



Desertification in the Arab Region: analysis of current status and trends

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The total area of the Arab Region is about 14.2 million km², 90% of it lies within arid, semi-arid and dry sub-humid areas. The area is characterized by harsh environment, fragile ecosystems and limited water resources and arable lands. Throughout its long history these lands were the main source of grain and animal production.

By the end of this century and in spite of the national, regional and international efforts to combat desertification and mitigate the effect of drought and desiccation, desertification is still one of the major environmental problems in the Arab Region. The rapid increase in population by some 3% annually, considered among the highest worldwide, along with the changing of consumption patterns and life styles, resulting in increasing food demand, have hastened land degradation in this arid environment.

Land degradation in the Arab Region due to misuse is widespread and is proceeding at accelerating rates. Failures of resource management policies are aggravated by overgrazing, overexploitation of water and land resources, overcultivation of marginal lands, deforestation, and the use of inappropriate technologies.

This paper attempts to provide:

1. A synthesis and analysis of the status of desertification in the Arab Region.
2. Identification of the major causes and trends of land degradation.
3. Highlighting the limitations and constraints on combating desertification in the Arab Region.

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Keywords: desertification; matrix of desertification; population growth and urbanization; water demand; cost; future outlook

Introduction

Desertification, as defined in Chapter 12 of 'Agenda 21' and in the International Convention on Desertification, is 'the degradation of land in arid, semi-arid and sub-humid dry areas caused by climatic changes and human activities'. It is accompanied by the reduction in the natural potential of the land, the depletion of surface and

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ground-water resources and has negative repercussions on the living conditions and the economic development of the people affected by it. On the other hand, 'land degradation' means reduction or loss, in arid, semi-arid and dry sub-humid areas, of the biological or economic productivity and complexity of rain-fed cropland, irrigated cropland, or range, pasture, forest and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns (UNCCD, 1992).

Desertification is a worldwide phenomenon, affecting about one-fifth of the world population, 70% of all drylands (3.6 billion ha) and one-quarter of the total land area of the world (Tolba *et al.*, 1992). The vulnerability of land to desertification is mainly due to climate, state of the soil, water, and natural vegetation, and the ways in which these resources are used. Vulnerability varies widely depending on the way in which the natural resources are used by human communities and their livestock. Globally, every year an additional 200,000 km² of productive lands — an area larger than Senegal — is reduced by desertification to the point of yielding nothing.

The following sections provide a synthesis and analysis of the problems of desertification, identify the major causes and trends of land degradation, and highlight the limitations and constraints that hinder combating desertification in the Arab Region.

Current status of desertification in the Arab Region

The Arab Region covers an area of 14.2 million km² or about 10.2% of the world extending from Iraq in the north to Somalia in the south and from Mauritania in the west to Oman in the east. It extends between longitudes of 17° and 60° east and between latitudes of 1°30' and 37°30' north. Such an area with wide latitudinal differences has different environmental conditions in its various parts. Extremely arid, arid, semi-arid and dry sub-humid areas cover about 90% of the Arab Region. These are characterized by great variability in both seasonal and annual precipitation, which is the most important climatic feature of the dryland ecosystems. Unreliable rainfall and unfertile soils make the major land uses, agriculture, forestry and range management, marginal on any given site in any of the countries of the Region. About 52% of the area receives an average annual rainfall of less than 100 mm, while 15% receives 100–300 mm, and 18% receives more than 300 mm (Table 1). This amount increases to reach 1500 mm of rainfall in parts of the region, e.g., highlands of Lebanon, Syria, North Africa and along the coastal areas and southern Sudan.

Total rainwater amounts to 0.04 billion m³ yr⁻¹ (Bcm yr⁻¹) in Bahrain and reaches 1169.8 in Sudan, totaling 2545.5 Bcm yr⁻¹ in the region (ACSAD, 1996). However, most of this water is lost by evaporation and uncontrolled runoff. The highest losses occur in the desert and semi-desert zones which represent 82% of the area receiving less than 300 mm annual rainfall or 42.7% of the rainwater (Table 1).

Historically, there has been a long and well-established relationship between the desert's marginal resources and the population of the region. These lands were the main source for cereal and animal production. Communities in the Arab Region have throughout the recorded history (last 12,000 years) developed indigenous tools, technologies and regulations to protect and improve their land and water resources. Their efforts kept a balanced and sustainable use of these resources to meet their needs for food and feed. However, when the demand on land and water resources exceeded their carrying capacities, land degradation has become an increasingly limiting factor to land's productivity. The effects of desertification were and still are amplified, as these fragile eco-systems are at- or near-their limits of resilience (Batanouny, 1998).

Table 1. *Rainfall Distribution in the Arab Region*

Climatic division	Area % of the total	Amount of rainfall received % of the total
1. Deserts (less than 100 mm)	52	14.1
2. Semi-desert (100–300 mm)	30	28.6
3. Sub-tropical/Sub-humid (300–500 mm)	7	15
4. Mediterranean/humid tropical (500–800 mm)	5.5	15.3
5. Equatorial (more than 800 mm)	5.5	27

Source: ACSAD (1997) with modifications.

Despite the severity of the problem, statistics on recent trends and the extent of desertification in the Arab Region are poor. There are, however, some good information on particular sites in some countries of the region. Table 2 displays a matrix of critical issues leading to desertification in the Arab Region while the major driving forces causing desertification in the Arab Region, their impacts and manifestations are summarized in Fig. 1.

Although modernization of observation facilities using satellite imagery and computers to analyse data are widely used at present, there are still many uncertainties at the global, regional and national levels on the causes, the extent and the seriousness of desertification. These uncertainties make it difficult to plan properly. They also introduce constraints on the operation of early warning systems with regard to drought, agricultural production and disasters, such as grasshopper infestations. The most recent synthesis of relevant data and material of the status of desertification in the Arab Region are those identified in the extensive study published by the Arab League (CAMRE) and UNEP and prepared by ACSAD (CAMRE/UNEP/ACSAD, 1996). However, most of the available information about desertification in the Arab Region are not quantitative.

Available information indicates that most of the land resources in the Arab Region are either desertified or vulnerable to desertification (Table 3), thus affecting food security and development in the region. In total, 88.4% of the total area is desertified or vulnerable to desertification (Shakhatra, 1987). Recently, Abdelgawad (1997) estimated the total areas desertified and vulnerable to desertification as 9.84 million km² or about 86.7% of the total area of the Arab Region.

The main forms of desertification prevailing in the Arab Region are:

- (1) Wind erosion: This is considered the most common environmental problem in the Arab Region leading to
 - Loss by removal of the fertile top soils.
 - Encroachment and accumulation of sands on productive rangelands and agricultural land, urban areas and civil construction (infrastructure).

