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Research Article

DESERTIFICATION STUDY OF WESTERN ARID RAJASTHAN USING GEO-INFORMATICS

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ABSTRACT

Desertification is considered as a major worldwide environmental problem mainly caused by the climate changes and human activities during the last decades. Areas affected by desertification processes are gradually losing their level of biological quality and productivity. Among the different indicators of desertification, degradation of vegetation cover and increasing amount of bare soil have been popularly used by researchers. In India, desertification is one of the major sluggish hazards which is found in northwestern part of this country, mainly in the state of Rajasthan. The infringement of the Thar Desert has become a serious problem in the adjoining districts of Bikaner, Churu, Hanumangarh, Ganganagarand Nagaur. In this study, Satellite Image is used to see the Land-use/land-cover changes, vegetation, soil erosion, water erosion changes. The long-term satellite data such as LISS-III (1996-19997) and Liss-IV (2005-2006) have been used in this study. The time series analysis of LISS-III Images of land-use/land cover, vegetation cover has been employed for monitoring desertification processes over a long period. After analyzing the changes, were identified within the region that clearly indicates the ongoing process of desertification over there.

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INTRODUCTION

Desertification is defined as land degradation in humid and semi-arid areas i.e. non-desert (arid) areas. It involves the loss of biological and economic productivity and it occurs where climatic variability (especially rainfall) coincides with unsustainable human activities. Desertification is defined as land degradation in humid and semi-arid areas i.e. non-desert (arid) areas. It involves the loss of biological and economic productivity and it occurs where climatic variability (especially rainfall) coincides with unsustainable human activities the process by which fertile land becomes desert, typically as a result of drought, deforestation, or inappropriate agriculture. The main causes of this desertification are over cultivation coupled with deforestation and overgrazing. The problem is made more acute by the increasing human and animal population, and the fact that rainfall is undependable and of high intensity. The trend of desertification can be reversed by (a) closing the area to grazing and uncontrolled wood cutting, (b) implementation of time-tested soil and water conservation measures and (c) large scale planting of suitable forage grasses and legumes as well as arid zone species of trees. The main research thrust of the trials with promising species of trees was to determine their suitability to wastelands and to investigate methods of establishing them rapidly and economically.

Causes of desertification

All highly variable rainfall. An exception to this are the parts of the rainforest desertified following inappropriate farming techniques.

Desertification occurs when already fragile land in arid and semi-arid areas is over-exploited. This overuse can be caused by: **overgrazing**, when pastoralists allow too many animals to graze on a fixed area of land; **overcultivation**, where the growing of crops exhausts soil nutrients; **deforestation**, in which too few trees remain after use as firewood to act as windbreaks or to prevent soil erosion.

Overgrazing is the major cause of desertification worldwide. Vegetation is lost both in the grazing itself and in being trampled by large numbers of livestock. Overgrazed lands then become more vulnerable to erosion as compaction of the soils reduces infiltration, leading to greater runoff, while trampling increases wind erosion. Fencing, which confines animals to specific locations and the provision of water points and wells has led to severe localized overgrazing. Boreholes and wells also lower the water table, causing soil salinisation.

Overcultivation leads to diminishing returns, where the yield decreases season by season, requiring an expansion of the areas to be cultivated simply to maintain the same return on the agricultural investment. Reducing fallow periods and introducing irrigation are also used to maintain output, but all

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these contribute to further soil degradation and erosion by lowering soil fertility and promoting salinisation.

Deforestation is most obvious where land has been cleared to extend the area under cultivation and in the surrounds of urban areas where trees are stripped for firewood. The loss of vegetation cover increases rain splash erosion and the absence of root systems allows easy removal of the soil by wind and water.

