rainy season. In general, during autumn the higher density of transient and permanent seed banks are available in the soils. On the other hand, there is a reduction in soil seeds bank in spring, due to the depletion by germination.

However, the density of soil seeds increased under the canopy of trees and shrubs. In contrast, the density decreased, away from the sources of seed production in places with low cover or devoid of vegetation.

In Marmarica plateau soil seed density ranged between 600-6,000 seeds/m^2, in south of El-Jabal El-Akhadar it ranged between 1,200-50,520 seeds/m^2, while in north El-Jabal El-Akhadar it ranged between 2,400-60,000 seeds/m^2. In places dominated by threatened species such as: *Juniperous phoenicea* and *Rhamnus lycioedes* in their last stands at altitudes of 510 m the soil seed bank reached 18,530 seed/m^2 [3, 8, 9].

This zone is mainly dependent on seasonal rainfall, the presence of great number of valleys sloping in different directions carrying large quantities of water, dams and rocky dykes are present along their course in different places preventing soil erosion, thus enhancing the increment of soil profile and the storing of more soil seed bank by accumulating seeds behind them. This must be considered to be an effective factor in enriching diversity. This activity in these zones has been carried out since long ago.

In Marmarica plateau, the density of soil seed bank in dam's soil ranged between 1,800-25,200 seeds/m^2, in south El-Jabal El-Akhadar it ranged between 1800-10,800 seeds/m^2, and in the areas north of El-Jabal El-Akhadar it ranged between 1200-6,600 seeds/m^2 [3, 8].

Marmarica and south El-Jabal El-Akhadar receive less amounts of rainfall compared with north El-Jabal El-Akhadar, but consisted of larger soil seed banks than north El-Jabal El-Akhadar. This may be explained by the fact that most of the vegetation in the former areas is xerophylous and composed mainly of annual species, which produces a large number of seeds.

At north and south El-Jabal El-Akhadar, the greatest proportion of soil seed banks belongs to Poaceae, Asteraceae, Fabaceae and Bracssicaceae respectively, while in Marmarica plateau, the greatest proportion of soil seed banks are composed of Brassicaceae, Chenopodiaceae, Fabaceae and Asteraceae respectively.

The proportion of soil seed banks of Fabaceae, which is an important species in rangeland, constituted about 1% of the isolated soil seeds in the areas of south El-Jabal El-Akhadar, 2% around the agricultural areas in north El-Jabal El-Akhadar, but in some areas of El-Jabal El-Akhadar and Marmarica plateau it reached up to 10%. However, in Mesus rangeland (south Benghazi) seeds of Fabaceae reached 31%, where species like *Medicago polymorha*, *Medicago coronata*, *Astragulus spinosus*, *Medicago turbinata* and *Trifolium campestre* are able to establish considerable soil seed banks, besides their seed characteristics, this enhanced fraction of seeds is mainly attributed to the reseeding programs of these grazing areas by the agriculture authority.

5. Anthropogenic Pressure

Global climate change, coupled with increased human activities in the study area is likely to affect the ecosystems and pose significant threats to biodiversity especially to rare and endemic species. The important

of this lie in the fact that the study zone (Cyrenaica and Marmarica) is holding more than 1,350 plant species which consist about 70% of Libyan flora [6].

Human activities have the most severe impact on retrogressive succession. Degradation caused by human activities is not unprecedented, this destruction has been going on throughout the ages, but what is new is that the pace of this decline accelerated significantly in recent decades.

The major degradation causes of ecosystems in the study areas are: the increase in population, overgrazing, uprooting of woody species for use as fuel or for medical uses, ploughing land for cereal production, infrastructure development, disposal of solid and liquid wastes, mining and mismanagement of natural resources.

5.1 Historical Background in the Area

From historical evidence, it is known that this region used to be flourishing, especially in Roman era, possibly with a large population and more prosperous cultivation of olives, figs, vines and cereals as it was in the Mediterranean basin [10]. Throughout history, the natural vegetation was the sole resource upon which the inhabitants lean on in this region.

Historical records indicate that the eastern region of Libya (Cyrenaica) was a populated region as well as an important pasture zone. Inscriptions on walls of temples of ancient Egypt recorded that the zone was inhabited by tribes and herders that supplied Egypt with livestock [11, 12]. Some of them described that oxen, donkeys, sheep and a special type of oil as well were all exported from the region to ancient Egypt [13].

During the Greek era (631-96 BC), many agricultural colonies were built. This induced Herodotus to point out that the reason of the agricultural settlements was mainly attributed to the grazing activities and the presence of great number of grazing animals specially caprins (the fourth book of Herodotus).

Moreover, ancient Greeks constructed several towns, villages and ports, as well as dykes and cisterns in order to harvest run-off water, and developed irrigation canals and organized water consumption (Figs. 3 and 4). They removed vegetation and turned forest areas to farmland in order to grow barley, wheat, fruit trees and vegetables.

