

ASSESSMENT AND MAPPING OF DESERTIFICATION STATUS IN BELLARY DISTRICT, KARNATAKA STATE, USING IRS DATA

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ABSTRACT

Drought is a common feature of this semi-arid district of Bellary, lying almost at the centre of the Indian peninsula. Under UNCCD's desertification monitoring and assessment theme, the district was taken on pilot basis for an assessment of desertification processes and to map the current desertification status in the district and make ameliorative recommendations. The degradation in the district was observed in agricultural lands (rainfed as well as irrigated), forest and scrub lands and by mining activities. About 2 % of the district area was under rocky, stony, sandy and other types of barren lands. The major processes recognized in agricultural lands were water erosion under rainfed conditions and salinization/alkalinization under irrigated conditions. In forest lands, logging for timber and fuel purposes and grazing and in scrub lands, cutting for fuel purpose and grazing were the major processes. About 28 % of the district was under these degradation processes, the vegetal processes being predominant in aerial extent. The water erosion was operative mainly in rainfed agricultural lands that too in black soils as red soils to some extent were protected by agricultural practices during the main rainy season. Water erosion was also observed in the reserve forest land facing vegetal degradation, but most of which was masked in the satellite data. The salinization/alkalinization processes on the other hand were prevalent mainly in irrigated black soils. However, differentiating saline lands from alkali lands was not possible from the satellite data. The measures for controlling these processes and to ameliorate the affected lands have been suggested.

INTRODUCTION

Desertification/degradation of land is a continuous process. The impact of desertification is much related to environment (Le Houerou, H.N., 1975). The dry land ecosystem is extremely vulnerable to in-appropriate land use and its overexploitation in the man's scramble for higher production under limitations. The drought is the most visible symptom of a degrading ecosystem of which land is a main component. Drought is a common feature of this semi-arid district of Bellary. Over half of the district is under rainfed agriculture. Even in irrigated areas, extensive salinity/alkalinity has forced many crops out of cultivation. With its vast reserves of high grade iron-ore, the district is attracting mining, steel and power industry to pollute its air and water. Any land system that has lost or losing its productivity and supports less and less humans and livestock is a case for study of desertification, its processes and current severity (Kassas, 1977). Under UNCCD's desertification monitoring and assessment theme, the district was taken on pilot basis for an assessment of desertification processes and in the process to evolve and standardize procedures for desertification status mapping in the semi-arid zones and make some immediate ameliorative recommendations (UN Conference on Desertification, 1978).

MATERIALS AND METHODS

The Bellary district with an area of about 8,500 km² is located almost at the centre of the Indian peninsula between 14° 33' and 15° 15' N latitude and 75° 40' and 77° 10' E longitude. During the

last decade, the district has received an average annual rainfall of about 545 mm with wide spatial variability ranging from 815 mm in the central hilly tract of Sandur schist belt to 243 mm in the rain shadow area immediately east of the belt. The normal average rainy days are 43 in an year. The maximum temperatures range from 23 to 42 °C. The normal potential evapotranspiration of about 1700 mm far exceeds the rainfall. About 51 % of the district area is under agriculture, 12 % under forests, 15 % under open forests and scrubs, 4% uncultivated lands and 18 % as fallow lands (Anonymous, 2005). About 21 % of the district area is under irrigation, most of it from the Tungabhadra irrigation project. The rainfed areas compose of the rocky inselbergs and knobs surrounded by red soils with low water retention. It is here the reserve forests and scrub lands are concentrated. The red soils cover an area of about 55 % of the district and black soils about 45 %. The major black soil area is irrigated from Tungabhadra irrigation project and remaining is cropped by dry crops only after the main rainy season. As such they remain bare and exposed to the splashes of rains during main rainy season and are thus prone to water erosion. The granite hills and inselbergs are seen extensively and the rocky knobs are especially present every where in the red soil areas. Thus, these areas have varied slopes and provide erosive runoffs of rain water. The reserve forests, open forests and scrub lands are mainly in the red soil region. A thick forest cover exists over the central hilly schist belt.

