ABSTRACT

The concept of desertification is generally associated with the expansion of desert-like conditions towards the desert fringe or semi-arid lands. Desert is generally acknowledged as an expanse of sand dunes. Desertification, however, is more than this apparent state of the environment. It is an endemic state of the weakening of natural life support systems or ecosystems in the vulnerable areas. Desertification is a long-term decline in the land’s biological production potential. As the problem of desertification is of serious dimension, a precise academic understanding of desertification is complex and needs serious enquiry.

The hot, dry, continentality striken study region of western Rajasthan covers an area of 2,08,751 square kilometers in a latitudinal extent from 24°40' to 30°12'N and its longitudinal extent covers areas between 69°31' and 76°0'E. It comprises twelve districts of Rajasthan viz. Barmer, Bikaner, Churu, Ganganagar, Hanumangarh, Jaisalmer, Jalore, Jhunjhunu, Jodhpur, Nagaur, Pali and Sikar. These districts comprise seventy-three tehsils of western Rajasthan. These unit areas encompass nearly 61 percent of the area of the state which is endemic to desertification by different measure, endangering the sustainability of over twenty million human population and a still larger livestock population.

Climatologically western Rajasthan lies in the region of the dry, subsiding airmasses of sub-tropical anticyclones. These stable and diverging airmasses generate conditions unfavourable for the development of convectional showers inspite of the great heat. Western Rajasthan is a part of the Great Indian or the ‘Thar Desert’ a true desert having its origin due to a marked climatic oscillation during the Pleistocene period.

The arid lands of western Rajasthan are characterised by the scarcity of water, vegetation, and fragility of the soil. A suitable land utilization to feed the increasing population will depend on how efficiently we manage the land and water resources without reducing the biological production
potential of the land. It has been estimated that in more than one-third of this area the process of desertification has intensified in recent decades. According to an estimate available (UNCOD, 1977) desertification threatens the future of more than 785 million people, or 17.7 per cent of the world's population who live in these drylands. Of this number, between 60 and 100 million people are affected directly by decrease in productivity associated with current desertification processes. It is also estimated that between 50,000 and 70,000 square kilometers of arable lands are rendered out of production every year through desertification.

According to UNEP’s concept, desertification derives from interaction of human population with environment in the arid, semi-arid and sub-humid areas. It implies impoverishment of arid, semi-arid and some sub-humid ecosystems by the combined impact of man's activities and the drought. While drought conditions are reversible this degradation can easily become irreversible, and can permanently reduce the capacity of the area to human life support system. This situation calls for a constant monitoring and management of the land resources against the forces of degradation or desertification.

Research enquiries on desertification in India were initiated in the wake of the alarm raised in 1952 at the National symposium on the Rajputana Desert by the Indian National Science Academy in which few studies raised an alarm that the Thar Desert is expanding through the twelve gaps in the Aravallis mountains towards the fertile Gangetic plains in the east at the rate of half a mile per year and that the eastern frontier is highly vulnerable to desertification hazards.

The present study of Regional Evaluation of Desertification Hazards in the Arid lands of western Rajasthan is an attempt to assess the inherent vulnerability of the land to various processes of desertification. The problems of desertification have been examined through several groups of indicators like the Meteorological, Topographical, Hydrographic, Edaphic, Biotic, Anthropogenic and the land use/land cover. All available results suggest that the Rajasthan desert, has not been and is not advancing
towards the east but that a fresh sand deposition is still going on towards the west, the desertic conditions have further deteriorated in the recent past. The inherent vulnerability of the land and intense biotic pressure combined to set in a process of deterioration within the desert.

The main objective of the study is to enquire the processes of desertification hazards in operation in the dry lands of western Rajasthan. It attempts to identify and measure the various indicators of desertification in their spatial context and the relative vulnerability of land to desertification.

The objectives of the enquiry which need serious consideration are:

The present study is aimed to evaluate the desertification vulnerability with regard to its intensity, magnitude, causes and ill-effects.

To assess the existing resources their present use and resource potential in the arid zone for their rational utilization. To analyse the human factor in the process of desertification, and to examine the role of livestock composition in causing desertification hazards.

The study was initiated to verify the following scientific assumptions and the departures from them in a spatial perspective.

(i) The relationship between the environmental fragility and the intensity of desertification hazards.

(ii) The inverse relationship between the amount of rainfall and the vulnerability to desertification.

(iii) A linear relationship between the rainfall variability and the environmental susceptibility to degradation.