They also introduced many plant species, now included in the natural vegetation of the region, such as olive trees, still today the remnants of olive oil mills are present in the region, carved in the rocks, scattered in many valleys and hills of El-Jabal El-Akhadar area, as an evidence of the expansion of olive tree cultivation at that time.

The archaeological inscriptions found in Cyrene showed that Cyrenaica granted more than 800,000 Medmni (Medmni is an old measuring unite equivalent to about 43.5 L) of wheat to more than 40 Greek cities during the famine period (330-326 BC). Cyrenaica was also famous for the production of barley, fodder, olives, legumes, fruits and other foodstuffs as well as various types of wine, olive oil, honey and various famous perfumes derived from wild flowers [14].

During the Roman era (96 BC-643 AD), the development of irrigation systems and cisterns continued, with the expansion in land reclamation and cultivation at the expense of natural vegetation. Cyrenaica was considered as the yield store of Rome.

The pressure on the region's natural resources continued as well during the middle ages. The region exported grains, fruits, tree tar, wine, fruits of *Juniperous phonicea*, honey, wool, cotton, cow hides, sheep and wood of pine trees particularly to Egypt. Even during the Arab era, these zones were wealthy with a lot of agricultural activities at the expense of plant diversity in the regions.

During the Arab era at the 7th and 8th centuries, remarkable changes in land use were introduced, and they encouraged the return of pastoral life and nomad livestock. That led to the abandonment of many irrigation constructions and disappearance of old

villages, and the cultivated areas were again taken over by natural steppic vegetation found today as *Artemisia herba-alba*, *Thymelae hirsuta* and *Anabasis articulata*.

In the 9th century, the famous sea port of Ptolemais located 30 km north the ancient prosperous city of Barce (the old city of El-Marj) situated 100 km east of Benghazi in northern Cyrenaica was famous by its natural resources and the richness of its surrounding villages and farms, however it imported textiles and cotton linen, and exported tar, honey, barley, wheat and sulfur, which constituted the products of the agricultural activities of the zone indicating the significance of these human activities.

All the chronologers who visited the area after the 9th century describe a dramatic change to poverty and a cute deficiency in natural recourses.

During the Ottoman era (1554-1911), a culture of cave dwellers (Troglodytes) developed in several wadis in Cyrenaica and in Tripolitania, due to the spread of tribe wars and famine, and their main requirements were based on the vegetation. Plant species affected at El-Jabal El-Akhadar were: *Olea europea*, *Ballotta andreuziana*, *Pinus sps*., *Juniperous pheonicea*, *Arbutus pavarii*, *Ceratonia siliqua*, *Phoenix dictalyfera*, *Myrtus communis*, *Phlomis floccosa* and many others.

During the Italian occupation (1911-1941), a big effort in the agricultural sector was undertaken, large areas were cleared and changed to farms, with the introduction of several types of plant species and cultivars, imported from abroad like, *Nerium oleander*, *Eucalyptus sp*, *Acacia sp* and many fruit trees and other agricultural crops.

During the second half of the 20th century, more efforts were made in agricultural development with extensive use of machineries at the expense of environment, especially in El-Jabal El-Akhadar which is still targeted heavily for the establishment of agricultural projects, urbanization and demographic expansion.

5.2 The Most Important Anthropogenic Factors Which Threaten the Biodiversity in the Region Are

5.2.1 Overpopulation

The Libyan population has increased significantly over the last 50 years, more than six-fold. The country's population was less than one million in the

Fig. 2 The north front slopes of El-Jabal El-Akhadar near the sea coast (authors camera, 2012).

Fig. 3 Big cistern from the Roman era for collecting runoff water. In old Ptolemais city (old sea port of Barce) north El-Jabal El-Akhadar at the sea coast (author's camera, 2013).

Fig. 4 The old hydraulic-engineering system in old Ptolemais city for collecting and distributing water from springs and Roman cisterns (author's camera, 2013).

Fig. 5 Xerophytic species dominated in Marmarica plateau (author's camera, 2012).

Table 1 Number of grazig animals in the area.

Area		Sheep	Goat	Cattle	Camel	
Marmarica area		206,258	59,171	2,516	9,250	
El-Jabal El-Akhadar area	Derna	147,542	52,879	6,492	3,923	
	El-Bayda	178,978	63,020	18,004	3,938	
	El-Marj	354,538	64,817	19,023	3,622	
	Benghazi	138,322	18,575	1,835	2,392	
Total		1,025,638	258,462	47,870	23,125	1355,095

Source: general authority for information [16].

1954 census and in 2006 it was about 6,310,434. The population of the study area of about 1,579,978 people consists 21.48% of Libya's population [15].

This significant increment caused a substantial increase in the volume of the environmental damage caused by pressure on the region's natural resources.

