

Aridity, Drought and Desertification

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I. INTRODUCTION

The Arab region extends from the Atlantic coast (Morocco, Mauritania) in the west to the Arab Gulf in the east. It occupies the main part of the Afro-Asian desert. With the exception of the humid and rainy territories in the coastal highlands of Morocco, Algeria, Tunisia, and Lebanon, southern Sudan, and the Iraqi highlands, the region is part of the arid belt that extends across Africa north of the equator to West Asia (the Arab Peninsula and its adjoining territories). The Arab region comprises the southern sector of the Mediterranean basin (winter rainfall), and extends southwards to territories of summer rainfall (tropical) in Mauritania, Sudan, Somalia, Djibouti, Yemen and Oman. On the whole, aridity prevails, and habitable territories are limited.

The Arab region is crossed by a limited number of large river basins: the Nile (Egypt and Sudan), the Euphrates and Tigris (Iraq and Syria), and Yarmuk (Syria and Jordan). Other small rivers are present in Lebanon, Morocco, Algeria and Tunisia. Underground aquifers are present all over the region: Nubia Sandstone aquifers prevail in north-east Africa (Egypt, Sudan, Libya and Chad), limestone aquifers prevail in Morocco, Mauritania, Algeria and Tunisia. A diversity of aquifer formations extend in the Arabian Peninsula. The water of these aquifers is available under artesian pressure in oases, but otherwise requires pumping that is

often expensive. Saudi Arabia and Libya have embarked on large-scale schemes of exploiting underground water resources. In Egypt the East-Oweinat project of land reclamation depends on underground water resources.

The area of the Arab region extends over 13.8 million km². Of this area, 3.4% is farmlands (crops, orchards, vegetables, etc.), 18.8% rangelands, and 10% forests and woodlands. This means that the total productive lands (4.1 million km²) represent just over 30% of the total area, while the remaining territory is very arid. These proportions vary considerably: productive lands represent 30% of the total areas of Syria and Lebanon, 3% in Egypt, Algeria and Sudan, to a minimum of 0.5% in Saudi Arabia, Oman and Mauritania.

The map (Fig. 1) shows isohyets (annual rainfall) in the Arab region (from Atlas of Arab Homeland, pp. 38-39, 1995). It shows that low rainfall prevails in most of the territories of the region.

Land resources in the Arab region face three main issues: aridity, recurrent drought, and desertification. Aridity relates to shortage in water resources: water income less the expenditure (potential evapotranspiration). Aridity is widespread in drylands of the world, where a shortage of water prevails through the whole, or most of, the year. Aridity may be assessed on the basis of (1) climate variables (index of aridity), or (2) number of days when water balance favours plant growth (length of growing season).

Low rainfall is the salient feature of aridity. But it is the efficiency of rainfall that matters. Efficiency is high with low temperatures and high humidity: low evapotranspiration; efficiency is low with high temperatures and low humidity: high evapotranspiration. Several formulae have been suggested for calculating the index of aridity. The UNEP *Atlas of Desertification* (1992) adopted the simple formula:

index of aridity = rainfall (mm)/ potential evapotranspiration.

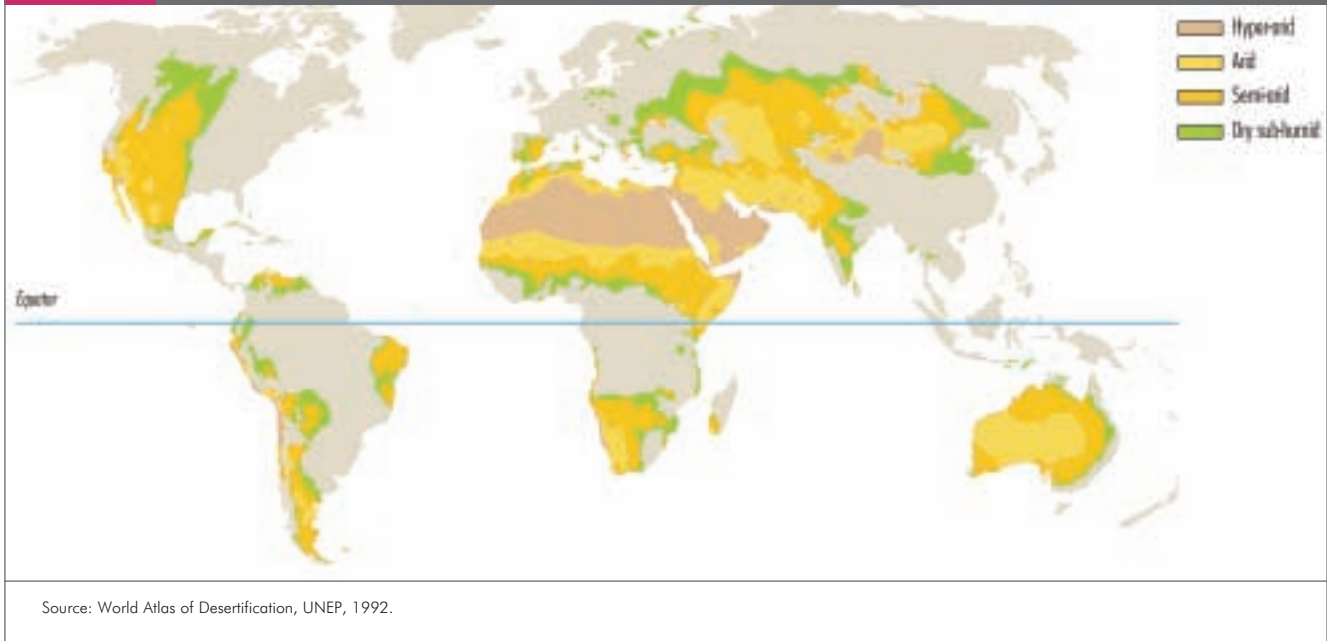
Drylands are accordingly classified into:

- extremely arid, aridity index = less than 0.05,
- arid, aridity index = 0.05 – 0.2, (200 mm. in winter rainfall territories, 300 mm. in summer rainfall territories).



