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PAPERS

BACK UP

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Drought and desertification

M. Kassas

A highly controversial and debated question is the ultimate cause of desertification. Is it due more to man or to nature? This article addresses this important question and, by use of examples from the Dust Bowl of the USA in the 1930s, argues that drought does not necessarily cause desertification, but that the actions of mankind do. In the 1930s, in the absence of land management legislation or policy, a drought resulted in severe land degradation. In the 1950s in the same area a drought went largely unnoticed, due mainly to the effective soil conservation measures and large-scale investments in infrastructure that had been imposed since the 1930s. Desertification is bound to continue in the absence of effective policy, planning and development.

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The climate in arid and semi-arid regions is characterized by low rainfall (0–350 mm/year) that is seasonal (winter rainfall in Mediterranean arid lands and summer rainfall in tropical arid lands) and highly variable. Moreau presents two generalizations: the lower the average annual rainfall, the higher is its variability; and reliability is less (variability greater) when rainfall is concentrated than when it is well distributed in time.[1] Drought is generally perceived as the incidence of *below average* natural water availability: low rainfall, reduced river flow, reduced groundwater discharge. Drought is keenly felt in arid areas as it adversely affects the precariously maintained farmlands and pasturelands.

Arid climates prevail in regions where: atmospheric subsidence is widespread and persistant (the Sonoran desert of North America, the Saharo–Sindian belt extending from North Africa to South-west Asia, the Kalahari of South Africa and the Australian desert); there is localized subsidence in the lee of mountain ranges (coastal deserts of Atacama in South America, Namibia in South Africa, and inland deserts of Argentina and Central Asia); rain-inducing disturbances are absent; and there are no humid airstreams. Several indices are used for quantifying aridity – they all indicate that the radiative energy income at the ground surface is much higher (often several times higher) than the energy needed to evaporate water income (precipitation).

Two features of drought have been subject to numerous studies, namely pattern in sequence of time (recurrence-persistence) and geographical extent. Certain studies seem to recognize a pattern in the sequence of dry (below-average rainfall) and wet (above-average rainfall) years. Jenkinson[2] and Walker and Rowntree[3] analysed rainfall in the sub-Saharan belt of Africa (1911–76) and recognized some pattern. Oladipo analysed rainfall records of the Great Plains from Canada to Texas and found 'the series of the seasonal drought index, statistically speaking, cannot be distinguished in its sequential pattern of occurrence from a random variable'.[4] Studies on rainfall in sub-Saharan Africa seem to recognize a persistent downward trend since the mid-1960s.[5] Other studies show that the African droughts display spatial coherence with drought extended over much of tropical Africa simultaneously.[6] Such coherence was not recognized in North America.[7] Beran and Rodier surveyed data on recent drought in tropical areas and concluded that 'a definitive zonality of the drought phenomenon exists, with an extensive band around the tropics, north

[1] R.E. Moreau, 'Climate classification from the stand-point of East Africa Biology', *Journal of Ecology*, Vol 24, pp 467–480.
[2] A.F. Jenkinson, 'Some quasi-periodic changes in rainfall in Africa and Europe', in *Proceedings of the WMO/IAMAP Conference on Long-term Climatic Fluctuations*, Norwich, UK, 1975, pp 453–460.
[3] J. Walker and P.R. Rowntree, 'The effect of soil moisture on circulation and rainfall in a tropical model', *Quarterly Journal of the Royal Meteorological Society*, Vol 103, 1977, pp 29–46.
[4] E.O. Oladipo, 'On the spatial and temporal characteristics of drought in the interior plains of North America – a statistical analysis', PhD thesis, University of Toronto, 1982, quoted in F.K. Hare, 'Climate and desertification: a revised analysis', *World Climate Programme*, WMO-UNEP, Vol 44, 1983.

