ARID LANDS: CHALLENGES AND HOPES

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Summary

Arid lands could be broadly and simply defined as regions where evaporation exceeds precipitation. Generally speaking, arid lands cover 47% of Earth's land surface. These include four categories according to their aridity index: hyperarid, arid, semiarid, and dry subhumid regions.

During the last 20 000 years, the extension as well as the position of arid lands have varied greatly, from the glacial maximum 20 000 years ago, to the humid optimum 11 000–7000 years ago, finally followed by drier conditions which have continued till the present day.

At present, almost 900 million people inhabit arid and semiarid lands. They are traditionally hunter–gatherers, agriculturists (rainfed or irrigated), and pastoralists. These traditional lifestyles are now rapidly disappearing under spreading urbanization, mining, industrialization, and tourism.

Although biodiversity among plants and animals might not be very high in arid and semiarid lands compared with more humid ecosystems, it seems that many of the crops and domesticated animals on which people and civilizations depended have originated in the semiarid belt. The natural heritage in arid and semiarid regions is still of utmost importance to the inhabitants who traditionally use and have real needs for the conservation of the biodiversity as well the indigenous knowledge linked to it.

Among the problems facing arid lands is the global climatic trend towards an increase in temperatures (global warming), which would lead to an increase in aridity and a decrease in the available moisture. This problem could probably be mitigated through carbon sequestration (CO_2 absorption and storage in plants).

Water resources in arid lands are scarce and are mainly underground water and rivers. Other resources to be sought include desalinization of salt water, precipitation inducement, horizontal wells, exploitation of dew and fog, water harvesting, and the use of runoff water in irrigation.

Human impact in arid and semiarid lands has led to soil degradation through salinization, waterlogging, and wind erosion and has entailed desertification now affecting almost 70% of the region. Desertification describes a situation where a productive land becomes less and less productive due to degradation until it becomes nonproductive and desertified. Desertification is a serious situation that has to be monitored, controlled, and combated through national and international efforts for it has to viewed as a global problem.

An overview of the history and current land use in arid and semiarid regions shows that only through sustainable development will poor and developing countries be able to exploit their resources and overcome the severe problems facing them in the future development of arid and semiarid lands.

1. Definitions

Arid lands were previously addressed as deserts or drylands; these are regions where a

combination of high temperatures and low rainfall causes evaporation that exceeds precipitation. They are characterized by extreme diurnal temperature fluctuations as dry air temperature drops abruptly after sunset. Precipitation is also highly variable, sporadic, and unpredictable. There is also a wide interannual variability of rainfall in arid lands. Droughts might last for several years, meaning that the extent of arid regions varies over time, which means that the boundaries of arid lands are neither static nor abrupt and complicates attempts to set limits for arid regions. The flexibility of boundaries could also be aggravated by human activities such as grazing and fuel wood collection. Streams are ephemeral, except for allogenic rivers such as the Nile, Euphrates, Murray, Rio Grande, and Indus, which begin in areas of high rainfall, and cross the desert area to empty in the sea. The plant cover is thin, mainly of widely scattered vegetation dominated by xerophytes and drought adapted shrubs and succulents.

The plant cover also shows notable seasonal variation and the bioproductivity is low. The soil is fragile with low organic carbon content and suffers from the formation of hardpans and low underground nutrient content. Many plant and animal species are at the limits of their temperature ranges and are thus very susceptible to climatic fluctuations.

At present, drylands cover 6150 million ha, that is, 47.2% of Earth's total land surface area. They are located between latitudes of 15º to 30º in both Northern and Southern Hemispheres in what is termed the arid zone. There are hot deserts and cold deserts, sunny continental deserts and foggy coastal deserts, deserts with winter rainfall and deserts with summer rainfall, sand dune deserts and rocky plain deserts. The main distinction, however, could be made between deserts (hyperarid and arid) and semideserts (semiarid). Hyperarid zones cover 7.5% of Earth's land surface, arid zones cover 12.1%, while semiarid zones are more extensive, occur in all continents, and cover 17.7% of Earth's land surface. The dry subhumid category covers 9.9% of Earth's land surface.