5.2.2 Pastoralism

Nomadic pastoralism is a traditional habit in the whole zone, it depends mainly upon natural vegetation, and because Mediterranean winters are generally more or less mild, vegetation is not protected against grazing during this season. About 30% of the population in these regions is involved in this activity, and the number of grazing animals in the area is about 1,355,095 head (Table 1).

The range lands in the study area are estimated to be about 5,284,000 hectares, accounting for about 40% of the grazing area in Libya, of which about 2,475,000 hectares (47%) receives a rainfall rate less than 100 mm/year, about 1,768,000 hectares (33%) have a rainfall rate between 100-150 mm/year, about 1,041,000 hectares (20%) have a rate between 150-400 mm/year [17].

The movement of herds within the region is

according to the rainfall and rangeland conditions. The improvement in transportation in last few decades has helped the herds to be always moved to other grazing areas. In addition, the continuous increase in the number of dug wells has made the herds more attracted to the area around those water sources. These entire activities act together to facilitate over grazing. In general, the movement of herds is towards the south of Marmarica and the south of El-Jabal El-Akhadar areas during winter and spring, where they depend on annuals plants. While in summer and autumn, they head north towards the coastal areas in Marmarica and toward El-Jabal El-Akhadar bushes, where they depend on perennial shrubs and sub-shrubs and the remains of rain-fed crops that are often left without harvesting after bad seasons to feed the grazing animals (the farms of wheat and barley). Also, the owners provide fodder to compensate the deficiency in pasture production, especially in the dry season of the year or in dry years. Camels graze in areas adjacent to the deserts southern of Marmarica and El-Jabal El-Akhadar Mountain.

It is very clear that the number of animals is more than the grazing capacity of the rangelands in the area, according to Census 2006 they represent about 600% of the grazing load of Marmarica [3], which has led to natural vegetation deteriorating causing the disappearance of many palatable species.

In addition to the devastating effects on vegetation, the movement of livestock caused trampling, especially around wells and water sources, where herds' ranging around water sources in circles was estimated nearly 10 km in diameter [18].

The rangelands degradation, especially by overgrazing and soil trampling, has resulted in the disappearance of perennial grasses, which in turn has increased pasture shortage. As a result of that and in the absence of range management, the more palatable species such as *Retama raetam, Atriplex halimus, Artemisia herba-alba, Avena fatua, Vicia sps., Medicago sps., Periploca angustifolia, Pituranthos tortuousus, Rhus tripartita* and many other species have been replaced by less/or unpalatable species, such as: *Euphorbia dendroides, Thymelaea hirsuta, Haloxylon scoparium, Asphodelus ramosus, Sarcopoterium spinosum, Peganum harmala, Phlomis floccosa, Marrubium alysson* and *Ballota pseudo dictamnus* that have invaded many areas.

In the past, traditional herders of rangelands in this area had learned to exploit ecosystem cycles sustainably through mobility and unwitting regulation because they were nomads. Recently that has been changed towards the centralization of the pastoralists in fixed area and the provision of supplemental animal fodder, and they nowadays focus more on economic sustainability and increase the pressure on ecosystems by allowing the herds for long or continuous stays in the same area.

5.2.3 Agriculture Expansion

Due to the lack of permanent water sources such as rivers or freshwater lakes, this region suffers from a deficiency of water, so rain-fed agriculture has prevailed in the region since ancient times. The crops which are most cultivated are wheat, barley, lentils, chickpeas and beans, in addition to the cultivation of fruit trees which well adapted to such harsh climate as fig trees, grapes, olives and palm trees.

However, the availability of modern machineries during the past few decades has given the inhabitants the ability to expand the rain-fed agriculture area towards the rangelands. The new lands have been cleared from perennial species such as *Lycium europaeum, Rhamnus oleoides, Ziziphus lotus, Suaeda vermiculata, Salsola sps., Haloxylon scoparium, Atriplex halimus, Anabasis articulata, Rhus tripartita, Junipeorus phoenicea, Pinus halepensis, Pistacia lentiscus, Olea europaea, Ceratonia siliqua, Querecus coccifera, Rosmarinus officinalis, Arbutus pavarii, Calicotome villosa* and many others. When the farmers leave the ploughed areas due to the drought, the above species are replaced by less productive annual species such as *Polypogon monspeliensis,*

Papaver rhoeas, Avena fatua, Malva sylvestris, Chenopodium murale, Echium angustifolium, Convolvulus sps., Achillea santolina, Cyperus kalli and *Chrysanthemum carinatum.* Under the environmental conditions of this area, the re-generation of natural vegetation cover after successive ploughing is a very slow process.

There is also a widespread trend towards the expansion of irrigated crops, especially in areas of El-Jabal El-Akhadar by drilling underground wells, and the establishment of agricultural projects that sweep towards areas of forests which are replaced by fruit trees and vegetable farms and the establishment of greenhouses.

