

Inventory on Desertification Status Mapping of India using multi-temporal AWiFS data

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ABSTRACT:

Desertification is the continuous degradation of land under the influence of natural and anthropological causes in arid, semi-arid and dry-sub humid conditions. Mostly, it is a slow and creeping process except for certain events like torrential periods leading to heavy soil erosion in short period of time, events of landslides, zoom cultivation leading to forest degradation etc etc. There exist no substantial base data on the status of desertification in India, as a whole. As such, to assess the status of desertification for entire country is a Herculean task and needs to be carried out using fast, accurate, cost effective and less efforting method like satellite remote-sensing. An attempt has been made to carry out Desertification Status Mapping (DSM) of entire India using multi-temporal IRS-Resourcesat AWiFS data on 1:500,000 scale. This has been accomplished by involving about 16 different institutions/ agencies in the country. The DSM output reveals the land use/ cover categories affected by various processes of degradation with varying severity.. The various processes of degradation observed includes water erosion, vegetal degradation, wind erosion, salinization/ alkalization, water logging, frost heaving, frost shattering, mass-wasting, man-made etc. The two main processes of degradation observed are vegetal degradation in forests and scrublands followed by water erosion in agriculture areas. This is a unique attempt to map both hot and cold regions in totality based on a comprehensive classification system developed for DSM through a pilot project in about 8 different test sites in the hot and cold regions of India at 1:50,000 scale. The study reveals that there exists about 104.94 m ha area under various processes and severity of desertification, which is nearly 31.92 %. This means that nearly one-third geographical area of the country is under desertification. The present paper deals with the description of the project, indicators used, classification system, methodology adopted, and the results achieved for the maiden inventory of India's status of desertification.

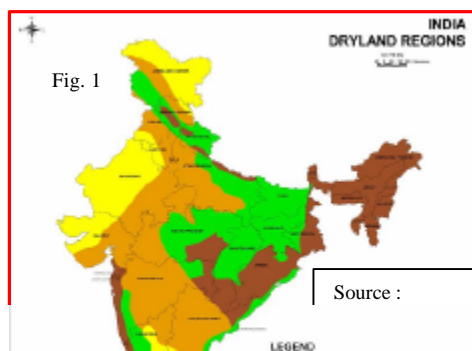
1. INTRODUCTION

The 1977 United Nations Conference on Desertification (UNCOD), in Nairobi, described desertification as the diminution or destruction of the biological potential of the land. United Nations Environment Program (UNEP, 1992) defined desertification as "The land degradation in arid, semi-arid, and dry sub humid areas resulting mainly from adverse human impact".

The recent definition of desertification accepted by United Nations is "**Land degradation in arid; semiarid and dry sub-humid areas resulting from various factors, including climatic variations and human activities**" (Paigdefabregas, 1995).

In India, reportedly, dryland comprises about 228 mha (69 %) of the total geographic area of the country. About 50.8 mha (15.8%) of the country's geographical area is arid, about 123.4 mha (37.6%) is semi-arid region and about 54.1 mha (16.5%) falls within the dry sub-humid region. (Fig.1)

At present, no comprehensive data base/ information is available on status of desertification in India. In this view, an attempt was made to evolve a methodology and comprehensive classification system through a pilot project in about 8 different test sites in the of arid, semi-arid and dry-sub humid hot and cold regions of India at 1:50,000 scale for assessing the desertification status of India using multi-temporal AWiFS



FCC's from Resourcesat - 1. It is a three-tier approach. At level - I, there are mainly ten classes of land use and land cover, at level -II, there are nine different processes of desertification and at level-III, there are two categories of degree of severity. (Table 1).

Table – 1: Classification System

Level 1: Landuse / Landcover –

The following categories have been identified: -

Agriculture – Unirrigated	(D)
Agriculture – Irrigated	(I)
Forest/ Plantations	(F)
Grassland/Grazing land	(G)
Land with scrub	(S)
Barren / Rocky area	(B/R)
Dune / Sandy area	(E)
Waterbody / Drainage	(W)
Glacial / Peri-glacial (In cold region)	C/L
Others (Urban, Man-made etc.)	(T)

Level 2: Processes of Degradation

Types of processes resulting in degradation:

Vegetal Degradation	(v)
Water Erosion	(w)
Wind Erosion	(e)
Waterlogging	(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 (Mining/Quarrying, Brick Kiln, Industrial Effluents, City Waste, Urban Agg etc.)	(m)

Level 3: Severity of Degradation

This level represents the degree and severity of the degradation.

