ECOLOGY OF TROPICAL DESERTS WITH SPECIAL REFERENCE TO ARID PLANT PHYSIOLOGY

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Summary

The tropical desert regions are most critical parts of world where land degradation and desertification conditions are severe. These regions are situated in different continents with varied problems. These regions differ in landforms, soil texture, fertility status, environment and ecosystems. Common features in all the tropical desert regions are low and erratic rainfall, adverse atmospheric conditions, low population density and scanty livelihood resources. There are various regions where rainfall does not occur for several years, occurrence of floods and famines are natural features. Forests and plantation areas are squeezing in terms of area and density. Many rare plantation species have vanished while others are at the verge of extinction. Wild life residing in forest and protected plantation areas is decreasing for want of proper environment, food and water availability.

Plantation activities are essential for maintaining the ecosystem but it is difficult to achieve the norm of 33 percent forest and plantation area. In addition to human activities, natural conditions have become unfavorable due to changing environment and ecosystem. Tropical desert regions cover 22 percent of global land area and 38 percent of population. The disturbed ecosystem is not limited to tropical desert region but has global impacts. Restoration of tropical desert regions is necessary and it is possible with concerted efforts, which are possible through empowerment of people of these regions in total decision making process and sharing of benefits from the plantation activities. Plantation activities in desert regions are possible through rain water harvesting and water saving devices. Plantation activities will be helpful in cultivation practices, changing the atmospheric conditions and arranging sustainable sources of livelihood to the people. The measures suggested in this chapter will be helpful in changing the ecosystem of these regions in a time bound and effective manner.

1. Introduction

Deserts are merely dry areas of the earth surface, where vegetation is usually stunted, often bizarre in form and either absent or patchily distributed. Geographers, hydrologists, botanists, zoologists, planners and administrators have visualized deserts from the points of view of their professions or interests. The generic characteristics of deserts are treated as waterless surface areas due to poor and erratic rainfall. Water is the most critical aspect of desert regions while other factors such as temperature, climate, humidity, moisture and solar impact are similarly critical. Tropical deserts predominantly lie within the tropics of Cancer and Capricorn or close to these latitudes (see Figure 1). These deserts are largely situated on the west coasts of large continents adjacent to cold ocean currents or in the interior of large continents. Westward locations of desert regions of continents or sub-continents in geographical conditions such as coastal areas of seas or oceans provide enough opportunities for occurrence of monsoon. The general causes which act either individually or in combination to produce dryland

regions and prevalence of aridity are due to geographical conditions which play an important role. Factors creating such conditions if an area is separated from a source of oceanic moisture either by large distances or topographical barriers like massive mountain ranges, desert conditions usually develop. Alternatively, aridity is frequently caused by persistence of dry stable air masses, which resist convective currents. There can be situations where aridity can result from lack of storm systems to create an unstable environment and to provide lifting necessary for precipitation. Out of these possible factors, persistence of high-pressure belts is the most important and critical factor in sub-tropical deserts as a peculiar flow pattern of air within pressure cells near the equator is formed. Sun effect on the equator is direct throughout the year and plays vital role. Trade winds blow in a particular direction of the equator in both hemispheres gathering moisture, which rises and cools adiabatically in equatorial regions. Cooling of an air mass results in condensation and causes high-level winds, which move in a direction opposite to that of the trade winds and become relatively dry. When stable high-pressure regions are created over sub-tropical zones, they help in making air dry towards the surface of the earth. In this process, a particular area becomes a desert or desert like conditions occur where the air is compressed, heated and relative humidity is reduced significantly. Tropical deserts are extended on both the sides of the equator up to the tropic of Cancer and tropic of Capricorn. The intensity and magnitude of a desert depends on the distance from the equator in both the directions towards tropics of Cancer and Capricorn. These regions are largely the result of persistent high-pressure cells and lie within the latitude 30 degree N and S.

The problems of survival of plants are dependent on atmospheric and geographical conditions. For thousands of centuries, nomadic tribes have survived in desert areas by relying on their expert knowledge of applied ecology peculiar to desert regions. In fact, desert regions do not differ from other terrestrial ecosystems inhabited by humans but limitations of natural and other resources and harsh climatic conditions impose certain discipline and respect for nature. Limited resources have never been able to support dense population and life may be difficult with tranquil and mystical qualities. It is not surprising that several major religions of the world have emerged from arid and semi arid regions.