FIGURE 1

MAP SHOWING THE WORLD DRYLAND. THE ARAB REGION OCCUPIES THE HEART AREA OF WORLD DRYLAND. ARIDITY ZONES OF THE WORLD



- semi-arid, aridity index = 0.2 – 0.5 (500 mm. in winter rainfall territories, 800 mm. in summer rainfall territories).
- dry sub-humid, aridity index = 0.5 – 0.65.

Within the boundaries of this classification, drylands occupy 47.2% of the terrestrial areas of the world: 7.5% is extremely arid, 12.1% arid, 17.7% semi-arid and 9.9% dry sub-humid.

The FAO classification based on “length of growing season” gives the following divisions: less than 120 days in drylands, 74 days or less in arid lands, and 75-115 days in semi-arid lands. The FAO assessment adds that arid lands climate is characterized by rainfall that is low and variable; this in turn means low and variable crops and livestock. This classification is based on rates of land productivity that depends on the volume of rainfall and its season.

Drought, a recurrent feature of rainfall in the world’s drylands, means that available water resources are less than average (calculated through finding the means of a series of years). It may be manifest as:

- rainfall less than average,
- river flow less than average,
- groundwater resources depleted.

Management of drought is comparable to management of other natural hazards, and comprises three principal elements: a system of early warning, a system of societal preparedness, and an enabling system that provides support and assistance to imperilled societies.

Desertification as defined in the UN Convention to Combat Desertification is “land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variation and human activities.” Land is defined as “the terrestrial bio-productive system that comprises soil, vegetation, other biota, and the ecological and hydrological processes that operate within the system.” Land degradation is defined as “reduction or loss, in arid, semi-arid and dry sub-humid areas, of the biological or economic productivity and complexity of rainfed 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.”

The three principal productive land systems in the drylands are: irrigated farmlands where additional water resources are available (rivers, underground aquifers), rainfed farmlands (in semi-arid

TABLE 1 AREAS (1000 HA) OF IRRIGATED FARMLANDS (I.F.), RAINFED FARMLANDS (R.F.), RANGELANDS (R.) AND EXTREMELY ARID LANDS (D) IN ARAB COUNTRIES

Country	I.F.	R.F.	R.	D.	Total
Algeria	338	6,934	38,120	190,063	235,455
Bahrain	1	0	50	0	51
Egypt	2,486	10	2,604	94,900	100,000
Iraq	1,750	1,950	38,395	0	42,095
Jordan	43	375	6,862	1,820	9,100
Kuwait	1	0	2,306	0	2,307
Lebanon	86	214	688	0	988
Libya	234	1,659	17,172	157,655	176,720
Mauritania	8	170	59,173	43,702	103,062
Morocco	525	7,484	36,693	1,050	45,752
Oman	41	6	19,642	7,506	27,195
Pal. + Israel	271	147	369	1,246	2,033
Qatar	0	4	876	220	1,100
Saudi Arabia	415	760	112,345	126,480	240,000
Somalia	16	1,039	60,669	1,260	62,984
Sudan	1,700	5,108	142,542	68,700	218,050
Syria	652	4,971	12,945	0	18,568
Tunisia	215	4,258	7,968	3,037	15,478
UAE	5	0	1,008	8,197	9,210
Yemen	309	1,209	32,590	1,692	35,800

Source: Dregne & Chou, 1992

and dry sub-humid territories), and rangelands. To this we may add scrub and woodlands (within rangelands and rainfed farmland) and tree belts planted as shelterbelts to conserve land and combat soil erosion (and to provide fuelwood). Desertification is manifest in diverse forms according to land use. In irrigated farmlands degradation relates to imbalance between excessive irrigation and poor drainage. This results in waterlogging, salinisation, etc. In rainfed agriculture degradation relates to soil erosion, loss of soil organic content, depletion of nutrients, etc. In rangelands, degradation relates to loss of plant cover and capacity of range to provide for feed needs of livestock, invasion of non-palatable species. An FAO (1982) report refers to desertification as the breakdown of the fragile balance that provides for plants, animals and man to survive in arid, semi-arid and dry sub-humid territories. This breakdown relates to physical, chemical and biological factors and presents the initiation of a self-destructive process of all aspects of life. Soil is exposed to erosion by water and wind, groundwater becomes deeper, plant life is impaired and its ability to compensate losses decreases. These are all outcomes of desertification.

II. LAND AND WATER RESOURCES

Table 1 provides estimates of areas of land use in the Arab countries, giving a broad picture of land resources. Estimates are subject to yearly changes due to land reclamation programmes, afforestation and range management schemes, land transformation due to non-agricultural land-uses (urban sprawl, roads, etc) in urban and rural areas, and due to land degradation (desertification).

Figures in Table 1 show that certain countries (e.g. Egypt) are riverain oases that depend on irrigated agriculture, and where rainfed farmlands are limited, and while rangelands seem extensive their contribution to agricultural economies is poor. In countries like Algeria, Morocco, Tunisia, Syria and Yemen, rainfed agriculture represents the principal element of farmlands. Rangelands in Sudan, Somalia, and Saudi Arabia are extensive; Sudan and Somalia are exporters of livestock products. Balance among the three principal land use systems prevails in Sudan, Iraq and Syria.

The following are general comments on the figures in Table 1:

- About half of all territories are extremely arid lands (deserts) that may be agriculturally reclaimed wherever water resources are available (groundwater). Other land uses (oil and mineral production, urban settlements, industrial centres, etc.) are welcome prospects.
- Rangelands seem to occupy the main bulk of productive Arab territories, and these are territories prone to desertification.
- Rainfed farmlands areas occupy four times the total area of irrigated farmlands, but are prone to desertification, and their share of agricultural production is often less than that of irrigated farmlands.
- All agriculturally productive lands in the Arab countries are fragile systems prone to degradation. It may be stated that desertification is the prime threat to productive lands in the whole Arab region.
- In some of Arab countries where precipitous highlands prevail (e.g. Yemen), rainfed farming depends on the establishment and maintenance of terraces and contour-lines that conserve soil and water. These are labour-intensive structures. Emigration of labour from Yemen to oil-rich countries caused labour shortages that led to degradation of these conservation structures. Again the 20th century witnessed change in agriculture on the Yemeni slopes from productions of traditional Arab coffee to production of qat; this is a special socio-cultural change.
- Rangelands in arid territories are prone to incidents of drought (rainfall below average). Range societies have, all through history, managed to survive through nomadism or transhumance: across-country movements of herders and their flocks from territories of water shortage to less austere territories. Nomadism is a societal mechanism for survival under conditions of extreme variability of water resources (such as rainfall). Nomadism is often a seasonal journey from winter ranges to summer ranges. An extreme case is the Gizzu range, where rainfall is not an annual event but an event that may only happen once in several years. When it

happens in otherwise rainless territories, e.g., northern Sudan, news attracts herders who with their flock to travel several hundreds of kilometres to take advantage of the almost accidental growth of vegetation (see El Shamy, 1965).