Low	1
High	2

It is note worthy that the classification system used for mapping DSM at 1:50,000 scale has three levels of severity i.e slight, moderate and severe. However, while attempting DSM at 1:500,000 scale it was decided to keep only two categories i.e. Low and High.

This work is done jointly by Space applications Centre (ISRO), Ahmedabad and about 16 collaborating agencies having in-house expertise on remote sensing / desertification.

To prepare a desertification status map of India at 1:500,000 scale using multi-temporal AWiFS data, the various land use/

land cover classes considered are Agriculture-unirrigated, Agriculture-irrigated, Forest/Plantation, Grassland/Grazing land, Land with scrub, Barren, Rocky, Dune/ Sandy area, Water body / Drainage, Glacial, Peri-glacial and others, delineated visually using the basic elements of interpretation.

Vegetal degradation, water erosion, wind erosion, water logging, salinisation/alkanisation, mass movement, frost heaving, frost shattering, and man made are the main desertification processes observed in India. 'High' and 'Low' are the two levels of 'degree of severity' which are mappable at 1:500,000 scale.

It is for the first time a national level spatial inventory has been carried out for the entire country giving the information on the various desertification processes and their severity . To achieve this , the indicators of desertification has been freezed using brain-storming sessions of experts and eventually a comprehensive list of indicators have been formulated as shown in table -2 . Among these, all those indicators amenable to remote sensing have been taken into account while preparing the Desertification Status Map of the country.

Table 2: Indicators Of Desertification

The exists numerous indicators of desertification. These are primarily grouped under four main categories viz. Pressure indicator, State indicator and Impact indicator and Implementation indicators. They are further discussed as below .

2.1 Pressure Indicators

Physical	Rainfall temperature wind humidity potential evapotranspiration solar radiation cloud cover
Socio-economic	Population density education status livestock density forest felling fuel and fodder consumption/supply collection of medicinal plants shifting cultivation diminishing of water resources land management practices

2.2 State Indicators

Physical indicators	Erosion status of the land salinity/alkalinity shifting in sand sheet/sand dunes water logging soil moisture soil types and properties stone coverage/barren rocky area number and spread of water bodies groundwater status turbidity of water bodies
Biological indicators	Types of vegetation species composition of vegetation condition and coverage of vegetation biomass and productivity of vegetation crop area and yield

2.3 Impact Indicators

Land use	Land use pattern
Socio-economic	Income migration mortality rate health conditions unemployment illiteracy food security and malnutrition prices of food grain energy consumption by source infrastructure security and development gender specific issues living standard
Eco-environmental indicators	Air and water quality occurrence of dust storm and sandstorm land pollution

2.4 Implementation Indicators:

Action indicators	Economic input for combating desertification investment level state of the development and implementation of action plan to combat desertification state of the legislation and execution related to combating desertification people participation NGO involvement
Effect indicators	Proportion of desertified land rehabilitated Socio-economic standard of the people improvement of environmental conditions

2. METHODOLOGY

The IRS-P6 (Resourcesat) AWiFS geo-coded FCC paper prints on 1:500,000 scale were visually interpreted for generation of DSM maps. In view of absence of any map at 1:500,000 scale, base map was prepared using mostly the standard maps on 1:250,000 scale, especially for forest boundaries. The base features like road, rail, habitation etc were incorporated in the base map. Drainage was taken from the satellite imageries due to their dynamic and shifting nature. The base map was used over laid on the AWiFS FCC paper prints and light table was used to delineate the desertification indicators, landuse/ land cover, processes of desertification, severity of desertification processes etc.

