A New Assessment of the World Status of Desertification

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Introduction

A new assessment of the world status of desertification was undertaken by the United Nations Environment Programme (UNEP) in 1990-1991. The aim was to provide reliable and consistent data on the present situation and recent changes in the world's drylands for the United Nations Conference on Environment and Development (UNCED), or *Earth Summit*, to be held from 1-12 June 1992 in Brazil.

Two previous global assessments of the status of desertification had already been carried out: the first in 1976-1977 for the United Nations Conference on Desertification (UNCOD, 1977); and the second in 1983-1984 for UNEP Governing Council's 12th Session which evaluated progress in the implementation of the United Nations Plan of Action to Combat Desertification (PACD). The PACD was adopted in 1977 by UNCOD and endorsed by the UN General Assembly.

Results of Past Assessments

It was accepted by UNCOD (1977) that *desertification is the diminution or destruction of the biological potential of land, and can lead ultimately to desert-like conditions.* At the time of UNCOD it was found that, within the drylands, the area affected at least moderately by desertification comprised some 3.97 billion ha, or 75.1% of total drylands, excluding hyper-arid deserts, and that the process seriously threatened the well-being and future of peoples in more than 100 countries in different parts of the world. Population in areas that had recently undergone severe desertification and directly affected was estimated at 78.5 million. Annual loss of productive capacity of land due to desertification (income foregone) was globally estimated at US $26 billion. A twenty-year world-wide programme to arrest further desertification required funding of about US $4.5 billion annually or US $90 billion in total.

The 1984 assessment confirmed the scale and urgency of the desertification problem as presented to UNCOD and addressed by the PACD. Desertification had continued to spread and intensify despite efforts undertaken since 1977 which were too modest to be effective. Land continued to be irretrievably lost through desertification or degraded to desert-like conditions at a rate of 6 million ha annually; land reduced to zero or negative net economic productivity was showing an increase of up to 21 million ha annually. Areas affected by at least moderate desertification comprised 3,100 million ha of rangelands (80% of their total area in drylands), 335 million ha of rainfed croplands (60% of their total area in drylands), and 40 million ha of irrigated croplands (30% of their total area in drylands) - in all, up to 3,475 million ha (or 70% of total area of drylands). Rural populations in areas severely affected by desertification numbered 135 million.

Recently, desertification has become one of the most serious environmental and socio-economic problems of the world, as was stressed in the report of the United Nations Commission on Environment and Development (*Our Common Future*, 1988).

The Concept of Desertification

At the start of this new assessment it was recognized that the existing definition of desertification as adopted by UNCOD in 1977 was not sufficiently operative and grossly inadequate for purposes of quantitative assessment. Two studies were commissioned

by UNEP to clarify the issue: the first was *A Review of UNEP's Definition of Desertification and its Programmatic Implications* by Professor Richard S. Odingo of the University of Nairobi, Kenya; and the second was *An Assessment of Global Desertification: Status and Methodologies* by Professor Boris G. Rozanov of Moscow State University, USSR.

After considering these studies as well as other relevant material, the Ad-Hoc Consultative Meeting on the Assessment of Desertification convened by UNEP from 15 to 17 February 1990 in Nairobi, adopted a new working definition of desertification which was taken as a basis for the compilation of the *World Atlas of Thematic Indicators of Desertification* (Edward Arnold, 1992) and for this present assessment.

However, while data were being collected for this assessment, it became evident that a further refinement of the definition and concept of desertification was required. The new definition was finally adopted by the Third Meeting of the Technical Advisory Group on Desertification Assessment and Mapping convened in Nairobi by UNEP from 5 to 7 June 1991. After extensive consultations with relevant United Nations agencies, including the UN Food and Agriculture Organisation, UN Educational, Scientific and Cultural Organisation and the World Meteorological Organisation, and with individual scientific experts in this area, the meeting elaborated a new definition:

Desertification is land degradation in arid, semi-arid and dry sub-humid areas resulting mainly from adverse human impact.

Land in this context includes soil and local water resources, land surface and natural vegetation or crops. Degradation implies reduction of resource potential by one or a combination of processes acting on the land. These processes include water erosion, wind erosion and sedimentation by those agents, long term reduction in the amount or diversity of natural vegetation, or decrease of crop yield where relevant, and salinization and sodication of soils.

The new definition recognizes that although the main cause of desertification is adverse human impact, the impact of natural climatic conditions, particularly recurrent droughts, on desertification may play a role under certain circumstances.

In the past there has been some confusion between the two different processes, the one called *desertification* and the other called *expansion and contraction of the desert*. It is important to recognize that desertification is a distinct process of land degradation throughout the drylands and must therefore be distinguished from the quite separate phenomenon of observed cyclic oscillations of vegetation productivity that occur at desert fringes. It is these oscillations in vegetation productivity, often sparked by climate fluctuations, that give the impression that the desert is expanding or contracting, as revealed by satellite data. But this is not *desertification*.

The most obvious symptoms of both the process of desertification and its results relate to a reduction of biological and economic productivity, value of land, and to pollution of water and air. In other words:

* reduction of yield or crop failure in irrigated or rainfed farmland;
* reduction of perennial biomass produced by rangeland and consequent depletion of food available to livestock;
* reduction of available woody biomass and consequent extension of the distance to sources of fuelwood or building material;
* reduction of available water due to decrease of river flow or groundwater resources;
* encroachment of sand that may overwhelm productive land, settlements or infrastructures;
* increasing flooding, sedimentation of water bodies, water and air pollution;
* disruption to human life due to deterioration of life-support systems; need for affected society to ask for outside help (relief aid) or to seek haven elsewhere (migrating environmental refugees).

The causes of these various forms of ecological degradation and corresponding socio-economic disruptions relate to a combination of:

* human exploitation that oversteps the natural carrying capacity of the land resource system and sometimes under-exploitation and abandonment of land due to the migration of people;
* the inherent ecological fragility of the resource system; and
* adverse climatic conditions, including severe recurrent droughts in particular.

High degrees of land degradation play a large part in increasing the susceptibility of farming systems to the shocks of drought, as was so clearly seen in the Sudano-Sahelian region of Africa during the last decades.

