Land degradation assessment and mapping in Banaskantha district, Gujarat using remote sensing and GIS techniques

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Abstract: Land degradation, a process of reduction in the productive capacity of land, is a subtle and progressive environmental change in time. Overexploitation of natural resources by humans and climatic conditions such as prolonged drought, further aggravates land degradation in fragile ecosystems. Desertification is the continuous degradation of land in arid, semi-arid and dry sub-humid regions. Mapping and quantifying the extent and geographical distribution of degraded lands form an essential input for planning reclamation/ conservation strategies. In Banaskantha district of Gujarat, drought is a common feature causing soil moisture deficiency leading to desertification. The present study deals with mapping and assessment of land degradation and desertification status of Banaskantha district, covering 10,743 sq. km area, located in semi-arid regions of Gujarat state using remotely sensed data. Desertification in the district is assessed using visual interpretation of three season (kharif, rabi and zaid) IRS LISS III satellite data of 2011-12 timeframe in GIS environment. Desertification Status Map is prepared at 1:50,000 scale using hierarchal classification system comprising of three elements viz. land use, process of desertification and its severity. The study revealed that Banaskantha district is classified into 37 desertification classes and about 47% of its area is undergoing degradation. The major degradation processes observed in the district are wind erosion (~32% of total area) and vegetation degradation (~10%). Rest of the areas shows water erosion (~3%), salinization (~2%) and water logging (~0.1%). The most significant classes of desertification in the district are wind erosion in agricultural lands and vegetation degradation in forest lands with medium to high level of severity.

Keywords: land degradation, desertification, remote sensing, GIS, visual interpretation, DSM

I. Introduction

Land is one of the most important natural resource for the country, on which all the human activities are based. India occupies 2.4% of world's area, supports 16.7% of its population. It has 0.5% of world's grazing land, supports 18% of its cattle population [6]. Huge demands on land resources leads to severe changes in the proportion of land utilized for agricultural activities, urbanization and industrial development. This leads to loss of biological and economic productivity of land in fragile ecosystems. The problem of land degradation continues to worsen in drylands due to human activities and climate change such as prolonged or frequent drought,

aggravating land degradation. This led formally defining desertification as “land degradation” in arid, semi-arid and dry sub-humid areas.

Land degradation assessment and mapping is an essential step before implementing any prevention, restoration and land protection policies. Identification of the susceptible areas at district / sub-district level and their severity on regular basis is necessary for curbing effects of desertification and efficient planning [5]. It is also important to study and understand if the land degradation (intensity in terms of the area and severity) is increasing or decreasing with time. This helps in making an appropriate strategy for developing action plans to arrest the processes of land degradation.

Remote sensing and GIS are effective technologies for detecting, assessing, mapping, and monitoring land degradation and desertification. The synoptic view of the area allows better monitoring capability, especially when the coverage is repetitive, interval is short, and resolution of the image is high. Remote sensing provides data in several discrete bands, enabling creation of false colour composites (FCC), thereby increasing visual and digital interpretation accuracy [3]. It provides real-time and unbiased base line information for assessing land degradation and desertification.

In India use of aerial photographs was initiated in deriving information on degraded lands since sixties and early seventies [4]. The application of remotely sensed data in mapping degraded lands space borne sensors started with the launch of the first Earth Resources Technology Satellite ERTS-1 / Landsat-1. Moderate resolution multispectral time series (AVHRR, MODIS, etc.) are generally used to assess vegetation response to land degradation at broad scale. The high temporal frequency of these series is suitable for characterizing vegetation dynamics and monitoring trends, but not appropriate for detailed scale applications. Currently, medium resolution multispectral satellites, particularly the Landsat and IRS (Indian Remote Sensing Satellites) series with better spatial and spectral resolution, still represent the main data source used for land degradation assessments over large regions and long term periods, especially where no information is available on the specific causes of degradation.

About 30% of India’s total geographic area is undergoing land degradation. Gujarat state is observed with 3% of the total area under desertification/land degradation for the period of 2011-2013 [2]. The state is subject to recurrent scarcity and drought conditions that cause soil moisture deficiency leading to desertification. Compared to many other districts of the State, Banaskantha district comprises of a small percentage of its area and population under the vicinity of drought, but the district has been selected for the study as it has a contrasting type of climatic conditions. Identification of susceptible areas at district level and their severity on regular basis is necessary for controlling the effects of desertification as well as for efficient planning.

