

Importance of Pastoral Human Factor Overloading in Land Desertification: Case Studies in Northeastern Libya

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Abstract—Grazing and pastoral overloading through human factors result in significant land desertification. Failure to take into account the phenomenon of desertification as a serious problem can lead to an environmental disaster because of the damages caused by land encroachment. Therefore, soil on residential and urban areas is affected because of the deterioration of vegetation. Overgrazing or grazing in open and irregular lands is practiced in these areas almost throughout the year, especially during the growth cycle of edible plants, thereby leading to their disappearance. In addition, the large number of livestock in these areas exceeds the capacity of these pastures because of pastoral land overloading, which results in deterioration and desertification in the region. In addition, rare plants, the extinction of some edible plants in the region, and the emergence of plants unsuitable for grazing, must be taken into consideration, as along with the emergence of dust and sand storms during the dry seasons (summer to autumn) due to the degradation of vegetation. These results show that strategic plans and regulations that protect the environment from desertification must be developed. Therefore, increased pastoral load is a key human factor in the deterioration of vegetation cover, leading to land desertification in this region.

Keywords—Overloading, pastoral, grazing, desertification, Libya

I. INTRODUCTION

AUBREVILLE (1949), a French scientist, coined the term desertification in 1949 to refer to the process of environmental degradation. Desertification starts with the removal of natural vegetation and ends with the transformation of land into a desert. He emphasized the role of human activities, more than climate, in this process [1]. Desertification is land degradation in arid, semi-arid, and dry subhumid areas due to various factors, such as climatic variations and human activities.

Degradation implies the reduction of the resource potential of a landscape through different processes [2]. Defined desertification as a form of degradation that affects the overall environmental regulations under the effect of appropriate climatic factors as well as the misuse of forests, natural pastures, agricultural land, and water.

Increased desertification and drought result in low land productivity and lead to the replacement of native vegetation by dry and scattered plants.

Any environment that takes a new set of attributes waste productive areas. On the other hand, the emergence of areas such as rocky or sandy marshes is productive. A rangeland with an area that is approximately 47% of the total area of the globe uses about 10% of the total global area (or around 28%) in the cultivation of field crops and commercial forest growth. Meanwhile, the snow-covered areas occupy 15% of the total area [4].

The pastoral land area in Libya that receives 50 mm/year to 200 mm/year rain is approximately 12 million ha, in addition to 1 million ha scattered between the various agricultural areas receiving rain of more than 200 mm/year. Grasslands and open forests with different degrees of dryness, as well as local and wetlands, contain a wide range of plants and shrubs. The nature of the land (such as winding and steep) or commercial forests has an estimated pastoral land area of around 12 million ha that receive 50 mm/year to 200 mm/year rain, in addition to 1 million ha scattered between the various agricultural areas receiving rain rates of 200 mm/year [5]. Natural pastures with the most important renewable natural resources are abundant in the Arab world despite the deterioration of most of the manufacturing industry.

These pastures provide food to meet the requirements of large numbers of grazing domesticated animals. Furthermore, wild plants are relatively low-cost compared with other feed sources and play an essential role in environmental protection and soil preservation against water erosion. In addition, aerial and watershed maintenance preserve the ecological balance, which is reflected by the reduction in the factors that accelerate desertification.

Moreover, natural pastures also serve as normal parks and are the main source of remedial plants such as honey, firewood, and traditional human food [6]. The decline in or lack of rainfall is one of the reasons behind the significant climate changes that contribute to land desertification and rangeland degradation. However, the increasing number of animals is the major human factor in land desertification and soil erosion, as well as the spread of edible plants in the pastures. Moreover, the scarcity of unsuitable plants in pastures is due to the increased pressure and intensity of grazing. Desertification seriously threatens the environment in general and natural resources in particular.

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Human factors are the major contributor to this phenomenon, aided to a certain extent by climatic factors.