(iv) It has been hypothesized that the areas of coarse sandy soils are immediately liable to deterioration and decay under the aeolian agencies. Similarly, the areas possessing soils of high organic matter and deeper soil profiles are less susceptible to denudation.

(v) It has also been hypothesized that the areas of better vegetative indices are more resistant to degradation.
(vi) The biotic interferences and desertification hazards appear to have a positive correlation.

(vii) More importantly, there should have been a strong association between the demographic structure, land use/land cover scenario and the intensity of desertification.

(viii) Whether desertification hazards are proportionate to the pressure of livestock and the human population.

(ix) Whether desertification is more akin to the dry farming practices or to the irrigation ecology.

(x) To trace an association between marginalization, shrinking culturable wastes and the propensity to desertification.

(xi) To enquire on association between the size of operational land holdings and the possibility of desertification.

The present study is based on published and unpublished as well as primary and the secondary data of 1981 and 1995 for the land-use analysis. In case of meteorological analysis data has been used for the period ranging from 1901-1980 (depending upon the data availability) for the twelve districts which comprise seventy three tehsils. The available meteorological data was obtained from the India Meteorological Department at Pune. Records of daily weather phenomena from the meteorological stations were assembled. Apart from this the meteorological data was also obtained from the Head Quarters of India Meteorological Department, New Delhi and Central Arid Zone Research Institute (CAZRI) at Jodhpur for the subsequent years.

Various other indicators of the study like population characteristics, livestock numbers, land use/land cover situation and the data of water resources were obtained from the district census hand books of western Rajasthan for the year 1981 and 1995. Beside this, various reports, maps, research papers, books, monograph and various other useful informations, published and unpublished material have been collected from different
agencies. Field surveys were conducted to ascertain the erosional hazards and the inherent soil vulnerability.

Simple statistical methods have been employed in data processing. The investigation has been conducted at tehsil level. The essential data have been collected from a wide range of sources. The available data has been analysed to evaluate the desertification hazards at different levels. Meteorological data which include rainfall distribution, rainfall variability, mean annual aridity indices, drought intensity regions and wind velocity have been analysed. Aridity indices have been computed on Thornthwaite's method. The maps of rainfall distribution and rainfall variability have been computed on the basis of severity of climate and the meteorological gradient. Eighty one unit areas have been examined in order to demonstrate the meteorological influence. Eight sub-unit areas of district Jaisalmer alone have been meteorologically analysed on the basis of grid method in order to understand the influence of different meteorological stations in the area.

The data of all the indicators has been analysed by assigning ranking levels. The available data has been arranged in descending order and divided into five groups i.e. very high, high, medium, low and very low to assess the nature of problem and pressure of these elements on land. Data of each desertification indicator were processed and mapped. In order to arrive at a composite figure of desertification hazards, vulnerability rankings were cumulated. Lowest ranking was assigned a vulnerability value of 1, likewise every indicators in its place of highest vulnerability was accorded a weightage of 5 on the ranking scale. It has been hypothesized that lower the amount of rainfall in a unit area, higher is the vulnerability to desertification and higher the rainfall variability proportionately higher is the desertification risk. It is envisaged that higher the fragility and instability in an area greater is its liability to desertification. Besides this, the decadal growth technique of per cent variation has also been used. By the statistical techniques co-efficient of variability (C.V.) of rainfall has been analysed on annual basis for all the
study units of western Rajasthan for the period of 1901-1980 using -

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\text{Mean } (\bar{X}) = \frac{X}{N}
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\[
\text{Standard Deviation (S.D.)} = \frac{\left(\sum (X-\bar{X})^2\right)}{N}
\]

\[
\text{Co-efficient of variability (C.V.)} = \frac{(\text{S.D./}\bar{X}) \times 100}{X}
\]

X average value of the variate and N is number of observations.

An attempt has been made to measure the intensity of vulnerability to desertification through meteorological, hydrographic, biotic, anthropogenic and land use/land cover indicators. By the synthesis of all these indicators a cumulative view of vulnerability to desertification were mapped. Moreover, desertification combat plan and strategies have also been suggested.

The analysis of meteorological indicators revealed that the average distribution of rainfall is inadequate by varying degree in different parts of the region to render the westward land increasingly vulnerable to desertification. There is an inverse relationship between the distribution of rainfall and vulnerability to desertification. There is a positive correlation between rainfall variability and vulnerability to desertification hazards.

A positive correlation was found between Aridity Indices and drought intensity with susceptibility to desertification. Besides, the water availability periods also reveal a large deficit in western districts which contributes to the fragility of the ecosystem.