Table 2. Matrix of critical issues leading to desertification in Arab Region

Problem Type	Evidence	Sources	Impacts
Limited water and arable land resources	Low per capita available water and arable land and decrease with time	Aridity	Slow down socioeconomic development plans
		Intensive agricultural schemes Rapid population growth Present agricultural and water policies Overexploitation of water	Decrease of food self-sufficiency
Water quality deterioration	Ground-water and surface water depletion Salt water intrusion (sea and saline water) Contamination of surface water and shallow water aquifers	Irrational water demand	Increasing water scarcity
		Discharge of wastewater	Salinization and loss of agricultural lands Negative impact on human and environment
		Lack of awareness Lack of integrated agricultural and water policies	
Progressive deterioration of irrigated lands	Increase of salinized cultivated areas and increase of soil salinity Decrease of soil fertility	Extensive traditional irrigation practices	Degradation of irrigated lands
		Intensive agricultural schemes	Reduction of agricultural productivity
	Decrease of agricultural productivity	Intensive use of agro-chemicals	Degradation of water resources
		Lack of awareness and participation of stakeholders Lack of integrated agricultural development policies	Increase of poverty and rural urban migration
Cultivation of marginal lands (lands between arable and rangelands)	Low and unsustainable productivity of marginal lands Increase of sand drifts and duststorms	Population pressure and increased food demand	Loss of rangelands and food production
		Inappropriate agricultural practices	Increase of soil erosion

Deterioration of rangelands	Change of natural plant cover	Lack of awareness	Escalation of sand dune encroachment
	Deterioration of land productivity	Policies adopted for development	Loss of
	Increased soil erosion, sand drafts and dust storms	Mismanagement of rangelands (overgrazing, wood cutting, tourism)	Productivity of rangelands
Development policies and interventions	Appropriation of productive lands for urban and industrial development	Socio-economic factors	Food resources
	Development of large-scale private agricultural	Increasing pressure for food security	Biodiversity
		Adopted policies and programmes for Development	Soil by wind and water erosion
Weak institutions	Continuing degradation of water and land resources	Increasing pressure on land at local and regional levels	Reduction of agricultural productivity
	Lack of integrated agricultural and water policies	Sedentarization of nomads and pastoral communities	Increasing poverty
	Duplication of efforts	Local effects of structural adjustment programme	Loss of rural income
	Lack of awareness	Inappropriate interventions such as top-down planning and implementation	Increasing rural – urban migration
		Lack of financial resources	Marginalization of rural areas
		Inadequate technical capabilities, training and research	Poor water and land development and management
		Lack of co-ordinating effort and networking for combating desertification	Wasteful uses of resources
		Lack of sustainable development plans for desertified areas	Progressive expansion of desertified areas

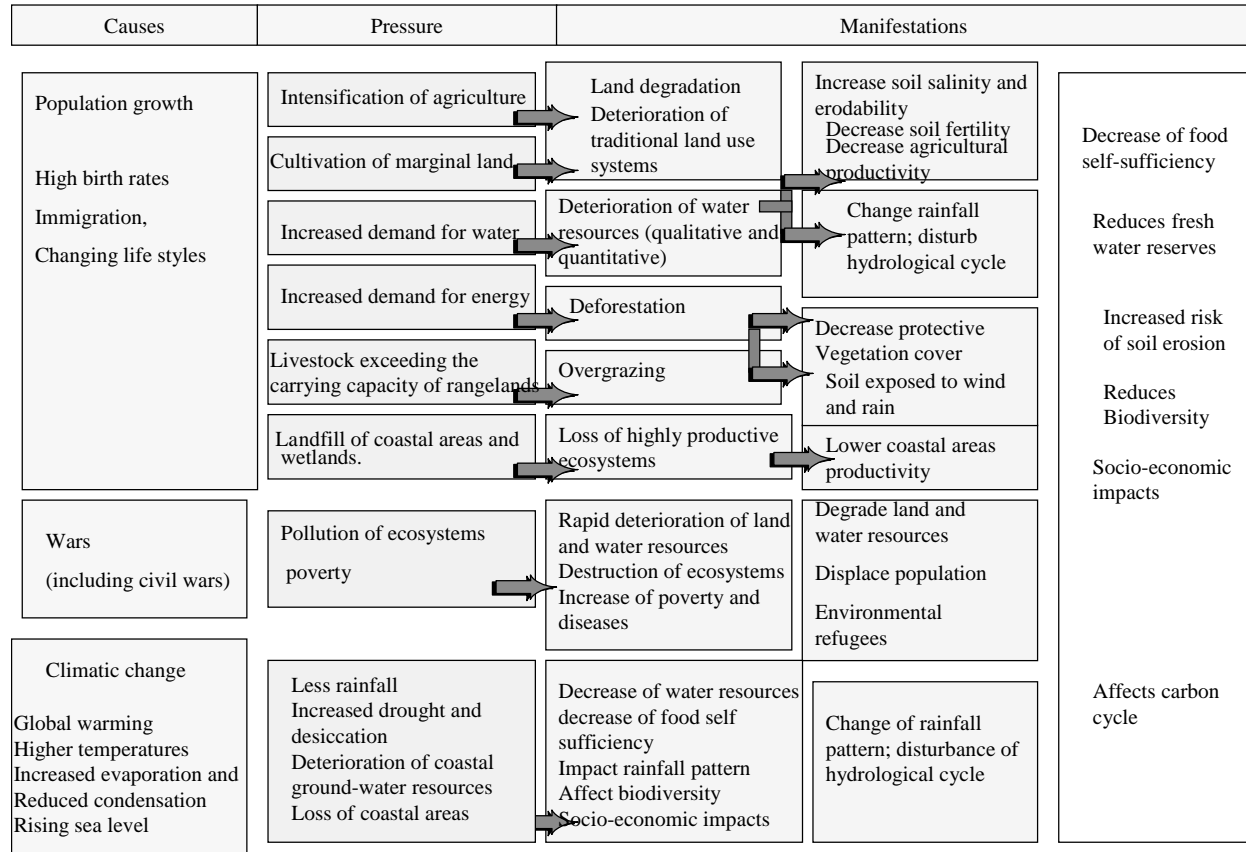


Figure 1. Major driving forces for desertification in the Arab Region and their impacts.

Table 3. *Areas desertified and vulnerable to desertification in the Arab Region*

Country	Country area (km ²)	Desertified area		Areas vulnerable to desertification	
		km ²	%	km ²	%
Algeria	2,381,000	1,970,000	82.74	230,000	9.66
Bahrain	670	670	100*	—	—
Djibouti	21,783	20,911	96	872	4
Egypt	1,100,145	1,064,145	96.73	36,000	3.27
Iraq	437,500	166,687	38.10	237,563	54.30
Jordan	89,206	71,000	79.59	10,000	11.21
Kuwait	17,818	17,818	100*	—	—
Lebanon	10,400	—	—	—	—
Libya	1,806,530	1,625,877	90	180,653	10
Mauritania	1,030,700	618,420	60	343,223	33.3
Morocco	710,850	455,000	64.01	195,000	27.43
Oman	300,000	267,000	89	23,000	7.67
Palestine-	21,090	8500	40.3	4408	20.9
Qatar	11,610	11,510	100*	—	—
Saudi Arabia	2,250,000	2,080,000	92.44	170,000	7.56
Somalia	638,000	87,000	13.64	534,000	82.7
Sudan	2,505,813	725,200	28.94	650,000	25.94
Syria	185,180	18,500	9.99	109,020	58.87
Tunisia	163,610	65,000	39.73	59,000	36.06
United Arab Emirates	83,600	83,600	100*	—	—
Yemen	536,869	407,182	75.84	89,687	16.18
Total	14,302,374	9,764,120	68.27	2,872,426	20.08

Source: Shakhtra (1987). The figures in this table are in line with the estimates of ACSAD in 1996 for some Arab countries and reported by Abdelgawad (1997).
*The authors believe that those countries still have some productive areas of rangelands, but their is lack of recent figures on national levels.