II. LITERATURE REVIEW

In this section, studies on the factors aggravating desertification problems around the world and in Libya in particular were reviewed. C-Loty stated that free and unregulated grazing are the main reasons behind the deterioration of pastures in Libya, as well as in the various areas of the Arab world and many parts of the world and the main factors that contribute to desertification.

However, desertification is caused by the eradication of vegetation. Therefore, soil erosion and low production capacity does not benefit from water, and rainfall increases the runoff speed, reduces soil permeability to rain water, and accelerates the evaporation process. The large number of animals has also caused severe damage to and deterioration of rangelands because of the failure to regulate grazing, walks, and the presence of animals, thereby resulting in a lack of plant growth (run over) [7].

The Arab Organization for Agricultural Development reported signs of the pasture deterioration and decline in vegetation in many areas of Libya. The overloaded range, which contains animals other than wild ones, as well as pastures, overlogging bushes, and cultivation of marginal land with low-fertility grain crops, disrupted the ecological balance, which is inherently weak in desert and semidesert areas, which in turn led to the intensification of desertification and soil erosion [8].

Sweco Company conducted a survey of pastoral areas in the southern Al Jabal Al Akhdar and Al-Abyar, with a total area of approximately 550,000 ha. The vegetation in the region, as well as its relationship with heavy rains and the impact of animals and humans, was investigated. In addition, land improvement of pastoral regions in terms of the introduction of pastoral crops and poisonous plants was also examined to determine its impact on animal production in the region and identify the toxic plant species and the measures to be taken to prevent cattle poisoning.

The study also investigated the methods of distinguishing palatable plants from other plants. Furthermore, the emergence of unpalatable plants and the occurrence of soil erosion were studied, and preliminary studies on erosion caused by water and wind, as well as the control of erosion by regulating grazing, were also conducted [9]. Kurochkina reported that dissolution and land degradation mark the decline of unpalatable pastoral species, which are eventually completely removed from the vegetation. Moreover, the continued loss of species from plant tribes is reduced along with their productivity because of the imbalance, which in turn leads to the reduced ability of these resources to regenerate. Therefore, the ecosystem undergoes degradation and elimination [10]. Al-Chaouch and Ben Mansoura reported that overgrazing and irrational grazing are causing the extinction of recommended plants, replacing them with less nutritious ones. The decrease in soil protection is a consequence of the presence of perennial plants and overgrazing. Anyone who is an average animal density sponsor contributes a real applicable load.

Productivity also precludes the seed composition of plants to ensure their reproduction and prevents the storage of energy reserves in the lower parts of new vegetation to regain and maintain its continuity [5]. Buhwarish reported the results of operations that ran over the seeds buried deep in distant soil. In addition, the presence of animals resulted in the stacking of surface soil on which animals continuously graze, thereby leading to a change in the nature of the plants in these regions [11]. AlJtalawi claimed that vegetation and environment have a bank of seeds for the pastures in the Masus desert (Al Agrmih). He observed soil deterioration and an increase in the salt concentration due to severe drought, erosion, and pressure of pastoral and human activities in the region. He also noted that a large number of sand deserts in the south contain randomly distributed sparse vegetation. In addition, the lack of rainfall led to a decline in the rates of seed germination [12]. El-Amrouni stated that overgrazing and increased load in the pastoral area of the Al-Hezam Al Akhdar district located in the southeast of Benghazi exceed the capacity of pastures, causing soil erosion and desertification. His results showed that overgrazing and indiscriminate and unregulated grazing increased the load on these lands, which contains only a few edible pastoral plant species and thus could not bear the large number of animals.