In western Rajasthan salinity hazards were also found dominant at different tehsils and these areas have high to very high risk of degradation of the land.

The hydrographic indicators in the study area revealed that Thar Desert is facing an acute water deficiency. The western tehsils of the study area have great need of water harvesting to support and subsist the water inadequacy of the weak natural ecosystem. An indicator of ground water depth at different unit areas shows that the occurrence of brakish water is relatively high in shallower wells as compared with the moderate to very
deep wells. Most of the deep wells of permanent water table were found in western part of the study area as compared to eastern fronts. Whereas, few areas like Ganganagar and Hanumangarh run a higher risk of its own situation like water-logging, salinity, alkalinity, over-cultivation as well as marginalisation. Therefore, most of the tehsils in western Rajasthan have higher vulnerability to desertification.

The quality of ground water in western Rajasthan deteriorates with the decrease in precipitation towards northwest. Ground water in the study area is inherited by the diversity of quality problems. The depletion of water in western tehsils is also triggering the desertification processes.

Soil profiles in the study area are not very deep except along the buried palaeo-channels. Shallow soil depth renders them highly susceptible to deflation as well as fluvial erosion. Thin soil cover has shown quick erosion losses on the steeper slopes in the eastern parts of the study area. Organic matter on the soil helps in binding the soil together. Most of the western margin have very low humus levels. Therefore, these areas are more vulnerable to desertification as compared to unit areas which have relatively higher humus levels on the eastern margins. Nitrogen in the soils of the desert holds a positive relationship with the incidence of rainfall and negative relationship with the thermal regime. Correlation has also been noted between nitrogen contents and seem to be less vulnerable to desertification hazards.

The coarse sandy structureless soils are highly vulnerable to aeolian agencies of erosion. Most of the soils in western Rajasthan are aeolian in nature with coarse texture and weak structure which renders them highly vulnerable to desertification hazards.

The calcium concretion layers are more commonly found in the drier and arid areas towards the western margin of the study area. In this category also, the soils of western Rajasthan have a higher risk to desertification. The phosphorus reserves are generally depleted in the arid soils of the western margin. Presence of phosphate gives strength to the soils. So there would be high risk of vulnerability to desertification.
The problem of salinity holds a concurrence with the aridity index. As the aridity increases westward, salinity also increases. This renders the soils highly vulnerable to desertification. In the western tehsils of western Rajasthan, the microbial environment is very poor which renders the soil unproductive. Micro-organism help in the breakdown and decomposition of organic residues and build up of soil humus. In Barmer, Bikaner, Churu and western parts of Jodhpur, the loose structureless sandy soils have excessive aeration and limited moisture. In these areas, thermal regime is intolerable. Consequently, the microbial activity is very poor. The soils remain non-cohesive and can easily be degenerated. Soil erodibility depends upon the inherent soil characteristics such as texture, structure, organic matter concentration, and crust formation. Areas of sandy soils have high basic erodibility in western Rajasthan.

The depletion of vegetation cover and plant varieties indicates higher susceptibility to degradation. A negative correlation was found between the plant cover and vulnerability to desertification. Most of the tehsils of the study area have reported very low percentage of vegetative cover. Therefore, these areas have high to very high vulnerability to desertification.

The stress of livestock population on pasture lands indicates that the lower density of livestock on the western front does not mean the lower vulnerability but risk is higher due to very poor grazing potential. The western frontier of the study area also reported high variation in livestock population. This also has a positive correlation with desertification hazards.

The tehsilwise break-up of the landuse/land cover data during 1981-1995 have been analysed. These landuse figures reveal the regional disparities and vulnerability levels within desert.

The maximum percentage under the category of uncultivable lands have positive correlation with vulnerability to desertification. High to very high decrease in area of uncultivable land shows that such areas have largely gone to the expansion of an irrigation. This also indicates that the
landuse pressure is encroaching upon less suitable areas. The positive growth of uncultivable land shows adverse land use practices and poor resource management.

Most of the western tehsils have reported higher percentage of culturable wasteland. In this category, the hypothesis was that if the extent of culturable wastes has decreased it suggests the corresponding sign of marginalization. It shows that the land use pressure is growing on the already weak and fragile ecosystems which is again an indication of desertification. An increased area of culturable wasteland at different unit areas is suggestive of the situation where some dry farming areas have become economically redundant due to rising costs and uncertainties in competition with the remunerative irrigated areas which are more stable in the vicinity of the rainfed areas. Such redundant dry farming areas may have been reduced to culturable wastelands.

