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Status and Monitoring of Desertification in India: A Review*

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Introduction

I take this opportunity to express my sincere gratitude to IIG Committee for nominating me to deliver the 4th Prof. A.B. Mukerji Memorial lecture during 40th session of IIG at JNU, New Delhi. I am deeply touched and beholden for this honour. Prof. A.B. Mukerji was one of the senior geographers of India whose contribution both in physical and cultural geography is well recognized internationally. He was undoubtedly among the tallest of all geographers both in physical stature and in intellect. Professor Mukerji will forever be remembered for his contributions on the alluvial fans of the Himalayan area and cultural geography. Prof. Mukerji's interest in aeolian geomorphology was immense. Hence, this is the reason why I decided to deliberate on the issue of desertification/land degradation? It is a matter of great pride for me that I have been deeply associated with the National Project on Status of Desertification/land degradation in India coordinated by Space Application Centre, Ahmedabad, (ISRO) sponsored by MOEF and climate change since 2001. It is a collective work of 17 to 19 organizations that has been coordinated by SAC. The contributions of geographers in this important project have been significant and remarkable.

Desertification: Definition and Extent

Desertification is a term that refers to the process of land degradation that ultimately leads to transformation of productive land into an ecological desert. It is a process involving a continuum change, from no degradation to very severe degradation. The 1977 UNCOD in Nairobi described desertification as the diminution or destruction of the biological potential of the land. The Rio Summit in 1992 defined desertification as 'Land degradation in arid, semiarid and dry sub-humid areas resulting from various factors including climatic variations and human activities.'

Desertification is a global phenomenon which causes arid, semi arid and dry sub humid ecosystem to deteriorate. Today, world's deserts cover about 5 million km^2 area, and an additional 40 million km^2 lands are arid or semi-arid. In total about 33 % of the world's land surface exhibits desert characteristics to some degree or other. The area covered under desert

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is not static. It is dynamic. The desert like conditions are added at the rate of 60,000 km^2 per year and threaten another 30 million km^2 area (The Environment Directory, 1998). 40 % of the productive land faces severe threat to desertification, resulting in an enormous loss of productivity. In India, about 320,000 km^2 is hot desert spread in Rajasthan (61 %), Gujarat (19 %), Haryana and Punjab (9 %). Karnataka, Andhra Pradesh and other areas occupy 10 % while 84,080 km^2 is cold desert spread in parts of Jammu and Kashmir, Himachal Pradesh and Uttar Pradesh. About 12 % of total geographical area of India falls under arid region. A cold desert is a vast tract of land which is cold and dry and is uninhabited, uncultivated and capable of supporting only a few forms of life. Temperature extremes touch the 50^0 C mark in hot areas while in cold areas it goes down to about – 40^0 C. The Thar Desert of Rajasthan is the main hot desert with the highest population density in the world (Arya *et al*., 2011).

The causative agent over the last one or two thousand years or more has been man than climate change. The man's misuse of land leads to the degradation of the productivity of vegetation and the fertility of soil as well as to various unfavorable alteration in the soil water balance (H.S. Sharma 1992).

Land degradation by man is initiated when the vegetative cover is reduced or destroyed by grazing, cultivation, mining, road construction, irrigation, urbanization and other activities that disturb the natural condition. Subsequently, water and wind erosion accelerates the degradation process. Finally conditions deteriorates to the point where land is abandoned (Dregne, 1986).

In the last few decades it has become evident that the processes of desertification have been very much enhanced mainly through rapid increase of human and animal population. Recurrent phases of drought in the marginal areas of Rajasthan desert have, of course, accentuated this situation from 1985 to 1988 (H.S. Sharma, 1988).

Climate change and desertification are closely linked. One of the impact which global warming may have on the surface of the Earth is to aggravate the worldwide problem of desertification. Decrease in the total amount of rainfall in arid and semi-arid areas could increase the total area of dry lands worldwide and thus the total amount of land potentially at risk from desertification.

Review of Literature on Desertification

Desertification is a serious threat to the sustainability of arid and semiarid areas, which cover 33 % of the land surface of the earth populated by approximately 1 billion people. Several researches in the last few decades (Sharma, 1993, 2008, 2010, 2017; Ajai 2011; Pathan et al, 2010; Arya et al. 2011); Bera et al. 2011, Ratan Priya and Padmini Pani, 2015, Kar, A. et. al. 2007) have been made to study, measure and evaluate the possible expansion or

contraction of the deserts in various parts of world. During the last 40 years, different assessment methodologies have produced widely conflicting estimates. In 1975, **Hugh Lamprey**, based on comparison of a vegetation map of 1958 and aerial and terrestrial surveys in 1975 observed a 90-100 km southward displacement, and concluded that the southern margin of the Sahara Desert is catastrophically advancing at a rate of 5.5 km yr into the Sahel region (Lamprey, 1975). This figure, together with the severe droughts between 1960 and 1970 in Africa, prompted many ineffective, anti-desertifcation, institutional recommendations and actions: planting 'green belts' around the Sahara (UNCOD), prohibition of goats, destocking of herds, prohibition of tree cutting or grass burning and the enforcement of soil conservation programmes (Batterbury and Warren, 2001).