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and south, similarly affected at the same time. The duration of droughts show very significant examples of persistence.'[8]

Reviewing the present state of knowledge on this matter, Hare addresses four principal questions and gives their answers as summarized here.[9]

(1) What is the present state of knowledge about secular or long-term shifts of dry climate? Rainfall is very variable in time and space. There is a weak two-to-three year rhythm in some areas that is overridden by non-periodic variations of large amplitude. These variations are of natural origin, but may be accentuated by feedback mechanisms of bad land use.
(2) To what extent can such climatic changes be attributed to man's influence? Degradation of plant cover (due to overgrazing, overcutting of woodland, etc) causes deterioration of surface microclimate, and increases surface albedo. Large increases in albedo lead to further decrease in rainfall.
(3) What are the prospects for long-term (seasonal or longer) forecasts? No present method is available, progress towards it is slow.
(4) What is the likelihood of significant human amelioration of the present conditions in dry climate? Better land use methods and green belts may improve microclimates. Rainfall-enhancement may offer some hope, though this is yet to be proved.

Actions of man may have some exacerbating effects on microclimate (change in ground surface albedo due to degradation of plant cover or to change in land use), regional climate (increase of particulate materials in the troposphere)[10] or global climate (increase of CO_2 and other greenhouse gasses in the atmosphere). Certain land use practices may alter local or regional hydrological regimes (affecting infiltration, runoff, stream flow, etc) and may thus cause immediate changes in water quantity and quality.

The likely relationship of human activities and the prolonged drought of the Sahel has been discussed by many scientists. Charney suggested that Sahelian rainfall could be modified through a process termed 'biogeophysical feedback', whereby drought is reinforced through changes it evokes in the land surface or through similar changes caused by impacts of land use.[11] Removal of plant cover increases surface albedo and in turn affects the atmospheric energy budget in a way that intensifies subsidence and hence increases aridity. Schnell suggests that destruction of vegetation reduces the availability of organic particles that act as freezing nuclei and hence reduction of rainfall.[12] Nicholson comments that 'any of the changes in the Sahel that have been suggested as potential feedback mechanisms (surface albedo, surface temperature, reduced production of freezing nuclei, reduced surface moisture, dust) can also result from human activity alone or can intensify when overuse is coupled with extreme meteorological drought'.[13] To this we add that evapotranspiration from soil and vegetation may be an important source of moisture to supply rainfall.[14] Destruction of plant cover reduces this source.

Desertification and soil degradation

Extensive areas of productive lands are subject to ecological degradation that reduces their productivity. Desertification operates through

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[5]S. Nicholson, *The Sahel: a Climate Perspective*, Club du Sahel, Paris, 1982; M.D. Dennet, 'MS time series precipitation over Sahel', 1982, quoted in F.K. Hare, *op cit*, Ref 4.
[6]S. Nicholson, 'The nature of fluctuations in subtropical West Africa', *Monthly Weather Review*, Vol 108, 1980, p 473–487; R.P. Motha *et al*, 'Precipitation patterns in West Africa', *Monthly Weather Review*, Vol 108, 1980, p 1567–1578.
[7]Oladipo, *op cit*, Ref 4.
[8]'Hydrological aspects of drought', in M.A. Beran and J.A. Rodier, eds, *Studies and Reports on Hydrology*, UNESCO–WMO, Vol 39, 1985.
[9]F.K. Hare, 'Climate and desertification: a revised analysis', *World Climate Programme*, WMO-UNEP, Vol 44, 1983.
[10]C. Morales, ed, *Saharan Dust*, SCOPE, Vol 14, J. Wiley, Chichester, UK, 1979.
[11]J.C. Charney 'Dynamics of deserts and drought in the Sahel', *Quarterly Journal of the Royal Meteorologic Society*, Vol 101, 1975, pp 193–202.
[12]R.C. Schnell, 'Biogenic and inorganic sources of ice nuclei for the drought stricken Sahel – 1974', *Report to Directors of Rockefeller Foundation*, New York, NY, USA, 1975.
[13]S. Nicholson, 'The climatology of Sub-Saharan Africa', in *Environmental Change in West African Sahel*, National Academy Press, Washington, DC, USA, 1983, pp 71–92.
[14]Beran and Rodier, *op cit*, Ref 8.

land use systems and it results from a combination of (a) the natural fragility of the resource ecosystems in arid, semi-arid and sub-humid territories, and (b) excessive pressures of land use exceeding carrying capacity. Manifestations of desertification include:

- deterioration of rangelands;
- degradation of rainfed croplands;
- waterlogging and salinization of irrigated lands;
- deforestation and destruction of woody vegetation;
- growth and encroachment of mobile sand bodies;
- declining availability or quality of water supplies.[15]

Desertification is a gradual process by which the productivity of land is reduced. This land degradation involves 'a continuum of change from slight to severe'.[16] It results from a combination of man's excessive use of ecosystems that are inherently fragile. Fragility means that the habitat is vulnerable to deterioration and is the functional manifestation of ecological features that include extreme seasonality of climate (the year is divided into a rainless season and a wet season), extreme year-to-year variation in annual rainfall and failure of rainfall – often nicknamed drought. Recurrent and/or prolonged drought is a non-predictable climatic incidence; its effect is often dramatic as it causes widespread failure of food-producing systems. If excessive exploitation (overgrazing, overcultivation, overcutting) coincides with the incidence of drought, rates of ecological degradation (desertification) often accelerate. Though related, desertification and drought should not be confused. Modalities of their management are different. Management of desertification relates primarily to improved land use systems; management of drought relates to societal means of insurance against natural hazards.

The UNEP global assessment of desertification showed that desertification undermines the life support system of some 850 million people and that it affects some 3.5 billion hectares of: rangelands (3.1 billion ha), rainfed croplands (335 million ha) and irrigated lands (40 million ha). Each year some 21 million hectares are reduced to a state of near or complete uselessness.[17] Dregne states that a 'conservative estimate of the amount of lost wheat production worldwide that could be attributed to desertification is 23 million metric tons each year. That much wheat is sufficient to meet the calorific requirements of 80 million people for one year. For all the arid regions, the current value of lost agricultural production is estimated to be about $26 billion each year.'[18]

All around the world soils are subject to hazards of degradation – physical, chemical or biological changes that undermine the structure and functioning of the soil system, and may eventually lead to decline of soil quality. Various forms of soil degradation, often related to land use practices that overtax the system, include erosion, salinization, waterlogging and chemical degradation. Soil degradation is one aspect of desertification but it is not confined to arid and semi-arid territories.

Erosion is a natural process that is often greatly increased (accelerated erosion) due to land use practices (shifting cultivation, overgrazing, overcutting, etc) that reduce the protective cover of plant growth. It is estimated that the mass of material moved annually by all rivers to the ocean (natural erosion) is about 9.3 billion tonnes, and that the actual volume (accelerated erosion) is about 24 billion tonnes.[19] There are evident regional differences. Asian rivers seem to contribute the largest

[15] J.A. Mabbutt, 'A new global assessment of the status and trends of desertification', *Environmental Conservation*, Vol 11, 1984, p 103–113.
[16] H.E. Dregne, *Desertification of Arid Lands*, Harwood Academic Publishers, London, UK, 1983.
[17] UNEP, 'General assessment of progress in the implementation of the Plan of Action to Combat Desertification: 1978–1984', *Report of the Executive Director*, UNEP/GC 12/9, Nairobi, 1984.
[18] Dregne, *op cit*, Ref 16.
[19] S. Judson, 'Erosion of the land', *American Scientist*, Vol 56, p 356–361.

share, estimated at 14.53 billion tonnes/year followed by the USA (1.78), South America (1.09), Africa (0.48), Europe (0.30) and Australia (0.21).[20] Data compiled in 1980 by the Chinese Yellow River Conservancy Commission indicate that the Yellow River carries 1.6 billion tonnes of soil to the ocean each year. The Ganges of India discharges a load of 1.5 billion tonnes of deposits into the Bay of Bengal each year.[21] Wind erosion moves much less material, although Saharan dust accounts for billions of tonnes per year.[22]

Societal aspects

Estimates show that more than 400 million of the rural populations are directly affected by desertification (see Table 1). Africa and Asia are most affected in terms of population, with crop-based populations most pronounced. It may be noted that 'the crop-based component represents 85% of the dryland rural population in only 15% of its area'. Populations affected by desertification in irrigated lands are high in Asia.