Table 4. Land degradation types and causes in the Arab Region (1000 Ha)

Country	Chemical degradation	Physical degradation	Water erosion	Wind erosion	Other inundated lands
Algeria	8406	—	3858	12309	1,72,378
Bahrain	—	—	—	—	—
Djibouti	—	—	54	381	—
Egypt	2486	88	—	1369	87,205
Iraq	10,457	21	1154	3090	—
Jordan	367	—	332	3237	287
Kuwait	40	—	—	281	—
Lebanon	700	—	65	—	—
Libya	1772	—	1264	23,722	97,044
Mauritania	1013	407	84	17,402	76,292
Morocco	551	—	3626	622	34,639
Oman	167	—	2772	3653	12437
Palestine-	—	—	—	—	—
Qatar	18	—	—	191	—
Saudi Arabia	2647	—	212	49,445	99,781
Somalia	234	—	2195	8872	10,543
Sudan	14157	2574	17,329	22,330	71,114
Syria	2531	21	1154	3090	—
Tunisia	862	—	3787	4023	3404
United Arab Emirates	449	—	118	1070	1665
Yemen	437	—	5582	6197	8657
Total	47,294	3111	43,586	1,61,284	6,75,446

Source: FAO (1992).

Inventory and assessment of land resources for Near East and Africa Region, paper for the 11th session of the Regional Commission on land and water use in the Near East, Tunis, Tunisia, 7–11 September.

The total area affected by wind erosion in the Arab Region was estimated at 161.3 million ha (FAO, 1992) ranging from 50 million ha in Saudi Arabia to 191,000 ha in Qatar (Table 4). This area is increasing gradually because of cultivation of marginal lands and movement of sand dune towards agricultural and rangelands (Harahash & Tateishi, 2000).

- (2) *Water erosion*: This process leads to
- Loss by removal of fertile top soils.
 - Accumulation of eroded material behind dams (siltation) in irrigation networks and on productive rangelands and agricultural lands.

The affected areas in the Arab Region were estimated by FAO (1992) to be around 43.6 million ha. The amount of eroded soil material reaches high levels, e.g., 2000 ton km⁻² yr⁻¹ (20 ton ha yr⁻¹) in Morocco and 4–9 million ton yr⁻¹ in Tunisia. In Yemen, the area affected by water erosion was about 5.5 million ha in 1992 (Table 4) and increased to approximately 12 million ha in 2000 (Yemen Environment Protection Council, 2000).

- (3) *Salinization and water logging*: This process leads to
- Accumulation of salts in irrigated arable lands.
 - Increased annual loss of large areas of valuable crop lands due to rising water table.

- Increased water consumption for leaching excess salts putting additional pressure on the limited water resources.

Salinization and/or waterlogging affect large irrigated areas in the Arab Region. Fifty percent of the reclaimed lands in the Euphrates plain in Iraq and Syria were seriously affected by salinization and water logging, and about 54% of the cultivated area in Saudi Arabia suffer from moderate salinization (CAMRE/UNEP/ACSAD, 1996). In Egypt 93% of the cultivated lands are affected by salinization and water logging. Yield reduction due to salinization and/or waterlogging amounts to 25% in Egypt and complete loss of productivity and abandoned agricultural activities in several countries (Abdelgawad, 1997).

- (4) *Loss of Nutrients*: Decline of soil fertility and productivity due to present policies of agricultural intensification and poor management practices.
- (5) *Soil and water pollution*:
 - Increased soil and water pollution with agricultural chemicals caused by inappropriate soil management and extensive use of fertilizers and pesticides in irrigated areas.
 - Accumulation of pollutants on the soil surface layer of agricultural areas close to industrial complexes.
 - Accumulation of polluting materials in both land and water resources due to hostilities (wars) in the region during the last five decades.

Governments have taken several steps to restore ecological balance in the rangelands (ACSAD, 1997). However, most of these plans have failed to produce significant results. Rangelands continue to deteriorate mainly due to fragility of ecosystems and the size of the grazing stock which far exceeds the carrying capacity of the land (UNEP, 1999).

Driving forces of desertification in the Arab Region

The complexity of the causes of desertification and the diversity of its effects make it difficult to evaluate accurately its magnitude. Estimates of the areas lost to or threatened by desertification are a matter of controversy because of the complexity and variety of the forms of desertification, and also due to the different notions of irreversibility in terms of the time-scales considered. An attempt to present the interrelations between the major driving forces for desertification in the Arab Region and their impacts is illustrated in Fig. 1.

One could identify the following major causes for desertification in the Arab Region

Population growth and urbanization

The increase in the population in the Arab Region from about 77 million in 1950 to about 288 million in 2000 (Table 5, Fig. 2) with the largest growth rate worldwide of about 3% during the period 1990–1995 (UNEP, 1992) has put considerable pressure on limited land and water resources of the region. This along with the changing life styles and consumption patterns, and the increasing food demand combined with the aridity of the environment have hastened the rate of land degradation.

Population growth and other demographic changes have led to losses of land to urbanization and the diminishing of per capita share of cultivated land in most of the countries of the Arab Region (Fig. 1). Land misuse and degradation are widespread

Table 5. *Total Population in the Arab Region, by Country (1950-2030) (in 1000)*

Country	1950	1960	1970	1980	1990	2000	2010	2020	2030
Algeria	8753	10,800	13,746	18,740	24,935	31,599	38,636	44,428	50,212
Bahrain	116	156	220	347	490	618	717	816	891
Djibouti	62	83	148	281	517	687	866	1045	1222
Egypt	21,834	27,840	35,285	43,749	56,312	68,119	80,260	90,606	1,00,616
Iraq	5158	6847	9356	13,007	18,078	23,109	30,422	38,013	44,847
Jordan	1237	1695	2299	2923	4259	6330	8458	10,735	12,976
Kuwait	152	278	744	1375	2143	1966	2390	2752	3032
Lebanon	1443	1857	2469	2669	2555	3289	3742	4193	4635
Libya	1029	1349	1986	3043	4545	6387	8724	11,448	14,301
Mauritania	825	991	1221	1551	2003	2580	3283	4054	4819
Morocco	8953	11,626	15,310	19,382	24,043	28,984	33,483	37,801	41,857
Oman	456	558	723	1130	1785	2717	3986	5610	7502
Palestine	240	302	343	451	627	975	1439	2097	2892
Qatar	25	45	111	229	485	599	693	764	796
Saudi Arabia	3201	4075	5745	9604	16,048	21,661	29,222	37,919	46,455
Somalia	3072	3785	4791	6713	8623	11,530	15,735	20,871	26,548
Sudan	9190	11165	13,859	18,681	24,061	29,823	36,850	43,760	49,619
Syria	3495	4561	6258	8704	12,388	16,126	20,468	24,563	28,089
Tunisia	3530	4221	5127	6468	8162	9837	11,410	12,832	14,167
United Arab Emirates	70	90	223	1015	1921	2444	2869	3185	3388
Yemen	4316	5247	6332	8219	11592	18,118	25,452	34,540	44,691
Total	77,157	97,571	1,26,296	1,68,281	2,25,572	2,87,498	3,59,105	4,32,032	5,03,555

Source: UN (1997) Population Division.