In India the main types of desertification include

- sandy desertification caused by wind erosion
- land degradation by water erosion
- land degradation caused by engineering e.g. construction of residential areas, communications, coal mine and oil fields and
- soil salinisation

Study area

The state of Rajasthan is the second largest state in India, with an area of 0.342 million sq km out of which 0.198 million sq km which is nearly 58 per cent, is occupied by Thar Desert (Figure 1). The Thar Desert is characterized by low and erratic rainfall, high evapotranspiration, large temperature variation, scanty vegetation, rodent infestation, absence of perennial rivers, sparse and nomadic population and dependence of man on animal rearing. The study area is located in the north-western part of India between 24°31′ to 30°12′ north latitudes and 69°15′to 76°42′ east longitudes. It is surrounded by Punjab in north, Gujarat in south, Pakistan in west and Aravalis in east. Its length is 640 km from north to south and width is 300 km from east to west. The western arid region includes12 districts i.e. Sriganganagar, Hanumangarh, Churu, Sikar, Jhunjhunu, Nagaur, Bikaner, Jodhpur, Barmer, Jalore, Pali and Jaisalmer. The study area can be divided into two main physical regions viz. i) Sandy Arid Region and ii) Semi-Arid. The western sandy plain includes the Marusthali and the adjoining Bangar to the west of the Aravalis. It is a wide expanse of poorly watered, sterile and wind-blown sand. The general aspect of this region is of an interminable sea of sand and sand dunes of different shapes and sizes varying from 6–60 meter in height and being sometimes 3–5 km in length (Figure 3). Semi-Arid region is drained by Luniin its south-eastern portion. Gullying has given rise toconglomerate landscape. The land is slightly undulating within venue of sand deposited by inland drainage and stream with salt lakes (Sharma and Sharma, 2002.

The Western arid region of Rajasthan has a population of 22.5 million as per census data of 2001. The Indian Thar Desert is most populous desert in the world, with density of around 84 persons per sq km. The population growth (42 per cent) is also very high between 1901 and 2001, and more than 70 per cent people lives in villages orscattered settlement called dhanis (Hamlets) where agriculture and animal husbandry are the main occupation.

IRS- Resourcesat-2 AWiFS digital data of three different seasons viz. summer, kharif and rabi, will be used for preparing DSM of the country at 1:500,000 scale. There will be around 24 scenes (60 quadrants) of AWiFS covering entire India.