During the last 30 years, the state implemented projects in El-Jabal El-Akhadar in an area of about 315,200 hectares, in places receiving higher rain-fall amount, having good soil and dense vegetation. After clearing them from vegetation they replaced with cereal crops.

There is a widespread trend from the local land owners to shift to irrigated crops, where data have shown that 50% of farmers in the areas of El-Jabal El-Akhadar switched to irrigated agriculture by drilling wells and deforested their lands (the area of private land that has been deforested and converted to irrigated farms is non-estimated yet) which introduce a considerable income for the owners of those lands [19].

Most of the farmers in the region do not practice crop rotation due to a low education (53% illiterate) and they tend to apply chemicals in irrigated agriculture where 76.8% are using chemical control against pests. The levels of knowledge about pesticides and fertilizers are very low (1.3% are familiar with) and there is no accuracy in the practice of pesticides and fertilizers (0.7% of them are accurate) but the big story is that 93.9% of the farmers were not familiar with the environmental pollution effects [19].

5.2.4 Firewood Collection and Charcoal Production

The natural vegetation in this region was the only source of fuel throughout the ages. Firewood collection has in the past led to the removal of large areas of natural vegetation (woody perennial), particularly around cities and urbanization centers.

Firewood collection in this area is a selective process on a certain species particularly trees and woody shrubs and sub-shrubs. In the past, the average daily consumption of wood for every family was about 10 kg per day; it increased and decreased depending on the number of family members and whether the season was warm or cold. There were markets for selling wood in all cities and villages; nowadays firewood collection in the region has dropped considerably due to the availability of alternative energy sources.

Charcoal production in the areas of El-Jabal El-Akhadar is still one of the good economic activities for the local nomads. It is applied in an intensive and selective way on woody species such as *Rhus tripartita, Pinus halepensis, Juniperus phoenicea, Pistacia lentiscus, Olea europaea, Ceratonia siliqua, Querecus coccifera* and *Arbutus pavarii*. The charcoal productivity of El-Jabal El-Akhadar is estimated at more than 4,575 bags (weighing 25 kg) per year. The exposed area for charcoal production is estimated annually at about 111 hectares [20].

5.2.5 Collection of Medicinal and Aromatic Species

The region is rich in species having medicinal uses. It is well known in folkloric medicine that it depends mainly on the use of the property from the parent plant. They are collected in large quantities and are sold in special stores (herbalist), which are widely found in all Libyan cities. Many of these species have not been studied yet.

Plant species used in folk medicine are *Peganum harmala, Ziziphus lotus, Thymus capitatus, Teucrium polium, Alhagi graecorum, Chenopodium murale, Chamomilla pubescens, Artemisia herba-alba, Pituranthos tortuousus, Olea europaea, Ceratonia siliqua, Rosmarinus officinalis, Salvia officinalis, Ricinus communis* and many others.

It is noted that the collection of these plants for medicinal purposes is concentrated in the El-Jabal El-Akhadar area, at a commercial scale. The plants are collected in random, unregulated and uncontrolled ways. These species are uprooted and collected without precautionary steps, which may lead to the extinction of many species.

Despite the great activity in the collection of medicinal and aromatic species in the region, and the availability of these plants in herbalist in all Libyan cities, there is still no accurate data concerning the quantities and the areas of collection.

5.2.6 Fires

El-Jabal El-Akhadar is the richest area of natural vegetation in Libya. It is also the area most threatened by fire, which is also in fact threatening the plant communities and changing the trend of succession, and causes major damage to the vegetation and soil.

More than 90% of fires in the region are due to human causes which in turn cause the disappearance of many species that are not able to regenerate after fires, such as *Juniperus phoenicea*, which is one of the most important species in El-Jabal El-Akhadar and is one of the climax species at the brink of extinction. For more than 20 years, there have been no records of regeneration of this species in the areas which suffered fire damage.

Retrogressive succession is very clear in the areas of wildfire due to the disappearance of many canopy species such as: *Juniperous phoenicea*, *Olea europaea*, *Querecus coccifera*, *Ceratonia siliqua* and *Phillyrea angustifolia*, and the establishment of other shrubs and sub-shrubs such as *Rhamnus oleoides*, *Cistus sps.*, *Sarcopoterium spinosum*, *Phlomis floccosa*, *Ballota pseudo dictamnus*, *Calicotome villosa* and *Rosmarinus officinalis*. It is worthy to note the spreading of certain species that have the ability to regenerate after fires like *Querecus coccifera*, *Rosmarinus officinalis*, *Arbutus pavarii* and *Pinus halepensis*.

During the period from 1986 to 2003, about 1,991 wildfires were recorded in El-Jabal El-Akhadar areas, which destroyed an area of about 161,533 hectares of mixed forest of *Arbutus pavarii, Pinus halepensis*, *Querecus coccifera*, *J. phoenicea*, *Olea europaea*, *Querecus coccifera*, *Ceratonia siliqua* and *Pistacia lentiscus*. From these about 463 wildfires were in pure forests of *J. phoenicea*, with an estimated area of about 14,490 hectares, in which no regeneration of *J. phoenicea* has been recorded [20].