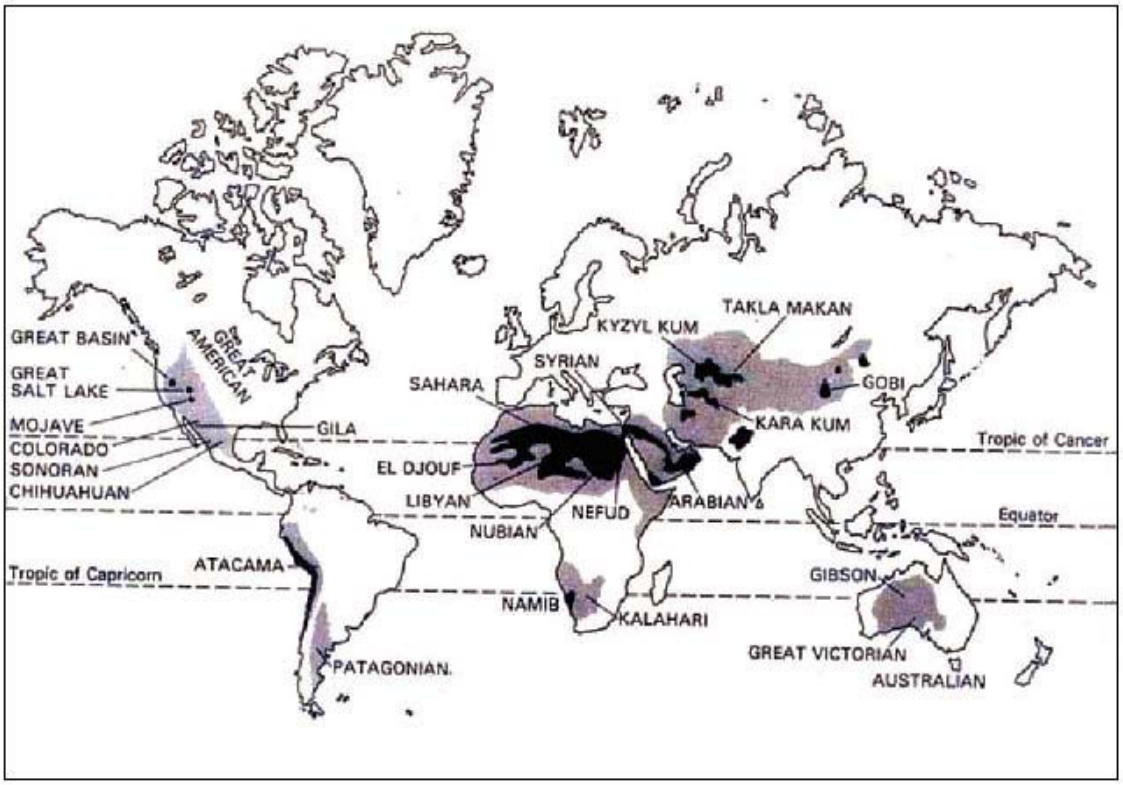

Figure 1. Location of Tropical Desert Regions

Interest of modern materialistic humans in desert areas has largely been centered on exploitation of minerals and fossil fuel. Geology is the first discipline to know more and more about desert conditions. Apart from harsh conditions, desert areas are natural regions possessing huge petroleum products, major and minor minerals, human and livestock population as market for industrial world who are interested to interact with the people of desert regions. Human interface plays a significant role in the activities on earth. Vegetation and livestock are meant for the use of human beings and being most capable to handle all possible issues on earth, humans play havoc in evolution and destruction over and under earth. Nature plays its role in a continuous process of development, whose balance is disturbed by human activities. There are positive and negative aspects of human interface and deforestation is the primary cause of the problems in various parts of the world. Desert conditions prevail over the areas as natural processes and human interface and both aspects are inter-related with diversified impact on the earth's environment. Tropical deserts are also evidenced with these conditions.

2. Tropical Desert Ecosystems

Existence of tropical deserts is generally from 15 to 30 degrees N and S of the equator while areas falling within 0-15 degree N and S are not deserts irrespective of some regional variations. Forests of tropical regions are thick to prevent sunlight from reaching the earth's surface. Countries lying within 15-30 degrees N and S of the equator are real problem areas with deficiency of rainfall, water, vegetation, animal and human population. Tropical desert regions are quite thinly populated, as means of

livelihood are quite meager for survival. Areas of topical deserts along with their magnitude are classified into hyper arid, arid and semi-arid types. Countries lying beyond 30 degrees N and S of the equator have been covered in the list as it is not possible to divide, total desert regions of countries falling within the range of 15-30 degrees and beyond have been considered without division according to political boundaries. Information reveals that total the geographical area of these countries is 43297.7×10^3 km^2, which is about 30 percent of total land area of the earth. The desert area of tropical countries is 31534.1×10^3 km^2 which is 22 percent of the world's land area. Thus, tropical desert regions are problematic regions and their ecosystems have been studied to make unbiased assessment of tropical desert conditions.