The scrub boundaries have been most challenging to delineate at this scale. However, enough caution has been taken care to minimize the errors in visual interpretation. These DSM mylars were finalized after the field checks. The final DSM mylars were sheet wise vectorised and then mosaiced and subsequently clipped to generate state wise DSM maps using ARC/INFO GIS environment. Ultimately all the states were mosaiced and the final Desertification Status Map of India was generated (Fig. 2). The map shows mainly the dominant processes and their respective severity acting in different land use/ land cover categories of various agro-climatic zones of the hot and cold dry-land regions of the country. This is the maiden DSM map of India ever prepared at any scale.

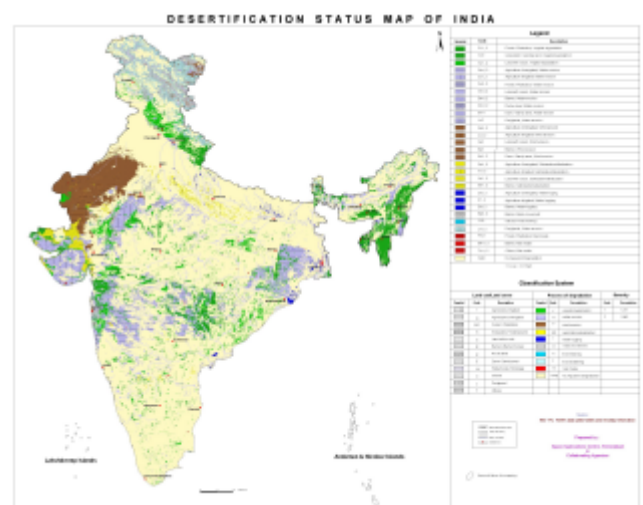


Figure 2. Desertification Status Map of India

3. RESULTS AND DISCUSSION

The total geographical area of India is about 328.73 m ha. According to the estimates of NBSS&LUP (2001), the drylands of India constitute about 69.6 % of the total geographic area of the country.

Various departments/institutions in the country have made estimations of the degraded land of the country mainly between 1976 and 1994 (Table 3). These estimates vary from 107 mha to 188 mha, mainly due to difference in the method of data collection, scales of mapping, classification system and definition of the degraded lands. Recently, an estimate by SAC, Ahmedabad has estimated the total area under desertification to be 104.94 mha (2006), the statewide statistics of the land under desertification country is given in table-5.

Table 3 : Estimation of Degraded Lands by Various Organisations :

Sr No	Organisation	Year	Extent of Land Degradation (in m ha.)	Criteria for delineation
1	National Commission on Agriculture (NCA)	1976	175.00	Based on Secondary data only
2	MOA	1985	173.64	Based on Land degradation statistics of the states
3	NBSS&LUP	1994	187.7	Mapping on 1:4.4 m scale (GLASOD guidelines)
4	Deptt of Agriculture & Cooperation, MOA	1994	107.43	Based on Land degradation statistics of the states
5	SAC (ISRO)	2006	104.94	Based on RS based mapping on 1:0.5 m scale

(Source: Velyutham 1999 and MoEF 2001 and SAC 2006)

Space Applications Centre has attempted to map the status of desertification of entire drylands of India and north east region on 1:500,000 scale using IRS Resourcesat AWiFS data. This work was started in 2004 and completed in 2006.

Some areas, like parts of Jammu and Kashmir beyond the L.O.C have been mapped but not been covered during field work for obvious reasons. Certain areas, which are not actually dry-lands and has fewer and smaller dimensions of degraded land, not commensurating with 1:500,000 scale, like Andaman and Nicobar Islands, Lakshdweep Islands etc., are not mapped as well.

It is noteworthy that NE region of India, Kerala and other areas (Fig 1), which are not drylands, have also been covered under this study as they do suffer from land degradation, at places profoundly. Jhoom cultivation in North-Eastern parts of the

country has been covered under vegetal degradation. Forest and plantations are clubbed together for convenience of delineation. Glacial and peri-glacial regions have been dealt as separate land cover classes due to different distinct processes. Mass movement includes the large landslide areas and scree slopes in hilly terrain, mainly Himalayan areas