The report of the Independent Commission on International Humanitarian Issues (ICIHI) estimates that 'at the time of the last major African famine in the early 1970s, it was thought that chronic hunger and malnutrition were the regular condition of 80 million Africans. The number is now 100 million. Each year the rate of growth of the population exceeds that of food production. The permanent food crisis therefore worsens year by year.'[23] The population in Africa is 'increasing at about 3.1% a year, food production was, during the five years until the drought, increasing at about 1.6% a year'.[24] Distinction is made between chronic shortage of food and famine that is associated with spells of drought and failure of the food-producing systems. By 1985, 20 African countries were seeking emergency food aid; the numbers seriously affected by food shortages and in urgent need of food aid were estimated at 30 million. It created up to 10 million migrants.[25]

The ICIHI report describes famine as 'more than people dying from starvation. It is an acute breakdown of society. Famine is that moment when a group's normal access to food so completely collapses that mass starvation occurs. Famine is also characterized by widespread disruption as people migrate or in other ways radically break with normal behaviour in their search for food . . . Famine is the tip of a much bigger underlying crisis. Even when Ethiopia is free of famine, 1000 children are thought to die each day of malnutrition and related illness.'[26]

The following statements are quoted from an OXFAM report on drought and the Sahel:[27]

[20]A.R. Robinson, *Relationship Between Soil Erosion and Sediment Delivery*, IAHS Publication No 122, USA, 1977.
[21]L. Brown, ed, *State of the World 1984*, W.W. Norton, London, UK, 1984.
[22]Morales, *op cit*, Ref 10.
[23]ICIHI, *Famine: a Man-made Disaster?*, Pan Books, London, UK, 1985, p 26.
[24]*Ibid*, p 64.
[25]*Ibid*, p 25.
[26]*Ibid*, pp 25–26.
[27]N. Twose, *Drought and the Sahel*, Oxfam, Oxford, UK, 1984.

Table 1. Rural populations affected by desertification (moderate and severe) by region (millions).

Region	Rangelands	Rainfed croplands	Irrigated lands	Total
Africa	39	125	5	169
Asia	25	86	65.5	176.5
Australia	0.03	0.13	0.1	0.26
Mediterranean Europe	3	17.5	2	22.5
Latin America	6	34	3.5	34.5
USA	2	2.5	1.2	5.7

Source: modified from J.A. Mabbutt, 'A new global assessment of the status and trends of desertification', *Environmental Conservation*, Vol 11, 1984, pp 103–113.

(1) The Sahel has a consistent record over the last 20 years of failure in food production for local consumption, but a steady success in cultivation of export crops (peanut, cotton): half of the cultivated land in Senegal is used to grow peanuts, in 1960 Senegal grew no cotton, by 1971 it produced 21 209 tonnes; in Upper Volta cotton production in 1960 was 2341 tonnes, in 1982 it reached 75 000 tonnes; in Mali during the drought years of 1967–1972 cotton production increased 400% and peanut production increased by 70%.

(2) Almost all the Sahel's cereal production comes from rainfed agriculture, but only 16% of the billions ($7.45 billions) of aid poured after 1975 was directed towards food crops. Irrigation programmes have been almost exclusively used to produce rice: a cash crop for urban consumption or for export.

The above quoted comments are similar to those contained in numerous reports diagnostic of the Sahel (and the African) crisis.[28]

The United Nations Environment Programme presented an assessment of progress in the implementation of the Plan of Action to Combat Desertification (1978–84).[29] This assessment shows that action at the national level was far from effective. The countries that are worst affected are disadvantaged climatically (recurrent drought) and economically (low-income countries), and are often beset by political unrest. Moreover, desertification-control projects do not seem capable of competing for the limited financial resources that are available – their rates of economic return are often lower, and their gestation periods are often longer, when compared to marketable projects. With these constraints, countries seem unable to accord priority to desertification control programmes within their plans for investment.