- While areas of food-producing land may have increased through land-reclamation projects, populations have increased at higher rates, and the balance between production and the needs of people has been upset. Many Arab countries (e.g. Algeria and Syria) were till the mid-20th century wheat exporters; now all Arab countries import considerable volumes of their food needs.
- The GEO 4 report (UNEP, 2007) sums up the situation in the eastern Arab region (12 Arab countries in the Gulf and Arab Peninsula): at the beginning of the 21st century 79% of land is impaired, 98% of which damaged by man and ill-management.

In Table 2 estimates are given of water resources available in the Arab region in 1996, as presented by a study of the Arab Centre for Studies on Arid Lands (ACSAD) and the Arab Fund for Development (1997).

The general picture is that the Arab region falls within the category of water stress areas (less than 1,000 m³ of water per head/ year).

Water resources in Jordan and Palestine rest at the lowest levels. In the Gulf states the role of desalination establishments is evident as a principal source of freshwater. Riverain countries with rich resources that provide for irrigated farming (Iraq, Syria, Egypt and Sudan) are downstream countries in international river basins; this is a situation conducive to conflicts, a situation that is prevalent around all international river basins.

The GEO 4 report (UNEP, 2007) addresses the state of water resources in the region:

The per capita share of available water resources per year decreased from 1,700 m³ in 1985 to 907 m³ in 2005, and is expected to decrease further to 420 m³ by 2050.

Riverain countries in the region need to enact regional river basin conventions that establish a

TABLE 2 WATER RESOURCES (MILLION M³/YEAR) IN ARAB COUNTRIES, 1996 ESTIMATES

	Traditional Resources		Non-traditional resources			Total
	Surface	Ground	Desal.	Agr.Dr.	Sewage	
Algeria	13,000	2,000	74.6	-	400.0	15,474.6
Bahrain	8	112	73.0	-	11.0	206.0
Egypt	55,570	4,100	31.7	3,800	600.0	64,101.70
Iraq	60,480	3,419	7.4	-	-	63,906.40
Jordan	692	276	3.0	-	51.0	1,022
Kuwait	-	182	350.0	-	42.0	574.10
Lebanon	4,800	4,250	1.7	-	2.0	9,053.70
Libya	397	650	210.0	-	110.0	1,367
Mauritania	5,800	1,500	1.7	-	67.6	7,369.30
Morocco	22,500	7,500	1.2	-	350.0	30,351.20
Oman	1,450	475	47.3	-	5.5	1,977.80
Palestine	306	185	-	-	-	491.0
Qatar	-	40	98.6	-	35.4	174.0
Saudi Arabia	3,210	2,340	7.95	-	100.0	6,445.0
Somalia	8,160	3,300	0.1	-	-	11,460.10
Sudan	26,000	1,000	0.6	-	-	27,000.60
Syria	16,375	5,075	2.0	1,270	-	22,722.0
Tunisia	2,700	1,200	8.7	-	6.0	3,914.70
UAE	185	120	385.0	-	108.0	798.0
Yemen	3,500	1,550	9.0	-	6.0	5,065.0

Note: Surface= rivers, Ground= aquifers, Desal= desalination, Agr.Dr= agricultural drainage, Sewage= treated sewage water. Source: ACSAD, 1997

framework of just and fair sharing of river resources (water and energy). The Nile Basin Initiative that is being elaborated by the ten countries of the Basin is a good example of action in the right direction.

Overexploitation of groundwater resources, which are mostly fossil (non-renewable), poses further threats to the water resources issues at present and in the future.

Exposure of surface and underground waters to pollution from industrial, agricultural and domestic sources, and especially from new urban centres, is a hazard that threatens water sources and human health. This is an especially important issue in Egypt where several land reclamation projects depend on the re-use of agricultural drainage water (15 billion m³ discharged into the northern lakes and the Mediterranean).

The high rates of water consumption in human settlements, exacerbated by increasing populations in Gulf cities, are issues that need to be addressed. Daily per capita water consumption ranges between 300 and 750 litres, among the higher ranges by world standards.

Water use by agriculture in the eastern Arab countries increased from 73.5 billion m³ in 1990 to 90 billion m³ in 2000.

From these comments, which may be repeated for the western section of the Arab region, it is evident that issues of freshwater (development of resources, protection against pollution, rational use of its limited resources) set one of the clear priorities for the Arab region. National and regional capacities in fields of science, technology and management to address such issues should be mobilized to guide water resources management in the region.

III. DESERTIFICATION IN THE ARAB REGION

Most of the territories of the Arab region fall within the boundaries of arid lands, where land degradation, primarily desertification, reduces abilities to produce. To clearly present an assessment of land degradation, we may remember that productive lands in arid regions include: irrigated farmlands, rainfed farmlands, and rangelands and animal husbandry. To this we may add



that man obtains his fuel (agricultural residues, wood from shrubs and trees) and other materials (drugs, etc.) from the products of land.

Table 3 gives estimates of irrigated farmlands and rates of their degradation in the Arab countries. Besides the low or slight degradation category (10% loss), we may consider losses (income foregone) of medium (10-25% loss), severe (25-50% loss) and very severe (more than 50% loss). This provides a useful measure of degradation (area of degraded lands as percentage of the total irrigated farmlands). The overall estimate of land degradation is 34% which is near the world estimate of 30% (Dregne et. al, 1991).