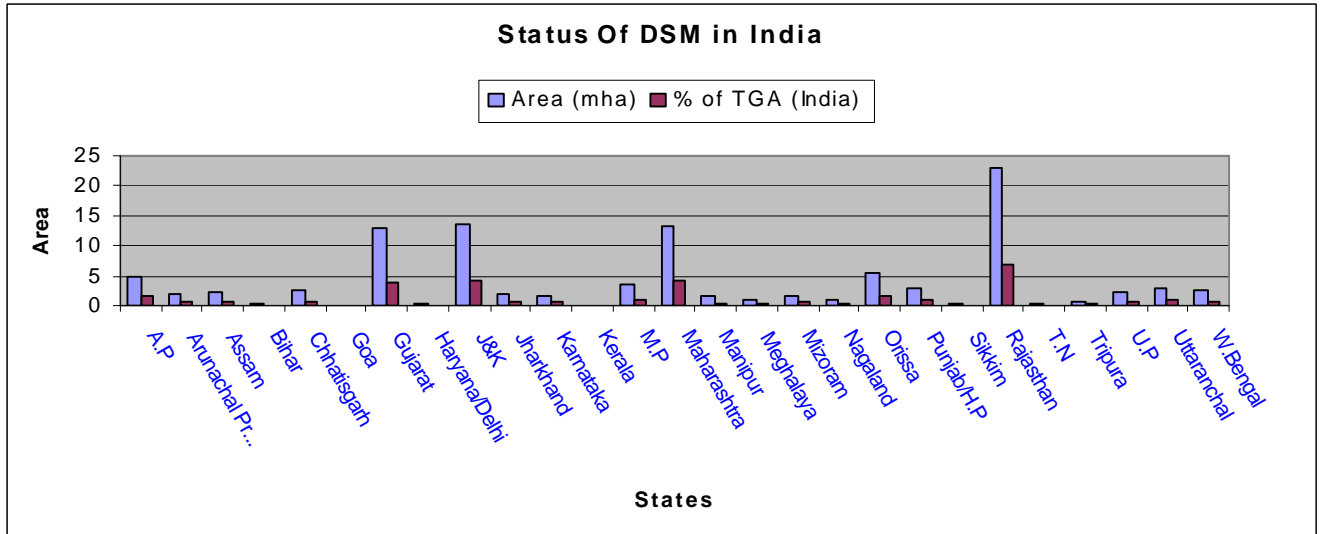
The estimate based on the digital analysis of the mapped information in GIS suggests that the total area of desertification in India is 104.94 million hectares (mha), which constitutes about 32 per cent of the total geographical area (TGA) . There are three major processes responsible for the desertification in the country. The water erosion is the main cause of degradation in the country followed by vegetal degradation and wind erosion. Table 4 gives the detailed break up of the estimated area (in mha) and corresponding per cent of TGA under desertification in various land use/cover, affected by different desertification processes and varying severity levels, in India. This table includes the major degradation processes in cold desert as well.

Table 4 Estimation of the land under desertification in India

Processes	SAC (2006) 1:0.5 m scale	
	Area (mha)	% of TGA
Water Erosion	33.56	10.21
Vegetal Degradation	32.70	9.95
Wind/Eolian Degradation	16.50	5.01
Frost Shattering	10.21	3.10
Salinity/Alkalinity	4.70	1.43
Mass Movement	4.45	1.35
Water logging	0.98	0.30
Rocky areas/ Barren	1.65	0.50
Others (Man made, frost heaving etc.)	0.15	0.04
	104.94	31.92

The total area of the country is about 328.73 mha. Each state is evaluated w.r.t its proportion of area under desertification to the TGA (Total Geographic Area) of India. Figure 3 shows the graphical representation of the DSM area (in mha) for each state and its percent contribution to the TGA of the country. Area wise (mha) Rajasthan (22.96) mha, has the largest area under desertification, followed by J&K (13.5), Maharashtra (13.36) and Gujarat (12.86).

