

MANAGEMENT OF DRYLAND AND DESERT AREAS

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Summary

The drylands of the world are becoming increasingly important for food production and are under increasing threat of desertification. Within the overall setting of dryness or 'aridity', they exhibit a tremendous diversity in climates, landscapes, soils, geological substrata, surface water and groundwater resources.

Although drylands are commonly perceived as fragile ecosystems, highly susceptible to degradation and desertification, it is not always easy to distinguish natural processes related to dryness from human-induced degradation trends. This uncertainty about the human-induced nature of dryland degradation applies in particular to salinization, wind and water erosion, and vegetation dynamics as related to climatic perturbations, fire and animal pressure.

The main principles for successful dryland crop management are well known. Essentially they boil down to retaining precipitation on the land, to reducing evaporation, and to use crops with drought tolerance and that fit the rainfall pattern. An exception is water harvesting, which is a form of irrigation whereby runoff is encouraged from a catchment area, in order to provide more water to a target area.

The rangelands probably constitute the most neglected agricultural sector of the drylands. Although generally of low productivity per unit area, they are the biggest land resource of the drylands.

The key principle of all sound range management is to adapt, through spatial and temporal stock management, grazing intensity to levels that allow the maintenance of palatable species and a sustainable cover.

In view of the diversity of vegetation, climate and seasonal conditions within the drylands, this principle is difficult to apply on a sustainable basis. Particularly the pastoral systems, dependent on communal grazing, are under threat, due to their inability to avoid overgrazing.

The key to successful dryland management is to convert the broad principles into site-specific management packages that take full consideration of local agro-ecological conditions, land user goals, and policy frameworks. Given the enormous complexity of possible interactions, a systems approach is necessary.

1. Introduction

The dryland areas of the world have an unexpected diversity in terms of agro-ecology and agricultural systems. They also constitute fragile environments that require very careful management.

The diversity, local problems and potentialities of the various dryland farming systems necessitate a holistic approach, on the basis of proven dryland management principles and location-specific management recommendations and packages.

An integrated natural resource management approach, which applies participatory research and technology development to locally defined problems and management goals, is vital for the sustainable management of dryland systems.

2. Drylands of the World

1. Hyper-arid zone (P^1/PET^2 ratio $< .03$)
This is the zone of the true deserts: very low and irregular rain may fall in any season, with an inter-annual variability of 100% or more. There is almost no perennial vegetation, except some bushes in river beds, although annual plants can grow in good years. In general agriculture and grazing are not possible.
2. Arid zone ($.03 < P/PET < 0.2$)
This zone has an annual rainfall of 80-150 mm in winter rainfall regimes and 200-350 mm in summer rainfall regimes, with an inter-annual variability of 50-100%. It has scattered vegetation including bushes, small woody, succulent, thorny or leafless shrubs. Only light pastoral use is possible, but not rainfed agriculture.

¹ P: annual rainfall

² PET: annual potential evapotranspiration

3. Semi-arid zone ($0.2 < P/PET < 0.5$)
This zone has a mean annual rainfall from 300-400 mm to 700-800 mm in summer rainfall regimes, and from 200-250 mm to 450-500 mm in winter rainfall regimes, with inter-annual variability of 25-50%. It is a steppe zone with some savannas and tropical scrub, which may contain good grazing areas. Rainfed agriculture is possible, although with great yield fluctuations due to great rainfall variability.
4. Sub-humid zone ($0.5 < P/PET < 0.75$)
This zone, with higher rainfall than the previous one, has inter-annual rainfall variability of less than 25%. It includes various vegetation types such as tropical savanna, maquis and chaparral, steppes etc. Agriculture is the normal use.

Table 1. UNESCO classification of the arid zones of the world: moisture regimes and summary characteristics.

The drylands of the world are receiving increasing attention by researchers and development planners for two main reasons. Firstly, future increases in agricultural production will increasingly depend on the contribution from rain-fed agriculture in marginal lands, notably in drylands.

A second reason is that the drylands under agricultural use, with 70% of them affected by some degree of degradation, are at the frontline of desertification.

As Noin and Clarke (1998) pointedly observe, “the term ‘drylands’ and its derivatives such as ‘desert, drought, desertification, semi-desert, sahel, steppe, arid, semi-arid, dry sub-humid’, have been variously and loosely used, understood, and defined by different people”.

To resolve the terminology issue and to characterize better the dry areas of the globe, UNESCO (1979) has proposed a simple but clear-cut worldwide classification system, based in first instance on the ratio of annual precipitation to annual potential evapo-transpiration, calculated by the standard Penman method (Table 1).