II. Materials and Methodology:

A. Study area:

Banaskantha falls in the north-western part of the Gujarat state (India) and lies between 23° 55’ and 24° 43’ North latitudes and 71° 16’ and 73° 0’ East longitudes. It is the fourth largest district in terms of area accounting for 5.47 % of the total geographical area of Gujarat i.e. 10.743 sq. km. In the north it is bounded by Marwar and Sirohi area of the Rajasthan State, in the east by a

part of Sirohi and Sabar Kantha district, in the southeast by the district of Mahesana, to the south by the district of Patan and in the west by the Rann of Kachchh which forms frontier with Pakistan.

As one of the semi-arid districts of Gujarat, Banaskantha receives meager amount of rainfall. The average annual rainfall is about 696 mm. Topographically the district can be divided into three main parts – the hilly or mountainous sub-region in the east, the piedmont zone in the central part and the plain area in the west.

According to Irrigation department report (1972), about 49% of the district is drought prone affecting about 34% of the total population of the district [8]. All the drought prone talukas of Banaskantha are confined on the western part of the district, on fringes of Rann of Kachchh, making them vulnerable to desertification. Furthermore, non-availability of forest cover i.e. 10.3% of TGA (Forest Department,2010-11) along with increasing population and livestock also enforce the process of desertification in the district.

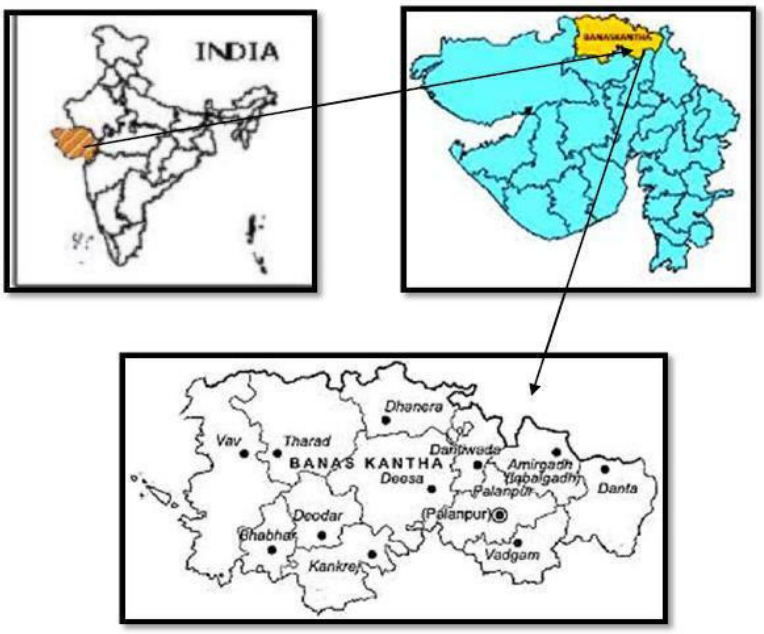

Figure 1: Location map of Bansakantha district, Gujarat

B. Data used:

*Ancillary Data**:*** Base layers to delineate water bodies, rivers, and administrative boundary are taken from Natural Resources Data Base (NRDB). Forest boundary layer is taken from Forest Survey of India.

Satellite data: For observing the processes and severity of degradation within each parcel of land under desertification, multi-temporal, geo-coded Indian Remote Sensing Satellite -Resourcesat2 LISS III data acquired during major cropping seasons like kharif (Sept-Nov), rabi (Dec-March) and summer (April-June) are used

Table 1: List of Resourcesat-2 LISS III data covering Banaskantha district, Gujarat (2011-12)

		Date of pass		
Path	**Row**	**Kharif**	**Rabi**	**Summer**
		September-November	December-March	April-June
91	54	13 October,2012	16 February, 2012	22 May,2012
91	55	13 October,2012	16 February, 2012	22 May,2012
92	54	24 October,2011	21 February, 2012	27 May,2012
92	55	24 October,2011	21 February, 2012	27 May,2012
93	55	5 October,2011	26 February, 2012	8 May,2012

C. Desertification Status Map:

Assessment and monitoring of land degradation/desertification status of Banaskantha district is an ordered process carried out by visual interpretation of three season satellite data (IRS LISS III geo-coded FCC imagery) in GIS environment. Satellite data along with ancillary data is first acquired and overlaid in GIS environment. Multi-temporal geo-coded images of all the scenes covering the district is then processed to generate false color composite images of all the three seasons. Land use/land cover classes are identified and delineated using visual interpretation. It serves as a base to identify the area undergoing desertification processes. The classes where there is no scope for degradation are first masked i.e. water body/drainages and built-up area. Then, degradation processes with varying levels of severity are identified and delineated according to the National Level Classification System.