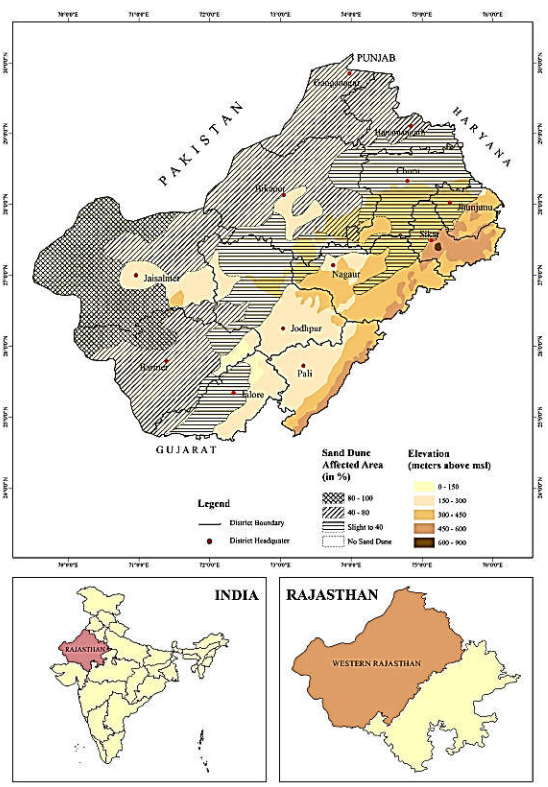

Fig:1

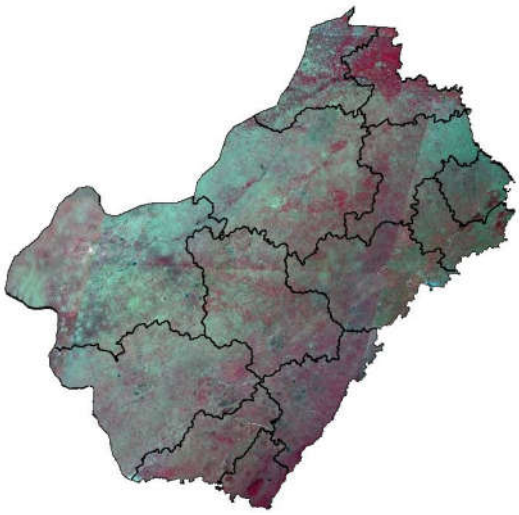

Fig:2 IRS Liss III Image of western Rajasthan

IRS LISS-III data of two different time series will be procured. During each of these years, three season viz. kharif, rabi & summer will be used. The dataset will be used for vulnerable areas mapping at 1:50,000 scale as well as for Desertification Vulnerability Modeling. In addition, various thematic layers viz climate, soil and socio-economic profile, prepared at 1:50,000 scale shall be used for vulnerability modeling. The methodology has already been developed and operationally used during the DSM project carried out earlier. In the proposed study, about 24 scenes (60 quadrants) of multidate AWiFS satellite data will be digitally interpreted through on-screen digitization method by employing ARC GIS software. As a reference, desertification status maps prepared earlier at 1:500,000 scale using AWiFS satellite data of 2003-05 will be used and changes in degree of severity will be incorporated.

Limited ground checks will be carried out throughout the country.

METHODOLOGY

The classification system adopted is a three level hierarchical classification system. This is given below:

Level 1 Land Use/ Land cover

Agriculture – Unirrigated		**(D)**
Agriculture – Irrigated		(I)
Forest / Plantation		(F)/P*
Grassland/ Grazing land		(G)
Land with Scrub		(S)**
Barren / Rocky Area	(B/R)#	B(Sc) indicating Scree areas in Cold Deserts
Dune / Sandy Area		(E)
Water body / Drainage		(W)
Glacial / Periglacial		C/L
Others		(T)

Level 2 Processes of Degradation

Vegetation Degradation	**(v)**
Water Erosion	(w)*
Wind Erosion	(e)
Water Logging	(l)
Salinization/ Alkalinization	(s/a)**
Mass Movement[in cold areas]	(g)
Frost Heaving [in cold areas]	(h)
Frost Shattering [in cold areas]	(f)
Man made	(m)

Level 3 Severity of Degradation

Slight	**1**
Moderate	**2**
Severe	**3**

The proposed study area includes the Arid, Semi-arid and Sub-humid regions as well as the North-East region of the country. There after DSM for some selected vulnerable districts will be carried out. It is proposed to study the vulnerable regions of India like the drought prone areas, regions of high degradation etc. Visual interpretation at 1:50,000 scale will be carried out using temporal LISS-III data so as to compare the change in the status of the desertification in these areas over the years. Desertification Vulnerability modeling will also be carried out for a district each in every state possible. Development of methodology for combating plan will be attempted at few places on larger scale, in selected micro-watersheds.

Preparation of DSM is an ordered process of certain logical steps carried out using visual interpretation of satellite data, mainly IRS-LISS-III geo-coded FCC paper prints, followed by ground truth, data collection at selected points and then finalization of preliminary DSM.

To start with, firstly a study area is selected from agro-ecological regions and areas susceptible to land degradation through various processes like wind erosion, water erosion, salinization, man-made, water logging, frost shattering, mass wasting and frost heaving and vegetal degradation etc. This is done through the available background information.

Once the study area is finalized, a suitable set of satellite data, preferably IRS-LISS -III geo-coded FCC are acquired for at least three different seasons viz.