This phenomenon led to the dissolution and degradation of land. The presence and expansion of some plants with a dry nature as well as pastoral and non-palatable plants such as *H. scoparia*, *Pitourathos tortuosus*, *Anabasis articulata*, *Artemisia herba alba*, *Retama raetam*, and *P. harmala* were also noted [13]. Hahn et al., constructed a simulation model of long-term climate, livestock, and vegetation interactions on communal rangelands in the semi-arid Succulent Karoo, Namaqualand, South Africa. This area was heavily utilized by a large number of subsistence farmers who kept sheep and goats. As a result of the continuous high stocking densities, significant changes in vegetation have taken place. Farmers were heavily reliant on an annual flush in vegetation following winter rains to keep their livestock alive. They used a combination of empirical data and consensus agreement. A computer model was developed to describe the long-term climate, livestock, and vegetation interactions on the communal rangelands and investigate the effects of a range of management strategies.

However, the model suggested that the system (including livestock) is sustainable but not stable, and that its sustainability may be due to climatic variability. On the other hand, the model supports the view that when livestock numbers vary in a manner consistent with recorded observations, herbivory has a slight long-term impact on the productivity of the system. This pattern in turn supports recent views on rangelands in semi-arid and arid environments, where non-equilibrium conditions are thought to dominate the ecosystem processes [14]. Yong-Zhong et al. studied the effects of continuous grazing and livestock exclusion on soil properties in degraded sandy grasslands in inner Mongolia, northern China. Overgrazing was one of the main causes of desertification in the semi-arid Horqin sandy grassland of northern China. The exclusion of livestock grazing was considered an alternative method of restoring vegetation in degraded sandy grasslands in that region.

However, few data on the effects of these activities on soil properties are available. In their study, the vegetation characteristics and soil properties under continuous grazing and livestock exclusion in representative degraded sandy grasslands for 5 and 10 year periods were examined. The grassland under continuous grazing was in a stage of severe degradation.

The exclusion of livestock grazing enhances vegetation recovery, litter accumulation, and development of annual and perennial grasses. These results suggested that the exclusion of grazing livestock on desertified sandy grasslands in the erosion-prone Horqin region has a great potential in restoring soil fertility, sequestering soil organic carbon, and improving the biological activity. Soil restoration is a slow process, but vegetation can recover rapidly after the removal of livestock.

Therefore, a viable option for sandy grassland management should be to adopt a proper enclosure in a grazing system rotation during the initial grassland degradation stage [15].

Zhao et al., studied the desertification processes caused by heavy grazing in a sandy rangeland in inner Mongolia, China. Their results showed that continuous heavy grazing leads to a considerable decrease in vegetation cover, height, standing biomass, and root biomass, as well as a significant increase in animal hoof impacts. As a result, small bare spots appeared on the ground and later merged into larger bare areas in the rangeland.

They concluded that a sandy rangeland with wind-erodible soil is susceptible to desertification. Heavy grazing in such a rangeland should therefore be avoided [16].

Mahmmod studied the desertification problem in the southern part of the Al Jabal Al Akhdar region. He claimed that the desertification in that region is due to several natural and human factors. However, the effect of natural factors, which include weather, land forms, soil, and plants, appears smaller.

Human factors seemed to have a stronger effect on desertification and rangeland degradation, including the high population rate, spread of city construction over the landscape, excessive agricultural activities, tree and bush cutting, and excessive well drilling. He found that the soil compacted by animal hooves as a result of overgrazing exhibited reduced leaching rate, resulting in increased runoff in the form of small streams instead of slow water leakage in soil [17].

El-Amrouni and El-Barasi claimed that the presence of animals in large numbers results in pastoral overload in these lands. However, operations involving grazing animals may be a cause of degradation.

Meanwhile, the large number of animals and run-over processes cause pressure on large portions of the soil as well as on pastoral plants, which lead to soil compaction, reduced soil permeability to rain water, and elimination of seeds by animals, either through ingestion or transfer to other places through wool. In addition, the operations conducted to bury the seeds deeply in the soil, as well as the presence of animals, frequently increase the soil pressure on these seeds.

They also found vegetation types such as *H. scoparia*, *P. tortuosus*, *A. articulata*, *A. herba alba*, *R. raetam*, and *P. harmala*, which is one of the species of unpalatable pastoral plants [18]. Sivakumar studied the relationship between climate and desertification.