The natural resources under stress, mainly arising out of the aridity of the climate and human and livestock pressure, are the soils and vegetation. The soils are eroded and salt affected. The vegetation is affected by grazing, cutting for fuel and fodder and extraction

for timber purposes. Thus, the main processes identified for study are soil erosion, soil salinization/alkalinization and vegetal degradation, in addition to man's industrial and commercial activity such as mining. An attempt was made to assess the severity of these processes as slight, moderate and severe. The study was made using remote sensed spatial-temporal data obtained from geocoded false colour composites of IRS 1C/1D LISS III satellite data along with Survey of India toposheets for base details such as district boundary, roads, streams, reserve forest boundary, open forests and scrub land locations, irrigation canals and settlements. The classification system for desertification status identification and mapping as evolved at the Space Application Centre (ISRO), Ahmadabad, by all the line departments and common for both hot and cold areas of the country was applied during the study (Anonymous, 2003). The classification system is given below.

The Map Legend

LEVEL 1: Land use/land cover

- Irrigated agriculture (I)
- Unirrigated agriculture (D)
- Forest (F)
- Land with scrub (S)
- Barren (B)
- Rock land (R)
- Sand area (E)
- Water body (W)

LEVEL 2: Processes of Degradation

- Vegetal degradation (v)
- Water erosion (w)

- Wind erosion (e)
- Salinization/alkalinization (s/a)
- Man-made (m)

LEVEL 3: Severity of Processes

- Slight (1)
- Moderate (2)
- Severe (3)

This system considers the land use at highest level as a result of the recognition of the fact that land utilization has a greater role to play in the desertification process as it enforces a shift from the delicate, naturally established equilibrium to the man-made one. An initial field traverse was made of the district to identify the land use categories and significant degradation processes vis-à-vis the general mapping legend. Within each land use type, the land degradation is classified according to the degradation processes that are basically land and climatic processes. The vegetation, though depending on land and climate, show degradation processes that depend on human use. The degradation processes are considered at second level and their severity at third level of mapping. An interpretation key for identifying different classes of the legend from IRS satellite data was developed to assist the visual interpretation of IRS data on 1:50,000 scale. The map units so identified from visual interpretation were verified during selective field survey, after which the map units were finalized. The desertification status maps were digitized and printed in GIS environment (EOS/NBSS & LUP, 2005). One such map sheet is shown in Fig 1. The soil samples were also collected from well-recognized saline and alkali areas and analyzed for correlating with satellite data.

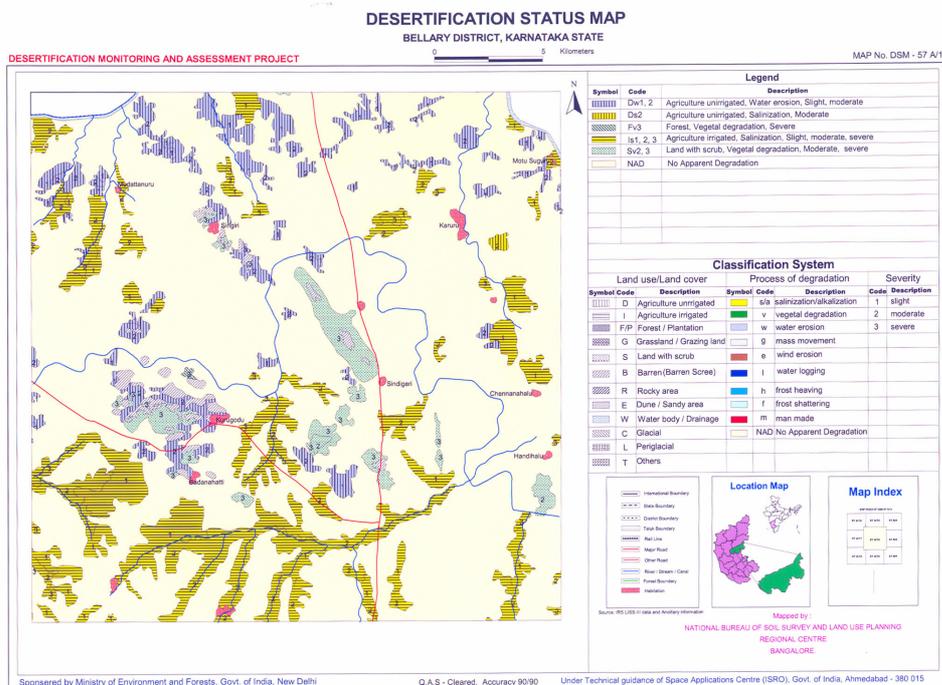


Fig. 1. The desertification status map of an area north of Bellary town (EOS/NBSS & LUP, 2005).