The average annual number of fires in El-Jabal El-Akhadar is about 111/year, and the average annual area burned was about 8,975 ha/year. These rates far exceed the natural fire rates, and make wildfires one of the main causes in decreasing natural vegetation and affecting the diversity of species.

5.2.7 Mining

There are about 164 quarries in El-Jabal El-Akhadar and Marmarica areas, most of which produce sand and different types of aggregates for infrastructure works and other constructions, in addition to the production of some material for factories of clay bricks and cement plants. The total area of these quarries is more than 1,600 hectares spread all over the area at the expense of natural vegetation. For the purpose of constructions a huge amount of sand from sea shore sand dunes are removed and carried in an uncontrolled way causing changes in shore landscape and destroying habitats.

In addition to the damage that mining has caused to the surrounding environment in those areas, it has also severely damaged the natural bees pastures in the southern region of El-Jabal El-Akhadar and Marmarica plateau, where they cause harmful impacts on plant species such as: *Ziziphus lotus*, *Phlomis floccosa*, *Ballota pseudo dictamnus* and *Thymus capitatus*, from which bees produce delicious kinds of natural honey.

Mining in this region is undoubtedly very destructive by direct and indirect impacts on the surroundings lands. First of all, it sweeps away natural vegetation and soil, and secondly it cuts the rocks and

removes the ores causing land degradation and the destruction of habitats as well as damaging the aesthetic beauty of the landscape.

5.2.8 Tourism

This area with its fascinating landscape, interesting geological formation, rich wildlife and numerous historical sites attracts naturalists, tourists and hunters. Tourists, scholars and practitioners as well as for hunting, are continuously increasing, especially in the areas of south El-Jabal El-Akhdar and Marmarica plateau.

El-Jabal El-Akhdar is more exposed to touristic activities, especially internal tourism. A very large number of local tourists from different regions of Libya visit these areas regularly, particularly in spring and summer because of its mild climate in addition to its growing forests, valleys and other natural places.

The main negative impacts of tourism are plant cutting and uprooting, solid waste pollution, damaging the wild beauty, fires, disappearance of many wild animals (especially birds and reptiles) and threaten of rare and endemic species that still exist in the region.

Cyrene, Ptolemais, Ras Al-Hilal and Apolonia are the most important archeological sites which suffer from damage and destruction as a result of intensive and non-regulated tourism activities. These sites are the most beautiful and rich in rare and endemic species.

5.2.9 Habitat Destruction

Developmental programs and urbanization of natural vegetation areas have caused many harmful impacts on wildlife habitats of many important species (flora and fauna).

Infrastructure development caused the disruption of the physical environment, altered the chemical environment and accelerated the introduction of invasive species [21-24].

There is no doubt that infrastructures in this area appear to play a major role in biodiversity losses simply because it accelerates and facilitates human access to scattered and patchy biodiversity hotspots.

It is quite clear that if human activities continue in the same way as they are now, it will lead to even more environmental degradation and severe loss in biodiversity and continuous retrogressive succession.

5.3 General Remarks

From the foregoing discussion, it is apparent that both zones (El-Jabal El-Akhadar and Marmarica plateau) are subject to multi types of anthropogenic pressure, although in some areas, valleys and depressions have deep strata with considerable soil seed banks, which offer great possibilities for the construction of plant cover, but adverse changes are proceeding at such a fast rate and becoming increasingly severe that degradation of its vegetation may be irreversible.

Human activities in the form of construction of cisterns, dams and small rocky dykes, roads and tourist villages in areas with dense forest and other settlements cause landscape change and the spread of solid and liquid waste which pollute the soil of these areas with copper, zinc, lead and other harmful heavy elements. Many exotic species were introduced in Libya from the beginning of the last century [25] like *Nicotiana glauca* started spreading and intermingling with natural vegetation in/and around the solid waste of workshops, restaurants, fuel stations, garbage, services buildings, roadsides and around other wastes. Companion species of *Nicotiana glauca* are *Sarcopoterium spinosus*, *Pallenis spinosa*, *Nerium oleander*, *Artemisia herba-alba*, *Artemisia campestris*, *Peganum harmala*, *Ecballium elaterium*, *Citrullus colocynthis* and *Datura strominiumin*, in mountainous, hilly, coastal, semiarid and arid areas south and east wards.