The first detailed world map of arid lands was produced in 1952 by Meigs. The most used however, is that established within the framework of a Man and Biosphere (MAB-UNESCO) program, updated and modified in the UNEP 1992 edition.

From a climatic approach, aridity is an overall moisture deficit under average climatic conditions. Various environmental and atmospheric factors contribute to the occurrence of aridity. In designation of aridity zones, the aridity index or the index of moisture deficit should be taken into consideration. This is calculated by comparing the incoming moisture totals with potential moisture loss: the evapotranspiration/precipitation levels.

The aridity index could be derived from climatic data, either from the total available data set or data for specific or designated time periods.

1.1. Types of Aridity

The main criterion for the determination of aridity, lack of moisture, could be the result of several different agents, such as atmospheric stability (where anticyclone subsidence results in stable moisture-deficient air), continentality (the distance from oceans

prevents the penetration of moisture-bearing winds), and topography (mountain barriers create rain shadow zones and cold oceanic currents reducing sea surface evaporation).

1.2. Levels of Aridity

The intensity of aridity varies from one place to the other due to the variation of moisture deficit, and might even vary within one zone where various environmental factors play roles. However, broad climatic and environmental attributes could be used to divide arid lands into four types according to their aridity index: P/PET. P, mean annual precipitation, divided by PET, mean annual evapotranspiration, yields a ratio as a decimal fraction, which classes the dry region into:

(a) Dry subhumid areas with $0.5 < P/PET < 0.65$. These are areas with low interannual variability in rainfall and are susceptible to degradation due to drought, seasonality of rainfall, and intensive human exploitation for agriculture and grazing.

(b) Semiarid areas with $0.2 < P/PET < 0.5$. These are areas with high seasonality and interannual variability in rainfall from 25 to 50%. They include steppe, dry savannas, and tropical scrublands with scattered good grazing lands. Rainfed agriculture is possible but unpredictable. Annual rainfall varies from 300–400 mm to as much as 800 mm in summer-dominant rainfall areas, 250–450 mm in winter-rainfall regions in the Mediterranean and tropics.

(c) Arid areas with $0.05 < P/PET < 0.2$. These areas have annual precipitation up to 200–350 mm and interannual variability of 50–100%. They support scattered vegetation including bushes, small woody shrubs, and succulent, thorny, or leafless shrubs. Pastoralism and very light grazing but no rainfed agriculture could be practiced.

(d) Hyperarid areas with $0.03 < P/PET < 0.05$. These areas have highly variable annual rainfall (100% variability) and support almost no perennial vegetation, but annuals may appear after the scanty rainfall. True deserts offer limited opportunities for human activities; grazing and agriculture are generally impossible. See aridity, desertification.

2. Paleoperspective

The paleoclimatic data now available indicate that the positions of the climatic boundaries shifted violently over the late quaternary, in low as well as in high altitudes. The mean values of precipitation in tropical Africa moved through a wide range in the late Quaternary. During the last 20 000 years, three periods of different climatic conditions could be distinguished. At the height of the last glacial period (20,000–13,000 BP) global biological activities and terrestrial biomass were at low levels. Ice deserts occupied most of the surface within lat 40º of the poles, loess formations were occupying the middle latitudes—the semiarid regions of today. The lakes occupying the southwest of the USA and other middle latitude areas, which nowadays are semiarid, were the result of low temperatures and evaporation rather than increased precipitation. The intertropical regions were drier than at present. Active dunes occupied much of the Sudan zone in Africa, the semiarid regions of northwest India, north-central Australia, and savanna lands in South America. Generally speaking, arid conditions extended into

regions that are nowadays semiarid.