Irrigated agriculture depends on the water resources of principal rivers in Egypt, Sudan, Syria and Iraq. Land degradation ranges from 17% in Syria to 70% in Iraq. The history of irrigated agriculture in Iraq (Mesopotamia) is old; it is the cradle of irrigated farming. All through its long history the rise and fall of agriculture related to the state of governance: political stability and rational government meant maintenance of irrigation and drainage networks and hence

flourishing of agriculture, and vice versa (Jacobson, 1958). Land degradation in river basins means imbalance between irrigation and efficiency of drainage. Conservation of land in irrigated farmlands requires undertaking projects to correct and maintain drainage networks (open drains and networks of tile-drains).

In irrigated farmlands that depend on small rivers or on underground water resources, excessive irrigation is not prevalent, but drainage networks are often limited or absent. Saudi Arabia is a special case (desertification 63%): here degradation does not relate to poor drainage and waterlogging (as is prevalent in lands of major river basins), but relates to failure in the management of water resources due to excessive use.

Studies presented to the UN Conference on Desertification in 1977 included a case-study on land degradation in irrigated farmlands in Iraq: the Greater Mussayeb Project. Work in this project extended for long years, aiming at reclaiming degraded lands and conservation of productive lands. The study showed that reclamation depends on a "packet of means" that

TABLE 3 ESTIMATES (1000 HA) OF DEGREE OF DESERTIFICATION IN IRRIGATED FARMLANDS (I.F.) IN ARAB COUNTRIES

Country	I.F.		Degree of desertification				%
		s	m	sv	vsv	m+	
Algeria	338	288	40	10	0	50	15
Bahrain	1	1	0	0	0	0	0
Egypt	2,486	1,735	700	50	1	751	30
Iraq	1,750	500	750	300	200	1,250	70
Jordan	43	30	10	3	0	13	30
Kuwait	1	1	0	0	0	0	0
Lebanon	86	80	6	0	0	6	7
Libya	234	179	50	5	0	55	24
Mauritania	8	7	1	0	0	1	12
Morocco	525	474	51	0	0	51	10
Oman	41	30	11	0	0	11	27
Pal. + Israel	271	230	31	10	0	41	15
Qatar	0	0	0	0	0	0	0
Saudi Arabia	415	155	200	40	20	260	63
Somalia	16	13	3	0	0	3	19
Sudan	1,700	1,340	350	10	0	360	21
Syria	652	542	70	30	10	110	17
Tunisia	215	145	60	10	0	70	33
UAE	5	3	2	0	0	2	40
Yemen	309	259	40	10	0	50	16

Note: s= slight, m= medium, sv= severe, vsv= very severe, m+=medium+severe+very severe. Source: Dregne & Chou, 1992

comprises: technical, economic and social means. Success requires integration of all elements. The situation in the Greater Mussayeb area is closely similar to problems of irrigated farmlands in the Indian sub-continent (a second case-study came from Pakistan, see Mabbut and Floret, 1980); similar conditions prevail in Syria, Egypt and Sudan. Lessons learned show that the way to combat desertification combines: technical means (completion, conservation and reclamation of drainage network; soil reclamation by adding conditioners as gypsum, etc.); and economic means relating to prices of reclaimed land, taxes, systems of agriculture subsidies and crop marketing. We may note that the World Bank and related agencies promote the idea of “pricing irrigation water” as a means of limiting excessive irrigation. Societal means include forming farmers’ organizations and land lords’ associations, that would be capable of providing support to farm management, enacting rules for owner-farmer and farmer-labour relationships, and setting rules of participation for all stakeholders in planning for development and in implementation of plans.

Table 4 provides estimates of land degradation in rainfed farmlands in countries of the Arab region. Rainfed farmlands prevail in semi-arid and dry sub-humid territories (annual rainfall more than 500 mm). Estimates of the total combined area of these lands in the Arab region amount to 36 million ha, degraded lands amount to 67%, compared with a world average of 47%.

Greater rainfed farmlands are present in Morocco (7.4 million ha), Algeria (7 million ha), Sudan (5 million ha) and Tunisia (more than 4 million ha). Countries with less rainfed farmlands include Libya, Somalia, Iraq and Yemen (1-2 million ha, each). Estimates of desertification (medium and more) are highest in Algeria (93%), and are also high in Morocco (69%), Tunisia (69%) and Syria (70%). The figure is less (41%) in Sudan.

Aspects of desertification in rainfed farmlands include:

- Soils are subject to erosion (wind-water) damage, through which organic matter and nutrient-rich surface layers are removed. Land dam-

TABLE 4 ESTIMATES (1000 HA) OF DEGREE OF DESERTIFICATION IN RAINFED FARMLANDS IN ARAB COUNTRIES

Country	R.F.	Degree of desertification					%
		s	m	sv	vsv	m+	
Algeria	6,934	484	5,800	600	50	6,450	93
Bahrain	---	---	---	---	---	---	---
Egypt	10	9	1	0	0	1	10
Iraq	1,950	550	1,150	230	20	1,400	72
Jordan	375	165	155	54	1	210	56
Kuwait	---	---	---	---	---	---	---
Lebanon	214	84	90	39	1	130	61
Libya	1,659	1079	540	40	0	580	35
Mauritania	179	150	27	2	0	29	16
Morocco	7,484	2284	4.9	270	30	5,200	69
Oman	6	3	2	1	0	3	50
Pal.+Israel	147	47	35	63	2	100	68
Qatar	4	3	1	0	0	1	25
Saudi Arabia	760	300	420	38	2	460	61
Somalia	1,039	489	450	95	5	550	53
Sudan	5,108	3018	1,870	205	15	2,090	41
Syria	4,971	1,471	2,840	650	10	3,500	70
Tunisia	4,258	1318	2,500	400	40	2,940	69
UAE	---	---	---	---	---	---	---
Yemen	1,209	429	700	73	7	780	65

Note: s= slight, m= medium, sv= severe, vsv= very severe, m+=medium+severe+very severe. Source: Dregne & Chou, 1992

aged by gullies, surface crusts that impede water percolation to root zones and increase surface runoff.

- Increases in crop losses by pathogenic and parasitic pests.
- The net outcome is a reduction of crop yields from land units (per hectare); this is “income forgone.”