RESULTS AND DISCUSSION

Climate change Temperature variability in the Western Rajasthan during last 30 years the temperature has shown a great variability with an average rise of about 0.5°C for the month of June. The temperature rose from average temperature of 33.25°Cin 1973 to 33.75°C in 2008. The maximum rise is visibleduring 1995–2000. Whereas for the month of January the average rise in temperature is about 1°C during last 30 years. The average monthly temperature for January has increased from 15°C in 1973 to 16°C in 2008 (Figure 4).The temperature rise for January is more consistent and the fluctuations are not so abrupt as compared to June. The local factor influencing the temperature rise is increased cloud cover during winter months. Rainfall variability The Western Rajasthan suffers from scarcity of rainfall. The average annual rainfall in the region is measured to be 350 mm per year and above that the rainfall pattern in the region shows large variability and has never been consistent (Figure 5). The scarcity accompanied by variability creates water stress conditions in the region and is responsible for droughts. During last 30 years the average annual rainfall has shown a decrease of 50 mm, it was measured 400 mm during 1973, which came down to 350 mm per annum. The decrease in precipitation can be attributed to rising temperature. As the temperature increases the moisture holding capacity of atmosphere increases and thus the condensation is delayed till further addition of moisture to the atmosphere which might lead to decrease in precipitation. Change in humidity provinces With an overall rise in temperature over the region and changing precipitation trends the humidity provinces as defined by Thornthwaite have shifted eastward. The results from correlation and regression matrix show that the changes in PE, which further led to change in humidity provinces, are caused by change in maximum temperature. The influence of change in minimum temperature and precipitation on PE is less as compared to impact of change in maximum temperature. In 1973 the Churu districts is saline, and therefore unfit for irrigation and drinking. Unconsolidated discontinuous aquifers with poor yield potential cover the western parts covering the Thar Desert in Jaisalmer.

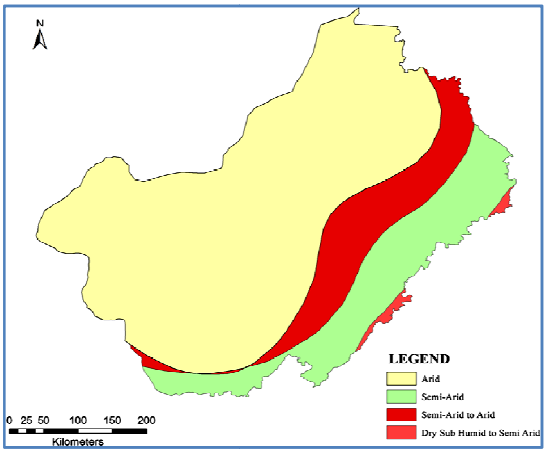

Fig: 3 Shift of Thornthwaites climate belts during 1970-2008 in western Rajasthan

Most of it is saline, except some patches in the extreme west. Semi consolidated aquifers of low yield potential are found in parts of Jaisalmer, Bikaner and Churu districts. There are patches of semi consolidated aquifers with moderate yield potential in Barmer district, and high yield potential in the lower northwestern parts, covering parts of Bikaner and Churu districts. These aquifers are inherently saline. But, over the years, the quality of gound water in this region has improved (Kumar *et al*., 2009).

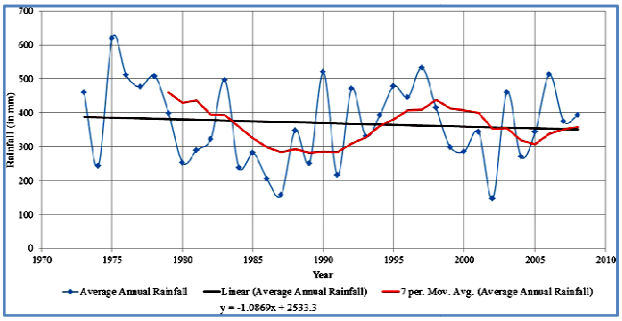

Fig: 4 Temperature Variations over past 35 years in Western Rajasthan during the month of Januaury.