Excessive human pressures on natural resource systems relate to:

* increase of population and escalation of human needs;
* socio-political processes that bring pressures on rural communities to orient their production towards national and international markets;
* socio-economic processes that reduce the market value of rural products and escalate the prices of rural people's needs;
* processes of national development, especially programmes for expansion of farmlands for production of cash crops, that exacerbate conflicts over land and water use and often reduce areas available to marginalized communities. The overriding socio-economic issue in desertification is the imbalances of power and access to strategic resources between different groups in society.

Desertification is a very distinctive global environmental and socio-economic problem requiring the special attention of the world community. It is different to the phenomenon of land degradation in other, more humid areas of the world because it proceeds under very harsh climatic conditions and acts adversely on what are already very limited natural resources, ie, soil, water and vegetation. Naturally, there are extents and degrees of desertification but, if the process is not arrested, it is merely a question of time before the land inevitably becomes degraded and abandoned.

Socio-economically, desertification:

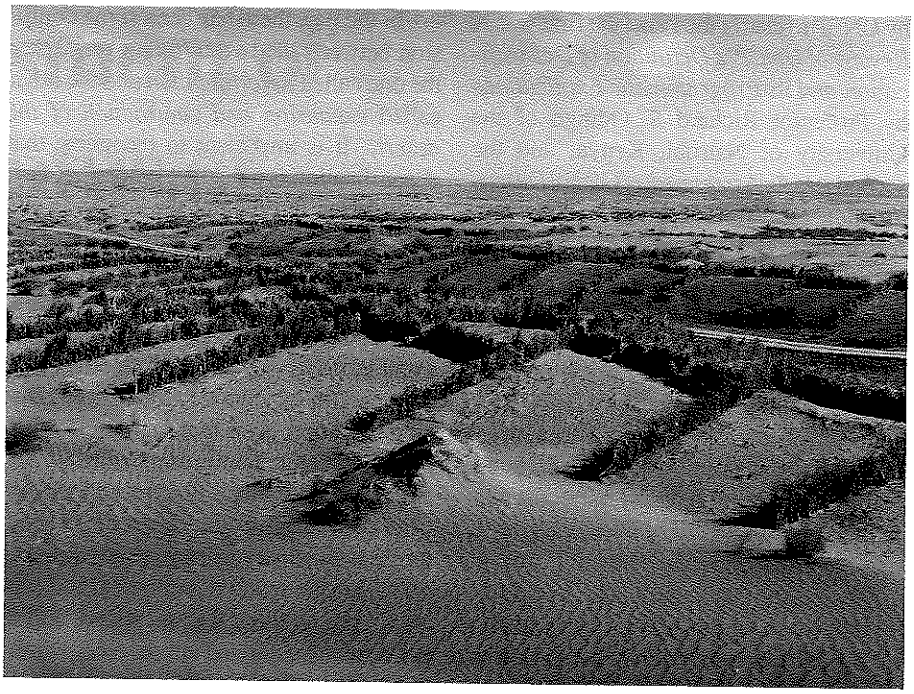
* constitutes the main cause and mechanism of global loss of productive land resources and thus reduces the world capability of providing sufficient food and shelter to growing populations, thus contributing to the spread of poverty and hunger;
* causes economic instability and

political unrest in areas affected as people struggle to survive with scarce land and water resources and are often forced to migrate in search of relief and refuge;

* brings pressures on the economy and stability of societies immediately outside areas affected by desertification through escalating the need for food aid and contributing to the influx of environmental refugees, etc;
* prevents the achievement of sustainable development in countries and regions affected and, therefore, in the world as a whole;
* directly threatens the health and nutrition status of populations affected, particularly children.

Environmentally, desertification:

* is one element of planetary environmental degradation that contributes to climate change, water, air and soil pollution, deforestation and soil loss;
* contributes to the loss of global biological diversity, particularly in areas which are the centre of origin of the major crop species of the world, such as wheat, barley, sorghum, maize, etc;
* contributes to the planet's loss of biomass and bioproductivity and to the exhaustion of the global humus reserve, thus disrupting normal global bio-geochemical turnover and reducing the global carbon dioxide sink in particular;
* contributes to global climate change by increasing land surface albedo, increasing the potential and decreasing the actual evapotranspiration rate, changing the ground surface energy budget and adjoining air temperature, and adding dust and carbon dioxide to the atmosphere.



Stabilizing sand dunes is costly, particularly for poor developing countries that are dependent on their drylands resources base. But the social and humanitarian value of this and other desertification control measures is immense.

Definition of World Drylands

Once the latest definition of desertification was established in June 1991 (see above) a world map of drylands was prepared at UNEP by the Global Environment Monitoring System (GEMS), Global Resource Information Database (GRID) and Desertification Control Programme Activity Centre (DC/PAC). The basis for this map was climatic data sets supplied by the University of East Anglia for the period of 1951-1980 (for aridity zoning) and the *Times Atlas of the World*, 1985 (for regional boundaries). This map will be published in the *World Atlas of Thematic Indicators of Desertification* (Edward Arnold, 1992).

Aridity zones (figure 1) were defined in accordance with their physical parameters using the following precipitation over potential evapotranspiration ratios (calculated by adapted Thornthwaite formula as opposed to the Penman formula used in 1977):

	Aridity Index
Hyper-arid	< 0.05
Arid	0.05-0.20
Semi-arid	0.21-0.50
Dry sub-humid	0.51-0.65
Moist sub-humid & humid	> 0.65

Estimates of the total area of the world drylands made in 1977, 1984 and 1991 were obtained using slightly different methodologies and different climatic data sets and therefore they should not be compared as a time-sequence. The latest (1991) data sets are regarded as more precise since they were based on time-dependent climatic data selected with most rigorous criteria from a larger number of observation stations. Nevertheless, all the data shown here should be regarded as approximate only, with a degree of accuracy ± 10% being restricted by the scale of assessment. This accuracy also relates to the previous assessments.

Because of this approximation, it follows that any accurate measurement of the changes in areas of lands affected by desertification during 1977-1991 at global or continental scales is presently impossible as the observed changes will fall within the range of standard error. However, estimates of changes and trends are possible for certain key areas where more precise data are available as a result of recent detailed assessment at national or local level.