One important factor in this area related to rises in population (increase in density), and hence increased competition for land, is the subsequent reduction in periods of fallow that are necessary for soil recuperation. Deficiencies or improper management of soil conservation measures such as bunds, contour terraces, shelterbelts, etc. are added causes for degradation.

Relationships between rainfed farmlands and rangelands could be “integration” when farmers and herders agree that herds may use farmland stubble (after harvest), and the soil would benefit from livestock droppings. Conflicts between the two groups arise when farmers expand their used lands onto rangelands, often in years with above-

average rainfall. Conflicts between tribes of farmers and rangers are societal issues that are parts of the history of the Sahel (sub-Saharan Africa).

Table 5 provides estimates of degradation in rangelands of the Arab countries. Rangelands are extensive (more than 593 million ha), rates of desertification (medium and more) here amount to 83%, higher than the world average of 73% (Dregne et al, 1992). Rangelands extend from the fringes of arid and semi-arid zones, and show gradation from cattle herds in semi-arid territories, to sheep and goat herds in arid territories, and camels in nomadic ranges.

Grazing lands in arid territories may not be widespread but can be confined to water-collecting sites in *wadis* and depressions. In semi-arid territories (annual rainfall 500 mm.) grazing lands are more spread out. Grazing and livestock husbandry are associated with transhumance: travel seeking plant growth. Journeys may be seasonal (summer range – winter range) or may be accidental in years of drought. Nomadism is part of the traditional

culture of the whole of the Arab region. In all cases rangeland degradation is caused by overgrazing, that is, exploiting the range beyond its carrying capacity.

Countries with extensive rangelands include Algeria, Iraq, Mauritania, Morocco, Saudi Arabia, and Sudan. Rates of desertification may be as high as 80%.

If we apply cost estimates of desertified lands (income forgone, Dregne and Chou, 1992): \$250 per ha in irrigated farmlands, \$38 per ha in rainfed farmlands, and \$7 per ha in rangelands, we calculate that yearly income foregone in the Arab region due to desertification is about \$5 billion. This may sound little compared with the total GNP of the region including the oil rich countries. But while traditional land uses including grazing may have receded in oil-producing territories, development programmes in all Arab countries, including Saudi Arabia and Gulf states, include agricultural schemes with a view to securing – at least partly – food security.

IV. COMBATING DESERTIFICATION IN THE ARAB REGION

Sudan was the site of earlier studies on “desert creep” and “desert encroachment” published between 1937 and 1953 (see Stebbing 1937, and Kassas 1970). The regular pattern of isohyets in the midlands of Sudan (between isohyet 200 mm and isohyet 800 mm) is associated with a regular pattern of vegetation types in belts from the arid north to wooded Savanna belts in the south. In west Sudan, Kordofan and Darfur (sand), and east Sudan, Butana and Gezira (clay), patterns of vegetation structure are similar though species are different. These patterns made possible the monitoring of change and degree of degradation by comparing maps (and aerial photographs) over a sequence of years. Land degradation causing deterioration of rangeland, degradation of gum arabic producing territories in the west and rainfed farmland in the east were matters of concern to government agencies and research institutions.

The Government of Sudan (Ministry of Agriculture and the National Research Council), with technical assistance of UNDP and FAO, for-

mulated a national plan for combating desertification and rehabilitation of degraded lands. The plan and programmes of action (projects) were completed in 1976, one year before the UN Conference on Desertification (UNCOD, 1977). The Sudanese document (DECARP, 1976) was presented to the UNCOD. This pioneering programme comprised 3 principal elements:

- 1- A unit for monitoring and assessment, preparing maps of environment and natural resources, and surveillance of land degradation.
- 2- A central unit for managing the programmes of action and providing supporting measures (training, public awareness, public participation, etc.).
- 3- Programmes (groups of field projects) for corrective actions (rehabilitation, reclamation, etc), and for establishing reserve areas. Special attention was given to rehabilitation of rangelands and the gum arabic belt, stabilization of sand formations, building green belts around towns and villages, and development of water resources.

The Government of Sudan – with international aid – implemented several of the DECARP projects. In 1984 the Sudanese Ministry of Agriculture with the assistance of UNEP set the second phase of the national plan guided by the UNCOD Plan of Action. This phase addressed in particular rehabilitation of rainfed farmlands in east Sudan and gum arabic belts in west Sudan.

Tunisia is one of the pioneering Arab countries in fields of survey of natural resources, land degradation, conservation of biodiversity and establishing nature reserves. Tunisia has a well perceived atlas of scientifically based maps. Features of desertification (land degradation) prevail in areas estimated to be 10 million ha, 64% of the total area of Tunisia. Aspects of desertification include:

- The number of grazing animals increased from 4 million to 7 million, leading to overgrazing.
- Water erosion menaces some 60% of farmlands, with one consequence being the silting of water reservoirs.
- Wind erosion is evident in building of sand bodies, and encroachment of sand dunes over productive lands.
- Salinisation of land expanded salt-affected areas (sebkhas), reaching 557 thousand ha.

TABLE 5 ESTIMATES (1000 HA) OF DEGREE OF DESERTIFICATION IN RANGELANDS IN ARAB COUNTRIES

Country	R	Degree of desertification					%
		s	m	sv	vsv	m+	
Algeria	38,120	3,820	9,200	25,000	100	34,300	90
Bahrain	50	40	10	0	0	10	20
Egypt	2,604	504	300	1,800	0	2,100	81
Iraq	38,395	3,815	7,000	27,250	250	34,500	90
Jordan	6,862	662	1,150	5,000	50	6,200	90
Kuwait	2,306	346	1,558	400	2	1,960	85
Lebanon	688	68	195	400	25	620	90
Libya	17,172	3,472	1,700	11,800	200	13,700	80
Mauritania	59,173	17,773	5,000	36,000	400	41,400	70
Morocco	36,693	3,693	3,000	29,900	100	33,000	90
Oman	19,642	1,942	5,000	12,650	50	17,700	90
Pal.+Israel	369	39	80	230	20	330	89
Qatar	876	86	100	685	5	790	90
Saudi Arabia	112,345	22,345	60,000	29,800	200	90,000	80
Somalia	60,669	15,669	10,000	34,900	100	45,000	74
Sudan	142,542	28,540	30,500	83,000	500	114,000	80
Syria	12,945	1,345	3,000	8,550	50	11,600	90
Tunisia	7,968	1,168	1,270	5,500	30	6,800	85
UAE	1,008	108	198	700	2	900	80
Yemen	32,590	6,590	10,000	15,900	100	26,000	80

Note: s= slight, m= medium, sv= severe, vsv= very severe, m+=medium+severe+very severe. Source: Dregne & Chou, 1992

- Forested areas decreased, by cutting and incidents of fire, and due to clearing for expansion of farmlands.
- Area of alfa-grasslands decreased from 950 thousand ha in 1931 to 433 thousand ha in 1985.