Countries listed in Tropical Deserts cover at least 10% or more area of their respective geographical areas as deserts. Desert areas have been classified into hyper-arid, arid and semi-arid as per laid down indicators based on intensity and magnitude of desert conditions. Hyper desert area is 7169.3 $\times 10^3$ km^2 or 17% of total geographical area of listed countries. Arid land is 15351.4 $\times 10^3$ km^2, which is 35% of their respective geographical areas. Semi-arid deserts are spread over in 9013.4 $\times 10^3$ km^2 covering 21% of their geographical areas. Thus the total desert area of the listed countries is 73% of their total geographical area. In tropical desert regions, African countries cover 16170.1 $\times 10^3$ km^2 of area and represent 87% desert land of their respective geographical areas. The desert area of Australia is 69% covering 5303.8 $\times 10^3$ km^2 of its area. Asian and Latin American countries falling under tropical deserts have 64% and 52% desert areas of their respective geographical land areas. The intensity of deserts in African countries is highest and possessing maximum hyper desert area. Countries which are fully deserts are Bahrain, Oman, Saudi Arabia, UAE, PDRY, Djibouti, Egypt, Libya, Mauritania and Niger.

2.1. Etymology

Etymology relates average rate of annual precipitation into number of days, total amount of rainfall, temperature, humidity, number of cloudy days etc. Arid and extremely arid and semi-arid grasslands are referred to as steppes. Lack of rainfall is not the deciding yardstick of desert region as there are many regions receiving rainfall less than 250 mm but are not desert lands. The difference lies in potential evapotranspiration, combination of water loss through evaporation . In areas where the rate of evapotranspiration is higher it is difficult to help vegetation, plantation and cultivation through rainfall cycle. Tropical deserts have other factors for development of vegetation but water is the main constraint.

Human population concentration is large in areas possessing sufficient means of livelihood and desert regions lack in this aspect, which is evidenced through low density of population. Rainfall is quite critical in most tropical deserts and some of the areas of South Africa and Asia have very low densities of population. Conspicuous features of tropical deserts are extremes in quantitative, temporal and spatial irregularity, unreliability and variability of rainfall, which is completely unpredictable. This uncertainty is of highest biological relevance since plants, which are able to adapt to it and develop strategies enabling themselves to cope with it to survive in deserts.

Exceptions are plants where water source is much more reliable, dew or fog occur in some regions. Desert dwelling humans have also created reliable water sources.

Due to the great variability of average annual precipitation, isohyets of deserts shift from year to year over large distances. In all tropical deserts, days with more than 0.1 mm rain are very few and variable. In most extreme deserts average number of rainy days is a fraction of unity. Chile has consecutive years without rainfall. Another typical feature is the occurrence of irregular sudden showers, extreme rain pulses, produced in large quantity of water falling at high intensities. Variability of rainfall is no less pronounced in seasonality than quantity. Average rainfall, season and quantity are such yardsticks, on which regional people rely for their plantation activities. Deviation from the general conditions and deviation in terms of the total duration and quantity create various problems limiting vegetation in any region. Variability in regions with seasonal rainfall is critical for vegetation of biological importance occurring between October to January and between February and May as biological efficiency of rains depends on thermo-photoperiod. Another important temporal variable of tropical deserts is the time gap between two consecutive biologically effective rain-pulses as the first spell sets the soil to extent for seed germination and seedling survival. But most desert regions suffer from these problems, as time spells of rainfall are unable to be maintained.

Affectivity of rain triggering germination depends on the environmental conditions in the post rain duration. Quantitative and temporal rainfall features are common to all tropical deserts, differ basically in respect of the main rainfall season. Most deserts receive summer or winter rains but some deserts receive rainfall from both systems. Some deserts have gradual change from winter to summer rainfall or vice versa from south to north and from east to west. Summer and winter rains differ in the thermo-photoperiod significant for germination and growth of plants . Evaporation is different during these two seasons. Spatial uncertainty of precipitation reveals the spotty feature of rainfall. A storm of a few minutes is usually localized in an average area ranging between 20-40 km^2 as the radii of clouds of convectional storms causing rains are significantly scattered. Another rain phenomenon typical to the extreme deserts is called phantom rain storms where rain evaporates before reaching the ground. The average monthly rainfall of some tropical deserts is given in Table 1, which reveals that minimum average rainfall at Dakhla station of Egypt is only 0.4 mm. Two stations of Peru receive an average of 43 mm and 2 mm annually, while two stations of Argentina witness diverse trends of 204 and 79 mm respectively. Occurrence of rainfall within the same country is quite varied which is evidence of short spell of rains with shorter area coverage. Rainfall is an important factor for supporting vegetation growth but regions receiving less than 100 mm rain have quite difficult conditions in terms of human and vegetation survival and growth. Monthly analysis of rainfall reveals that some regions have higher rain occurrence during June-September while other areas have rains during October-December and January-March of single a season or both summer and winter rains.

Fog and dew are also important for desert regions. The central parts of the Namib desert and the Peruvian-Chilean desert receive considerable amount of condensed fog, measured in quantitative terms of 40-50 mm per year. Plants are able to receive, condense, and absorb fog. *Prosopis tamarugo* in Atacama Desert is able to transport fog

water from leaf to soil and use it for growth of the plant in the post fog duration. The frequency of fog is highest during winter-rainfall areas and during summer rainfall areas. Fog occurrence depends on the relative humidity of air. It is also claimed that fog is rich in salts due to its maritime origin.

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Biographical Sketches

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