According to the data in table 1 (page 6), the driest continent of the world is Australia which has 75% of its area as drylands; then follow Africa (66%) and Asia (46%). In Europe, North and South Americas, the drylands comprise about one third of their respective areas. In absolute figures, however, the largest drylands occur in Africa and Asia - totalling about 64% of the world's drylands. The total area of drylands constitutes about 6.1 billion ha or 41% of the total land area of the world, among which nearly

Table 1: World drylands in millions of hectares (UNEP/GRID, 1991)

	Africa	Asia	Australia	Europe	North America	South America	World Total	%
Hyper-arid	672	277	0	0	3	26	978	16
Arid	504	626	303	11	82	45	1,571	26
Semi-arid	514	693	309	105	419	265	2,305	37
Dry sub-humid	269	353	51	184	232	207	1,296	21
Total	1,959	1,949	663	300	736	543	6,150	100
% world total	32	32	11	5	12	8	100	
% total global land area	13.1	13.0	4.4	2.0	4.9	3.6	41.0	
% continent area	66	46	75	32	34	31	41	

0.9 billion ha or about 6.6% are hyper-arid deserts and nearly 5.2 billion ha or 34.4% are arid, semi-arid and dry sub-humid drylands which are inhabited and exploited for their admittedly limited but important biological productivity.

Figure 2 shows additional characteristics of the world's drylands and the ratios between different aridity zones within each of the continents. In Africa, hyper-arid and arid zones dominate the drylands; in Europe, North and South Americas semi-arid and dry sub-humid zones prevail.

Desertification in Drylands

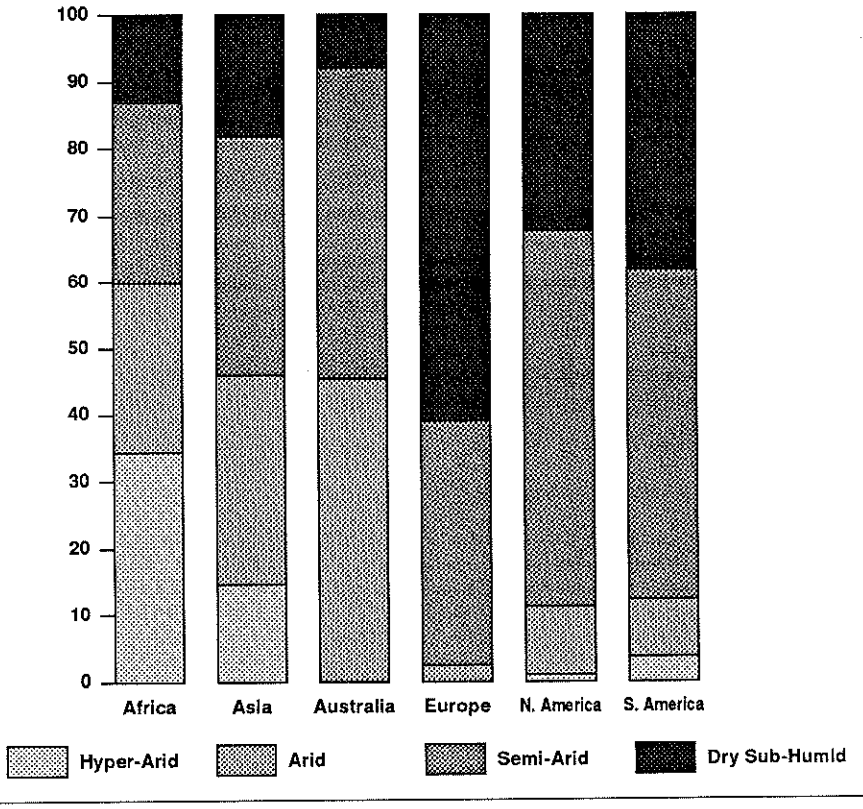
Two global data sets showing different aspects of desertification were obtained in the course of the present assessment.

The first data set was produced in the International Center for Arid and Semi-Arid Land Studies (ICASALS) of Texas Technical University, USA, on the basis of available country statistics with reference to major land uses in drylands. It shows various forms of *land degradation* in drylands delineated in previous assessments with a correction for subdividing the sub-humid zone into two parts, dry and moist.

The second data set related to *soil degradation* within drylands of the world delineated by UNEP aridity zones. It is based on the World Map of the Status of Human Induced Soil Degradation (GLASOD) prepared by the International Soil Reference and Information Center (ISRIC) in Wageningen, the Netherlands and UNEP in 1990 at an average scale of 1:10,000,000. Due to scale limitations, this map shows the situation by continents only, with no relation to major land-use systems.

The two data sets are different, although interrelated: they can be compared at a global and continental level but they should not be directly compared at a country level. The major difference between the global figures for degraded areas within the drylands can be attributed to extensive rangeland areas with significant vegetation degradation but no recorded soil degradation, eg, all extensive areas of rangelands in Australia or the Aral-Caspian Basin of the USSR. These rangeland areas are included in the figures of *land degradation* but not in

Figure 2: World drylands (%) - 6,115 million hectares



the figures pertaining to *soil degradation*, ie, they have been treated as non-degraded stable lands in the GLASOD assessment.

Reconciliation of these two data sets of global figures provides the following picture of the status of desertification in the world: (table right)

		Million hectares	% of total drylands
1	Degraded irrigated lands	43	0.8
2	Degraded rainfed croplands	216	4.1
3	Degraded rangelands (soil and vegetation degradation)	777	14.6
	1+2+3 = GLASOD (ie, drylands with human-induced soil degradation)	**1,036**	**19.5**
4	GLASOD (ie, drylands with human-induced soil degradation)	1,036	19.5
5	Degraded rangelands (vegetation degradation *without* recorded soil degradation)	2,556	50.0
	4+5 = Total degraded drylands	**3,592**	**69.5**
6	Total degraded drylands	3,592	69.5
7	Non-degraded drylands	1,580	30.5
	6+7 = Total area of drylands excluding hyper-arid deserts*	**5,172**	**100%**

* *Hyper arid deserts are excluded from further consideration as not being subject to desertification*

The breakdown of degraded areas indicates that some 2.6 billion hectares, mainly in rangelands, suffer from degradation processes not recorded in the data compilation carried out in the framework of GLASOD. Additionally some 1 billion ha also suffer from soil degradation, making a total area of drylands affected by degradation at present as nearly 3.6 billion ha or about 70% of total drylands.