One of the case studies presented to UNCOD (1977) prepared by Tunisia, with assistance of UNESCO and UNEP, addressed desertification in the Oglat Merteba Region representing winter rainfall (Mediterranean) drylands, an area of 20,000 ha. The study provided analyses of land degradation and means for rehabilitation (Mabbut and Floret, 1980).

In 1985, Tunisia completed – with international assistance – setting a national plan of action to combat desertification guided by the UNCOD (1977) world plan of action. The Tunisia plan comprised 21 projects of corrective measures with estimated costs of implementations of 50 million Tunesian Dinar. The Government managed to mobilize international aid and national resources to implement most (14) of these projects.

Other Arab countries set national action plans in the light of the UNCOD world action plan: examples are Mauritania (principal issue movements of sand formations) and Yemen (principal issue conservation of mountain slopes and of water resources).

Several Arab countries responded to the UN Convention for Combating Desertification (1994) by revising earlier plans or preparing new ones. An example is the national action plan prepared by Egypt (Desert Research Centre). The plan envisaged two frames: a set of thematic land use systems (irrigated farmlands, rainfed farmlands, rangelands and sand movements) and a set of four eco-agricultural regions (coastal belt of north Egypt, Nile Basin and Delta, oases and remote areas of western desert, deserts in Eastern Egypt and Sinai). A matrix of the two sets indicates areas of action. To this is added a programme of supporting measures: field surveys, monitoring, manpower development, and societal participation. (For details see ACSAD, 1996.)

The Arab countries established science institutions capable of addressing issues of arid lands,

dealing with conservation and development of natural resources; ACSAD (Damascus) and ICARDA (Aleppo) are two of these regional institutions. The Council of Arab Ministers of Environment set the issues of drylands among the priorities of its agenda and established a workforce of experts to set frameworks of regional programmes of collaborative actions.

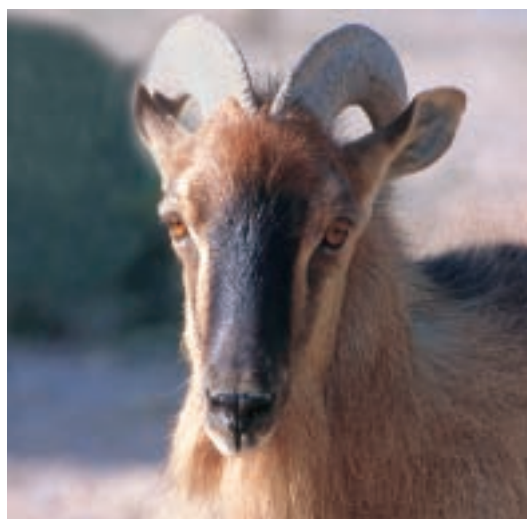
These are all commendable efforts that deserve appreciation, but are still short of what would set back menaces of land degradation. More resources (financial, manpower, etc) need to be mobilized in this area.

V. DROUGHT

Drought is (often) due to a failure of rainfall, that is, the volume of rainfall is less than expected (long-term mean). Mean annual rainfall at the agricultural research station at Borg-el-Arab (45 km to the west of Alexandria) is 150 mm.; this is a mathematical mean, and actual rainfall may be 250 mm or more ('fat' years) or 50 mm or less (lean years - drought). An incident of drought may be short (one year) or may be long: a drought of several consecutive years, as menaced the African Sudano-Sahel belt from 1968 to 1984, is referred to as a protracted drought. In years of drought range and livestock deteriorate, and crops fail. Drought is a natural hazard, as lean years are a naturally recurring aspect of dryland climate. This is one difference between desertification that is primarily the result of mismanagement of the land system and whose combating requires revised procedures of development and use of natural resources, and drought that is a natural hazard.

A Pioneering Syrian Drought Management Programme

We refer to a Syrian pioneering experiment that is nearest to complete management of drought, and it provides lessons to be learned. Rangelands prevail all over the Arabian Peninsula, and the Syrian Badia is its northern part. The Syrian rangelands are menaced by recurrent incidents of drought associated with losses in livestock. Between 1958 and 1961 the sheep population decreased from 6 million to 3 million. Losses were due to death or low-priced hurried sales. It



was usual for the Syrian Government (and donor institutions) to rush relief support to menaced societies. The Syrian Government wanted a system that would enable these often menaced rangelands to survive incidents of drought. This was the pioneering programme (Draz, 1995) that was implemented. It comprised four principal sectors: societal organization, technical support, financial resources, and research and training.

1- Societal organization

Herders communities are usually organized on a tribal basis: ethnic or cultural. Here they re-organized themselves on the basis of their relation to space: hema. The re-organized community became a cooperative, a functional unit of herders. Between 1969 and 1973 eight cooperatives were formed: six in Hama Governorate and one in Damascus rangelands, and one in Homs rangelands. Then the process became widespread, and the number of cooperatives in 1979 became 46 covering rangeland territories of 4.5 million ha.

The concept of cooperatives was further developed by establishing specialized cooperatives: a first sheep fattening cooperative was created in Hama; 14 such cooperatives were operative by the end of 1972, each with feedlots and feed storage barns; and by 1979 there were 65 such cooperatives with feed storage capacities of 160 thousand tons.