Agricultural activities especially shifting cultivation, which is intensively practiced in the region, caused ploughed and denuded areas. These activities encouraged the spreading of *Thymelaea hirsuta* in abandoned fields, while overstocking enhanced the spreading of non palatable species such as

Sarcopoterium spinosus, *Anabasis articulata*, *Peganum harmala* and *Haloxylon scoparium.* In the southern fringe of the region, which has more arid climate, it is apparent that the trend of succession is toward retrogressive changes due to anthropogenic pressure beside the fragility of ecosystems. We consider this trend to be an expression of secondary succession which resulted from the disturbance of normal succession (e.g., overgrazing) that destroys the main species of an established community. In degraded steppes around water sources, villages and other settlements enriched the soils with nitrogen from sewage and livesock wastes, *Peganum harmala* formed associations with *Pallenis spinosa*, *Nicotiana glauca*, *Asphodelus ramosus*, and other species.

Still for unknown reasons collective deaths of several canopy species is spreading throughout the whole of El-Jabal El-Akhadar region such as: *Juniperous pheonicea*, *Pinus helepensis*, *Olea europea*, but regeneration of this species is not affected. It should be remarked that most of these species are densely covered by Lichens, more over for more than 40 years the whole zone has been suffering from increased aridity with an increase in temperature and a decline in rain-fall.

6. Options of Conservation in the Area

The present status of plant diversity in the study areas is very critical. The region is characterized by the apparent variation in their habitats, where the high and opened lands are exposed to severe erosion by wind and water all year around, especially in the southern fringe. Wind sheeting erosion is most pronounced in Marmarica plateau and south El-Jabal El-Akhadar areas, while water erosion is more active in El-Jabal El-Akhadar area.

The harsh environmental conditions added the overgrazing, wide species collection and hunting, deforestation, unsuitable agricultural regime and other irresponsible human activities which undoubtedly hinder the natural vegetation regeneration and soil formation and development. Some zones, e.g., wadis and depressions, have deep strata with considerable soil seed bank, which offer great possibilities of progressive succession. Degradation of the land gradually makes species less common and rare, and increasing the endangered.

Measures of conservation are urgently needed in these two zones (El-Jabal El-Akhadar and Marmarica plateau). According to Boulos [26], these regions have the richest number of species and contain the most endemic species in Libya.

The first step in any conservation program is to prevent the harmful impacts of human activities. Another issue is the choice of priority, i.e., rare, medicinal or endemic species have priority. Complete protection may be imperative, if the objective is the conservation of an ecosystem as a whole, there is more room for manoeuvre, but at the end we must save both species and ecosystems.

A large proportion of the indigenous species, especially with a high heritage, historical or biogeographic value in the area, are only represented by small or very small populations, very often only a few individuals or in small area.

As it was said before, the study area is rich in its endemic taxa. Endemics are usually rare and restricted to rather small geographical regions or even in small pockets, so they deserve special attention for their conservation. They represent an important part of our heritage and may provide us with important food, medicinal or other resources in the future.

The most important step in conservation should be a general plan for all the regions and all their components, focusing especially on soil, plant diversity, beauty and local inhabitants and ending with the declaration of El-Jabal El-Akhadar as a protected zone with all the legal regulations required.

6.1 Soil Conservation

The topography of El-Jabal El-Akhadar consists of a large number of hills dissected by a huge number of

wadis. Therefore, it is very important to prevent water and wind erosion resulting from several factors, such as ploughing, clearing and overgrazing. So, attention must paid to establish soil by dams and terraces in the slope areas and in wadis and watersheds, afforestation and windbreak trees play a key role in soil establishment and preventing erosion. But the most important object is to reduce tillage operations and rain-fed agriculture as much as possible.

Recently, the authorities implemented many programs for soil conservation by building dams and rocky dykes, north and south of El-Jabal El-Akhadar Mountain and in Marmarica plateau. In the latter case, there were remarkable results in stabilizing and preventing soil erosion and increasing the amount of water harvested but more efforts are needed.

6.2 Plant Diversity Conservation

The markedly increased rate of plant diversity loss in the study area is mainly attributed to the continuous increased rate of anthropogenic pressure.

The priority of plant diversity conservation in the region is to focus on medicinal, rare and endemic species, by focusing on species that are important to the ecosystem such as *Arbutus pavarii*, *Pinus halepensis*, *Querecus coccifera*, *Juniperus phoenicea*, *Olea europaea*, *Ceratonia siliqua*, *Pistacia lentiscus*, *Ziziphous lotus*, *Myrtus communis*, *Rosmarinus officinalis*, *Thapsia sylphium*, *Thymus capitatus* and *Artemisia herba alba*. The attention of conservationists should focus not only on the community or population levels but also at different life stages of the species from seedling until adult stage (life cycle).

Generally, adult plants are subject to be harvested by local people during their peak vegetation growth for use as a forage material for livestock or as a fuel. The challenge is not to prevent people from using them, but to rationalize the harvesting process while maintaining the minimum viable population of the species in different sites. Since the reproductive value drops with age, the partial harvest of plants should be restricted to the oldest individuals of the population. This solution may be applicable for the sowing of many wild plant species by: (1) sowing introduced plant species and (2) reseeding native plant species by selecting seeds of indigenous species, with the aim to create communities of plants that are nutritious to livestock resilient to grazing and protective to the soil surface, where the concept of preventing local people from using any natural resource is not easily acceptable. In this way, the species population would remain large enough so as not to be vulnerable to extinction.