Desertification manifests itself as land degradation in major land use systems such as irrigated and rainfed croplands and rangelands within the above defined drylands of the world, excluding hyper-arid deserts where this process does not occur. Tables 2, 3 and 4 show how desertification affects these major land use systems.

The largest areas of degraded irrigated lands are situated in the drylands of Asia, followed by North America, Europe, Africa, South America and Australia in descending order. This order almost fully coincides with a sequence of percentages of the areas that are at least moderately affected.

About 43 million ha of irrigated lands or 30% of their total area in the world's drylands (145 million ha) are affected by various processes of degradation, mainly waterlogging, salinization and alkalinization. This is an increase of some 3 million ha (about 7.5%) in comparison with the assessment in 1984 but this falls within the range of ± 10% accuracy. It would be safer to assume that the situation did not change appreciably during this period and remained unsatisfactory with a tendency to get worse.

Irrigated lands in drylands constitute nearly 62% of the total irrigated area of the world (240 million ha). Soil scientists have established that the world is now losing,

Table 2: Extent of desertification/land degradation in irrigated areas within the drylands of the world, by continents (Dregne, 1991)

Continent	Total Irrigated Land	Desertified ('000 ha)					
		Slight-none	Moderate	Severe	Very severe	Total (> moderate)	% > moderate
Africa	10,424	8,522	1,779	122	1	1,902	18
Asia	92,021	60,208	24,335	5,788	1,690	31,813	35
Australia	1,870	1,620	100	130	20	250	13
Europe	11,898	1,993	1,340	460	105	1,905	16
N. America	20,867	15,007	4,930	730	200	5,860	28
S. America	8,415	6,998	1,047	310	60	1,417	17
Total	145,495	102,348	33,531	7,540	2,076	43,147	30

Table 3: Extent of desertification/land degradation in rainfed croplands within the drylands of the world, by continents (Dregne, 1991)

Continent		Desertified ('000 ha)					
	Total rainfed cropland	Slight - none	Moderate	Severe	Very severe	Total (> moderate)	% > moderate
Africa	79,822	30,959	43,187	5,153	523	48,863	61
Asia	218,174	95,890	100,638	18,578	3,068	122,284	56
Australia	42,120	27,800	13,900	400	20	14,320	34
Europe	22,106	10,252	8,538	3,227	89	11,854	54
N. America	74,169	62,558	10,770	721	120	11,611	16
S. America	21,346	14,711	5,950	561	124	6,635	31
Total	457,737	242,170	182,983	28,640	3,944	215,567	47

annually, about 1.5 million ha of irrigated lands due to various processes of soil degradation, mostly salinization, and this mainly in drylands. It would thus be safe to assume that about 1.0-1.3 million ha of irrigated land are currently lost every year throughout the world drylands. This loss is compensated for by involving the best rainfed croplands and rangelands in irrigation and consequently the area of rainfed croplands and rangelands decreases accordingly.

Nearly 216 million ha of rainfed croplands or about 47% of their total area in the world drylands (457 million ha) are affected by various processes of degradation, mainly water and wind erosion of the soil, depletion of nutrients and physical deterioration. This shows some decrease in comparison with the 1984 assessment.

Rainfed croplands in drylands constitute nearly 36% of the total area of rainfed croplands in the world (out of 1,260 million hectares). It was estimated that the world is losing annually about 7-8 million ha due to various processes of soil degradation, mainly erosion and urbanization, and more than half of this is in the drylands. Therefore, it follows that about 3.5-4.0 million ha of rainfed croplands are currently lost every year throughout the world's drylands. This is being compensated for by involving the best rangelands in cultivation. But this means that the area of available rangeland decreases accordingly.

The largest area of degraded rangelands occurs in Asia, followed by Africa. The percentage of degraded rangelands is similar in both these continents and in Europe and the Americas. The figures for Australia seem to be underestimated but this has to be studied further as earlier published figures also showed about two thirds of the rangelands as being affected by degradation.

Table 4: Extent of desertification/land degradation in rangelands within the drylands of the world, by continents (Dregne, 1991)

Continent		Desertified ('000 ha)					
	Total rainfed cropland	Slight - none	Moderate	Severe	Very severe	Total (> moderate)	% > moderate
Africa	1,342,345	347,265	273,615	716,210	5,255	995,080	74
Asia	1,571,240	383,630	485,221	691,602	10,787	1,187,610	76
Australia	657,223	295,873	277,040	55,310	29,000	361,350	55
Europe	111,570	31,053	27,372	51,937	1,208	80,517	72
N. America	483,141	71,987	116,102	284,858	10,194	411,154	85
S. America	380,901	93,147	88,007	184,431	15,316	287,754	76
Total	4,546,420	1,222,955	1,267,357	1,984,348	71,760	3,323,465	73

Cattle grazing has impoverished the cover of high grass which once restrained water run-off on the slopes of the Wukari Valley, Nigeria. As a result, deep ravines have been hollowed out on the hillside.

About 3,333 million ha of rangeland or nearly 73% of its total area in the world's drylands (4,556 million ha) are affected by degradation, mainly by degradation of vegetation which on some 777 million ha is accompanied by soil degradation, mainly erosion. This shows an increase of some 233 million ha (about 7.5%) in comparison with the 1984 assessment. This falls within the range of ±10% accuracy. As in the case of irrigated lands, it would be safer to assume that the situation did not change appreciably during this period and remained very unsatisfactory with a tendency to get worse.

There are no reliable data on actual losses of rangelands and their conversion into agricultural land, wasteland, badland, desert or urban lands. However, if the above estimates of losses of agricultural lands and compensation for this through using better rangelands are correct, then it follows that annual losses of the rangelands within the drylands are around 4.5-5.8 million ha and even more if so far unaccounted sand encroachment, urbanization, etc, is to be considered.

Seventy per cent of all agriculturally-used drylands are affected to some degree by various forms of land degradation. This is mostly by degradation of natural vegetation, partly accompanied by serious deterioration of soil. It would appear that the situation is better in Australia (53.6% degraded) and Europe (64.8% degraded) than elsewhere in the world. But the situation in Australia could be underestimated. The worst degradation is in North America (74.1% degraded) and Africa (73% degraded) although the problem is not much less serious in South America (72.2% degraded) and Asia (69.7% degraded).