2- Technical Support

The first technical centre was established at Wadi El-Azeeb in 1959 to train herders and to provide

extension services. The success and utility of this centre encouraged the creation of eight centres in 1971-75 at Hesya (Homs), El-Manqora (Damascus), Marg-Maryan (Hama), Tool Eleba (El-Ragga), Om-madfa (El-Hasaka), El-Shoula (Der-el-zour), Orai (Esuweida), and Shatha (Hama). Other centres were added, all providing technical support and services to herders, and they also helped in clearing and rehabilitating ancient water storage cisterns, and in building water conservation dams on *wadis*.

3- Fodder Fund

This was a financial mechanism to support the herders and fattening cooperatives, established in 1965 with resources from:

- Sales of materials provided by the World Food Programme;
- Government contributions;
- Loans and donations from the World Bank.

By 1983 the Fund had collected 120 million Syrian Lira. The Fund provided loans to the cooperatives and through them to members.

4- Research and Training

Seven research centres participated in programmes for selecting and testing plant species that may be used in range improvements, and development of water-harvesting studies. Faculties of agriculture participated with research centres in training technicians and specialists.

With this integrated scheme the rangelands (land) and the herders (societies) became capable of withstanding incidents of drought without losing their herds through death and urgent sales. This pioneering scheme deserves to be studied so as to be emulated on a regional scale, with appropriate modifications to suit rangelands in Arab countries.

VI. BIODIVERSITY

The most apparent and visible manifestation of desertification is degradation of vegetation (plant cover) and its insufficiency to protect soil against erosion; subsequently its productivity fails to provide fodder in rangelands or crops in farmlands. Loss of plant cover entails loss of animal life. This degradation has another aspect: loss of biodiversi-

ty, that is, loss of elements of plants and animals that fail to withstand habitat deterioration (desertification). This loss has special global importance.

The Fertile Crescent is a region that embraces the Levant and its adjoining territories in Asia Minor and Iraq. Specialists in the history of agriculture including history of domestication of plants (crops) and animals (livestock), consider the Fertile Crescent region one of the centres of origin of agriculture. This means that certain species have been domesticated (and husbanded) into crops. The Russian scientist Vavilov (1949) concludes that the East Mediterranean region is the centre of origin of 83 cultivated plants:

- 18 crop plants,
- 39 fodder plants,
- 26 fruits and spices plants.

Principal crop plants, whose centre of origin is designated in East Mediterranean Basin, include:

- *Triticum turgidum* subsp *dicoccum* (emmer wheat)
- *Triticum monococcum* (Einkorn wheat)
- *Hordeum vulgare* (barley)
- *Pisum sativum* (pea)
- *Cicer arietinum* (chickpea)
- *Vicia faba* (broad/fava bean)
- *Linum usitassimum* (flax plant that linen can be produced from)

In addition we may include several species of legumes and grasses that provide fodder. The importance of this region relates to the presence of a diversity of wild relatives of these crop species that maintain valuable gene-resources (see Balter, 2007).

To this we may add that the flora of the Arab region include hundreds of plant species that have long provided the people of the region with useful drugs. The pharmaceutical industry supports survey missions in many parts of the world for plant prospecting for chemical resources. The island of Socotra (Yemen) is one of the world's "hot spots" for such surveys. The relics of the once extensive *Cedrus libani* (Lebanese cedar) forests of Lebanon represent another "hot spot" area. Conservation of biodiversity in the Arab region has critical regional and worldwide significance. It is therefore the responsibility of the region to guard these biodiversity resources for the benefit of the world.

TABLE 6 FOREST AREAS AND AREA CHANGE (1990-2000) IN ARAB COUNTRIES, (IN 1000 HA.)

Country	Forest Area		Annual change 1990-2000 (%)
	Forest Pl.in 2000	Forest Pl.in 1990	
Algeria	2,145	718	1.3
Bahrain	--	--	--
Egypt	72	72	3.3
Iraq	799	10	--
Jordan	86	45	--
Kuwait	5	5	3.5
Lebanon	36	2	-1.2
Libya	358	168	1.4
Mauritania	202	13	-0.6
Morocco	3,025	534	--
Pal.+Israel	132	91	4.9
Oman	1	1	5.3
Qatar	1	1	9.6
Saudi Arabia	1,504	4	--
Somalia	7,515	3	-1
Sudan	61,627	641	-1.4
Syria	461	229	--
Tunisia	510	202	0.2
UAE	321	314	2.8
Yemen	445	--	-1.9

Source: FAO, 2005

Territories with ample rainfall that could support forest growth are limited in the Arab region. But certain countries have areas of forests. Table 6 presents estimates of forest areas and areas of afforestation projects (in 1,000 ha) in the Arab countries (FAO, 2005).

The largest forested areas are in Sudan, whose southern humid territories and eastern and western highlands have forest habitats. Somalia, Morocco, Algeria and Saudi Arabia have areas of forest that range from 7.5 million ha (in Somalia) to 1.5 million ha (in Saudi Arabia). Areas of afforestation seem limited, but there is an apparent parallel between areas of natural forests and areas of afforestation. We refer later to forests and afforestation in Sudan (a case study).

The plantation of trees in drylands of the Arab region relates to sewage treatment plants. The purpose is often to use the treated water for establishing green belts (to protect human settlements against sand storms), environmental improvement, and as a source of fuelwood. In Egypt such projects consider planting African mahogany trees

(timber for furniture), mulberry shrubs (for silkworm husbandry), and species of *Jatropha* (for production of biofuel). Almost all Gulf States have carried out field projects for rehabilitation of mangrove forests in their coastal zones.

The FAO established six forestry commissions in the world, including the Near East Forestry Commission (1953) and the African Forestry and Wildlife Commission (1959). Each Commission holds a general conference every two years. The two commissions held a joint conference in Khartoum, Sudan in February 2008. The conference addressed issues related to impacts of climate changes in the 21st century on forests.

VII. CONCLUDING REMARKS

Desertification and recurrent drought are among the most serious menaces that damage land productivity in areas of irrigated agriculture, rainfed farming and rangelands, and also in woodlands and scrublands. The two menaces cause degradation of the food-producing capacities of the Arab region and hence undermine the bases of food security. As populations increase and their rates of consumption continue to rise, the gap between production and consumption of food increases, and dependence on the importation of food increases.

