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Abstract

Desertification and land degradation represent a major threat to agricultural sustainable development. It puts the livelihoods of billions of people around the world at risk in arid and semi-arid regions. This is especially the case for people living in rural areas where the majority of the poor live in rural areas. Human pressures and climate variations are the main causes of land degradation and desertification. It occurs because drylands ecosystems are extremely vulnerable to over-exploitation and inappropriate land use that resulted in underdevelopment of economies and in entrenched poverty among the affected population. Libya is no different from other parts of arid and semi-arid zones in terms of the climatic conditions and human activities as the main reasons behind land degradation and desertification. However, many human factors are contributing to the deterioration of environmental conditions and the occurrence of desertification in Libya. This chapter discusses land degradation and desertification in Libya, emphasizing the main causes, impacts of the phenomena, and efforts to combat it.

Keywords

Libya • Mediterranean region • Population • Sahara desert • Soil resources • Soil erosions • Salinization

8.1 Introduction

Land degradation and desertification are among the most serious global, regional, and local environmental issues (UNEP 1997). Nowadays, desertification is considered to be one of the greatest environmental challenges. It constitutes a major difficulty in meeting basic human needs and sustainable agriculture development in semi-arid and arid lands. It has severe consequences on many living aspects such as food security, economic activity, infrastructure, human health, natural resources, and the environment. The direct effect of land degradation varies from the reduction in land productivity or the complete abandonment of agricultural land. The desertification leads to agricultural productivity losses and increases poverty. This could cause a food crisis facing wide areas in arid regions.

Land degradation puts the livelihoods of billions of people around the world at risk (IPBES 2018). Over 250 million people are directly affected by desertification and one billion people in over 100 countries are at risk. This is especially the case for people living in rural areas where the majority of them are poor. Estimates report that 80% of the extremely poor live in rural areas and 65% work in the agricultural sector (Castaneda et al. 2018).

Desertification is recognized as a complex phenomenon that requires researchers' expertise in disciplines such as climate science, soil science, meteorology, hydrology, range science, agronomy, veterinary medicine, geography, political science, and economics. Researchers in these and other disciplines, as well as many national disciplines, have defined it in many different ways. As a result, there were a number of definitions for desertification; for instance, at the 1992 Rio Conference it was defined as degradation of sensitive drylands resulting from several factors, including climate variations and human activities. The United Nations Convention to Combat Desertification (UNCCD) has defined desertification as "land degradation in arid, semi-arid

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and dry sub-humid areas resulting from various factors, including climatic variations and human activities” (UNCCD, Article 1, 1994). All these definitions agree that desertification can be caused by the complexity of climate variations and human activities. MEA (2005) stated that desertification is caused by a combination of factors, which change over time and vary by location.

Desertification occurs in drylands around the world and its impacts are felt locally, nationally, regionally, and globally. Drylands occupy 41% of Earth’s land area where more than 2 billion people live. This represents a third of the human population in the year 2000. The drylands include all terrestrial regions where water scarcity limits the production of crops, forage, wood, and other ecosystem provisioning services.

Human pressures on the environment and climate crises are the main reasons for the degradation of natural resources. These crises lead to social changes, modified consumption habits, the search for non-farming work, and temporary labor migration, as well as the sale of productive assets and permanent migration. Societies affected by desertification suffer declining incomes and decreasing food security (UNCCD 2007). Drought and desertification are at the core of serious challenges and threats facing sustainable development in Africa. These problems have far-reaching adverse impacts on human health, food security, economic activity, physical infrastructure, natural resources and the environment, and national and global security.

The African continent is the most affected by land degradation and desertification. Reich et al. (2001) stated that desertification processes affect about 46% of Africa. This number is very important, taking into consideration that about 43% of the continent is characterized as extreme deserts. Only about 11% of the land can be excluded from desertification processes. Rising temperatures are forecasted by IPCC in North Africa which could have a severe impact on the regions including Libya. This could have an impact on the regions already facing stressed resources including water and food (IPCC 2007). In addition to climate change, misuse of water and soil resources, urbanization, overgrazing, removal of natural vegetation, and rapid changes in land use are important reasons for increasing land degradation and desertification in Libya. This chapter discusses the causes and effects of land degradation and desertification and effort to combat desertification and land degradation in Libya.