A comparison of total estimates for the areas affected by desertification shows an increase from 3,475 million ha in 1984 to 3,592 million ha in 1991, ie, 117 million ha or 3.4%. This increase falls within the range of ± 10% accuracy and thus should not be considered as a proven change. The conclusion is that the situation remains the same and very unsatisfactory.

Despite the inaccuracy of available data, the present assessment shows very dramatically that about 70% of the world's drylands are affected by desertification or various forms of land degradation. It is difficult at this stage to make definite predictions for future trends but the process, if unabated, may lead to very serious socio-political and economic consequences for the world, particularly in developing countries. 18 industrialized or oil-producing countries out of the 99 countries affected are believed to be able to cope with the problem and may combat the desertification of some 1.5 billion ha of their territories. For the 81 developing countries with 2.1 billion ha of land affected by desertification the problem cannot be solved

Table 5: Global status of desertification/land degradation in agriculturally used drylands

Continent	Irrigated Lands			Rainfed Cropland			Rangeland			Total Agriculturally Used Drylands		
	Total	Degraded		Total	Degraded		Total	Degraded		Total	Degraded	
	m.ha	m.ha	%	m.ha	m.ha	%	m.ha	m.ha	%	m.ha	m.ha	%
Africa	10.42	1.90	18	79.82	48.86	61	1,342.35	995.08	74	1,432.59	1,045.84	73.0
Asia	92.02	31.81	35	218.17	122.28	56	1,571.24	1,187.61	76	1,881.43	1,311.70	69.7
Australia	1.87	0.25	13	42.12	14.32	34	657.22	361.35	55	701.21	375.92	53.6
Europe	11.90	1.91	16	22.11	11.85	54	111.57	80.52	72	145.58	94.28	64.8
N. America	20.87	5.86	28	74.17	11.61	16	483.14	411.15	85	578.18	428.62	74.1
S. America	8.42	1.42	17	21.35	6.64	31	390.90	297.75	76	420.67	305.81	72.7
Total	145.50	43.15	30	457.74	215.56	47	4,556.42	3,333.46	73	5,159.66	3,562.17	69.0

without major external assistance through international partnership.

Desertification Rate

Apart from the figures in tables 2-4 for land losses of irrigated land, rainfed cropland and rangeland there are no reliable global data on the present rate of desertification. However, certain local studies provide more detailed additional information in this respect.

Kenya

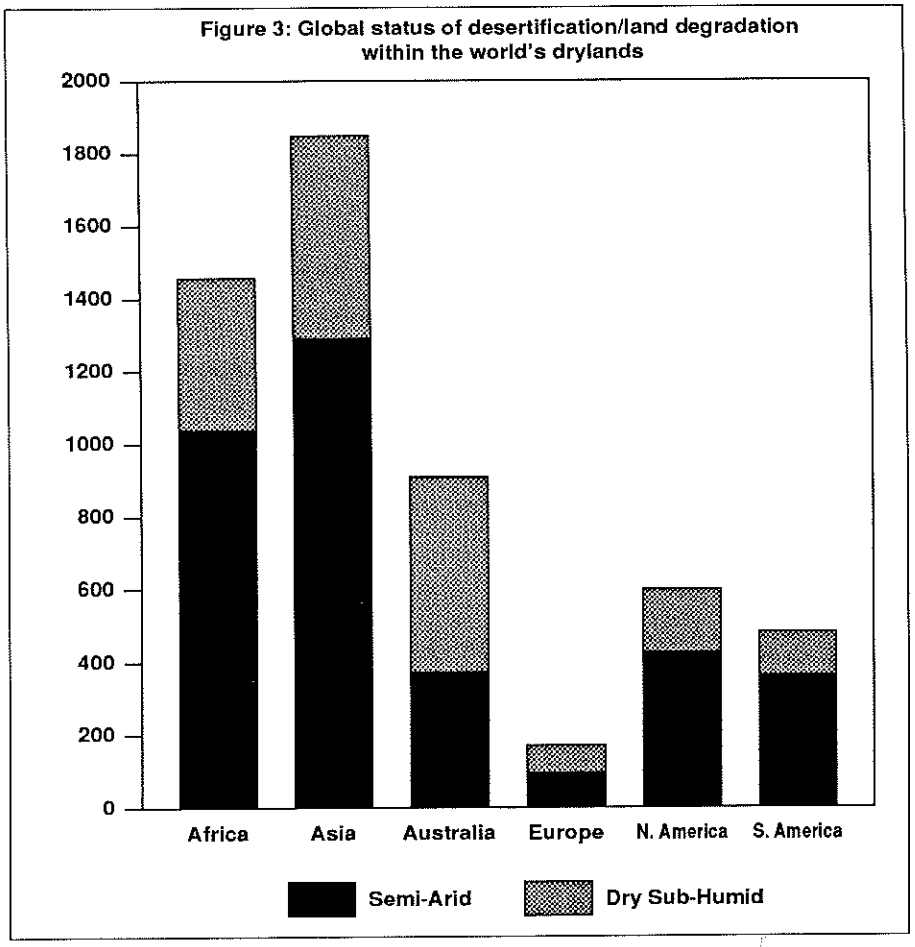
In the Baringo study area of 360,000 ha, situated in a transitional zone with annual precipitation of nearly 600 mm rising to 1,900 mm in the surrounding mountains, and mostly used as rangeland with some irrigated agriculture, the following changes were observed from 1950 to 1981:

	% of total area
Areas improved to better vegetation class	11.0
Areas degraded to worse vegetation class	14.0
Expansion of agricultural area	5.3

Calculations give the rate of vegetation degradation as 1,626 ha per year, which gives the annual desertification rate of 0.6%.

In the Marsabit study area of 1,400,000 ha, situated in a more dry zone with annual precipitation of less than 250 mm rising to 800 mm in the surrounding mountains, and mostly used under extensive pastoralism with some mixed farming, the changes during 1956-1972 were:

Figure 3: Global status of desertification/land degradation within the world's drylands



	% of total area
Areas improved to better vegetation class	0.0
Areas degraded to worse vegetation class	20.5
Areas mainly unchanged	79.5
Expansion of agricultural area	0.0

Calculations give the rate of vegetation degradation as 17,937 ha per year, or an annual desertification rate of 1.3%.