Although the Council of Arab Ministers of Environment gave priority to this issue, the actual efforts and resources devoted to the purpose are less than are needed to face up to the problem. The ventures at both the national and regional level remain modest. More mobilization of national and regional inputs remains necessary.

Governmental agencies should play the principal role in setting work plans, national and regional programmes and field projects. Mobilization of national and regional efforts is necessary. Non-governmental bodies should play their active roles in ensuring positive public participation, a cardinal element of success.

Reviewing worldwide endeavours to combat desertification, we note that this movement was spurred by the widespread damage caused by droughts that menaced the countries of the Sahel in West Africa in 1969 and extended in time across several years (1969-1982) and in space

until it menaced the whole Sudano-Sahel belt. Relief materials were rushed in for salvation, and the UN General Assembly resolved in 1974 to hold a UN Conference on Desertification (Nairobi, Kenya, August 1977) to set a plan of action to combat desertification. Years passed and the UN held its conference on environment and development in 1992. This conference reviewed the world status of desertification and the outcomes of world action in the 1977-1992 period. Outcomes were very modest. The conference decided that there was need for a legally binding convention that would commit governments to action. A draft convention was ready in

1994, became operational in 1996 and its first conference of parties was held in the same year.

One question persists: How did the Arab countries participate in these international concerns? The few positive answers include the laudable actions of Sudan which formulated a national plan of action to combat desertification in 1976 (one year earlier than the UN 1977 Conference), and of Tunisia which pioneered setting a national plan of action to combat desertification in the light of the World Plan of Action set by the 1977 Conference. Steps by other Arab countries were slow. Countries are strongly urged to give priority

CASE STUDY: SUDAN

Data presented in Table 6 show that forest areas in Sudan, at 61,627 thousand ha the largest forest area in countries of the Arab region, cover the equivalent of 28% of the total area of Sudan. Most of these areas are in southern Sudan (upper Nile, Equatoria, Bahr El-Ghazal, Darfur and Kordofan) and in limited areas in highlands in the middle territories.

To the natural forest areas are added areas of afforestation that consist of indigenous species and a number of exotic (introduced) species especially eucalypts and casuarina. Afforestation schemes aim at planting crop-trees to produce timber, fuelwood, gums, etc., and at rehabilitation of degraded forests especially in gum Arabic producing woodlands. Degradation is often due to overcutting or to desertification. Principal afforestation areas planted with indigenous species include:

52,227 ha Acacia Senegal (gum Arabic tree)

18,200 ha Acacia nilotica (qarad tree)

10,130 ha Tectona grandis (teak).

Areas planted with introduced species (eucalyptus) include 41,442 ha.

The Doum forests grow along the banks of water courses of seasonal rivers (El-Gash, Atbara, etc) and principal wadis and khors (valleys) in semi-arid territories. The Doum palm, though not a timber-producing tree, has notable economic value to rural communities. A button-producing industry dependent on the fruits of Doum (vegetable ivory) was initiated in Sudan, but new synthetic materials undermined this industry. The efficacy of germination and saplings growth sustain the survival of Doum growths against negative impacts of rainfall variations and hence availability of water in *khors* and *wadis*.

To these land-based woodlands we may add mangrove formations (mostly *Avicennia* and in a few localities *Rhizophora*) along the coastal littoral of the Red Sea. Surveys show 19 sites of mangrove with a total area of nearly 4,200 ha.

Forest management in Sudan, and in other African countries, relates to the management of nature reserves and national parks, and establishes links between forest management and the management of nature reserves (plant and animal biodiversity conservation). In Sudan there are 3,225 conservation sites, with a total area of 11.9 million ha. Nature reserves in forest areas are sites of tourist attraction, notable are the Dinder National Park in the east and Random Park in southern Darfur. There are several reserves in the south that were subject to deterioration during the long years of unrest; these will hopefully regain their status in years of peace.

The growth of the gum Arabic producing trees (*Acacia Senegal*) has a notable place in the economy of Sudan. The gum Arabic belt extends in Africa south of the Sahara from the Atlantic to the Red Sea, between latitudes 10° and 14° N.; in Sudan this belt covers one fifth of its area. *Acacia Senegal* plantations in sand territories of the west (Darfur and Kordofan) represent the main gum Arabic producing areas. Sudan used to command the main share (nearly 80%) of the world production until the early 1990s, but desertification in Sudan damaged this belt and dropped the Sudan share of world production to 50% (World Bank 2007). Plans to rehabilitate this gum Arabic belt aim at combating desertification and recapturing Sudan's previous position of gum Arabic production in the world market.

to the formulation and implementation of plans and programmes for combating desertification.

Success can be achieved within the frame of national policies that make the combating of desertification an integral part of national endeavours to develop natural resources sustainably as outlined in Agenda 21 (1992) and the outcomes of the UN Summit on Sustainable Development (2002). Every country is invited to set a national plan to combat desertification and to manage incidents of drought. Such a plan should be part of the national plans for sustainable development of land and water resources and for the conservation of ecosystems producing renewable resources (croplands, rangelands, woodlands and fisheries).

Sustainable development that is the framework within which land degradation (including desertification) is mitigated depends on the integration of three processes:

- 1- Economic and technological efficiency, which requires the support of institutes of research and development and economic assessment;
- 2- Social equity that does not allow the deprivation of the marginalized, and that ensures positive public participation;
- 3- Conservation of the environment, both in terms as a human habitat, and as a depot of natural resources.

To set and to implement national policies for sustainable development (combating of desertification is one element) requires the collaboration of various government sectors, non-governmental organizations concerned, and research institutions. The Arab region has several international research centres concerned with land resources (The Arab Centre for the Studies of Arid Lands and Dryland – ACSAD, Damascus, and the International Centre for Agriculture Research in Dry Areas – ICARDA, Aleppo). In all Arab countries there are centres of desert research or university units of research on dryland problems. The potentials of these scientific institutions are yet to be effectively utilized to provide sound bases for regional and national development schemes. We note and welcome the initiatives in Saudi Arabia and Qatar to establish funds for supporting research; it is hoped that these institutions will include programmes for sustainable development of land and water resources in their priority areas.

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