In fact, the conservation of all components of wildlife in the region is very important. Each one has a basic role in the ecosystem cycle and all the components are greatly interdependent with each other. The life and continued existence of any plant or animal species are linked to the existence of the other types of organisms and even the existence of other environmental elements (such as location, climate, soil and topography, etc.).

6.3 Beauty Conservation

The beauty of the region is so essential to tourists and residents and is a further priority for conservation. It has a very rich wild life in addition to many historical and ruins sites, mild climate, shining sky, and its long and fascinating coast.

These areas of natural beauty suffer from wide damage due to intensive human activities and the gradual increase of tourism activities. The beauty of the region needs to be an important priority for conservation programs. It is extremely necessary now to stop all harmful activities and begin a program of environmental impact assessment for all the development programs in the area.

6.4 Inhabitants Conservation

The people in this area and their habits and traditional ways of cultivation and their grazing

animals have been a part of the ecosystem for thousands of years.

Therefore, the local population must be paid special attention. Their activities should not be prohibited but to modified in order to suit the potential of the region. The awareness must concentrate on changing the behaviors of inhabitants to get a large economic income by the maximum possible utilization of the available resources with minimum extinction and environmental damage. To make any conservation program successful, various demands of inhabitants needs must be balanced with the capacity of the area resources.

The awareness of local people about environmental degradation, biodiversity loss and their consequent effects not only on the surrounding areas, but even on themselves, is a fundamental step in any conservation program.

Somewhat similar, but more broadly focused, are the FIRM (forums for integrated resource management), through which inhabitants take the lead in coordinating their own development trajectories [27].

By establishing a FIRM and inviting all relevant service providers (including agricultural and water extension officers, education and health authorities, conservancy representatives, regional councilors and traditional leaders, and universities and research centers) to participate in coordinated development planning and regular monitoring of progress, local people can take charge of their own development according to their own preferences, and plan for and manage anticipated risks as they occur.

7. Recommendations

In fact, until now the development in these zones lacks environmental vision. A new more balanced vision is really needed where the natural resources and inhabitants are valued both by government and civil society, where the sustainability and the inhabitants are given the highest priority. The development of the area should be guided by a long planning strategy that is based on an acute understanding of the limitations and potential of this very unique environment.

Obviously, the key of any conservation program in this region is more and ever-better environmental education and concomitant awareness.

Generally, the following recommendations are essential to conserve the species and to assist in devising management strategy:

- Representative natural species populations (flora and fauna) should be maintained in situ for conservation;
- Establishment of new populations in similar habitats on the Mediterranean coast;
- Encouraging botanical gardens and research institutes to maintain ex situ populations;
- Biological and ecological management of the natural and artificial population;
- Preservation of plant seeds in a gene bank;
- Plant harvesting in case of human use for any purpose should be restricted to the oldest individuals of the population;
- Establishment of small protected areas within the two regions with adequate legal protection, and the collaboration of the local tribes in their territories, especially in the areas of valleys that are refugial sites, for a number of rare and endemic plant and animal species;
- Re-cultivation of endemic, rare, medical and economic plant species in order to find a good source of income source for the local inhabitants;
- Re-afforest the destroyed areas of *J. phoenicea*, by re-collecting its seeds and treated in the laboratory to break the inhibiting stage (where it is very difficult to germinate in nature) and then re-disseminated, especially in areas that burned down or where *J. phoenicea* has disappeared;
- Re-seeding and cultivation of plant species of environmental and pastoral value, such as leguminous seeds in the southern areas of El-Jabal El-Akhadar and Marmarica plateau;

- There must be a vision of an integrated and far-reaching plan to deal with all environmental components in the region, including conservation of all natural resources in the short and long term;
- Environmental impact assessment for any project or activity in the region;
- Re-afforestation in the areas of south El-Jabal El-Akhdar Mountain and Marmarica plateau is very important for soil conservation and to increase biodiversity. The afforestation must be with local plant species.

References

[1] H.J. Jawda, Studies on Geomorphology of Libyan Lands, Faculty of Science Publications, Benghazi University (Previous Gar-Yunis), Libya, 1973. (in Arabic)

[2] N.A. EL-Fakhri, Study of soil seed banks in Sidi El-Hamri area (south of El-Jabal EL-Akhadar Mountain), Master of Science Thesis, Botany Department, Faculty of Science, Benghazi University (Previous Gar-Yunis), Benghazi, Libya, 2009.

[3] M.W. Barrani, Study of plant deterioration factors on Daphna zone (north eastern part of Libyan coast-Tobruck), Master of Science Thesis, Department of Environmental and Engineering Science, Academy of postgraduate studies, Benghazi Branch, Libya, 2008. (in Arabic)

[4] M.A. Omar, Vegetation composition and seed bank, study of beach sand dunes on Karkora area (a part of eastern coastal zone of Libya), Master of Science Thesis, Botany Department, Faculty of Science, Benghazi University, Benghazi, Libya, 2009.