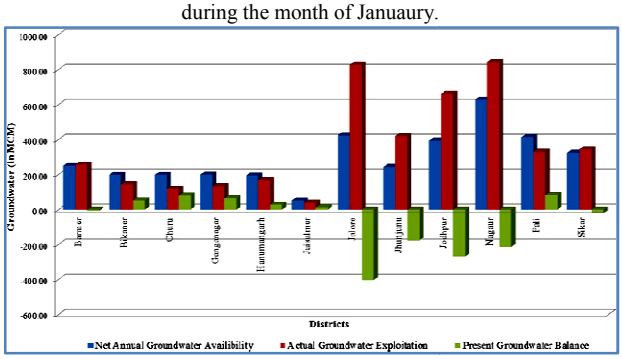

Fig: 5 Groundwater resources potential of Western Rajasthan.

- India has about 18% of world's human and 15% of livestock population to be supported with only 2.4% of the world's geographical area and 1.5% of forest and pasture land. Per capita availability of land in the country has reduced from 0.4 ha in 1950-51 to 0.14 ha in 200 At country level as many as 20 states reported decrease in cultivable land to the extent of 790,000 hectors in four years from 2007-08 to 2010-11. (The Ministry of Agriculture).
- Reason: Diversion of Cultivable land for non-agricultural purpose
- Impact: Could be disastrous for the nations food security.

Degradation category	Arable land (mha)	Open forest (mha)	Total (mha)
Water erosion (>10 t/ha/y)	73.27	9.30	82.57
Wind erosion	12.40	-	12.40
Exclusively salt-affected	5.44	-	5.44
Salt-affected & water eroded	1.20	0.10	1.30
Water logging	0.88	-	0.88
Exclusively acidic soils	5.09		5.09
Acidic and water eroded soils	5.72	7.13	12.85
Mining/industrial wastes	0.19		0.19
Total affected	104.19	16.53	120.72

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Serial No.	Western Arid Rajasthan	Area (%)
1	Wind erosion (severe)	16.64
	(Slight to Moderate.)	59.0
2	Water erosion (severe)	0.05
	(slight to moderate)	1.82
3	Salinity/alkalinity (severe)	0.31
	slight to moderate	1.85
4	Vegetation degradation (severe)	0.06
	slight to moderate	2.72
5	Water-logging	0.08

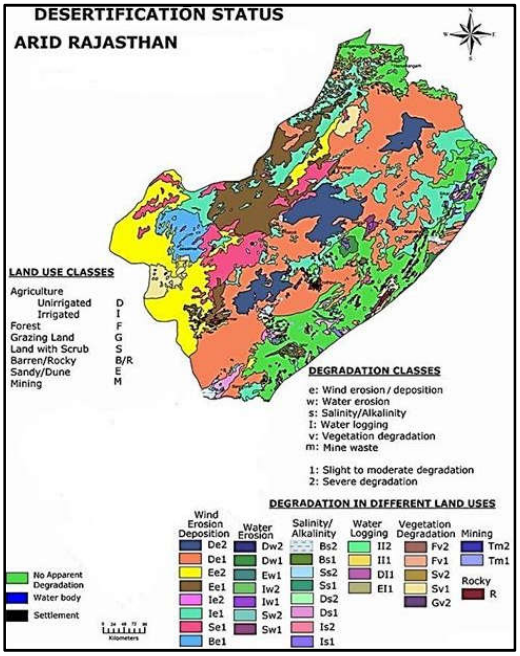

Fig: 6 Land Degradation of Western Rajasthan in 2009

CONCLUSION

- The human population in western Rajasthan has also increased more than 2.5 fold during 1961-2011.
- Population of farm animals (> 29 million in 2007) even more than human population
- Area under saline/sodic soil - increasing due to irrigation with poor quality water.
- Ground water extraction; more than 100% in 9 out of 12 districts.

The rangelands and common grazing lands are in utter degraded condition; because of their poor management and due to increasing grazing pressure.

Among the arid and semi-arid states, Rajasthan had the maximum degraded area (21.8% of the country).

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