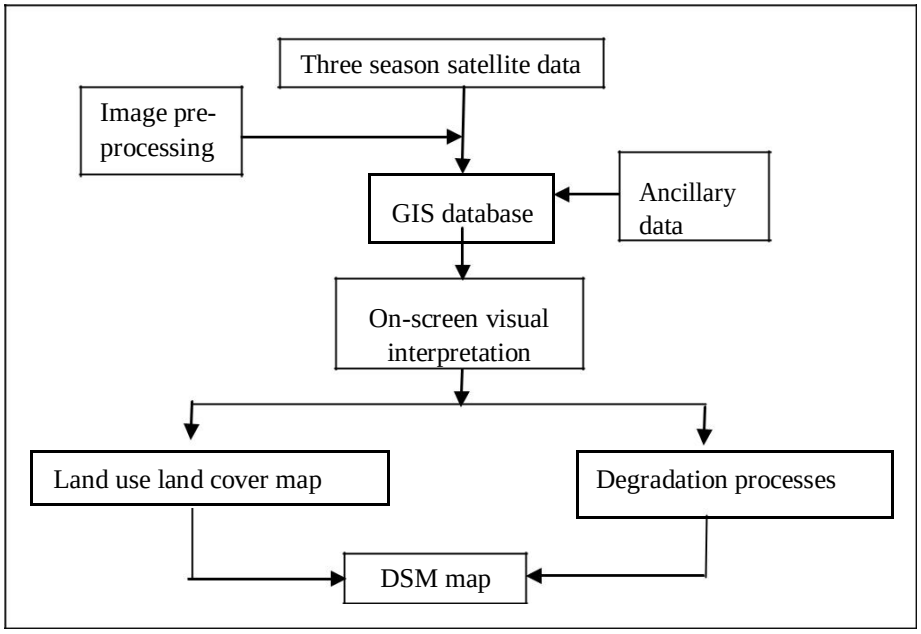

Figure 2: Methodology for generating Desertification Status Map of Banaskantha district, Gujarat.

D. Classification System:

A National Level Classification System and the broad methodology for the Desertification Status Mapping (DSM) using satellite data, evolved during the previous studies/projects at Space Applications Centre, ISRO, has been followed in the present work.

Table 2: Classification System for Desertification Status Map

Level-1:Land Use		**Level-2:Process of Desertification**	
Agriculture irrigated	I	vegetation degradation	V
Agriculture unirrigated	D	water erosion	W
Forest/Plantation	F/P	wind erosion	E
Grassland/Grazing land	G	salinity/alkalinity	s/a
Land with scrub	S	mass movement	G
Barren	B	frost heaving	H
Rocky area	R	frost shattering	F
Dune/Sandy area	E	man made	M
Glacial	C	**Level-3: Severity**	
Periglacial	L	Low	1
Others	T	Medium	2
		High	3

A three level Alpha-numeric code is used for codification of the DSM maps i.e., Level 1: land use/land cover denoted by a capital English letter , Level 2: process of degradation denoted by a small English letter , Level 3: severity of desertification denoted by a numerical i.e. 1,2, or 3.