8.2 Desertification Land Degradation and Status in Libya

According to The National Plan to Combat Desertification (ACSAD and Libyan experts 2005), much of Libya’s agricultural land is under pressure from either soil erosion, loss of natural vegetation cover, or over-use of irrigation water. Problems such as soil salinity and rising groundwater all appear to be on the rise. The environmental impacts of agricultural activity are the result of a complex chain of biophysical and other factors, which are linked to the natural characteristics of the land. The total land degradation areas from 1981 to 2006 were about 1,024,053 km² (Table 8.1).

Libya is suffering from desertification in various types and degrees. It can be noted that many areas of Libya were exposed to the over-use of the natural resources which led to their deterioration and the acceleration of desertification problems in these areas. The types and aspects of desertification in Libya are as follows (Ben Mahmoud 2013).

8.2.1 Soil Erosion by Wind

It is considered to be the most common environmental problem in Libya with respect to the loss of the fertile surface layer or the problems caused by the transfer, encroachment, and fall of the sands, especially for the population centers in addition to their adverse effects on public health.

8.2.2 Soil Erosion by Water

This phenomenon leads to the loss of the fertile surface layer and the transfer of large quantities of soils to other sites leaving rocks, shallow soils, or bare lands. The eroded materials settle in certain areas behind the dams or in the agricultural fields, causing destruction and forming another deterioration aspect.

8.2.3 Loss of Nutrients

The agricultural intensification and failure to abide by the agricultural instructions lead to the decline of soil fertility and the loss of vast areas of the agricultural lands. The loss

Table 8.1 Statistics of degrading areas in Libya (1981–2006) based on (GTZ 2009)

| Country | Area in (km ²) | % Total population | LD areas (km ²) | Improved areas (km ²) | Affected people |
|---------|----------------------------|--------------------|-----------------------------|-----------------------------------|-----------------|
| Libya | 1.759.540 | 6.310.434 | 1024052.28 | 527.86 | 14651730 |

of nutrients in the irrigated areas leads to the decrease of the production capability of the lands and their deterioration at varying degrees.

8.2.4 Soil and Water Pollution

Soil and water resources in Libya are exposed to many pollutants that differ according to the types of the prevailing farming systems and the techniques used by farmers. This problem becomes clearer when fertilizers and pesticides are used irrationally, especially in the areas of the irrigated agriculture and where the industrial constructions are close to agricultural fields, as this leads to the settlement of the pollutants resulting from these constructions either on the soil surface or in the soil.

8.2.5 Salinization

Salinization is also the primary type of soil degradation in Libya. This problem becomes clear in the irrigated areas or when the water table is increased. It starts with the accumulation of salts which make the soils not suitable for growing crops, and after sometime these soils become desertified.

8.2.6 Aridification

The depletion of the groundwater resources, especially those near the surface, leads to the aggravation of the desertification and aridity processes and adversely affects the quantity of the available waters. When these waters become dry or of bad quality, the people go elsewhere and leave the lands exposed to desertification and aridity.

8.2.7 Deforestation

The forested and shrublands areas have been suffering from severe deforestation, and that is considered one of the biggest environmental challenges in the country (Zurqani et al. 2019). Deforestation increases soil erosion rates due to exposure to soil mineral by removing the humus and litter layers from the soil surface.

8.3 Causes and Consequences of Desertification

8.3.1 Causes of Desertification

Literature has widely discussed land degradation's causes (Thomas 1997; Lambin et al. 2001; Reynolds and Stafford Smith 2002; Geist and Lambin 2004; Ben Mahmoud and Lolo 2010). It has been concluded that desertification is caused by multiple direct and indirect factors. It occurs because drylands' ecosystems are extremely vulnerable to over-exploitation and inappropriate land use, which results in underdevelopment of economies and in entrenched poverty among the affected population. Whereas over-cultivation, inappropriate agricultural practices, overgrazing, and deforestation have been previously identified as the major causes of land degradation and desertification, it is, in fact, a result of much deeper underlying forces of socio-economic nature, such as poverty and total dependency on natural resources for survival by the poor. It is also true to state that desertification problems are best understood within the dictates of disparities of income and access to or ownership of resources. The primary cause of deforestation and natural pastures in the country is due to the rapid urbanization process and wood extraction for charcoal (Fig. 8.1a, b).