Hellden (1991) and Tucker *et al.* (1991) showed through a combination of field work and satellite remote sensing that desert boundaries are very dynamic, their locations being highly linked to annual rainfall. In fact, a detailed rainfall analysis showed that Lamprey's assessment was, actually, a comparison between a wet year (1958) preceded by a series of wet years, and a dry year (1975) preceded by a series of dry years (Veron et al., 2006). Prince *et al.* (1998) and Nicholson *et al.* (1998) assessed the desertification status of the Sahel region by means of indicators of ecosystem functioning like the rain use efficiency (RUE) – the ratio between annual above-ground primary production and annual precipitation, and argued that there was not enough evidence to indicate extensive Sahelian desertification (Nicholson *et. al.,* 1998; Prince *et. al.,* 1998), New research (Veron *et al.,* 2006) has, however, also called into question even these studies, as a result of methodological or conceptual problems, illustrating that desertification assessment remains controversial.

The coexistence of conflicting definitions and divergent estimates lead to skepticism in policy making, opens the door to misusing the concept, and ultimately, to a delay of eventual solutions. Geomorphologists can contribute to this unresolved desertification assessment effort – essentially a resource inventory exercise by using the methodological progress (from general observations spuriously correlated with whether changes or overgrazing, to unifying indicators of ecosystem functioning) already made in desertification ecology and remote sensing.

Status of desertification in India

In India attempts have been made to assess the area under land degradation and the processes operating in different areas by National Commission on Agriculture (1976, 1994), Ministry of Agriculture (1985), National Bureau of Soil Survey and Land use Planning (1994) and National Remote Sensing Centre (NRSC, 1986, 2001). The result is varying which are indicated in Tables 1 and 2.

Table 1. Estimates of land degradation in India

Agency/Organization	Year	Extent In Mha)	Criteria for delineation
National commission on agriculture	1976	175.00	Based on secondary data
Ministry of agriculture, GOI	1985	173.64	Based on land degradation statistics of the states.
National bureau of soil survey and land use planning	1994	187.70	Mapping on 1:1 million scale based on global assessment of soil degradation guidelines.
Ministry of agriculture, dept of agricultural cooperation	1994	107.43	Based on land degradation statistics of the states.
National remote sensing agency (NRSA)	1986	53.28	Wasteland mapping on 1:1 million scale based on satellite imagery.
National remote sensing agency (NRSA)	2000	63.90	Wasteland mapping on 1:50,000 scale, thirteen categories of wastelands.
Source: Government of India, 2001			

Table 2. Different causes of land degradation

Land type	Extent of degradation in M ha	% of area degraded
Water Erosion	107.12	61.70
Wind Erosion	17.79	10.24
Ravines	3.97	2.28
Salt affected	7.61	4.38
Water Logging	8.52	4.90
Mines and Quarry Waste	0.09	0.05

Degradation due to shifting cultivation	4.91	2.82
Degraded forest lands	19.49	11.22
Special problems	2.73	1.57
Costal and sandy area	1.46	0.84
Total land degradation	173.69	100.00
Extent of area degraded in dryland (arid, semi-arid and sub-humid regions	130.00	74.85

Source: Government of India, 2001

Realizing the seriousness of desertification: Ministry of Environment and Forests, Government o India gave a serious thought to this issue and also to fulfill the obligation of UN Convention to Combat Desertification (UNCCD, 2000). Regional Action Plan (RAP) for Asian region has been initiated as collective effort by the member countries.

Desertification Status Mapping-First Cycle (2001-2007)

Under the auspices of UNCCD, in India, Space Applications Centre (SAC) has been identified by the Ministry of Environment and Forests as the national focal institution to coordinate and implement. Thematic Programme Network (TPN) – 1 activities of UNCCD in the country. In order to realize the objectives of TPN – 1 i.e. the Desertification Status Mapping (DSM), was required to evolve and standardize a national level classification system as well as a methodology for DSM using satellite remote sensing. Accordingly a pilot project was taken up at the behest of the Ministry of Environment and Forests, Govt. of India. The pilot project has been executed by SAC in collaboration with 17 important organizations of the country viz. AISLUS, CAZRI, NBSSFXLUP, NATMO. EOS (ISRO), NRSC, RRSS – Jodhpur, University of Rajasthan, JNU, DERS Srinagar, I-I ARSAC, IRS – Anna University, MPRSAC and Jammu University. It is significant to note that in these organizations number of geographers have been working and contributed immensely.