Fallowing is largely associated with dry farming practices, a decrease in fallow land is a reflection of adverse land management. The decrease in fallow land associated with irrigation farming would have been an indicator of improved land management. It was hypothesised that a decreased in hectarage of fallow land is suggestive of marginalization and therefore, it is an important indicator of land degradation. A positive growth of hectarage under this category shows the degradation of the land. Hectarage change in Net Sown Area indicates an inverse relationship with degradation of the land. In monoculture areas, where human control is less the risk to desertification is more. In the areas of positive growth of Net Sown Area overcultivation is dominant on the land of weak and fragile environment, the risk of vulnerability is more.

In double cropped, irrigated areas human control is of higher order, the areas are scarcely left unattended to the vagaries of nature. Therefore, the vulnerability to desertification would be marginal in such areas. In double cropped areas the size of land holdings is generally smaller. In smaller size of land holdings, very little land is left unattended or fallow.
Thus the land is more actively under human control. This situation makes
the land scarcely liable to desertification.

A decreased hectarage in the grazing and pasture land is a clear sign
of biotic pressure. It suggests that due to negative growth in the grazing
and pasture land the livestock pressure would squarely increase (if coupled
with the increase in livestock population). On the otherhand positive
growth of an area provides more opportunity for grazing and covers larger
area. There is a positive correlation with vulnerability to desertification
hazards.

Positive growth of Irrigated area is generally seen in good rainfall
areas or along the Indira Gandhi Canal Command Area. In these areas,
there is a sign of amelioration as well as deterioration of the land. In few
areas there is risk of waterlogging, salinity and alkalinity so, again risk of
desertification is higher.

Hectarage change in dryland farming has been analysed through the
growth on net sown area and the hectarage change in the area sown more
than once. In the areas of monocultural activities where human control is
less the risk of desertification is high. In double cropped Irrigated areas
where human control is of higher order, the vulnerability to desertification
would be marginal in such areas.

The increasing human population is a serious threat, particularly on
the meagre vegetal resources of the arid lands. The trees and shrubs and
even their roots are indiscriminately cut by the rural population for
domestic fuel. Thus, rendering the land vulnerable to erosion and
degradation.

Population distribution and density give an important insight in
understanding the man-land ratio and the human resource availability. The
high population density also leads to cultivation on the marginal lands
which decline in crop productivity per unit area. The very low population
density has also been a cause of desertification because land is not
adequately taken care of in the year of natural calamity. Due to the paucity
of human resources. The protection and rehabilitation of the lands becomes difficult in the years of severe droughts. In both extreme cases, the susceptibility of land towards the desertification would be higher. A population growth on fragile ecosystem is also a serious problem. Most of the western tehsils reported very high growth rate of population which is more than a match to the sustainability of the land.

An indicator of sex-ratio in western Rajasthan shows that the areas are economically underdeveloped because most of the male population emigrates to the urbanised areas. Hence, its ratio decreases. An indicator of rural and urban population includes a peculiar feature with respect to population density, degree of ethnic and cultural diversity and occupation and social stability. It has been analysed that nature of social group is totally different in the rural and urban areas of the region.

Occupational structure is also an important indicator to measure the economic workforce in the study area. Most of the western tehsils shows higher percentage in primary occupation which reveals that region’s economy is rural oriented and largely depends on agriculture and pastoralism. Pastoralism is the dominant activity in those places where the land is not available for farming and water-scarcity is very severe.

An indicator of work participations is very helpful to measure the dependency ratio. Most of the western units reported very high dependency ratio. Higher the dependency ratio higher is the vulnerability to desertification.

Lastly, the cumulative map of vulnerability to desertification hazards by the summation of all the indicators of natural and human environments gave a composite impression of regional vulnerability to desertification.

In the ultimate analysis, the study reveals that the inherent vulnerability of land to desertification is very high to high along the western front in the districts of Jaisalmer, Barmer, Bikaner and a few tehsils of district Churu, as against the popular notion of higher desertification risk along the twelve gaps of Aravallis in the east. Medium
vulnerability is noticeable in few tehsils of Ganganagar and Hanumangarh, parts of Barmer, Churu, Nagaur and Jalore. Relatively lower vulnerability to desertification could be ascribed to parts of Jhunjhunu, Sikar, Nagaur in the north east. It has been found that the western tehsils run a much higher risk of desertification as compared to the eastern realm.