RESULTS AND DISCUSSION

The degradation in the district was observed in agricultural lands (rainfed as well as irrigated), forest and scrub lands and by mining

activities. The extent of different categories of degradation in terms of land use/land cover is presented in Table 1.

Table 1. The degradation under different land uses and its extent.

Land use/land cover	Process of degradation	Per cent of total district area		Per cent of total degraded area
		Individual process	All processes	
Agriculture - Irrigated	Water erosion	0.13	3.89	8.23
	Salinization/alkalinization	3.76		
Agriculture - Unirrigated	Water erosion	4.30	4.34	15.62
	Salinization/alkalinization	0.04		
Forest	Vegetation	12.10	12.81	17.99
	Salinization/alkalinization	0.03		
	Mining	0.58		
	Water erosion	0.10		
Land with scrub	Vegetation	5.13	5.18	18.54
	Mining	0.05		
Sand (dune) area	Wind erosion	0.41		1.23
Others	Man-made	0.10		0.34
Barren lands		0.12		0.36
Rock lands		1.01		3.62
Total, percentage		27.86		99.31
Total (100%), hectares		846,300		235,900

Accordingly it is seen that the major degradation in terms of aerial extent is in the vegetal cover of the district. This is followed by the degradation of agricultural lands. And in terms of the

processes, the extent of degradation can be worked out as shown in Table 2.

Table 2. The degradation processes, their severity and their extent.

Degradation process	Extent		
	Per cent of total district area	Hectare	Remarks
Soil			
Water erosion	Slight-2.61, Moderate-1.80, Severe-0.12; Total-4.53	38,400	17.2% of agricultural lands
Wind erosion	Slight-0.05, Moderate-0.24, Severe-0.12; Total-0.41	3,400	
Salinization/alkalinization	Slight-1.85, Moderate-1.83, Severe-0.15; Total-3.83	32,400	
Vegetation			
Canopy degradation	Slight-4.62, Moderate-6.24, Severe-6.37; Total-17.23	145,800	63.8% of forest and scrub lands
Man-made			
	Slight-0.41, Moderate-1.81, Severe-0.27; Total-2.49	21,200	62.5% of uncultivable lands

About 64% of the vegetal cover and about 29% of the net sown (17.2% gross sown) agricultural lands are under various types and degrees of degradation. Most of the open forests and all the scrub lands are degraded either severely or moderately. Low rainfall, its short span of distribution and non-availability of water conservation structures in addition to rampant overgrazing, cutting for fuel and fodder and extraction for timber are the main reasons for the observed vegetal degradation. The human and cattle pressures are so particular in the dry land areas that their maintenance is particularly difficult. Most of the forests and scrubs are spread over the red soil areas of the district. The black soil areas are nearly cent per cent cultivated.

Among the agricultural lands, spread over both red and black soil areas, the degradation is caused by either water erosion (9%) or salinization/alkalinization (7%). While the water erosion is seen in both soil areas, the salinization/alkalinization is mostly confined to black soils under Tungabhadra canal irrigation. A few of the major

stream beds in the red soil areas of the dry land agriculture are also salt affected, mostly alkalinized. The chemical analysis of a few selected salt affected soils and their soil water is shown in Table 3. The results indicate that the soils, though not having very high pH values, have very high salt content and very high SAR (sodium adsorption ratio). This shows that during their reclamation, gypsum has to be added while leaching away their salts through underground drainage, as otherwise their pH would raise extremely high, soils would disperse and further aggravate the problem. However, differentiating saline lands from alkali lands was not possible from the satellite data nor the image tones could be correlated with the salinity levels in the agricultural lands. In the irrigated black soils, paddy is being cultivated over and over again, as no other crop would be suitable because of salinity and the impounded water when paddy is grown would have a dilution effect on salt content and in addition the paddy is salt tolerant to some extent. As a result, soils will become further saline and saline, leading to sodic soils. This is a vicious circle, a perfect

situation for desertification. The required drainage solution to the problem is not an individual farmer's concern but is a watershed concern, requiring cooperative participation or government's intervention. At present, the government's efforts have failed, because of the non-cooperation from the tail end farmer, who is seen blocking the drainage hole as he is in short supply of water

for his paddy crop being at the tail end. Knowing fully well about this impending danger long before, the irrigation project was started only to provide supplementary irrigation to the dry crops on these soils, and paddy was clearly prohibited. Later, the type of land use for these potential agricultural lands seems to have gone out of control.