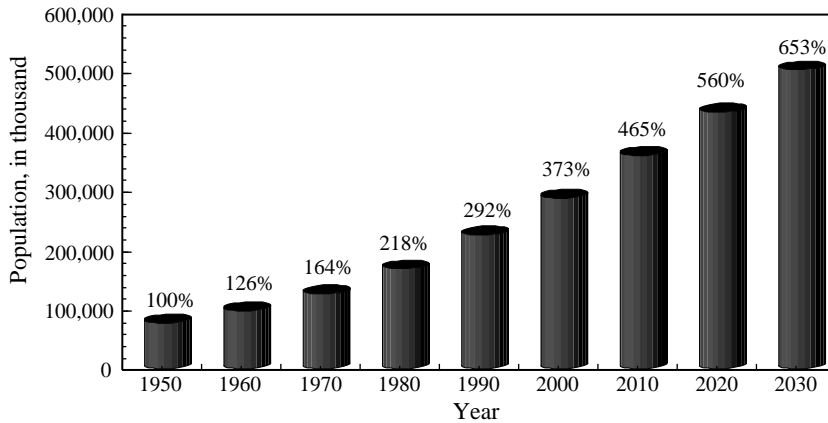


Figure 2. Population growth in the Arab Region and relative increase, 1950 = 100%.

and is proceeding at accelerated rates prompted by the ever increasing demand for food. The failure of resource management policies is aggravated by overgrazing, overexploitation and overcultivation of marginal lands, deforestation, and improper technologies employed.

The Arab Region has a relatively high urban population. At present, more than 56% of the total population live in urban areas (Table 6, Fig. 3). This figure was much less than that four decades ago, where only 23.7% of the population in 1950 were urban. Urbanization has increased since then and it is predicted to increase to 62%, 66.8% and 70.9% in the years 2010, 2020 and 2030, respectively (UNEP, 1997). The figures for West Asia sub-region are even higher. In 1995, the urban population was as high as 69.4% (UNEP, 1999). In some countries of the region nearly the whole population is urban (e.g. Kuwait, 97%; Bahrain 90%; Saudi Arabia 83% and UAE, 84%).

Urban areas consume natural resources from both near and distant sources. Cities encroach onto agricultural lands, where the urban fringes and peripheries grow faster than the cities and spontaneous or squatter settlements do it even faster. This uncontrolled growth lead to rapidly increasing amounts of wastes (solid and liquid) causing pollution of land and water resources and aggravate the desertification problem. Intensification of agricultural production to meet urban demand for food lead to heavy, concentrated use of fertilizers and pesticides causing pollution of land and water resources. This along with the fast growing industrialization near urban centers add to the active desertification process (UNEP, 1999). Efforts to control such rapid urbanization processes are numerous, but with limited success. However, the magnitude of the problem, its socio-economic impacts and the cost of mitigation need to be assessed.

Water demand and desertification

Desertification directly reduces the world's freshwater reserves (Table 2). It has a direct impact on river flow rates and the level of ground-water tables. The reduction of river flow rates and the lowering of ground-water levels leads to the silting up of estuaries, the encroachment of salt water into aquifers, the pollution of water by suspended particles and salinization, which in turn reduces the biodiversity of fresh and brackish water and fishing catches, interfering with the operation of reservoirs and irrigation channels, increasing coastal erosion and adversely affecting human and

Table 6. *Urbanization in the Arab Region, by country (1950–2030) (in 1000)*

Country	1950	1960	1970	1980	1990	2000	2010	2020	2030
Algeria	1948	3288	5430	8127	12,899	18,727	25,190	30,949	36,938
Bahrain	74	129	173	279	429	570	677	778	853
Djibouti	25	41	92	207	415	572	739	911	1084
Egypt	6971	10,541	14,894	19,178	24,743	31,297	40,456	51,098	62,226
Iraq	1812	2937	5254	8523	12,987	17,752	24,441	31,483	38,106
Jordan	429	724	1162	1752	2895	4697	6628	8707	10,833
Kuwait	90	201	579	1240	2054	1919	2343	2704	2985
Lebanon	327	735	1466	1967	2151	2951	3448	3902	4351
Libya	191	307	900	2019	3719	5597	7825	10,410	13,159
Mauritania	19	57	167	424	871	1489	2178	2865	3588
Morocco	2345	3409	5286	7969	11,596	16,035	20,621	25,188	29,685
Oman	11	20	83	356	1109	2282	3645	5228	7051
Palestine	121	207	282	406	586	922	1370	2007	2783
Qatar	16	33	89	196	436	554	650	723	757
Saudi Arabia	509	1211	2796	6325	12,602	18,572	26,008	34,252	42,500
Somalia	391	655	975	1492	2088	3170	5132	8183	12157
Sudan	579	1150	2271	3728	6405	10,772	16,566	22,667	28,617
Syria	1071	1677	2713	4066	6219	8784	12,170	15,865	19,416
Tunisia	1102	1521	2283	3323	4729	6445	8133	9654	11,108
United Arab Emirates	17	36	127	726	1554	2099	2526	2851	3076
Yemen	250	478	842	1660	3350	6886	11,702	18,055	25,969
Total	18,298	29,357	47,864	73,963	1,13,837	1,62,092	2,22,448	2,88,480	3,57,242
Urban% of total population	23·7	30·1	37·9	44·0	50·5	56·4	62·0	66·8	70·9

Source: UN (1997) Population Division.

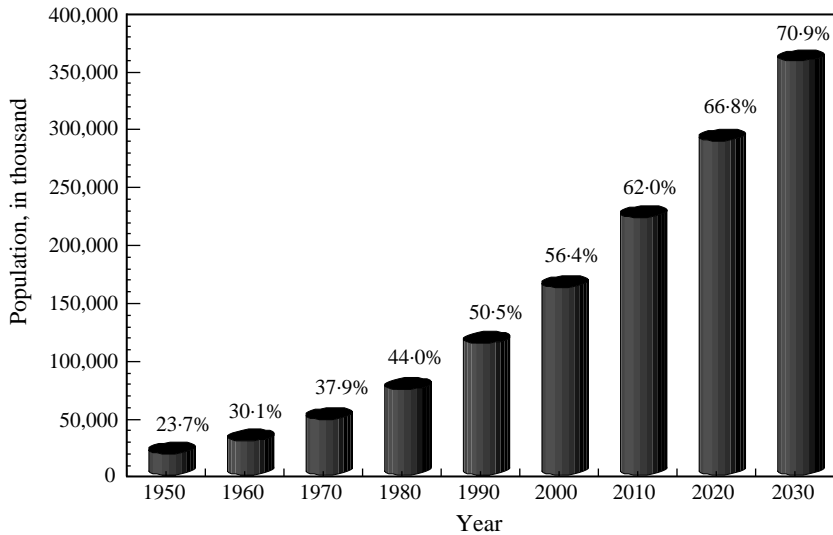


Figure 3. Urban population and percent urbanization in the Arab Region.

animal health. Lastly, desertification leads to an accelerated and often unbridled exploitation of underground fossil water reserves and their gradual depletion (Koohafkan, 1996).