The effects of desertification on climate have been described mainly in terms of changes in land use and land cover that lead to land degradation, overgrazing, biomass burning, atmospheric emissions, agricultural contribution to air pollution, forest and woodland clearing, accelerated wind erosion, anthropogenic land disturbances and wind erosion, and the effect of irrigated agriculture on surface conditions in dry lands.

Sub-Saharan African rangelands are currently undergoing land degradation and desertification, which can lead to an irreversible decline in productivity as a result of climate change combined with overgrazing, overstocking, and damaging soil management practices, including nutrient mining. Overgrazing in rangelands is widely considered to be a major cause of desertification because of the depletion of grass and shrub covers and the accelerated loss of top soil.

These human-induced changes significantly affect the balance of energy in both land and the atmosphere. Changes in both land use and land cover have contributed to land degradation in terms of both surface albedo and soil moisture effects. However, other anthropogenic activities, such as overgrazing, biomass burning, and improper management of irrigation, have clearly contributed to land degradation, with consequences for the climate as well [19].

Amiraslani and Dragovich studied the methods used to combat desertification in Iran over the last 50 years as an overview of changing approaches. Overgrazing of rangelands is a particular problem.

Desertification was initially combated mainly at the local level and involved dune stabilization measures, especially the use of oil mulch, revegetation, and windbreaks [20]. Slimani et al., studied the 30 years of protection and monitoring of a steppic rangeland undergoing desertification. *Stipa tenacissima* L., which has long been recognized as the typical dominant perennial plant in the North African arid rangelands, is currently under threat of extinction in the steppic high plains of Algeria.

From 1993 to 2006, the plant cover, species composition, and soil showed major changes both inside and outside the enclosure. In addition, *S. tenacissima* completely disappeared in 2006. Such land degradation has been widespread in the entire steppe region of Algeria. The agricultural development programs in Algeria are still considering the arid "Steppe" region, which covers more than 20 million ha, as an area that can satisfy the increasing demand for ovine production.

However, they did not take the actual productive potential of such rangelands into consideration, nor did they have adequate knowledge or engineering skills to apply range management rules based on relevant ecological principles.

The main results were as follows: (1) an overall significant decrease in precipitation and droughts was observed throughout the entire study period; (2) vegetation degradation and changes in the physicochemical soil properties were less intense and slower in the protected zone until 1993, when a decrease in the vegetative cover and an alteration in the edaphic conditions within the overgrazed land were observed; (3) the gradual loss of perennial vegetation, represented almost exclusively by *S. tenacissima* up until its extinction in 2006, was observed, as well as the appearance of new perennial species at a significantly lower density; and (4) the generalized

accumulation of sand at the site and changes in the edaphic conditions, which no longer permitted the maintenance of vegetation and the floristic composition of the pre-existing system [21]. The main objective of this study is to investigate the phenomenon of desertification in northeastern Libya and confirm that overgrazing and livestock increase are important human factors that contribute to land desertification in northeastern Libya.

III. AREA OF STUDY

The study area was confined to the southern parts of Al-Abyar and Al Jabal Al Akhdar and is located in the northeastern part of Libya at 31°00.00 N/23°55.47 N and 20.44.09 E/23°09.12 E, which includes the area between the 200 mm and 50 mm rain lines. It has an area extent of approximately 9288 km², extending from Al-Magron in the west to Al-Tamimi in the east, as shown in Figure (1).