According to the Global Forest Watch, the total area covered by forest trees was about 24,344 hectares in 2000, and it decreased over time as it was about 12,107 hectares in 2011 and 11,866 hectares in 2018. Figure 8.2 shows deforestation activities in the north-western coastal areas stretching from Tajoura to Misurata (north-east Tripoli): (a) before December 2006, (b) after December 2016.

In general, the environment in Libya is vulnerable. The variability of rainfall and the occurrence of occasional relatively heavy showers characterized as high intensity can produce runoff. The removal of natural vegetation from the land surface is the main factor that accelerates soil erosion. The combination of these factors in addition to the topography has increased the rate of soil erosion by water in this area (Nwer 2005).

Subsequently, the causes of desertification are too complex to be simplified. Desertification is driven by a group of main variables, mainly climatic factors (Yang and Prince 2000; Hulme and Kelly 1993). The natural factors include changes in climate: mainly rain, wind, and temperature.

Fig. 8.1 Deforestation activates; **a** cutting trees for charcoal production, and **b** charcoal packed in white polypropylene bags



(a)



(b)

These factors vary from one site to another in response to changes in external and internal influences in the air system (Emgaili 1993). For example, in the spring and autumn, strong southerly winds, known locally as “Ghibli” blow from the desert, filling the air with sand and dust and raising the temperature to approximately 50 °C (Fig. 8.3). These strong winds are a major erosion factor in the desert, transporting sand from one place to another.

As previously mentioned in the climate section, the climate in Libya can be divided into two main climate conditions: arid climate inland and Mediterranean climate on the

coast, see Chaps. 1 and 3. As for arid conditions and drought, it is well documented and discussed. However, the nature of the Mediterranean climatic condition could contribute to land degradation and desertification. According to Sevink (1988), climatic characteristics of the Mediterranean region include rare freezing, hot summers with at least two to three dry months, and cool rainy winters; precipitation often falls as storms of high intensity which produce torrential runoff (Bradbury 1981). Because of these violent storms, the Mediterranean climate is described as one of the most aggressive with respect to erosion. Also, in regions

Fig. 8.2 Deforestation in the north-western coastal areas stretching from Tajoura to Misurata (north-east Tripoli): **a** before December 2006, **b** after December 2016. Google Earth imagery (<http://www.earth.google.com>)



(a)



(b)

such as the southern Mediterranean, cracks can form by desiccation during dry summers, causing extreme dissection of the slopes. A major problem in the climate in this region is that the winter rainfall, which causes erosion, does not coincide with the vegetation cover that protects the soil surface, especially in cultivated cropland and heavily grazed pasture. The Mediterranean climates do not favor the development of a dense vegetation cover on most slopes, which are poorly stabilized at ground level. As a result, areas with Mediterranean type climates are traditionally classified as areas with high potential erosion rates (Saunders and Young 1983; Brown 1990).

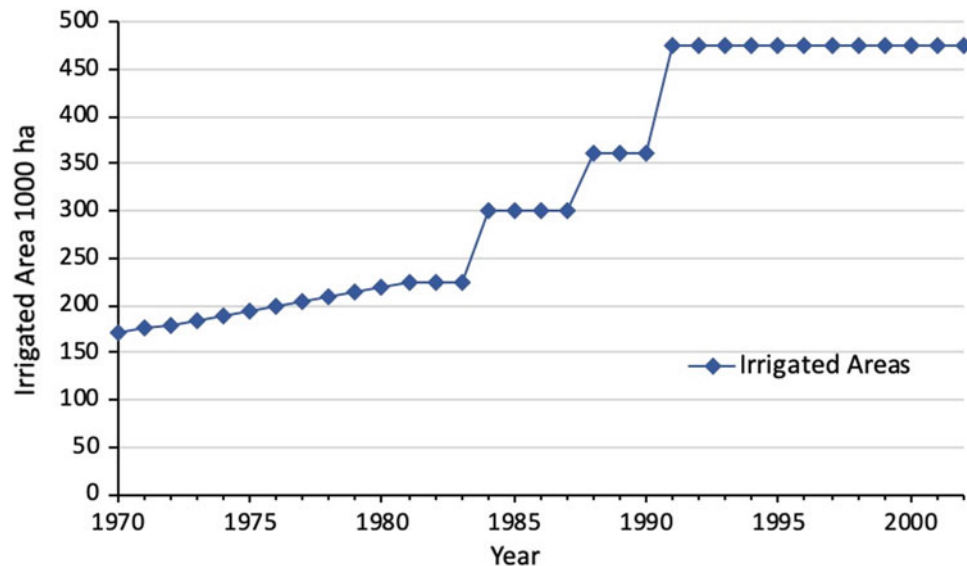
Libya is no different from other parts of arid and semi-arid zones in terms of the climatic conditions and human activities being the main reasons behind land degradation and desertification (Zurqani et al. 2019). However, many human factors are combined, contributing to the deterioration of environmental conditions and the occurrence of desertification in Libya. Urbanization can intensify land degradation and desertification. FAO (2015) stated that urbanization has led to over 25% of highly fertile lands being converted to urban areas.