Actions for combating desertification are inseparable from actions of resource development and management in arid and semi-arid lands. But schemes that aim at: checking land degradation in pasturelands, rainfed farmlands and irrigated agricultural lands; stabilizing sand dunes; establishing large-scale green belts; introducing soil and water conservation systems in resource management or reclaiming new territories of arid and semi-arid lands, are apt to be costly. Projects involving irrigation schemes are particularly expensive. Such schemes are commonly non-competitive by prevalent market values. Investment in land reclamation projects commonly do not pay well financially, but their social dividend is invaluable. This shift towards social benefit rather than commercially feasible ventures relates mainly to costs of capital investment in land-reclamation projects, and not to the running expenses of farming. National policies and policies of aid institutions should recognize this situation and develop practices of operation that accommodate it.

A case study

Recurrent drought (and associated ecological degradation) is an inherent feature of arid and semi-arid climate. Can management of this natural hazard relate to different levels of development? Consider, as one of many examples, the case of USA arid and semi-arid lands.[30] In the early 1930s the area was menaced by a drought comparable in its severity and its impacts to the Sahel drought of 1968–73. The area became an extensive dust bowl and sights of villages overwhelmed by sand encroachment and deserted farms and ranches became common.

[28]For example, L. Timberlake, *Africa in Crisis*, Earthscan, London, UK, 1985.
[29]UNEP, *op cit*, Ref 17.
[30]R.F. Logan, 'Post-Columbian developments in the arid regions of the USA', in L. Dudley Stamp, ed, *A History of Land-use in Arid Regions*, UNESCO Arid Research, Vol 17, 1961, pp 277–297; National Science Foundation (NSF) 'The study of aridity', *Mosaic*, Vol 8, 1977, pp 36–43.

The resource ecosystems were seriously damaged. In the 1950s drought recurred but passed almost unnoticed. Two questions arise from this. What happened in this area during the period prior to the 1930s that caused the systems to be so fragile as to be seriously damaged by the 1930s drought? what happened during the 1930–50 period that imparted on the system an ability to withstand drought with little damage?

In the late 1860s an influx of settlers, chiefly graziers, flowed westward to these poorly administered territories. For some 50 years the practice was open range, and conflict and violence were widespread. During this long period of unrestricted grazing the rangelands were subject to overstocking and little management. When the drought of the 1930s occurred the territories were so vulnerable that they soon became the dust bowl of the USA. Impacts similar to those that menaced the Sahel countries in the early 1970s were rampant.

What happened in these territories between 1930 and 1950 provides us with the packet of corrective measures.

One: in 1934 the Taylor Grazing Act set in operation the recommendations made by a technical group (Wesley Powel Commission) 55 years earlier. It established federal control of numbers of animals and land use according to land suitability. Under what became the Bureau of Land Management measures of soil conservation and balance with carrying capacity of rangeland were implemented. In 1934 the first national survey was made to assess the severity of the erosion problem in the USA. In 1935 a legislation established the Soil Conservation Service, a federal agency, as a part of the Department of Agriculture.

Two: in the following 40 years (1935–75) some $15 billion of federal funds were spent on soil conservation activities. Rehabilitation and relative stability became evident by 1940.

Three: the railway lines extended into the arid lands and the highways and trucks followed. These provided means of transporting livestock from summer ranges to winter ranges and to markets. The cross-country transhumance became mechanized.

Four: the hardy Texas Longhorn cattle that was well adapted to long distance travel was gradually replaced by less hardy but better quality breeds of Hereford, Brahman, Shorthorn, etc.

Five: the widespread use of cattle fencing allowed for adoption of ecologically sound range management including deferred and rotation grazing.

Six: mechanical innovations provided improved well pumps and well-drilling equipment that allowed for tapping aquifers at great depth. Stock watering facilities, miles of pipelines and large storage tanks became common features.

Seven: large-scale water management projects included the establishment of several dams, eg Grand Coulee, Boulder, Shasta and Friant. These provided irrigation for extensive farmlands and allowed for production of fodder and feed materials under irrigation. Irrigated farmland became an integrated part of the livestock-range industry, most evident in the eventual development of the feedlot industry.

Eight: in this period new sciences of applied ecology were developed (soil conservation, range management) and provided, through effective extension services, advice and vocational training to farmers and graziers.