Figure:3



Within each state, the status of desertification is graphically shown in Fig. 4. It is computed in two ways viz. area under desertification within the state (in mha) and DSM-percent of the total area of state. Within the states, the NE-states have very high ratio of land under desertification as percent of total area of the state. Mizoram has the highest percent of land under desertification (80%), followed by Manipur (68%), Tripura (67%), Nagaland (65%). Outside NE-

region, the other states having significant percent of desertification include Gujarat (69.5%), Rajasthan (67%) and J&K (59%). This indicates the ratio of area affected by desertification to the total area of the state. It is also strongly suggestive of the 'land under tress' The entire statistics of India is given in Table-5, shows the status of DSM both - process wise and state wise.

Figure:4

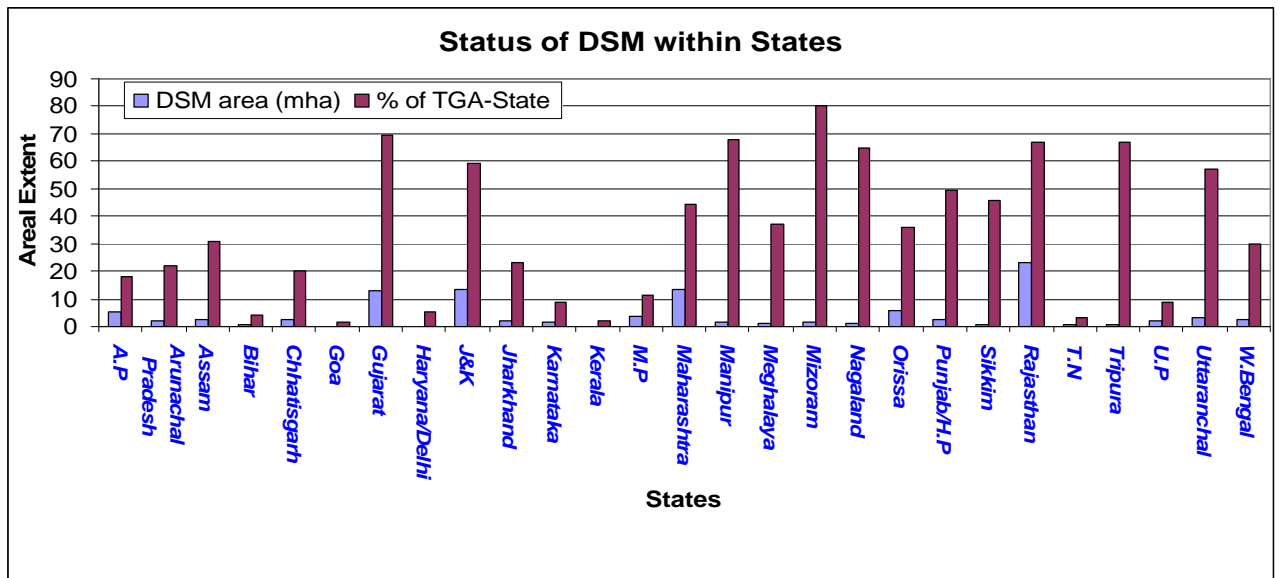


Table 5- Status of Desertification in India (area in sq kms.)