The discovery of oil and development of the agriculture sector in the country has also contributed to the process of

Fig. 8.3 Wind with sand and dust, known locally as “Ghibli”



Fig. 8.4 Irrigated Areas in Libya from 1970 to 2002 (adapted from Nwer 2005)



land degradation and desertification. The wealth created by oil has led to a huge investment in agriculture. Nevertheless, agricultural development has put severe pressure on local ecosystems, especially in sensitive and fragile areas. This was because of the change in production patterns, and the need to produce more food for the growing population. The rapid expansion of the irrigated areas in Libya has put pressure on resources already at stress. The irrigated area has increased four times in 2002 compared with 1970. Figure 8.4 shows the rapid increase in the irrigated areas from 1970 to 2002.

It can be seen that the irrigated area was less than 160,000 hectares in the 1970s, whereas in 1986 it has increased to 300,000 hectares. Compared with 1970 and 1986, the

irrigated area in 2002 has rapidly increased three times and four-times, respectively. It has expanded to more than 450,000 hectares. Consequently, this led to the intensification of pressure on already limited natural resources, thus escalating land degradation and desertification problems (Ben Mahmoud et al. 2003).

This section has explained the causes of land degradation and desertification in general with specific reference to nature and caused in Libya. Land degradation and desertification in causes are climatic variations and human activities. However, many human factors such as increased human population, urbanization and intensive agriculture, are combined contributing to the deterioration of environmental conditions and the occurrence of desertification in Libya.

8.3.2 Consequences of Desertification

The impact of the land degrading process varies according to the natural characteristics of the land. These characteristics include soil type, slope, vegetation, and climate. Therefore, the degradation process could take place in one site and may not cause the same degradation in another site. This is due to the fact that soil characteristics, topography, and climatic conditions are different. So, similar rates of soil loss will be different as a result of erosive rainstorms occurring above different soil types and slope degrees. Therefore, identification of reasons behind land degradation must recognize the natural interactions between different elements in the landscape which affect degradation, and also the site-specificity of degradation. For instance, thunderstorms and flash floods increase the problem of soil erosion by water extensively (IPCC 2001; GTZ 2009).

Land degradation adverse consequences are both environmental and socio-economic. It weakens the structure and functions of environmental systems such as the biogeochemical cycles (i.e. carbon, hydrological, and nutrient cycles) which are threatening the survival of human beings. This put at risk more than 1 billion people in developing countries in their livelihoods and economic wellbeing, and their nutritional status (World Bank 1998). According to ACSAD (2007), more than 40% of the Libyan population are affected by desertification.

According to the UN (1992), land degradation can also cause food and water scarcity, loss of income, resource conflicts, and environmental deterioration. Poverty is closely linked to land degradation. Most of the affected areas are rural poor, and the land is the main provider for their income to survive. Usually, competition among people in those areas takes place for declining natural resources. Therefore, the