Further subdivisions were based on the temperature regime during winter and summer, resulting in a system of 44 classes. A simplified world map, derived from the UNESCO map, is given in Figure 1.

The patterned areas indicate where cold conditions accompany aridity. Based on the UNESCO classification system the drylands are defined by UNEP (1991) as those lands with a precipitation over potential evapo-transpiration ratio of less than 0.65. Drylands thus defined cover approximately 41% of the world’s land area, with two-thirds of these in Africa and Asia (Table 2).

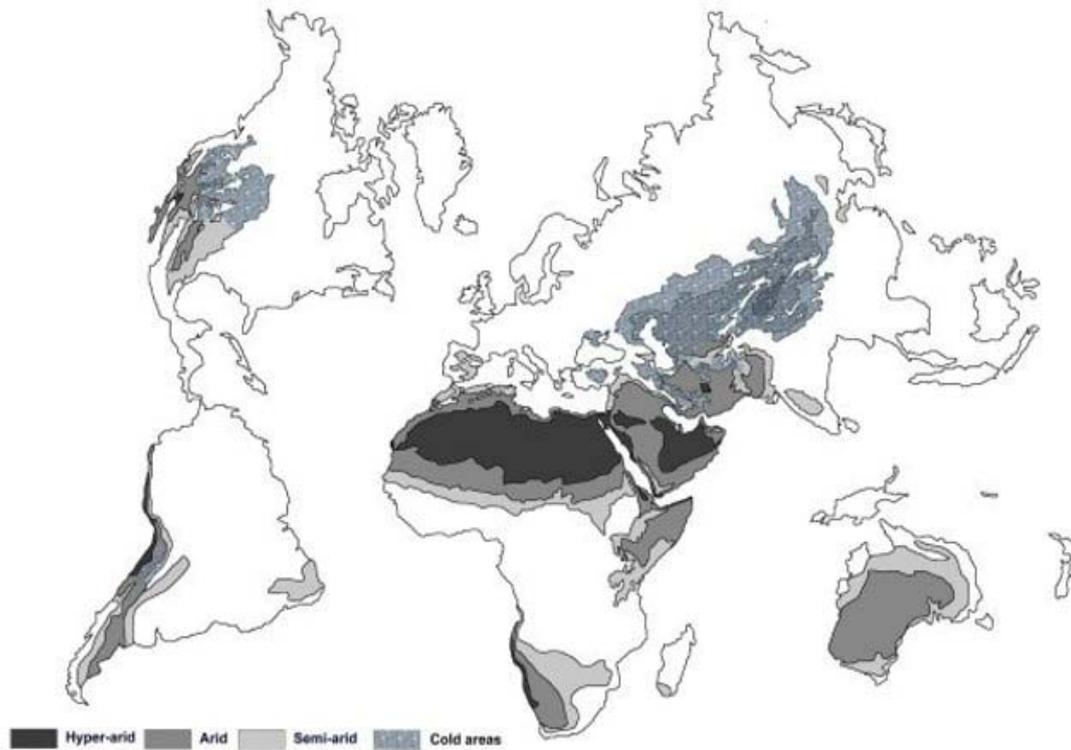


Figure 1. Distribution of the drylands of the world (based on UNESCO, 1979; sub-humid areas not included; Oceania displaced)

Dryland category	Areas (in million hectare)					
	Africa	Asia	Australia	Europe	N.America	S.America
Hyper-arid	672	277	0	0	3	26
Arid	504	626	303	11	82	45
Semi-arid	514	693	309	105	419	265
Dry sub-humid	269	353	51	184	232	207
Total dryland	1,959	1,949	663	300	736	543
Total land area	3,022	4,461	768	1,040	2,423	1,781

Table 2. Distribution of the drylands by continent

3. Geographical Distribution of Drylands

Drylands occur under a wide range of temperature and precipitation regimes. At the most generic level arid conditions are created by the interaction between global atmospheric circulation patterns, the distribution of land and sea and local topography. The air that is heated at the equator rises and cools, loses its moisture in the tropical belt, subsides towards subtropical latitudes 30°N and 30°S and heats up, creating two subtropical high pressure belts from which trade winds blow hot and dry air back towards the equator.