This sequence of events occurred through a combination of government control (legal instrument), government assistance and guidance

(land use policies), national development schemes (railways, roads, reservoirs, etc), advancement in science and technology and its application, development of natural resources within the framework of an ecologically sound land use policy and integration – not conflict – of various uses. These actions together provided for the sustainable use of land resources, promoted the capacity of the resource ecosystem to withstand the inevitable spells of drought and ensured positive participation of people.

There are fears that the efficacy of this operation has recently been relaxed and that the incidence of a future drought may cause serious damage.[31]

National policies

National policies for control of desertification need to be formulated, endorsed and integrated into national policies for development. These policies should accord priority to the sustenance of productivity of land, to the well-being of human communities in the desertification-prone territories and to their food security. National policies need to combine:

- giving higher priority in national plans for development to programmes of combating desertification;
- establishment of national machinery for combating desertification with the capacity to coordinate national endeavour, to remove constraints that hinder action and to monitor and assess degradation and enhancement;
- creation of conditions and institutions that promote participation of rural populations affected by desertification hazards;
- vast increase in funds and resources apportioned to desertification control;
- institution of programmes of monitoring and assessment of desertification, early warning of drought hazards, research studies and training of technicians and managers.

Experience shows that many measures aimed at arresting desertification failed to meet with the success their sound technological bases promised, because they lacked community participation and support. This underlines the special importance of setting and implementing government policies that provide appropriate mechanisms, incentives and education programmes which are needed for the acceptance and implementation of measures at community level, their maintenance within improved and productive land use systems, and eventually their self-regeneration towards improvement of living conditions. These policies would secure community involvement in determining priorities and in planning and implementation of combative and preventive measures. Such measures would relate to reduction of population pressures on land, maintaining balance between range carrying capacity and livestock grazing, sustainable use of woodlands and conservation of soil and its protective plant cover.

Demographic patterns (including nomadism) and land-right systems (including free grazing) that prevail in arid lands and desertification-prone lands may not be conducive to effective public participation. Settlement of nomads may not be the answer, except within the framework of transformation of land use systems, development of land resources, and changes in land-tenure systems. For community parti-

[31] P.R. Crosson and A.T. Stout, *Productivity Effects of Cropland Erosion in the United States*, Resources for the Future, Washington, DC, USA, 1983.

cipation to be effective, societal instruments (legislation, institutions, means of mobilizing public support, etc) may need to be developed.

Government policies that do not accord high priority to anti-desertification programmes often indicate the light political weight of the communities directly affected. As desertification further undermines their life-support systems they are increasingly marginalized. Further constraints include lack of national machineries that have desertification control as their principal function, shortages of trained manpower and shortages of financial resources.

In a Study on Financing the UN Plan of Action of Combat Desertification various estimates are given of the cost.[32] The average cost of a 20-year programme in developing countries requiring aid would be about US$2.4 thousand million per year. The total external assistance involving desertification control was estimated (in 1978) at about $600 million annually, leaving a requirement from additional sources of about $1.8 thousand million annually for 20 years. It is evident both that available aid sources are short, and that available domestic sources fail to provide priority to anti-desertification projects. Innovative means for financing such projects need to be explored.

National plans

A national plan of action to combat desertification would aim at: (1) halting further ecological degradation of productive lands, (2) reclaiming desertified lands, and (3) developing land and water resources of arid and semi-arid territories. Such a plan needs to be set as an integral part of national plans for development and would incorporate the following principal elements:

- monitoring and assessment;
- land use policy and planning;
- environmentally sound management of land resources;
- appropriate legislation;
- indigenous science and technology capabilities;
- education and training programmes;
- sources of investment;
- organizational institutions.

The success of the implementation of such national plans will depend on the willingness and ability of the government concerned, and the creation of national machinery for elaboration and implementation of national programmes.

Success will depend on application of scientific knowledge and appropriate technologies relevant to the management of resources and to remedial and corrective measures. General Assembly resolution 3337 (XXIX), which convened the United Nations Conference on Desertification, underlined the need to strengthen indigenous scientific capabilities in countries affected by desertification. Scientific capabilities related to activities dealing with monitoring and assessment, land use planning, management, etc, integrate natural sciences, social sciences and application of science and technology. Indigenous scientific capabilities could provide three needs: trained personnel, facilities and experimental tools, and programmes oriented towards solving problems.