Freshwater is the most precious and limited resource in many countries of the Arab Region. Freshwater resources are classified as renewable (surface and shallow ground-water) and nonrenewable (deep fossil ground-water). Rainfall is the major renewable water form in the region and amounts to about 2446 Bcm yr^{-1} (Table 7; ACSAD, 1996); most of it, however, does not contribute effectively to the wealth of the region as great part of it is lost by evaporation (high aridity) and/or runoff. Rainwater harvesting is yet to be exploited and needs proper assessment and appreciation of appropriate techniques. This would, in turn, help decrease wind and water erosion of land and hence decrease the rate of desertification.

Recent estimates of water resources in the region indicate that the total available natural water resources are $262.9 \text{ Bcm yr}^{-1}$, made of 226.5 surface and 36.3 ground-water, in addition to $11,874 \text{ Bcm}$ of nonrenewable (fossil) ground-water (Table 7; ACSAD, UNESCO, 1990; and ACSAD, 1996). There is, however, great variability among the countries in their share of these water resources. The share in Bcm yr^{-1} renewable surface water ranges between 0.0 in Kuwait and Qatar to 60.48 in Iraq, while renewable ground-water ranges between 0.11 in Bcm yr^{-1} in Bahrain and 7500 Bcm yr^{-1} in Morocco (ACSAD, 1996); fossil water resources are very low in Lebanon (1.36 Bcm) compared to Sudan and Libya which possess 4000 Bcm each (ACSAD, 1990).

The available per capita water share can be used to measure the severity of the water scarcity in the Arab Region and its development (Fig. 4). In 1950, five countries of the region faced water scarcity. Currently, results show that 16 countries are suffering from chronic water scarcity (Engelman & LeRoy, 1993). If rapid population growth and fast urbanization continue, the per capita availability of water is likely to be reduced in the Arab countries by about 50% by the year 2025. The increased use of fixed water resources in response to rising water demands is not only reducing its availability but also jeopardizing its quality, both having direct impact on accelerating the desertification process in the region.

Table 7. *Water resources in the Arab Region and predicted water demand and deficit*

Water sources, use, demand and prediction	Range		Arab Region	Source
	Minimum (Country)	Maximum (Country)		
Average annual rainfall, mm yr ⁻¹	15 (Egypt)	657 (Lebanon)	—	ACSAD (1996)
Amounts of rain, billion m ³ yr ⁻¹	0.04 (Bahrain)	1169.8 (Sudan)	2545.5	ACSAD (1996)
Renewable surface water resources, billion m ³ yr ⁻¹	0.0 (Kuwait & Qatar)	60.48 (Iraq)	226.5	ACSAD (1996)
Renewable ground-water resources, billion m ³ yr ⁻¹	0.11 (Bahrain) ⁽¹⁾	7.5 (Morocco)	36.25	ACSAD (1996)
Total Renewable water resources, billion m ³ yr ⁻¹	0.21 (Bahrain) ⁽¹⁾	64.04 (Iraq)	262.89	ACSAD (1996)
Nonrenewable water resources, billion m ³	1.36 (Lebanon)	4000 (Sudan & Libya)	11,874	ACSAD (1990)
Water use, total, billion m ³ yr ⁻¹	0.075 (Djibouti)	59,500 (Egypt)	148,755	Shahin (1989)
	0.122 (Djibouti)	63,100 (Egypt)	191,117	ACSAD (1996)
Water use, according to sector %, Agriculture	50.9 (Bahrain)	97.0 (Somalia)		Attia <i>et al.</i> (1999)
Domestic	3.0 (Iraq & Somalia)	39.2 (Bahrain)		Attia <i>et al.</i> (1999)
Industry	0 (Somalia)	12.6 (Algeria)		Attia <i>et al.</i> (1999)
Predicted water demands, billion m ³ yr ⁻¹	Year 2000	Year 2015	Year 2030	Attia <i>et al.</i> (1999)
	211.61	295.73	413.1	
Predicted total water deficit m ³ yr ⁻¹	28.303 ⁽²⁾	75.410 ⁽³⁾	173.822 ⁽⁴⁾	Attia <i>et al.</i> (1999)
Countries with no water deficit	Mauritania, Morocco, Sudan, Somalia, Algeria, Djibouti, Syria, Lebanon, Iraq, Oman, and Yemen	Mauritania, Morocco, Somalia, Algeria, Djibouti, Syria, Lebanon,	Mauritania, Morocco, Somalia, Algeria, Lebanon	

Note: (1) Al-Zubari (1999); (2) Deficit in 10 countries; (3) Deficit in 14 countries; (4) 16 Deficit countries.

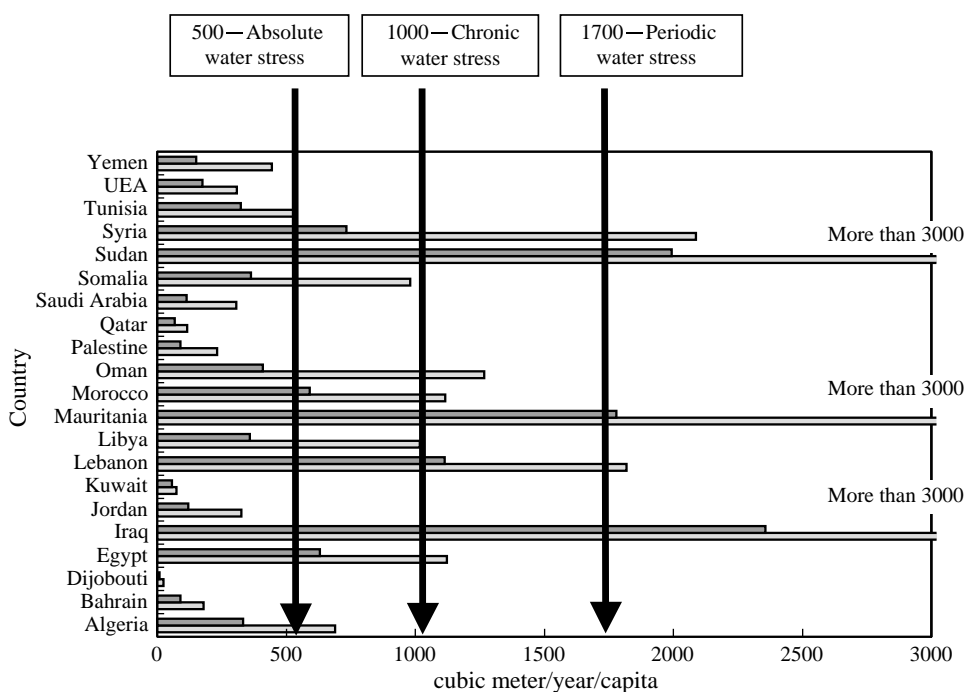


Figure 4. The available per capita water share in the Arab Region and its development. (■) 2025; (□) 1990.