Indicators of desertification

One of the important elements of desertification monitoring and assessment is to identify/define the indicators. Many of the indicators are amenable to remote sensing and thus are depicted on the satellite images.

The task of defining and finalizing the indicators for Desertification Monitoring and Assessment (DMA) to be used in the country, was taken up by the TPN-1 national working group. The indicator systems were finalized by the working group. The literature survey,

the benchmarks and indicators have been already in use at international level (Ajai, 2001). The finalized indicators were discussed and fine tuned in the brain storming session at Space Applications Centre, Ahmedabad in 2001. These indicator systems are in harmony with the indicator systems adopted for the Asian region under TPN-1.

The indicator system for desertification monitoring and assessment is classified into four categories viz.

1. Pressure indicators: mainly climatic indicators
2. State indicators: hydrological, physical, biological etc.
3. Impact indicators: socio-economic, migration, unemployment etc.
4. Implementation indicators: the changes in the land cover conditions owing to mitigation measures aimed at combating desertification.

The national classification system for desertification/land degradation status mapping was evolved and standardized through a pilot project and adopted for the present purpose. Level I comprise of identification of land use classes, Level 2 describes the land degradation process and Level 3 deals with the severity of degradation.

It is important to mention that the mapping of desertification status in the first cycle was done on two scales i.e. 1:50,000 at a district level. Eight districts (4 from hot desert and 4 from cold desert) were selected as a pilot project and on 1:500,000 scale at the state level. This study was carried out using multidate data from Advanced Wide Field Sensor (AWiFS) on board IRS P-6 (Resourcsat). The data acquired during the year 2003, 2004 and 2005 were used. Ground truth were collected and used in preparation of DSM. The present lecture is mainly focused on state level analysis of this National Project.

Results of First Cycle DSM

The Table 3 indicates that the total area undergoing the process of land degradation in India is 105.48 Mha, which constitutes 32.07 % of the total geographical area. There are three major processes of desertification in India. The water erosion (10.21%) is the major process of degradation in the country followed by vegetal degradation (9.63%) and wind erosion (5.34% of TGA).

Among the states, the NE-states have very high percentage of area under land degradation (79 %), with Manipur, 67 %, Tripura, 65 % and Nagaland, 64.27 %. Outside NE-region, the other states having high percent of desertification/degradation include Gujarat (68.27 %), Rajasthan (67 %) and Jammu & Kashmir (60.70 %). In Rajasthan 67 % of area is affected due to desertification/land degradation. The most significant process of desertification in the state is wind erosion (44.42 %), followed by water erosion (11.22 %), vegetal degradation (6.25 %) and salinisation (1.70 %).

Table 3. Process wise distribution of the area under land-degradation for India.

Processes of Desertification/ land degradation	Area covered	
	Area (M ha)	% of total Geog. Area
Water erosion	33.56	10.21
Vegetal degradation	31.66	9.63
Wind /Aeolian degradation	17.56	5.34
Frost shattering	10.21	3.10
Salinity/ alkalinity	05.26	1.60
Mass movement	04.45	1.35
Water logging	00.98	0.30
Rocky areas / barren	01.65	0.50
Others (manmade, frost heaving etc.)	00.15	0.04
	105.48	32.07

Source: Desertification & Land Degradation Atlas of India, SAC, 2007

Status and Monitoring of Desertification-Second Cycle Mapping-2013-16

In 2013 it was realized by the Ministry of Environment, Forest and Climate Change, Government of India to monitor desertification status using two time frame data. In this cycle mapping was also done on two scales i.e. 1:50,000 at district level and 79 districts from the whole country were identified. Similar to first cycle the state level mapping was carried out on 1:500,000 scale using Geo-coded IRS AWiFS digital data of three seasons (Kharif, Rabi and summer) for time frame 2003-5 and 2011-13.

Statewise statistics were generated for different processes for both the time frames. Changes in desertification and land degradation classes were brought out for the timeframes 2011-13 and 2003-05. Insignificant land degradation observed in all Union Territories, hence included in No Apparent Degradation (NAD) class. Mapping of area under Frost Shattering process was carried out from the images showing maximum ablation zone for both the time frames.

The analysis of second cycle data revel that 96.40 mha area of the country was undergoing the process of land degradation 29.32% of the total geographical area of India during 2011-13 while during 2003-05 the area undergoing process of land degradation is 94.53 mha (28.6% of TGA). There was a cumulative increase of 1.87 mha area undergoing process of desertification in India constituting 0.57% of the TGA of India.