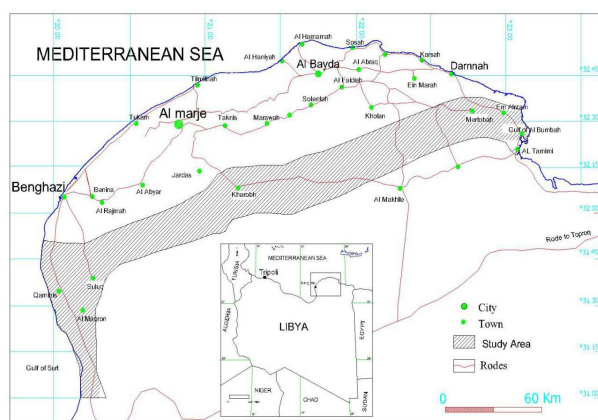


Fig. 1 Location of the study area

IV. METHOD OF STUDY

Field visits to the grazing areas concentrated mostly in the southern parts of Al-Abyar and Al Jabal Al Akhdar were conducted, as well as the collection of data and information on the subjects through direct and personal correspondence with relevant authorities and some environmental specialists, particularly the Environmental General Authority, Ministry of Agriculture and Livestock, and Ministry of Health and the Environment. Previous and modern studies on desertification were also used.

V. RESULTS AND DISCUSSION

Desertification was evident in the southern Al-Abyar pastures and extended to the Al-Tamimi area at the southern part of Al Jabal Al Akhdar. Large numbers of grazing animals were found in the region, which increased the pastoral load on a few edible plants. Moreover, the emergence of nonpalatable pastoral plants caused by the increase in livestock, as well as the lack of rainfall in these areas, led to the disappearance of pastoral plants. The prevalence of certain plants was found to be an indicator of soil degradation and desertification, which spread from the areas in south Al-Abyar (Magrun-Suluq-Masus-Wadi Al Bab) and extended to the areas in south Al Jabal Al Akhdar to the Kherobh, Al-Makhile, and Al-Tamimi regions.

The presence of plants such as *P. harmala* and the other findings are similar to those of previous studies [12; 13; [17]; [18]). The Sweco Company studied the toxic plant species and the measures to be taken to avoid cattle poisoning. They also studied ways to distinguish palatable plants from other vegetation and identify the emergence of unpalatable plants [9]. Kurochkina reported that dissolution and land degradation mark the decline in unpalatable pastoral species, which are eventually completely removed from the vegetation. The loss of species from the plant tribes is reduced along with their productivity because of the imbalance, which in turn leads to the reduced ability of these resources to regenerate [10]. Zhao et al. showed that continuous heavy grazing results in a considerable decrease in vegetation cover, height, standing biomass, and root biomass [16].

However, Slimani et al. found that degradation of the vegetation and changes in the physicochemical properties of soil reduced the vegetative cover and resulted in an alteration in the edaphic conditions within the overgrazed land. The gradual loss of perennial vegetation until its extinction and the appearance of new perennial species at a significantly lower density were also observed. Despite the lack of rainfall in these areas, overgrazing and increased pastoral load remain the most important human factors of land degradation and desertification, along with the presence of a multiplicity of animals that exceed the capacity of these lands [21]. These results are in line with the findings from previous studies ([7]; [5]; [11]; [12]; [13]; [17]; [18]). C-Loty reported that free and unregulated grazing is the main cause of pasture deterioration in Libya, as well as in the various areas of the Arab world and many parts of the world.

This activity leads to the eradication of vegetation, which is the main factor that contributes to desertification [7]. Yong-Zhong et al. found that overgrazing is one of the main causes of desertification in the semiarid Horqin sandy grassland of northern China. In addition, the exclusion of livestock grazing is considered an alternative method of restoring vegetation in degraded sandy grasslands in this region [15].

Hahn et al., suggested that the system (including livestock) is sustainable but not stable, and that its sustainability may be due to climatic variability. However, the model supports the view that when livestock numbers vary in a manner consistent with recorded observations, herbivory has a slight long-term effect on the productivity of the system. Therefore, this finding supports the recent views on rangelands in semi-arid and arid environments, where non-equilibrium conditions are thought to dominate the ecosystem processes [14].

Sivakumar found that overgrazing in rangelands is widely considered to be a major cause of desertification because of the depletion of grass and shrub covers, as well as accelerated top soil loss. These human-induced changes significantly affect the energy balance of both land and the atmosphere [19]. Amiraslani and Dragovich, claimed that overgrazing of rangelands is a particular problem that contributes to the desertification in Iran.