Furthermore, predictions made by UNESCO and ALECSO (Attia *et al.*, 1999) indicate that the water deficit in the region (the difference between renewable water resources available and demand) will be about 28.3 Bcm in the year 2000. This figure is expected to increase to 75.4 in 2030. Water shortages will certainly speed up the rate of desertification in the region, particularly in those Arab countries with larger deficit in freshwater, (i.e. Saudi Arabia water deficit 36.5 Bcm yr^{-1} in the year 2030, Egypt 32.2; Iraq 28.0; Sudan 18.0; Libya 14.4 and Syria 5.6). Unless appropriate alternative water policies are empowered and corrective measures are taken soon, the impacts of desertification will become catastrophic in most of the Arab countries. Technologies for mitigation are known and local and international experiences are available, however, proper assessment is needed, sustainable development plans are required and allocation of sizeable financial resources at national, regional and international levels should be given top priority in future development plans.

Food security and desertification

By impoverishing the natural potential of the ecosystems, desertification also reduces agricultural yields making them more unpredictable. Therefore, it affects the food security of the people living in these areas. The people develop a survival strategy to meet their most urgent requirements, and this, in turn, helps to aggravate desertification and hold up development. The most immediate and frequent consequence of these survival attitudes is the increased overexploitation of accessible natural resources. Lastly, desertification considerably heightens the effects of climatic crises (droughts) and political crises (wars), generally leading to migration, causing suffering and even death to hundreds of thousands of people worldwide. These

consequences, in turn, weaken the economies of the countries affected by desertification, particularly when they have no other resources than their agriculture.

Intensification of agricultural on marginal lands

Subsistence farming and grazing were the main forms of agriculture prevalent on the arid lands of the Arab Region since time immemorial. By the middle of the last century, modern agricultural systems were introduced to meet increasing food and feed demand. Marginal lands and some rangelands were put under cultivation. Aridity, deforestation, overgrazing and the cultivation of field (cereals and forages), vegetables and fruit crops on rangelands have led to the deterioration of natural vegetation cover and accelerated desertification (Nahal, 1995).

Mismanagement of rangelands in the Arab Region

Rangelands occupy about 509 million ha or about 35.6% of the total area of the Arab Region (Shorbagy, 1986; Table 8) and are the main form of vegetation cover (Batanouny, 1998). The rangeland area varies with annual rainfall fluctuations. The plant cover of rangelands is characterized by low viability plant density and coverage, poor variety and plant productivity per unit area. The carrying capacity of these lands changes annually according to the varying rates and distribution of rainfall. Estimates of the annual productivity of animal feed of dry matter in kg ha^{-1} rangeland, range between 8 in Jordan and 1000 in Lebanon with an average of $276 \text{ kg ha}^{-1} \text{ yr}^{-1}$ in the Arab Region, while the total production of the dry matter from rangelands was estimated to be about 141 million ton yr^{-1} (Shorbagy, 1986). It is estimated that about 70% of the rangelands have either deteriorated (50%) or been destroyed (20%); good rangelands occupying only 20%, and 10% of the total area of rangeland are in excellent condition (Shorbagy, 1986).

In the past, nomadic tribes developed a number of forms of rangeland protection for sustainable use known as the 'Al-hema System' (protection system) which are historically among the oldest in the world (Batanouny, 1998). However at present, out of the 509 million ha of rangelands in the Arab Region about 330 million ha suffer from severe desertification (64.8%) and 150 million ha (29.5%) have moderately deteriorated (Abdelgawad, 1997). In other words, about 94% of the rangelands have been affected by desertification.

Causes of desertification of rangelands and their impacts

Drought, overgrazing and uprooting woody species for use as fuel, tillage and mismanagement of water resources are the principal causes of rangeland deterioration. Desirable range species have been slowly disappearing and several important medicinal forage plant species have been destroyed. More than 28% of grazing land in Saudi Arabia is deteriorating as a result of overgrazing, gathering of woody plants and dryland farming (Al-Khatib, 1974; Abdelgawad, 1997). Moderate to severe land degradation affects more than 90% percent of the rangelands in Oman, Qatar, Iraq, Syria, Jordan, and Lebanon (Al-Hassan, 1991; Al-Kuthairi, 1992; Shorbagy, 1986; UN-ESCWA, 1994; Batanouny, 1998; Harahash & Tateishi, 2000). Abdelgawad (1997) reported that 59.2% and 42.5% of the total area of rangelands were desertified in Sudan and Somalia, respectively.

Sheep density on some rangelands is more than one mature head per hectare, some four times the natural carrying capacity (Le Houerou, 1995). UN-ESCWA figures for sheep densities in 1990 range between 0.14 sheep head ha^{-1} rangeland in Saudi

Table 8. Landuse in the Arab Region in 1990 (area in 10³ ha)

Country	Area	Irrigated area	Seasonal crop area			Forestry	Range-lands*
			Rain-fed	Irrigated	Fallow		
Algeria	238,174	554	3016	227	3864	4061	31,615
Bahrain	69	—	—	3·0	1·0	—	20
Djibouti	2320	—	—	—	—	6·0	945
Egypt	100,160	364	108	2797	—	—	4000
Iraq	43,505	187	2392	1493	2116	1890	32,874
Jordan	8930	94	121	35	165	140	85,000
Kuwait	1782	1·0	—	3	0·2	2·0	1350
Lebanon	1040	93	210·0	—	62·0	80·0	50
Libya	175,954	350	1279	—	526	690	—
Mauritania	103,070	256	161	92	2·4	137	39,002
Morocco	71,085	614	7189	—	1700	8970	23,000
Oman	30,000	45	—	16	—	—	5311
Palestine-							—
Qatar	1143	1·4	—	4·3	6·6	0·4	700
Saudi Arabia	214,969	87	1288	—	—	1800	120,600
Somalia	63,766	17	988	—	16	9060	51,016
Sudan	250,580	70	10,500	1848	456	44,840	145,000
Syria	18,518	753	4138	575	160	723	10,179
Tunisia	16,230	2051	1712	152	875	1094	4355
United Arab Emirates	8360	20	N.A	17	—	200	1500
Yemen	52,797	57	845	215	510	4060†	16,065

Source: AOAD (1995).

*Shorbagy (1986).