Mali

In three study areas of Mali, the following soil losses were observed within the last

30 to 35 years: (table right)

This study gives an average annual soil loss rate of 0.1% but does not provide any data on vegetation degradation and thus does not give a full picture of desertification.

Tunisia

The following changes in Tunisia were noted in the areas of different land uses: (table right)

Calculations give the average annual loss of productive land by desertification as around 10,000 ha within this last century. Thus an average annual desertification rate of 10% is characteristic of the desert fringes of Tunisia.

China

Certain studies conducted by Chinese scientific institutions show the present rate of desertification expansion on the fringes of the desert as being around 210,000 ha per year. Given that China has approximately 33.4 million ha of desertification-prone lands, this means a present average annual desertification rate of 0.6%.

However, some local studies even showed that the present annual rate of desertification was 1.3% in Kangbao County north of Beijing in Hebei Province, while in Fengning County it was 1.6%.

USSR

The annual desertification rate in certain districts of Kalmykia north-west of the Caspian Sea was recently estimated as high as 10%; in other areas it varied between 1.5%-5.4%.

The desert growth around the drying Aral Sea was estimated at about 100,000 ha per year during the last 25 years, which gives an average annual desertification rate of 4%. With the same annual rate of about 4%, desertification is expanding on the adjoining rangelands, greatly reducing their productivity.

Syria

An area of some 500,000 ha in the Anti-Lebanon Range north of Damascus was studied recently to assess the changes in land and land-use patterns from 1958 to 1982. It was found that the area of rocky shrub land and bare skeletal land has increased from 50,000 ha or 10% to 80,000 ha or 16%. This gives a present average annual rate of desertification of 0.25% for this area.

Mali

	Nara	Mourdiah	Yanfolila
Total area, ha	60,241	69,622	67,888
Annual precipitation, mm	400	800	1,200
Annual soil loss, ha	16.5	143	8
Annual soil loss, %	0.03	0.2	0.01

Tunisia

Per '000 ha	Year 1880	1980	Balance
Cereals cultivation	400	2,000	+ 1,600
Trees cultivation	200	1,600	+ 1,400
Total cultivated land (cereals + trees)	600	3,600	+ 3,000
Grazing land	10,000	6,000	- 4,000
Loss of productive land to desert (grazing land - cultivated land)			1,000

Yemen

Existing statistics show that the average annual rate of cultivated land abandonment due to soil degradation has increased from 0.6% in 1970-1980 to about 7.0% in 1980-1984.

Sahel

According to a recent (1989) publication (*Le Sahel en Lutte contre la Désertification: Leçons d'Expériences*) of the results of a co-operative study in the western part of the Sudano-Sahelian region conducted jointly by Comité Inter-Etats de Lutte Contre la Sécheresse au Sahel (CILSS) and Programme Allemand CILSS (PAC), in the southern parts of Mauritania, Mali and Niger between 1961 and 1987, the desertification rate was around 2 million ha per year.

The national case studies show very large variations in the annual rate of desertification in different parts of the world, ranging from 0.1% to 10.0% (ie, a hundred times greater in some areas). The main conclusion is: the more arid an area, the higher its rate of desertification. If we assume, on the basis of the above case studies, that the annual rate of desertification is about 10% in arid lands, 1% in semi-arid lands and 0.1% in dry sub-humid lands, then calculations for the present annual increase in lands affected by desertification will be: 156.9 million ha in arid areas, 23.05 million ha in semi-arid areas and 1.3 million ha in dry sub-humid areas, making a total of 181.2 million ha throughout the drylands of the world. This will give an average rate of current desertification progress of 3.5% per year. Further studies on the basis of the global monitoring system are needed to obtain more precise data.

Desertification costs: damage and rehabilitation

There is no methodology to estimate accurately the total economic loss due to desertification as there are too many unaccountable losses involved, particularly off-site and social losses. Direct on-site losses can be calculated more or less reliably taking into account an estimated loss in productive capacity (income foregone) due to land degradation in different land use systems. This can roughly be calculated based on the experiences of several countries with

varying economic situations.

In 1977, UNCOD calculated that the process of desertification made a significant contribution to land degradation throughout the drylands of the world and that the subsequent losses in productive capacity (income foregone) amounted to nearly US $26 billion per year. It was further estimated in 1980 that the cost of not stopping land degradation in drylands over the next 20 years was around US $520 billion, excluding the price of suffering of the millions of affected people.

The following basic figures for the average yearly income foregone due to desertification were assumed for the present assessment, at 1990 prices:

US $250 per hectare of irrigated land at least moderately degraded;

US $38 per hectare of rainfed cropland at least moderately degraded;

US $7 per hectare of rangeland at least moderately degraded.

Based on these figures and taking into account the total areas affected by degradation in each of the land use categories (see table 5) table 6 shows the annual average income foregone due to land degradation:

Naturally, this global direct annual loss (income foregone) of US $42.3 billion is a very rough average estimate as the actual figures vary greatly from country to country and from continent to continent. This figure just gives an idea of the magnitude of the loss involved. It also shows that the cost of inaction over the next 20 years will be around US $850 billion as compared with the earlier estimate of US $520 billion.

However, the inter-continental comparison gives an idea of the differences between various regions of the world. The major loss appears to occur in Asia since this is the largest area affected; then follows Africa; Europe appears to lose the least amount.

With regard to different land use systems, the major loss occurs due to degradation of global rangeland because of the enormously large area which is affected. Global losses in irrigated land and rainfed cropland are more or less the same. However, large differences exist between continents and, of course, between individual countries.

If the 1980 figure is taken as the lowest estimate and the 1991 figure as the highest, both being rather conservative, then the calculations show that global inability to combat desertification during the fourteen years from 1978 to 1991 has already cost the world some US $300-600 billion in income foregone alone.

Table 6: Annual average income foregone (in millions of US$)

Continent	Irrigated land	Rainfed cropland	Rangeland	Total
Africa	475	1,855	6,966	9,296
Asia	7,953	4,647	8,313	20,913
Australia	63	544	2,529	3,136
Europe	474	450	564	1,488
N. America	1,465	441	2,878	4,784
S. America	355	252	2,084	2,691
Total	10,785	8,189	23,234	42,308

Presently, there is not even a rough estimate available of off-site indirect economic losses due to desertification. Some studies suggest that it might be 2-3 or even up to 10 times higher than the direct on-site losses. This question should be more extensively studied and, of course, site-specifically, since the differences between various ecological and socio-economic situations throughout the world do not permit any generalization in this respect.