State	Wat Ero	Veg Deg	Eolian	Frost Shat	salinity	Mass	Wat Logg	Rock/ Barn	Others	Total
A.P	20846.12	25468.18	130.54		1369.76		1065.43	595.52	172.36	49647.913
Arunachal Pradesh	1744.66	10604.23	0	5817.98						18166.87
Assam	8466.12	15264.54	0				460.21			24190.87
Bihar	1084.89	1048.12	0		94.66		1880.71	36.46	2.99	4147.8276
Chhatisgarh	7073.81	18942.73	0		6.47		5.21	148.34	176.34	26352.896
Goa	11.72	0	0					50.73		62.448953
Gujarat	67904.68	27378.67	5433.22		27426.77			235.21	259.5	128638.05
Haryana/Delhi	0	0	1123.04		720.64			506.43		2350.1064
H.P	972.32	19186.28	2.59	7417.83		48.43				27627.45
J&K	2079.05	3133.04	6183.45	79030.08		44474.28			74.28	134974.18
Jharkhand	11609.28	6412.35	0				33.21	113.57	20.95	18189.358
Karnataka	6834.51	9348.61	45.37		566.21			128.84	3.84	16927.38
Kerala	287.75	606.92	0					4.11		898.78
M.P	13142.76	20834.23	0		20.54		3.33	619.9	32.83	34653.59
Maharashtra	92515.94	40347.49	0		450.14			83.71	194.51	133591.79
Manipur	3090.38	11791.51	0							14881.89
Meghalaya	942.56	7810.36	0				16.06			8768.98
Mizoram	10.36	16640.18	0							16650.54
Nagaland		0	10655.78	0						10655.78
Orissa	32065.05	20110.39	12.02				2428.38	25.44	51.07	54692.35
Punjab	60.49	43.31	0							103.8
Sikkim	206.49	1529.24	0	1547.76						3283.4884
Rajasthan	38405.03	21384.96	152030.7		3646.42		41.09	13834.73	317.06	229659.99
T.N	947.95	3452.26	30.9		15.65				63.53	4510.29
Tripura	0	6671.22	0				147.21			6818.43
U.P	6489.38	1676.96	0		12722.39		1314.27	129.19	42.82	22375.009
Uttaranchal	824.73	20730.48	0	8272.79	8.11					29836.109
W.Bengal	17997.20	6185.57					2404.8		116.34	26703.91
Total	335613.23	316601.8	175647.6	102086.44	47047.76	44522.71	9799.91	16512.1718	1528.42	1049360.08

The results are further scrutinized so as to get the distribution of various processes of Desertification with High and Low severity. The areas with high severity is of greater importance for prioritizing the future mitigation measures to combat desertification. Figure 5 and 6 show the distribution of the Low and high severity of various processes, as the per cent of the total Desertification, in that category, respectively

Figure 5 : Shows the % distribution of the processes of desertification with low severity.

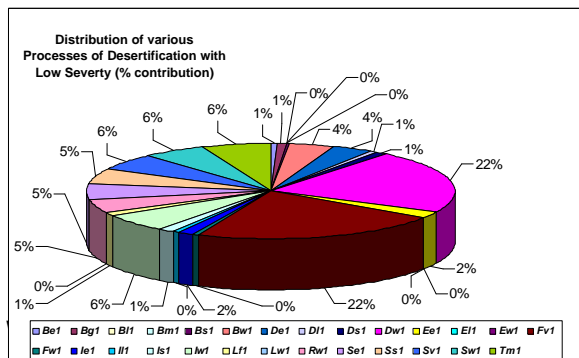
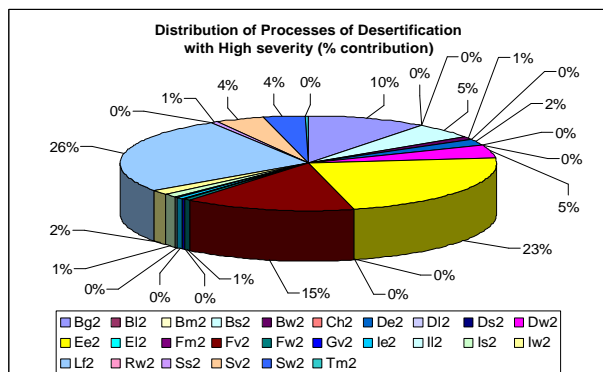


Figure 6 : Shows the % distribution of the processes of desertification with High severity.



4. CONCLUSION :

- 1) The IRS-P6 Resourcesat AWiFS data has been successfully used to generate DSM of entire country on 1:500,000 scale
- 2) Nearly one third of the country (32%) is inflicted by desertification with varying degree of severity of different land degradation processes

- 3) There are about 8 major processes of degradation identified in India, of which , the water erosion is most pronounced process, followed by vegetal degradation and eolian processes leading to desertification
- 4) Total area under desertification is 104.94 mha, which is close to the earlier estimate (107.43 mha) generated by MOA (1994) on the basis of statistics collected from various states.
- 5) Area wise Rajasthan, J&K, Maharashtra and Gujarat have high proportions of land under desertification.
- 6) Within the states, the states of NE-regions have very high ratio of land under desertification as percent of total geographical area of the state (% of TGA).
- 7) This study provides base-line data and information for future monitoring of progression/regression of desertification by repeating the exercise every five years.

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