Arabia to 2.75 in Lebanon. Grazing intensities of up to 19 head ha⁻¹ are recorded for Egypt irrigated pastures. Grazing intensities have more than doubled within the decade 1980–1990 in Bahrain (105%), Oman (131%) and Egypt (107%) and increased by 3–79% in the other Arab countries (UN-ESCAWA, 1993). This was made possible by heavily subsidized complementary feeding (Saudi Arabia, Al-Mutairi, 1991), and by facilitating drinking centers (Oman, Al-Kuthairi, 1992), and transport for grazing animals. Dust storms, sand dunes, desert pavements and various forms of wind and water erosion follow (UNEP, 1999).

Deterioration of forests

Deterioration of forests in the Arab Region took several forms, namely, reduction of their areas, drop in the productivity of existing forests and loss of reproduction capabilities. Accurate estimates of forest areas in the region are not available or not complete. However, some examples can highlight the seriousness of the problem. It is estimated that the annual rate of change of forest areas in the region between 1990 and 1995 is -0.8% and varied from -0.2% in Somalia to -7.8% in Lebanon (FAO, 1997, 1999). The productivity of the existing forests was also reduced; in Sudan, for example, 75% of forest productivity was lost. However, the economic value of the losses of both, area and productivity, need to be assessed. The devastating impacts on biodiversity and on social life of the local communities are obvious but no proper analysis is available so far.

Droughts, climatic changes and desertification

Droughts occur frequently in the areas affected by desertification, and are generally a feature of their natural climate. The relations between desertification and drought on the one hand, and the human influence on the other, are complex. Occasional droughts (due to seasonal or inter-year variations in rainfall) and long-term droughts covering wide areas are both caused or aggravated by the influence of man on the environment (the reduction in vegetation cover, the change in the Albedo effect, changes in the local climate, the greenhouse effect, etc.). But the degradation of land due to desertification has a serious compounding effect on drought, and thereby reduces the chances of the local people to cope with difficult periods (Hare, 1993).

Climatic changes are both a consequence and a cause of desertification. The destruction of natural grass and woody vegetation cover in dry areas affects the topsoil temperature and air humidity, and consequently influences the movements of atmospheric masses and rainfall. Furthermore, the drying of the soils and the destruction of soil cover encourage wind erosion. Even though the cycles of drought years and climatic changes can contribute to the advance of desertification, it is mainly caused by changes in the ways man uses the natural resources, mainly by overgrazing, land clearance, overcropping and cultivation of marginal lands and uprooting of woody plants, and more generally using land in a way that is inappropriate for the local conditions. Human activities connected with agriculture, livestock and forestry production vary widely from one country and from one type of society to another, as do the strategies for land use and the technologies employed.

In many cases, traditional and durable rain-fed agricultural methods (food crops and alternating fallow) and ancestral pastoral practices are no longer suitable under present-day conditions. Strong demographic pressure has increased the demand on land resources, aggravated when cash-crop farming spreads to the detriment of subsistence farming of the rangelands by nomadic peoples. However, the impact of human societies on natural resources does not depend solely on the demographic

density, and hence, the notions of 'load capacity' and 'critical threshold' must be handled with great care. Many examples demonstrate that these criteria can vary enormously, depending upon the strategies and the technologies used by the people.

Desertification also has consequences at the global level, primarily because of the influence on carbon exchange. A substantial amount of carbon stored in the vegetation in the dry zones, averaging about $30 \text{ ton ha}^{-1} \text{ yr}^{-1}$ (Koohafkan, 1996), declines when the vegetation is depleted or disappears. Furthermore carbon-rich soils, which are frequently found in dry zones, store an important amount of this element (practically half the total quantity of carbon is stored in the organic matter in soil), the destruction of these soils has a very powerful effect on the carbon cycle and boosts the greenhouse effect as a result of the depletion of carbon (Koohafkan, 1996).

Loss of biodiversity

Another consequence of desertification at the local and global level is the reduction in biodiversity, since it contributes to the destruction of the habitats of animal and plant species and micro-organisms. It encourages the genetic erosion of local livestock and plant varieties and species living in fragile ecosystems. It is extremely difficult to put a figure on this loss because of our inadequate familiarity with the features, the locality and the economic importance of the biodiversity of the dry zones. A substantial part of it, is still fairly unknown to scientists, even though some local people are still familiar with it. Reducing the biodiversity directly affects the food and health of the local people who rely on a large number of different animal and vegetable species. But it is also a loss to the whole of mankind. Many genetic strains of cultivated plants which form the basis of the food and health of the world's population originate from the dry zones; their disappearance can affect the possibility of producing plant-based medicines to combat specific diseases or epidemics (Koohafkan, 1996).

It has been estimated that there are 300,000 - 500,000 species of higher plants, of which about 250,000 have been identified or described worldwide. About 30,000 are edible and 700 have been cultivated or collected by humans for food during the history of mankind. Thus, several thousand species may be considered to contribute to food security. Today, only 30 crops deliver 90% of the world's caloric intake (e.g. rice, 26%; wheat, 23%; maize, 7%, and millet and sorghum, 4%, FAO, 1996). In the Arab Region about 25,000 plant species, one-tenth of the recorded plants of the world, were recorded, indicating the importance of this region for the world genetic resources. Most of these species are endemic to the arid and semi-arid ecosystems and 25% of species are endemic to the Arab Region of which 10% are medicinal plants (El-Eisawi, 1998). The region has lost thousands of plant varieties, strains and cultivars of vegetables and crops during the last decades, and 799 plant species are threatened to disappear from the region (Batanouny, 1996). Many of the rich and diverse forms of small mammals and birds in the region are consequently threatened (Batanouny, 1996). Despite the chronic situation and the importance of biodiversity in the region, the available data are inaccurate, incomplete and the economic impacts of biodiversity loss are not assessed.

Furthermore, desertification's destruction of vegetation may result in the loss of many critical flora species in arid and semi-arid nations. Additionally, desertification threatens fauna species by denuding critical habitats. For example, in Kuwait, desertification is one of the primary threats to several species of animals, including deer, Arab ostriches, baboons and several important apex predators (UNEP, 1997).

Despite the fact that the people of the Arab Region have traditionally made sustainable use of their natural habitats and conserved biodiversity until recently — for example through the 'Al-Hema system' of rangeland protection and by prohibiting hunting during certain months of the year— and their early efforts to screen for

genetic improvement of cereals, sheep and Arabian horses as long as 10,000 years ago (Ucko & Dimbelby, 1969), the present uses led to overgrazing, deforestation and extinction of several native plants and animals (Kingdon, 1990; Balonuet, 1990; Batanouny, 1996, 1998). However, no accurate statistics are available about the magnitude and the economic values of the losses on biodiversity and their habitats in the Arab Region.

Matrix of critical causes leading to desertification in the Arab Region

Since desertification is a long-term process —long in terms of its development and impact— it is difficult to pinpoint its cause–effect relationships. It is also difficult for the general public to understand it, other than as an existing fact of life. The public usually perceives only the consequences of desertification, such as famine, dying herds and people. Because of its long-term nature and association with other more obvious or pressing problems, decision-makers have great difficulty addressing it as a problem. A matrix of critical issues leading to desertification in the Arab Region (Table 2) has been developed as a trial to highlight the above-mentioned forms (types) of desertification, the evidence of their presence, the causes and their impacts on land, water, biodiversity resources and on human life in the Arab Region.