Action to combat desertification is inseparable from action to develop resources and management in drylands. Schemes that aim to arrest degradation of rangelands, rainfed and irrigated croplands, to stabilize sand dunes, establish large-scale green belts, introduce soil and water conservation systems in resource management, or to reclaim new areas for productive use are apt to be costly. In the majority of developing countries that are fully or partly dependent on their dryland resource base and have accumulated problems of poverty and underdevelopment, costs will be higher. In terms of market values rehabilitation projects are generally non-competitive, especially when compared with prevalent rates of interest. Investments in land rehabilitation projects commonly do not pay well financially, but their social and humanitarian values as a means of ensuring food security and participation in production are immense.

It is assumed that it is worth rehabilitating all degraded irrigated land (43 million ha). However, only 70% of affected rainfed cropland (151 million ha), and only 50% of desertified rangeland (1,667 million ha out of 3,333 million ha) can justify the cost of rehabilitation. This is because the remaining land in both categories is in areas too dry for good yields, or has soils too sandy and shallow, and is therefore only marginally productive.

It is further assumed that drylands that are not affected or only slightly affected by desertification would require measures directed to prevent land degradation and sustain the land's productivity. Moderately affected land would require certain additional corrective measures, such as provision of adequate drainage in irrigated croplands. Drylands which are severely or very severely degraded need serious efforts for their rehabilitation and return to productive use. In different land use systems the costs of preventative, corrective and rehabilitation measures will be quite different, as will the costs in different ecological and socio-economic situations in various countries of the world.

Table 7 shows the global average indicative figures for the costs of direct anti-desertification measures in different land use systems and for various degrees of land degradation. These figures were obtained on the basis of an analysis of large numbers of relevant projects in different parts of the world.

Taking into account the above costs (table 7) and the relevant figures for the world status of desertification (table 5), costs of direct anti-desertification measures, which should be considered as showing only an order of magnitude for the world as a whole, are shown in table 8.

Compared with the 1980s estimate of US $90 billion, or US $4.5 billion a year for a 20-year programme, the present estimate of US $171-363 billion, or US $8.6-18.2 billion per year for corrective and rehabilitation measures in drylands affected by desertification at least moderately is three to four times higher. This is due to more accurate land degradation assessments in 1991 and the increase in world prices and costs of land reclamation. No similar comparison can be made for the cost of preventative measures in drylands as it was not calculated in the 1980 studies.

The global indicative sums and averages for anti-desertification measures over a 20-year period are compared in table 9.

From table 9, the following simple cost/benefit ratios can be calculated: 1:2.5 for irrigated croplands, 1:1.5 for rainfed croplands, 1:3.5 for rangelands, and 1:2.5 for the whole anti-desertification campaign in the drylands. It would be misleading, however, to use these figures as accurate guiding points for an economic evaluation of the Plan of Action to Combat Desertification (PACD) because the time profiles of costs and benefits are different. This is because anti-desertification programmes have a long gestation period and benefits do not appear until many years after. Therefore the above global calculations provide only a general picture of the order of magnitude: accurate economic cost/benefit analyses should be made site-specific on a country-by-country basis in order to obtain meaningful operational estimates.

The global costs of direct preventative, corrective and rehabilitation anti-desertification measures should be divided between the 18 industrialized and other countries which need no financial assistance and the 81 developing countries which need external assistance to implement their programmes to combat desertification (see table 10).

The majority of developing countries affected by desertification are the poorest countries in the world, including those that are least developed with very weak economies and are overburdened with persistent poverty and growing foreign debts. It may thus be assumed that, in order to implement anti-desertification preventative, corrective and rehabilitation measures in 81 developing countries at a total cost of US $119-292 billion within 20 years, some 50% of the cost could at least be covered by the countries themselves while the other 50% needs to be provided through external assistance. Naturally, there will be a great difference between individual countries in this respect: some will require only 10% external assistance, while others might demand almost 90%. Table 11 gives a summary of these calculations on a yearly basis.

Table 7: Global average indicative figures for the costs of direct anti-desertification measures in different land use systems*

Degree of land degradation	US $ per ha Irrigated lands	US $ per ha Rainfed croplands	US $ per ha Rangelands
Slight to none	100-300	50-150	5-15
Moderate	500-1,500	100-300	10-30
Severe	2,000-4,000	500-1,500	40-60
Very severe	3,000-5,000	2,000-4,000	3-7