[5] Meteorological records, unpublished data for Tobruck, Derna, Al Bayda and Benina meteorological stations, Meteorological department, Libyan Government, Tripoli, Libya (Deferent periods of time).

[6] S. Brullo, F. Furnari, Taxonomic and nomenclatural notes on the flora of Cyrenaica (Libya) Webbia 34 (1) (1979) 155-174.

[7] H.N. Le Houerou, The Sahara from the bioclimatic viewpoint, definition and limits, Annals of Arid Zones 34 (1) (1995) 1-16.

[8] B.M. Buhwarish, The effect of human activities on the dynamics of soil seed bank in an area south of El-Jabal Al-Akhadar, Master of Science Thesis, Department of Environmental Science and Engineering, Academy of Graduate Studies, Benghazi Branch, Libya, 2005 (in Arabic).

[9] N.F. Abdel-Hadi, Vegetation and oil seed bank in south El-Marj area (Barce), Master of Science Thesis, Botany Department., Faculty of Science, Banghazi University, Benghazi, Libya, 2009. (in Arabic)

[10] H.N. Le Houerou, Impact of man and his animals on Mediterranean vegetation, in: F. Di Castri, D.W.Goodal, R.L. Specht (Eds.), Mediterranean Type Shrublands, Elsevier, Amsterdam, 1981, pp. 479-522.

[11] F. Chamoux, Cyrene sous La monarchie des Battiades, Paris, 1953. (in French)

[12] A. Rowe, A history of Ancient Cyrenaica, Cairo, Cyrenaican Expedition of the University of Manchester, 1952.

[13] G. Galassi, Tehenu e le origini mediterranee della civilta egizia, la libreria dello Stato, 1942 (in Italian) (Tehenu and Mediterranean origins of Egyptian civilization, the library of the State, 1942).

[14] F.A. EL-Athram, Political and Economical History of Cyrenaica (from the 7th century B.C. to 96 B.C.), Benghazi University Publications, Benghazi, Libya, 1988. (in Arabic)

[15] Censuses from 1954 to 2006, General Authority for Information and Documentation, The Libyan Government, Tripoli, Libya.

[16] The Dynamic Statistics, The General Information Authority, The Libyan Government, Tripoli, Libya, 2008. (in Arabic).

[17] O.M. EL-Chaouch, A. Ben Mansoura, Assessment of the current status of Libyan pastures, the Technical Centre for Environmental Protection, Tripoli, Libya, 1991. (in Arabic).

[18] H.N. Le Houerou, Natural Pastures and Fodder Resources of Libya and Problems of Their Improvement, Report to the Government of Libya, FAO, Rome, 1965.

[19] Y.M. EL-Barasi, N.A. Ahmaida, M.W. Barrani, A.O. EL-Amrouni, A. Omran, Pollution of agricultural lands by fertilizers and pesticides on EL-Guba and EL-Abrag area in Libya, Annals journal, Tome VIII, Fascicule 1 (ISSN 1584-2665) (2010) 97-102.

[20] S.M. AL-Hadad, The ability of natural vegetation in EL-Jabal EL-Akhadar to regenerate after fires, M.Sc. Thesis, Dept. Environmental and Engineering Science, Academy of graduate studies, Benghazi branch, Libya, 2004. (in Arabic)

[21] A. Andrews, Fragmentation of habitat by roads and utility corridors: A review, Australian Zoologist 26 (3 & 4) (1990) 130-141.

[22] R.T.T. Forman, L.E. Alexander, Roads and their major ecological effects, Annual Review of Ecology and Systematics 29 (1998) 207-231.

[23] S.C. Trombulak, C.A. Frissell, Review of ecological effects of roads on terrestrial and aquatic communities, Conservation Biology 14 (1) (2000) 18-30.

[24] C. Nellemann, Globio-Global methodology for mapping human impacts on the biosphere, United Nations Environmental program, Nairobi, Kenya, 2001 (available at http://www.globio.info).

[25] H.G. Keith, A Preliminary Check List of Libyan Flora, Vol. 1 and 2. Ministry of Agriculture and Agrarian Reform, Tripoli, Libya, 1965,

[26] L. Boulos, Endemic Flora of the Middle East and North Africa, in: H.N. Barakat, A.K. Hegazy (Eds.), Reviews in Ecology, Desert Conservation and Development, A festschrift for Prof. M. Kassas on the Occasion of 75th Birthday, IDRC/CRDI, UNESCO/South Valley University, Cairo, 1997, pp. 229-260.

[27] J. Kambatuku, The Forum for Integrated Resource Management, Putting Communities at the Centre of Their Own Development Process, Windhoek: NAPCOD, 2003.