Education and training need to be conceived in their broadest sense

[32]UN document A/35/396–17, NY, USA, 1980.

and to cover formal and non-formal education, conventional and non-conventional means, and vocational training and training of high-level technicians. Another objective is to inform citizens and to persuade them to cooperate meaningfully and effectively in national programmes. Programmes of vocational training and extension services are important for the application of science and the transfer of technology. Universities have cardinal roles to play in education, training and research related to arid lands.

Activities for combating desertification involve a number of government departments. A national machinery capable of mobilizing national components needs to be set. There is no single structural organization for such a machinery, but it may include the following national components: policy and planning authority; national desertification control commission; monitoring network; programmes for research and development; programmes for education and training; and programmes for public participation.

Management of drought

Reference may be made to paragraphs 66–68 of the Mar Del Plata Action Plan[33] and to Recommendation 17 of the Plan of Action to Combat Desertification.[34] The former is primarily concerned with water resource development and conservation, the latter with insurance against the risk and the effects of drought. A combined text of the two recommendations would read:

There is a need to develop improved bases for planning land and water management in order to make optimum use of land and water resources in areas subject to severe drought. Comprehensive programmes should be formulated for the progressive implementation of the development of water resources for the benefit of drought-affected areas. There is also a need to study basic meteorological processes with a view to formulating long-term forecasts in weather behaviour in any given area. It is further recommended that preventive measures be taken and protective strategies adopted for effectively combating the risks and effects of drought, and that insurance schemes be adopted at the national level which are compatible with the socioeconomic needs of the local people and the national interest in relation to the long-term protection of resources and the quality of the environment.

The Mar Del Plata Action Plan contains the following recommendations with regard to water resources:

(a) Undertake studies on climate, hydrometeorology and agronomy and on local management techniques in order to define the best means of extending and intensifying rainfed cultivation while incurring a minimum of risk from scarcity of rain.

(b) Make an inventory of all available water resources and formulate long-term plans for their development as an integral part of the development of other natural resources, and within this framework prepare medium-term and long-term plans for the development of these water resources. These activities may require cooperation with similar activities in neighbouring countries.

(c) Consider the transfer of water from areas where a surplus in water resources is available to areas subjected to droughts.

(d) Intensify the exploration of groundwater through geophysical and hydrogeological investigations and undertake on a regional scale

[33]Mar del Plata Action Plan, UN Water Conference, 1977.
[34]Plan of Action of Combat Desertification arising from the UN Conference on Desertification, 1977.

large-scale programmes for the development of wells and boreholes, to be explored in groups where appropriate for water for human and livestock consumption, taking into account the needs of pastures while preventing overgrazing and avoiding overexploitation of underground aquifers.

(e) Determine the effect of drought on aquifers and in the assessment of the response of groundwater systems to drought, basing such assessment on concepts such as storage/flow ratio in order to characterize groundwater flow regions in periods of drought.

(f) Arrange to complete as expeditiously as possible feasibility reports for well-defined surface water projects and for the implementation of projects deemed to be feasible.

(g) Make arrangements for the proper maintenance of existing wells and the development of new ones, using the resources and energies of the affected population in rural areas on the basis of self-help, supplemented by state assistance and external resources.

(h) Undertake studies on technologies geared to the improvement of water pumps, efficiency of uses and the reduction of losses from evaporation, seepage, transpiration, etc.

(i) Develop drought-resistant plant species.

(j) Set up systems for the observation and control of the processes of desertification and carry out research on the basic causes of drought.

(k) Strengthen institutional arrangements, including cooperation among various agencies, for the preparation and dissemination of hydrological, hydrometeorological and agricultural forecasts and for the use of this information in the management of water resources and disaster relief.

(l) Wherever possible, institute a deliberate policy for the transfer of population from drought-prone areas to other suitable regions with the view of reducing harmful effects on the ecosystem and promoting long-term rehabilitation programmes.

(m) Evolve contingency plans to deal with emergency situations in drought affected areas.

(n) Study the potential role of integration of surface and underground phases of water basins utilizing the stocks of water stored in groundwater formations in order to maintain a minimum supply under drought conditions.