The most significant processes of desertification in the India are water erosion (10.98% in 2011-13 and 10.83% in 2003-05) vegetal degradation (8.91% in 2011-13 and 8.60% in 2003-05) and wind erosion (5.55% in 2011-13 and 5.58% in 2003-05) (Table 4).

Table. 4 : Desertification Processes in India

Process of Desertification/Land	2011-13		2003-05		Change (mha)
Degradation	Area (mha)	Area (%)	Area (mha)	Area (%)	(2011-13)-(2003-05)
Vegetation Degradation	29.30	8.91	28.28	8.60	1.01
Water Erosion	36.10	10.98	35.61	10.83	0.49
Wind Erosion	18.23	5.55	18.35	5.58	0.12
Salinity	3.67	1.12	4.01	1.22	0.34
Water Logging	0.65	0.20	0.60	0.18	0.05
Frost Shattering	3.34	1.02	3.11	0.95	0.23
Mass Movement	0.93	0.28	0.84	0.26	0.09
Manmade	0.41	0.12	0.37	0.11	0.04
Barren/Rocky	1.89	0.57	1.88	0.57	0.01
Settlement	1.88	0.57	1.48	0.45	0.40
Total Area under Desertification	96.40	29.32	94.53	28.76	1872523
No Apparent Degradation	226.73	68.97	228.68	69.57	1954372
Total Geographical Area (mha)			328.72		

Source: Desertification and Land Degradation Atlas of India, Space Application Centre, ISRO, Govt. of India 2016

The analysis of data obtained from Second Cycle Atlas (2016)reveals that 96.40 mha area of the country is undergoing process of land degradation i.e. 29.32 % of the TGA of the country during 2011-13, while during 2003-05 the area undergoing process of land degradation is 94.53 mha (28.76 % of the TGA).

Around 23.95 % (2011-13) and 23.64 % (2003-05) of the total DLD with respect to country TGA is contributed by Rajasthan, Maharashtra, Gujarat, Jammu & Kashmir, Karnataka, Jharkhand, Odisha, Madhya Pradesh and Telangana in descending order. All other remaining states are contributing less than 1 % (individually). However, the analysis with respect to TGA of individual states show that Jharkhand, Rajasthan, Delhi, Gujarat and Goa are showing more than 50 % area under DLD, whereas states with less than 10 % area under DLD are Kerala, Assam, Mizoram, Haryana, Bihar, Uttar Pradesh, Punjab and Arunachal Pradesh.

There is a cumulative increase of 1.87 mha area undergoing process of DLD in the country (constituting 0.57 % of the TGA of the country) during the time frame 2003-05 and 2011-13. The change analysis carried out for 2011-13 and 2003-05 time frames indicates that around 1.95 mha land has been reclaimed and 0.44 mha land has been converted from high severity to low severity degradation class, indicating improvement. On the other hand, around

3.63 mha productive land has degraded and 0.74 mha land has converted from low severity to high severity degradation class. Further, during this time fame, high desertification/land degradation changes are observed in the states of Delhi, Tripura, Nagaland, Himachal Pradesh and Mizoram (11.03-4.34 %), whereas Odisha, Rajasthan, Telangana and Uttar Pradesh have shown improvement (-0.11 to 1.27 %).

The most significant process of desertification/land degradation in the country is Water Erosion (10.98 % in 2011-13 and 10.83 % in 2003-05). The second most significant process is Vegetation Degradation (8.91 % in 2011-13 and 8.60 % in 2003-05), which is followed by Wind Erosion (5.55 % in 2011-13 and 5.58 % in 2003-05). Wind Erosion and Salinity have shown improvements from 2003-05 to 2011-13.

The above analysis reveals difference in data under desertification in First Cycle DSM of 2007 and Second Cycle DSM of 2016 conducted by Space Application Centre, Ahmedabad. As per earlier study the total area under desertification in India in 2003-05 was 105 mha or 32.07% while in the recent study it was reported as 94.53 mha (28.76% of total geographical area). The difference of 10.47 mha or 3.31% is a big difference at the national level which warrants attention and justification.

Conclusion

The present study based on National Projects of SAC (2001 to 2016) brings out that nearly 30% area of India is undergoing the process of desertification and land degradation, majority of this area is falling under arid regions. There is a cumulative increase of 1.87 mha area undergoing process of desertification and land degradation in India during 2003-05 and 2011-13. The most dominant process of desertification is water erosion in 2011-13 (10.98 %), followed by vegetal degradation (8.91%) and wind erosion (5.55%). The present study has provided valuable inputs to India's reporting process of UNCCD and it is also sound basis for combating desertification in India.

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