However, the pressure exerted by animal grazing on the rangelands in the region leads to several problems, including soil compression and compaction, reduced soil permeability to water, increased water flow on the soil surface, and run over animals.

The deposition of seeds into the soil and the compaction of soil due to its non-permeability to rainwater may lead to the lack of growth [20]. These results are similar to those of previous studies ([11]; [13]; [17]; [18]). C-Loty found that free and unregulated grazing leads to soil erosion and low production capacity and does not benefit from water. In addition, rainfall increases the runoff speed, reduces soil permeability to water, and accelerates the process of evaporation. Walks and the presence of animals also hardened the soil, reduced the permeability to rainfall, and increased the runoff at the shelf surface layer, thereby causing a lack of plant growth of plants (run over) [7].



Fig. 2 Frequent dust and sand storms in Benghazi city, Libya in 2009

However, Zhao et al. reported a significant increase in animal hoof impacts. They found that small bare spots appeared on the ground and later merged into larger bare areas in the rangeland. They concluded that sandy rangelands with wind-erodible soil are susceptible to desertification. The creation of sand dunes resulting from land desertification was also noted. Sandy encroachments were also observed on the main roads and secondary towns and villages such as Suluq, Al-Abyar, and Masus. Moreover, frequent dust and sand storms during the autumn occur, affecting a number of cities such as Benghazi, Tobruk, Al-Marj, and Al-Abyar (fig. 2).

These results confirm the occurrence of land desertification resulting from the degradation of vegetation, which protect cities from sand and dust storms. These findings are similar to those previously reported ([7]; [12], [13]; [17]; [18]).

VI. CONCLUSION AND RECOMMENDATIONS

Rapid livestock growth has led to severe desertification and plant cover problems in the southeastern part of Libya.

The current pastoral land situation in south Al-Abyar and south Al Jabal Al Akhdar was reviewed in this study. The increased livestock and desertification in southeastern Libya still pose many problems. Overgrazing or grazing in open and irregular lands is practiced in these areas almost throughout the year, especially during the growth cycle of edible plants, thereby leading to their disappearance.

In addition, the large number of livestock in these areas exceeds the capacity of these pastures because of pastoral land overloading, which results in deterioration and desertification.

Therefore, increased pastoral load is a key human factor in the deterioration of vegetation cover and desertification of land in this region.

In addition, rare plants, the extinction of some edible plants in the region, and the emergence of plants unsuitable for grazing, in addition to the emergence dust and sand storms during the dry season (summer–autumn) due to the degradation of vegetation, should be taken into consideration when developing strategic plans and regulations to protect the environment from desertification [16]. The current findings show that the present policies and plans are inadequate in dealing with the desertification and pastoral land problems of the areas in southeastern Libya.

The following recommendations are thus made for the development and implementation of a more effective and efficient desertification and pastoral land plan in the south Al-Abyar and Al Jabal Al Akhdar parts of southeastern Libya:

1. The development of a general strategy by the Libyan state to reduce the livestock in these and similar areas in Libya;
2. The development of a complete environmental plan to protect the vegetation cover of pastoral lands and prevent degradation and desertification;
3. The conduct of laboratory analyses of soil characteristics to develop appropriate treatment programs and identify the right kinds of plants to grow in the regions;
4. The shutdown of some of the land exposed to desertification and deterioration for several years to sow seeds suitable to the area, as well as the monitoring of these lands by competent authorities such as the Environment General Authority, Ministry of Agriculture and Livestock, and Ministry of Environment;
5. Increased attention on the farming of local trees and shrubs in these areas during the first periods and the placement of a fence around them; and
6. Focus on growing drought-resistant trees in the valleys, valley sides, and on hill tops to protect the soil from erosion. These trees may include olives or any other trees that are resistant to drought during summer and autumn.

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