Table 3. The chemical analysis of soils and their soil water

Sample	Clay %	Saturation %	pH, water (1:2.5)	EC, dS m ⁻¹ (1:1)	Major ions in soil water, meq dm ⁻¹						SAR
					HCO ₃ ⁻	Cl	Ca ⁺⁺	Na ⁺	Anion total	Cation total	
Salinization/alkalinization, Dry land agriculture, Karur village											
1	32	49	7.7	0.95	0.6	0.3	0.7	0.1	1.0	0.9	0.1
2	13	30	8.1	64.7	1.3	91.6	8.5	75.7	101.1	92.5	26.3
3	28	36	7.4	35.2	0.8	51.9	45.5	2.9	53.7	53.5	0.6
4	29	43	7.9	10.4	0.5	10.4	7.3	0.7	11.0	8.7	0.4
5	20	37	7.8	68.1	-	100.4	21.7	68.7	104.2	99.3	17.6
Salinization/alkalinization, Irrigated agriculture, Kolagallu village											
1	29	53	8.8	49.7	1.5	5.7	1.9	49.8	40.4	52.1	47.5
Salinization/alkalinization, Irrigated agriculture, Koluru village											
1	32	54	8.4	47.0	0.8	33.1	3.7	34.9	46.5	39.7	23.0

A typical salt affected land is shown in Fig. 2.



Fig. 2. A typical salinized/alkalinized soil.

The third major degradation process in the district is soil erosion by water, though wind erosion is also seen but to a very limited extent. The water erosion is mainly found in the dry land areas of both red and black soils. More of red soils than the black soils are eroded as the former are more susceptible and erode deeper with the development of rills and gullies. Black soil areas show mostly sheet and rill erosion. However, if the land is cultivated, the erosion does not proceed to severity as there would be some soil and water conservation practices being followed traditionally as part of cultivation, as seen during the field traverses. On the other hand, many reserve forests were seen during field traverses to be affected significantly by soil erosion due to lack of soil and water conservation measures. But this was not observable from the satellite data as the vegetal signatures were so prominent that the signatures from other processes were masked. For this very reason, such areas including those of open forests and scrub lands are mapped with regard to vegetal degradation only. In addition to these areas, about 3,400 ha of dune/sand areas along a 25 km-stretch of east bank of *Hagari* river were found to suffer from wind erosion and were also mapped.

There were also other degradation processes, such as mining, stone quarrying up to about 5,300 ha and barren lands up to about 1,000 ha. The mining for iron ore in the central hilly Sandur schist belt, where vast reserves of high grade ore have been found, has totally eliminated the forests in significant patches, in addition to creating dust and water pollution and related health hazard for people and livestock. The rock lands up to about 9,000 ha also add up to unproductive area in the district.

CONCLUSIONS AND RECOMMENDATIONS

The study reveals that vegetal degradation, soil erosion and soil salinization/alkalinization were the prominent processes of degradation in the district. The vegetal degradation of the forest and scrub lands was most extensive. This was followed by soil erosion by water in aerial extent. The man-made processes such as mining and quarrying were also found to be operative locally but severely. The following measures could be recommended to

control these processes from further degrading the productivity of the lands.

Soil and water conservation measures in rainfed agricultural areas and forest lands.

Water harvesting structures within the forest and scrub lands to recharge ground water and provide drinking water to human and livestock population.

Proper irrigation water management especially in the black soils to reduce soil salinity/alkalinity.

Development and maintenance of underground drainage system under local community responsibility and addition of gypsum during reclamation of saline lands.

Encouraging the change over from paddy cultivation to n cultivation of other crops.

Afforestation of the protected lands with social plantation and their protection.

Development and maintenance of the scrub lands and grazing lands under local community leadership and responsibility.

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