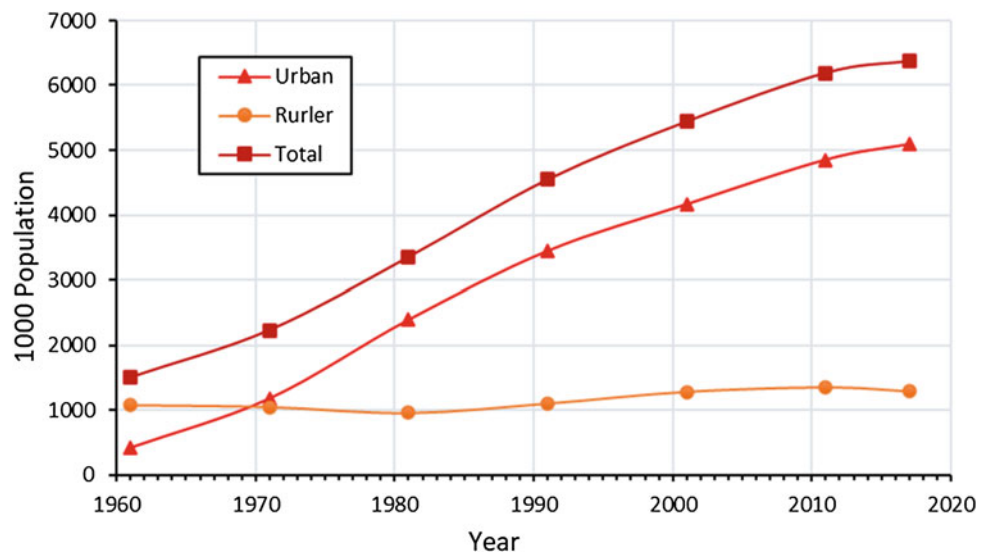
land becomes further degraded and the cycle of poverty is perpetuated. In Libya, this has caused internal migration in the past from rural areas to urban areas where opportunities for employment and better living conditions exist. As can be seen (Fig. 8.5) in 1961, the urban population in Libya was 28.5% of the total population, whereas in 2017 it increased to 79.8% (FAO STAT 2019). This led to increased pressure on the services of the main cities such as Tripoli and Benghazi, as well as increased the pressure on the groundwater resources in the coastal strip (El-Tantawi 2005).

In addition, one of the most significant causes of the current civil war is fighting for resources. This can be concealed by different political and social reasons. In fact, land degradation and desertification led to poverty and competition on natural resources (oil in Libya). The feeling of injustice in underdeveloped areas ignites conflicts.

Because the causes and effects of land degradation are unaffected by the boundaries of land ownership or use rights, degradation may occur on a farmer's land as a result of actions taken by other land users upslope. Similarly, actions taken on a farmer's field may affect other land users' downslope. The interest in preventing land degradation may not coincide with the cause. Therefore, this will have serious implications when it comes to the costs and benefits of different courses of action are assessed.

The impact of land degradation and desertification is witnessed in Libya in many aspects. Land degradation causes the deterioration of the pastoral environment and a decline in the productivity of livestock, and thus reduces the productivity of meat and milk. Moreover, the deterioration of water resources, soil erosion, and the loss of biodiversity are the main impacts of land degradation. The reduction in biodiversity may contribute to the destruction of the habitats of animal and plant species and micro-organisms.

Fig. 8.5 Population growth in Libya (Source FAO STAT 2019)



Biodiversity loss is also expected to encourage the genetic erosion of local livestock and plant varieties and species living in fragile ecosystems (Abahussain et al. 2002; Mansour et al. 2011).

The consequences of desertification are deeply felt in rural areas. They can be listed as follows: the decline of soil productivity, intensive erosion, salinization, loss of biodiversity, climate change, and degradation of rangeland (Zurqani et al. 2018, 2019). This will lead to complicated social-economic consequences which have an effect on the stability of the country recently and in the future.

8.4 Efforts to Combat Desertification in Libya

Since the early 1960s, Libya has taken serious measures to combat desertification as part of a broad policy in the framework of the National Plan for Agricultural Development which takes into account the objectives of local development on one hand and the harsh environmental conditions prevailing in the countries on the other. Libya has adopted a number of measures and actions to control desertification during the last four decades by implementing a range of diverse projects in many areas (i.e. forest, pastures, sand dune fixation, soil and water conservation, resistance to erosion and integrated agricultural development).

Libya has conducted a number of measures and projects to control desertification, which include sand dunes fixation, the establishment of windbreaks, reforestation of fallow forest land, establishment of terraces to combat soil erosion, preservation of rainwater on sloping agricultural land, and following of the special agricultural cycle to maintain soil fertility, especially in the areas of cultivation of grain, as well as the protection and improvement of natural pastures (ACSAD and Libyan experts 2005).