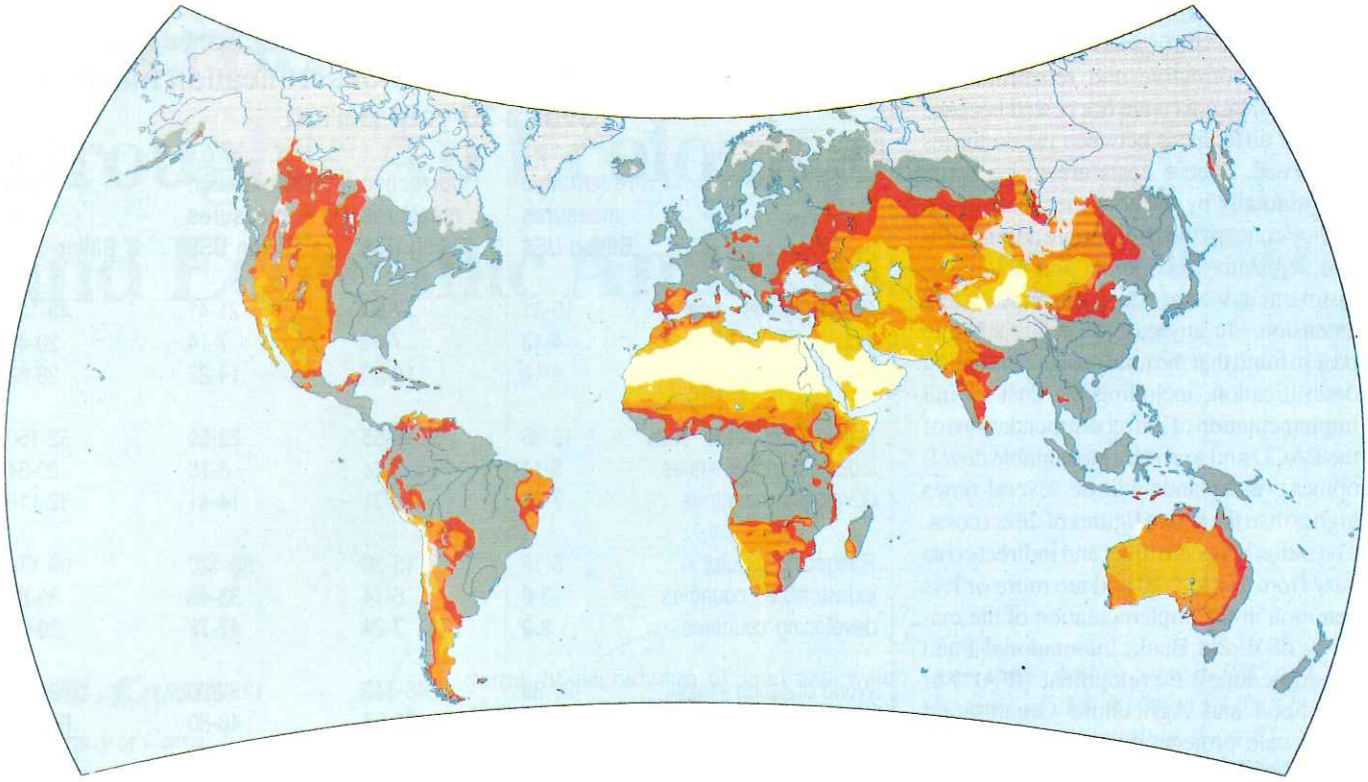
* Measures do not include insurance against recurrent drought. The range of cost for each land use system is mostly determined by the specificity of local natural and socio-economic conditions at the site of every particular project and not by the fact that it is implemented either in a developed or in a developing country or in any specific continent; there are certain extremely low and extremely high costs in some instances throughout the world but they are excluded from these global average ranges.

Table 8: Global costs of direct anti-desertification measures (billions of US $)

	Preventive measures	Corrective measures	Rehabilitation measures	Total
Irrigated lands	10-31	17-50	21-41	48-122
Rainfed croplands	12-36	18-55	22-59	53-150
Rangelands	6-18	13-38	80-120	99-176
Total drylands	28-85	48-143	123-220	200-448
Per one year for a 20-year programme	1.4-4.2	2.4-7.2	6.2-11.0	10-22.4

Table 9: Comparison of global indicative sums and averages (in billion US $) for annual losses and prevention/correction/rehabilitation costs

	Annual income foregone due to desertification	Annual cost of preventive measures	Annual cost of corrective measures	Annual cost of rehabilitation measures	Total annual cost of all measures
Irrigated lands	10.8	0.5-1.6	0.9-2.5	1.1-3.0	2.4-6.1
Rainfed croplands	8.2	0.6-1.8	0.9-2.8	1.1-3.0	2.7-7.5
Rangelands	23.3	0.3-0.9	0.7-1.9	2.0-6.0	5.0-8.8
Total drylands	42.3	1.4-4.2	2.4-7.2	6.2-11.0	10.0-22.4



The people most directly affected by desertification are usually among the poorest and least educated with limited to access to power. Unable to survive with scarce land and water resources, they are often forced to migrate in search of relief and refuge. But the influx of these environmental refugees can put enormous pressure on the economy and stability of societies immediately outside the area of desertification, exacerbating political differences and leading in some cases to civil strife.

Table 11 indicates only the costs of direct anti-desertification measures (preventative, corrective and rehabilitative). Support measures were not costed because of great differences between the countries concerned. These costs are to be borne almost totally by the countries themselves as they concern the appropriate administrative, legislative, economic and policy adjustments as well as education, training and extension. In any case, it is advisable to bear in mind that the total cost of combating desertification, including the cost of full implementation of the recommendations of the PACD and to ensure sustainable development of drylands will be several times higher than the above figures of direct costs. The ratios between direct and indirect costs vary from 1:4 to 1:10 and are more or less common in the implementation of the majority of World Bank, International Fund for Agricultural Development (IFAD) or UN Food and Agriculture Organisation large-scale projects concerned with land development and rehabilitation.

Conclusion

The global assessment carried out by UNEP in 1990-1991 shows that desertification continues to spread and intensify despite efforts undertaken during 14 years of implementing the PACD since DESCON. The inevitable conclusion is that the efforts were too modest and grossly inadequate to be effective. There is no evidence that the situation has improved appreciably anywhere in the world although there is some local success in rehabilitating degraded land and protecting it from further deterioration. It means that the world community has to intensify its efforts to stop desertification and to reclaim desertified lands for productive utilization.

Table 10: Estimated global costs of direct preventative, corrective and rehabilitation anti-desertification measures over a 20-year period

	Preventative measures Billion US$	Corrective measures Billion US$	Rehabilitation measures Billion US$	Total cost Billion US$
Irrigated lands - total	10-31	17-50	21-41	48-122
industrialized countries	4-13	7-20	7-14	20-40
developing countries	6-18	10-30	14-27	28-82
Rainfed croplands - total	12-36	18-55	22-59	52-150
industrialized countries	5-14	7-24	8-18	20-34
developing countries	7-22	11-31	14-41	32-116
Rangelands - total	6-18	13-38	80-120	99-176
industrialized countries	3-9	6-14	33-48	39-82
developing countries	3-9	7-24	47-72	60-94
World drylands - total	28-85	48-143	123-220	199-448
industrialized countries	12-36	20-58	48-80	80-156
developing countries	16-49	28-85	75-140	119-292

Table 11: Annual cost of preventative, corrective and rehabilitation measures for developing and industrialized countries

	Preventative measures Billion US$	Corrective measures Billion US$	Rehabilitation measures Billion US$	Total Billion US$
Total global cost	1.4-4.2	2.4-7.2	6.2-11.0	10.0-22.4
Cost to 18 countries not requiring external assistance	0.6-1.8	1.0-3.0	2.4-3.0	4.0-7.8
Cost to 81 countries requiring external assistance	0.8-2.4	1.4-4.2	3.8-8.0	6.0-14.6