Where the trade winds blow overland, they are responsible for the major desert belts and arid fringes of the world. To this category belong: the Sahara, the Arabian and Iranian

deserts in the Middle East, the Turkestan desert in Central Asia, the Namib and Kalahari deserts in southern Africa, the Australian desert and the Atacama-Peruvian desert in South America. On the other hand, where the trade winds blow onshore, such as on the east coasts of Africa, South America and Australia, they bring moisture and preclude the existence of arid conditions. Other arid zones, such as the Gobi and Takla Makan in Central Asia, are created simply by their central position within a huge landmass, which isolates them from oceanic sources of moisture.

Outside the subtropical belt extensive arid belts may occur within the high latitudes as a result of rain-shadow effects. They are typically located on the leeward side of major topographical barriers. This is the case for the North American and Patagonian deserts which are in the rain shadows respectively of the Sierra Nevada and the Andes.

The drylands are unevenly distributed across countries. Given the physical principles that govern the occurrence of aridity, countries in subtropical belts are more prone to arid conditions. However, there is no simple way to classify countries into either humid or arid groups. As Table 3 indicates, 'dryland' countries are usually composed of areas with different degrees of aridity. This has important implications for economic development. In countries where a complementary mix of different climatic zones exists, a higher diversity of agricultural production systems is possible, which could compensate for the physical constraints related to aridity elsewhere. However, in countries where arid zones dominate, the contribution of agriculture to the national economy is by necessity limited.

Continent	Country	Degree of aridity				
		HA	A	SA	SH	H
N. America	Mexico		in	as	do	as
	USA	in	in	as	as	do
S. America	Argentina		as	as	as	as
	Bolivia		in	in	in	do
	Chile	as	as	in	in	as
	Colombia				in	in
	Ecuador			in	in	do
	Paraguay			in	as	do
	Peru	in	in	in	as	do
	Africa	Algeria	do	as	as	
	Angola		in	in	as	do
	Botswana			do		
	Chad	as	as	as	as	in
	Egypt	do	in			
	Eritrea	as	do	as		
	Ethiopia		as	as	as	as
	Kenya		as	as	as	as
	Libya	do	as	in		in
	Mali	as	as	as	as	in
	Mauritania	as	as	in		
	Morocco		as	as	in	in

	Namibia	as	as	do		
	Niger	as	as	as		
	S. Africa		as	as	as	as
	Somalia	in	do	as		
	Sudan	as	as	as	as	as
	Tunisia		do	as		in
Asia	Afghanistan		as	as	as	in
	Azerbaijan		do	as		
	Bahrain		do			
	China	as	as	as	as	as
	India		in	as	as	as
	Iran	in	do	as	as	in
	Iraq		do	as	as	
	Israel	as	as	as		
	Jordan	in	do	in		
	Kazakhstan		as	as	in	
	Kyrgyzstan			as	as	as
	Kuwait		do			
	Lebanon			do		
	Mongolia	as	as	do	as	
	Oman	as	do	in		
	Pakistan		as	do	in	in
	Qatar	as	do			
	S. Arabia	as	as	in		
	Syria		as	as	in	
	Tadjikistan		as	as	do	as
UAE	do	as				
Uzbekhistan		do	in	in		
Yemen	in	do	as			
Oceania	Australia		do	as	as	as

Table 3. Countries with drylands

Explanatory notes:

(a) Degree of aridity: HA: hyper-arid; A: arid; SA: semi-arid; SH: semi-humid; H: humid

(b) The symbols used refer to relative importance within the country: in : inclusion (< 5% of country); as: associated (at least 5-10% of country); do: dominant (> 50% of country)

In terms of population characteristics the dryland countries are a very heterogeneous group. Noin and Clarke (1998) reckon that in the twenty most arid countries of the world total population has multiplied more than six times since the beginning of the twentieth century. They also estimate that the contribution of these countries to the world population is expected to increase from a base of 4.3% in 1900 to 11.5% in 2025.

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Biographical Sketch

Dr. Eddy De Pauw is a citizen of Belgium, where he was born in 1948 in Ghent. He holds M.Sc. degrees in Geology, Soil Science and Development Cooperation from the University of Ghent, as well as a Ph.D. in Soil Science from the same University. Since 1996 he has been Research Project Manager and agroclimatologist at the International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria, where he leads the Agroecological Characterization Project and the GIS unit.

In this position and as former staff member of the Food and Agriculture Organization of the United Nations (FAO) and the International Board for Soil Research and Management (IBSRAM), he has lived and worked for 25 years in Africa and Asia. His research interests include land evaluation, drought monitoring, land degradation, and GIS.