National actions recommended from the Plan of Action to Combat Desertification as regards insurance include:

(a) Establish or reinforce crop and livestock insurance schemes, and savings and credit institutions designed for small farmers and livestock owners.

(b) Create food, fodder, fuel and pastoral reserves against disaster, as well as reserves of seeds.

(c) Plan in advance for periods of less than normal precipitation.

(d) Investigate existing local risk-reduction and insurance mechanisms so that these may be strengthened and supplemented during crises and where appropriate, incorporated in more permanent insurance schemes.

(e) Consider ways to maintain the purchasing of dry land farmers and pastoralists during periods of drought so as to protect them against the effects of price instability, and organize pilot projects based on locally available resources.

(f) Establish national and provincial commissions to work towards

agreements between farmers and pastoralists about the shared use of common lands and water supplies during periods of crisis.

(g) Provide for a portion of the proceeds of taxation, where taxation of livestock and other means of agricultural production exists, to be set aside for insurance purposes for the people subject to taxation.

(h) Establish food reserves within agricultural areas vulnerable to desertification, with due regard to factors of storage, transportation and management.

(i) Establish special forms of risk insurance for pastoralists, including: loans of breeding stock, including traditional exchanges; identification of reserve pasture areas, with appropriate management schemes; establishment, maintenance and improvement of permanent breeding stocks; establishment of emergency markets for disposal of surplus animals.

(j) Provide alternative forms of relief employment for people affected by drought, including the stockpiling of tools.

(k) Design essential services, such as water supply, transport, medical and veterinary services, to meet periodic drought crises.

(l) Consider the establishment of national insurance schemes, operating from suitably located centres, for people at risk, to assist them during periods of crisis.

General remarks

The UNEP assessment confirms that desertification is a world problem by reason of its scale and urgency and through the universality of its impacts and causes.[35] National and international efforts during 1978–84 were not commensurate to the required actions. The Plan of Action was based on the premise that desertification could be halted and eventually reversed by the year 2000. In 1984 this was evidently not attainable. Desertification continued to spread and intensify.

Action to combat desertification needs to rest within the national domain. The Plan of Action suggested modalities for national institutional arrangements. Few countries established national machineries – of the three national agencies designated by 1982, only one was effective. This reflects the low national priority accorded to combating desertification.

The Plan of Action notes the transnational nature of desertification and calls for a variety of regional collaborative actions. Experience with respect to transnational projects endorsed by the UN Conference on Desertification was negative. Examples of success of regional activities include achievements of the Permanent Inter-State Committee on Drought Control in the Sahel (CILSS), the Institut du Sahel and the Centre for Applied Agrometeorology and Hydrometeorology.

The Plan of Action envisaged three likely sources for financing its implementation:

(1) A Special Account established by the General Assembly in 1979. Its resources remained below the minimum level required to make it operative in 1986.
(2) The Consultative Group for Desertification Control (DESCON) remains the only mechanism available to assist in mobilizing existing or additional financial resources for implementing the Plan of Action. Funds in excess of $25 million have been secured in six

[35]UNEP, *op cit*, Ref 17.

years (1978–83). Its effectiveness as a forum is greater than indicated by the level of funding obtained.

(3) It was estimated that the effective implementation of a 20 year programme to arrest further desertification in developing countries would require $48 billion. The financing of such a programme would require a flow of additional resources. In a series of resolutions the UN General Assembly requested studies on means for financing the implementation of the Plan of Action to Combat Desertification. These studies, and the debate related to them, express the need for securing additional and predictable finances for combating desertification.

The UN General Assembly by resolution 35/73 (of 1980) called for the institution of programmes of research and training (related to desertification control) at the national, regional and international levels. It called upon UNEP, in cooperation with organizations and bodies of the United Nations, to institute this much needed programme. Private foundations and other grant-making institutions were called upon to cooperate financially in the implementation of these programmes. Preparatory and planning studies were carried out but implementation is still minimal. For a report on this subject see Baker.[36]

[36]R. Baker, *Research and Training for Desertification Control*, UNEP, Nairobi, 1985.