From 15,000 BP, global climatic conditions ameliorated with increasing precipitation and temperatures. By 9,500 BP, basins in tropical Africa held very extensive lakes and temperatures were similar to the present while the annual rainfall was 150% that at present. Semiarid conditions were limited to certain west-coastal strips in low altitudes and to regions that are now arid. The present semiarid regions were much better watered than they are today. Lakes now confined to closed basins overflowed (Turkana into the White Nile, Galla in the Awash Ethiopia).

About 7000 years ago, climate began to deteriorate, with abrupt climatic changes and fluctuations in temperature and precipitation until, by 5000 BP, it became markedly drier at least in Africa. Fluctuations continued to a much lesser extent from 4500 BP onwards.

The climatic changes that took place during the last 20 000 years are important because of their deep impact on the present day semiarid and arid regions. Land surfaces in semiarid regions still bear the traces of wetter climates. Soils are closely related to the sedimentary landforms, soil properties vary greatly over short distances according to the sediments underlying them, and the morphology of landforms resulting from past winds and water action.

Also, the availability and reliability of underground water in semiarid and arid regions is related to past climatic conditions. The aquifers were charged during the humid periods in the past and thus could not be replenished and the use of this type of fossil water would be exploiting a nonrenewable resource. See *Holocene*.

3. People and Land Use in Arid Regions

At present, there are an estimated 841 million people (15% of Earth's population) living in arid and semiarid regions, 524 million of whom are in semiarid regions. The overall population density, however, is less than half the world average. While fewer people inhabit the hyperarid regions, so that in true deserts, population density does not exceed 2 persons per square mile (259 ha). The unevenness of population distribution is highly characteristic of arid regions. Eighty-six percent of the population lives in Asia and Africa, and 50% live in south Asia and north Africa. The population growth in semiarid regions is rapid and the number of people inhabiting these regions has grown substantially during the recent decades as in the rest of the world.

Generally speaking, humans who live or have lived in arid and semiarid regions all over the world have used very similar strategies of survival. Traditionally, there are three main modes of production among the dwellers of arid and semiarid lands.

3.1. Foragers/Hunter–gatherers

Although agriculture has been practiced for the last 10 000 years, hunting-gathering was still a widespread mode of life only 200 years ago. In fact, the !Kung Bushmen in the Kalahari in South Africa were still hunter–gatherers until mid-twentieth century**.**

Hunter–gatherers were also found in western North America, in southern Texas and northern Mexico, where it is arid and no agriculture was possible before irrigation technologies were invented. Hunter–gatherer societies are characterized by their mobility, low population density, small social units (two persons to small bands), a wide knowledge of plants and their uses, and high adaptability to arid environments and to their limited resources. The Hadza of Tanzania live in the dry savanna scrubland with abundant wildlife. Their diet consists mainly of vegetables, because of the presence of the tsetse fly in the region, African cattle do not survive in this environment. Gathering is mostly carried out by women on a daily basis, fruits and berries in the dry season and edible roots in the wet season. Men also gather vegetables but mainly hunt. The hunt is only shared if the animal is large enough to bring back to camp. This is in contrast to !Kung Bushmen where more sharing is practiced, possibly due to the scarcity of wildlife. Nowadays, this mode of subsistence is shrinking and fewer and fewer people are involved in it.

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Biographical Sketch

H.N. Barakat received his Ph.D. in Paleoecology at Iniversité Aix-Marseille III in France but he graduated in botany and archeobotany in Cairo. He is currently working as ecology lecturer in Department of Botany of Cairo University in Giza. He is vice-president of Nature Conservation of Egypt (NCO).

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1999, Istabl Antar (Fustat) Early Islamic settlement in Cairo.

1999, Wadi Gabgaba Neolithic site, southern part of the Eastern Desert, Egypt.

1998, El Qa'a depression Neolithic sites, southern Sinai.

1998, Survey of Tushka region, southern Egypt.

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1997, 1998, Ain Manawir Persian settlement, Doush, Kharga Oasis, Egypt.

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