The adverse impacts of the above-mentioned forms and causes of desertification are continuing at accelerated rates as a result of the pressures mentioned above. If the present policies in the different Arab countries continue, such processes of irreversible desertification will become widespread and the cost of importing food and combating desertification will become a real burden on the economy and the development of the Arab countries.

Cost of desertification and mitigation measures

UNEP calculated that between \$ 150 and \$ 600 billion would be needed to be spent over a 20 year period to halt further desertification of the world's 5.2 billion ha of drylands. However, it has been estimated that the direct annual income foregone due to desertification is \$ 42.3 billion (Tolba *et al.*, 1992). The annual cost of preventative, corrective and rehabilitation measures combined are between 10.0 and 22.4 billion, less than half the costs (which do not include indirect and social costs that are difficult to calculate such as the destruction of human potential or the loss of biodiversity). In 1993, UNEP indicated that \$ 10–12 billion was required annually to assist countries affected by desertification, although the total expenditure on desertification control had amounted to less than \$ 1 billion in 1991. In 1980 it was estimated that the direct income lost due to desertification (income foregone) worldwide was about US \$ 26 billion (Tolba *et al.*, 1992). Information about the losses due to desertification in the Arab Region are not available, incomplete and need verification if available for few locations in some Arab countries. Combating desertification is costly and tends to become more extensive each year if not undertaken immediately.

A 20 year programme of direct corrective and rehabilitation measures in desertified or moderately degraded drylands would have cost in 1980 about US \$90 million. This figure has increased three-fold in an assessment made in 1990–1991 for only 30% of the drylands. The cost to combat desertification in the world drylands will be in the order of US \$200–448 billion for a 20 year programme (UNEP, 1992).

The cost to rehabilitate desertified and moderately degraded drylands in the Arab world needs to be assessed for all Arab countries. Such assessment is crucial to national development plans and should be based on the verified data on the present status of desertification, loss of land, biodiversity, economic revenues of different

activities on desertified areas and loss of job opportunities. The urgency of such assessments are accentuated by the following factors:

- The time for action is running out as desertification expands threatening new areas in each Arab country and, while combating desertification measures tend to be long-term and time consuming.
- The cost of such actions escalates from year to year, as the areas affected increase annually, the magnitude of damage grows, and prices of rehabilitation measures rise, sometimes to prohibitive levels.
- Off-site and social costs of desertification continue to increase.
- Other environmental and economic problems are competing and may distract the attention of decision-makers and donor organizations at regional and international levels.
- If the process of desertification is not arrested soon, food shortage in the region will increase dramatically, as well as the cost of food imports. The only well-documented information in the Arab Region estimates this increase to be US \$4.8 billion in 1980 to US \$23.3 billion in 1990 (FAO/RONE, 1994).

Efforts to assess and combat desertification in the Arab Region

Efforts to assess and combat desertification are numerous at local, regional and international levels. One should appreciate all these efforts, especially those of the international organizations (UNEP, FAO, UNESCO, UNDP, WB, ICARDA), those of the regional organizations (UN-ESCWA, AOAD, ACSAD, CEDARE, ALECSO), and other organizations. At the local level there have been a number of scientific conferences and symposiums on desertification, e.g., Bahrain (1993), Kuwait (1996), Saudia Arabia (2000), and Dubai (2001). Success stories of combating desertification are recorded for several countries in the region; however, the achievements were limited to small areas, the approaches were in many cases neither integrative nor well financed and their impacts on the desertification problem were minimal.

During the last two decades (1979–1999) projects to prepare national plans of action to combat desertification (NPACD) for almost all countries of the region were developed by UNEP, UN-ESCWA, FAO, and other international organizations (UN-ESCWA, 1993). The NPACDs along with studies, research and training activities carried out by ACSAD, ICARDA, FAO, CEDARE and national and regional institutions aimed at improving utilization methods of the available natural resources in a way compatible with the principles of sustainability. However, by the end of this century and inspite of continuous efforts to combat desertification and mitigate the effect of droughts and desiccation, desertification is still one of the major environmental problems in the region.

There is a shortage of material, research results, pilot projects, and recommendations about the causes and impacts of desertification phenomenon and national and international action to halt its spread and reverse its processes. After more than three decades of planning and implementation in the Arab Region to date, evidence indicates that little has been achieved and actually desertification continues to intensify, and hence, aggravating the loss of land productivity and lowering its capacity to support the growing population. One should, therefore, raise the question: assuming that comprehensive efforts to combat desertification will succeed, would we be able to meet the human carrying capacity in the Arab Region? This question, although outside of the domain of the present paper, is of great importance and worth thorough investigation.

Limitations

Despite the intensive efforts to combat desertification and drought in the Arab Region, the problem is continuing to be on top of the agenda of all concerned institutions at national, regional and international levels. Constraints that hinder the reversal of the desertification processes are mainly due to the lack of:

- Adequate and validated information on the different aspects of the problem.
- Integrated land-use plans and policies.
- Well-identified sustainable development plans for desertified areas.
- Appropriate integrated natural resource management policies.
- Application of appropriate technologies for efficient land and water uses.
- Allocation of financial resources.
- Active awareness campaigns.
- Neglect of local stakeholders (local communities and nomadic groups).
- Targeted appropriate training on assessment and mitigation of desertification.

Future outlook

The problem of desertification is manageable, in principle, as can be seen by numerous examples of achievements given for several Arab countries, although they were limited to certain aspects of desertification and to some locations. Improvement of irrigation systems and water management practices, introduction of new advanced technologies into rain-fed agriculture, improvement of rangeland management and animal husbandry technologies, fixation of shifting sands and reforestation of denuded lands, conservation and sustainable use of biodiversity, and provision of new alternative employment of local people all were successfully achieved in several locations in some Arab countries and proved their technical feasibility. Extending these achievements at the national level, however, need political will and economic resources with due consideration given to social aspects of the development process in order to be effective and sustainable. Such actions are badly needed and require adequate and accurate information in order to prepare well-identified action plans for combating desertification, accurate assessment of the affected resources, the economic losses due to desertification, the real cost to mitigate and the revenues of desertification programmes.

The indigenous experience and successful efforts in the Arab Region to combat desertification as well as the enormous research findings gathered during the last four decades about effective technologies, techniques and approaches to improve productivity of natural resources call for collective and co-ordinated work at the level of the Arab Region to:

- Identify the magnitude of the different causes for desertification and evaluate the actual implications on natural resources in the different Arab Countries.
- Assess the economic losses and cost of mitigation based on real successful trials, which are applicable to similar localities in Arab countries.
- Survey the indigenous and new modern technologies for combating desertification in the region.
- Establish a regional database for desertification in the Arab countries capable of providing efficient services to all countries in the region.

This task can be achieved through the commitment of national and regional research institutions and authorities in the Arab region with support (technical and financial) of the international bodies concerned with the desertification problem.

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