III. Results and discussion:

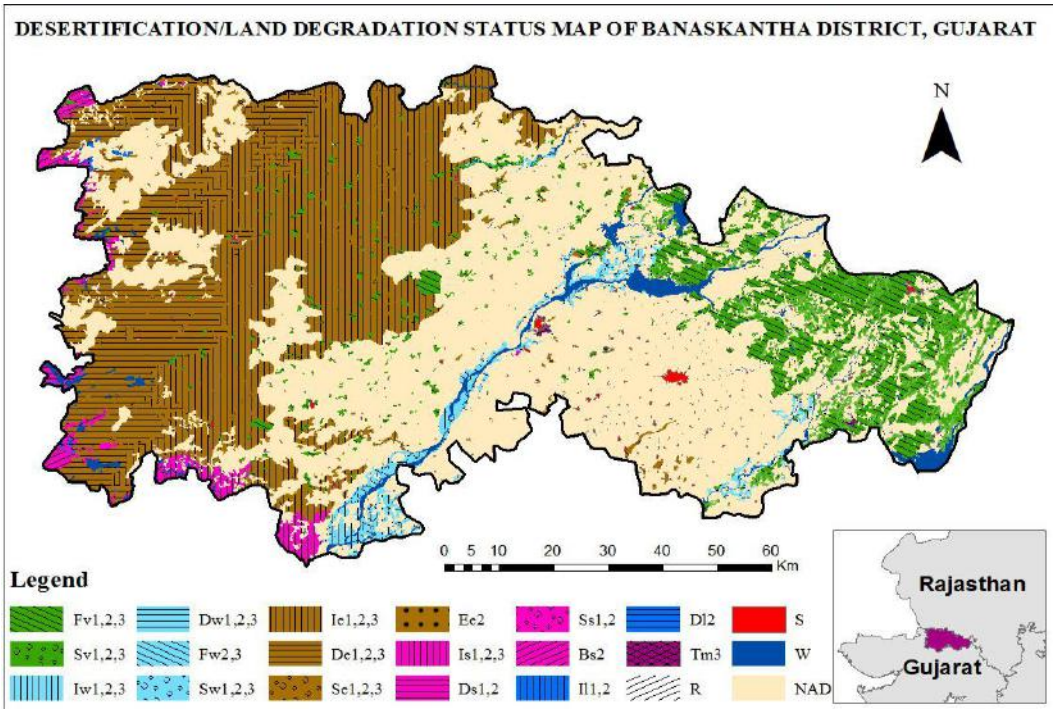

Figure 3: Desertification Status Map of Banskantha district, Gujarat.

The study of land use/land cover of Banaskantha district shows that there are 12 identified in the district. About 79% of the district in under agriculture (irrigated as well as unirrigated). Other classes include forest (10.22%), scrublands (6.27%), sandy area (0.09%), barren land (0.66%), rocky area (0.04%), and other mining activities (0.08%). About 3.5% of the total district is covered by water bodies, drainage and settlements, having no scope for desertification.

Desertification Status Map of Banaskantha district is shown in figure 3. It is evident that about 47% of the district is undergoing degradation. The degradation processes subjected to different land use land cover classes with varying levels of severity makes about 37 desertification classes. Their extent in terms of % of total district area and % of total degraded area is presented in Table 3. Major desertification classes observed are Ie1 (18.24%), De2 (6.09%), Fv2 (3.51%), Fv3 (3.23%), De1 (3.35%), Fv1 (1.35%), Ie2 (1.35%) and Ie3 (1.21%).

Table 3: % Area under various types of degradation classes

DSM Code	**% of TGA**	**% of Desertic land**	**DSM Code**	**% of TGA**	**% of Desertic land**
Fv1	1.35	2.85	Sv1	0.63	1.33
Fv2	3.51	7.39	Sv2	0.91	1.92
Fv3	3.23	6.81	Sv3	0.67	1.40
Total	8.09	17.05	Total	2.20	4.64
Iw1	0.23	0.47	Dw1	0.01	0.02
Iw2	0.21	0.44	Dw2	0.05	0.11
Iw3	0.27	0.57	Dw3	0.05	0.11
Total	0.71	1.49	Total	0.11	0.23
Fw2	0.04	0.08	Sw1	0.11	0.22
Fw3	0.35	0.73	Sw2	0.76	1.60
Total	0.39	0.81	Sw3	0.14	0.30
			Total	1.00	2.12
Ie1	18.24	38.45	De1	3.35	7.07
Ie2	1.35	2.85	De2	6.09	12.83
Ie3	1.21	2.56	De3	0.95	1.99
Total	20.81	43.86	Total	10.39	21.89
Se1	0.65	1.36			
Se2	0.77	1.62	Ee2	0.07	0.14
Total	1.42	2.98			
Is1	0.13	0.27	Ds1	0.10	0.22
Is2	0.46	0.97	Ds2	0.06	0.11
Is3	0.29	0.61	Total	0.16	0.33
Total	0.88	1.85			
Ss1	0.23	0.49			
Ss2	0.09	0.20	Bs2	0.66	1.38
Total	0.33	0.69			
Il1	0.03	0.06			
Il2	0.02	0.05	Dl2	0.03	0.07
Total	0.05	0.11			
Tm3	0.17	0.36	**Grand total**	47.45%	100%