Sand dunes stabilization projects have been conducted in Libya since the 1950s. A number of methods and techniques were used to protect lands from moving sands. One of the most famous methods is sand stabilization with oil. This method was used in 1953 when the Forestry Department of Agriculture in Libya began a long-range program of afforestation and sand dune stabilization to reclaim some of the wastelands of the Libyan desert. The basic aim of the program is the creation of a “green belt” 50 km wide extending the entire length of the Libyan coastline from Tunisia to Egypt. In 1953 the Forestry Department reclaimed 60,000 hectares of dune land. Most of the area has been planted with some 36 million acacia and eucalyptus

seedlings grown in Libya. In 1960, the Forestry Department working with Esso Standard Libya Inc. initiated an experiment with an oil product which sprayed oil on sand dunes to form a coating that stabilized the dunes for a year. The seedlings were planted before spraying oil. The plant trees then grew to stabilize the sand dunes. The method that was used proved to be successful. This method replaced the traditional method called “dissing”. Dissing involves planting seedlings in plots during the rainy winter season and surrounding the plots with windbreaks of dried grass. This method was expensive, slow, and limited (Commonwealth Forestry Association 1969). Libya has embarked yearly plantation campaigns since 1990 which aimed at severely degraded lands in order to rehabilitate lands and establishment of national parks and wildlife to combat desertification and preserve biodiversity.

Other measures that have been taken by Libya were to establish institutions working in combating desertification to plan and organize these efforts. The main task was assigned to the Agriculture Ministry to liaise and coordinate these efforts. This led to the signature of United Nations Conventions to Combat Desertification (UNCCD) in 1984 and to the formation of the National Committee to Combat Desertification (NCCD). NCCD is assigned as the national coordinator to combat desertification and is a focal point to UNCCD.

NCCD is a cross-sector committee formed by members from all interested parties in combating desertification. The NCCD has produced a National Action Plan (NAP) to combat desertification which includes a number of policies, plans, and projects. The NAP is an integrated plan as a part of the development plan of Libya and provides a scientific framework for combating desertification and the development of natural resources within a comprehensive concept that conforms to the Agenda of the twenty-first century and is in line with international efforts to combat and reduce desertification.

Therefore, there was a necessity to develop and update laws and legislative basis to aid efforts to compact desertification and achieve goals and requirements of sustainable development. There are two types of legislation which aid in combating desertification and protecting natural resources. They are natural resource protection legislation and legislation regulating institutions involved in the protection of natural resources. Table 8.2 listed the legislation mentioned.

Despite a dedicated effort from state governments and communities and the range of policy initiatives to promote sustainable natural resource use, Libya still has some significant challenges ahead to achieve ecologically sustainable land management.

Table 8.2 Legislation in Libya (Source NAP 2002)

| No. | Legislation | Laws | Objective |
|-----|---|----------------|---|
| 1 | Natural resource protection legislation | Law (27) 1966 | Plant protection |
| | | Law (46) 1975 | Protection of small lands |
| | | Law (5) 1982 | Protection of Forest and Rangeland |
| | | Law (7) 1982 | Protection of Environment |
| | | Law (790) 1982 | Organization of Drilling and Water Resources |
| | | Law (1) 1983 | Agriculture Technology |
| | | Law (15) 1984 | Protection of Animals and Trees |
| | | Law (15) 1992 | Protection of Agriculture Land |
| 2 | Regulation of Institutions | Law (109) 1971 | Establishment of Agriculture Research Centre |
| | | Law (827) 1992 | National Research Organization |
| | | Law (72) 1982 | Establishment of the Arab Center for Desert Research and development of desert communities. |

8.5 Conclusion

Desertification and land degradation is a global phenomenon that is threatening the livelihoods of billions of people around the globe. The causes of land degradation and desertification are well documented and explained. Climate conditions and human activities are the main reasons for desertification. However, the causes of land degradation are too complicated to be simplified. The impact of desertification has countless negative consequences on natural resources. These consequences are likely to become much more complicated unless major new efforts characterized by profound changes in local and international behavior are made. These efforts have to address the livelihood needs of dryland populations and the reversal of the desertification process on war footings through short-term goals and long-term initiatives with a political will and commitment.

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- UNCCD and a rapporteur of the Ninth and Tenth Session of CRIC, UNCCD. Dr. Nwer has attended UNCCD, COP5-COP11, and most of the regional meetings of UNCCD. Dr. Nwer has published a number of papers in the use of GIS and RS in land evaluation and degradation.

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