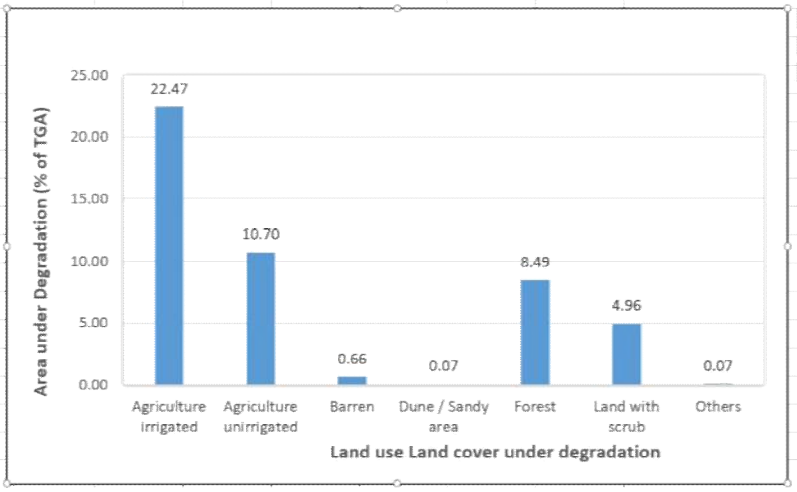

Figure 4: Land use/land cover under degradation of Banaskantha district, Gujarat

Figure 4 shows the land use/land cover classes affected by degradation. The major land use/land cover classes affected by desertification process are irrigated agriculture (22.47% of TGA), unirrigated agriculture (10.70%), forest (8.49%) and scrublands (4.96%).

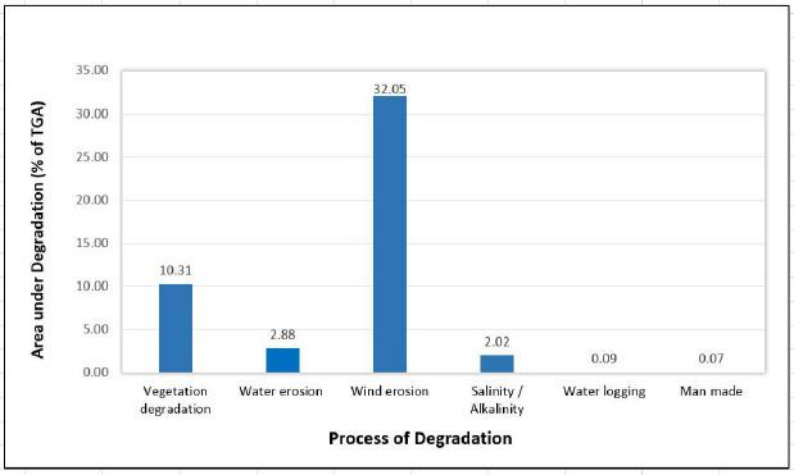

Figure 5: Desertification/land degradation status of Banaskantha district

Figure 5 shows distribution of various degradation process identified in the district. The observed processes in the district are vegetation degradation (30.33%), water erosion (2.88%), wind erosion (32.05%), salinization (2.02), water-logging (0.09%) and man-made activities (0.07%).

IV. Conclusion

The study revealed that 47% of the Banaskantha district is undergoing desertification. Major land use/land cover class affected by desertification is agriculture (irrigated as well as unirrigated) covering about 79% of the district. The barren lands and agricultural areas on the western part of the district, adjacent to Rann of Kachchh, are subject to salinization. Scarce vegetation along with high wind velocity from the western to the eastern direction is the causes of intrusion of sands from Rann of Kachchh in this area. Some portion of this agricultural land gets water-

logged in monsoon. The agricultural areas in the western part of the district receive less rainfall as compared to eastern part of the district and are comparatively quite dry. It falls under areas classified as drought prone. It shows that the whole agricultural economy of the area depends on the kharif crop and a single drought year can give a fall to the economy of the area. During rest of the year, the areas remain bare and are subject to wind erosion of moderate to high severity.

The central part of the district and all the agricultural areas surrounding the Banas river get adequate amount of water for irrigation and no apparent degradation is observed here. Water erosion on the banks of Banas river is observed to be affecting surrounding agricultural areas, scrublands and forest area. About 8.49% of district area covered by forest in the hilly mountainous regions in the eastern part of the district is subject to vegetation degradation of moderate to high levels of severity. The man-made processes such as mining and quarrying were also found to be operative locally but severely.

The most significant classes of desertification in the district are wind erosion in agricultural lands and vegetation degradation in forest lands with medium to high severity. The study clearly indicated that satellite data could be effectively used to provide quick and timely information on the process of the desertification, land use and land cover classes affected by the processes and severity of degradation.

V. References

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