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# LAND DEGRADATION STUDIES IN YADAWAD, HUKKERI AND KHANAPUR MICRO-WATERSHEDS IN AGRO-CLIMATIC ZONE 3 (NORTHERN DRY ZONE), ZONE 8 (NORTHERN TRANSITIONAL ZONE), AND ZONE 9 (HILLY ZONE) OF BELGAUM DISTRICT, KARNATAKA, INDIA

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**ABSTRACT**

The study focused on land degradation in the three distinct agro-climatic zones: Zone 3 (Northern Dry Zone), Zone 8 (Northern Transitional Zone), and Zone 9 (Hilly Zone) of Belgaum district, Karnataka, India,. Three micro-watersheds Yadawad (Zone 3), Hukkeri (Zone 8), and Khanapur (Zone 9) were selected to represent these zones and were analyzed for land degradation using satellite data, field surveys, and soil analysis. Satellite images from Resourcesat-1 (IRS-P6) during the kharif, rabi, and zaid seasons of 2005-06, along with ancillary topographic maps and wasteland data, were used to identify and map land degradation classes. Field observations and ground truth data collection, supported by soil sample analysis at depths of 0-15 cm and 15-30 cm, were conducted to verify the findings. Results showed that land degradation was most pronounced in Zone 3, where 33.36% of the total geographical area (TGA) was degraded, primarily due to sheet and rill erosion. In Zone 8, 28.86% of TGA was degraded, mainly by sheet erosion, while Zone 9 had the least degradation at 17.43%, primarily caused by sheet erosion and barren rocky/stony waste. The Yadawad micro-watershed (Zone 3) experienced significant sheet and rill erosion, particularly in catchment areas, while the Hukkeri micro-watershed (Zone 8) showed widespread sheet erosion with some salinity issues. The Khanapur micro-watershed (Zone 9) had relatively less degradation, with less extensive sheet erosion and rocky waste. The study highlighted the intensity of soil erosion in semi-arid regions and the varying impacts of degradation across agro-climatic zones, emphasizing the need for targeted soil conservation measures in the region.
***Keywords*:** Land degradation, Micro-watersheds, Soil erosion, Remote sensing, GIS.

## Introduction

Land degradation and decline in land quality caused by human activities has been a major global issue during the 20$^{th}$ century and will remain high on the international agenda in the 21$^{st}$ century. During the past century, land use and associated human activities have degraded about 5 billion ha (about 43%) of earth's vegetated land (Brady and Well, 2007). The importance of land degradation among global issues is enhanced because of its impact on world food security and quality of the environment. Land degradation can be considered in terms of the loss of actual or potential productivity or utility as a result of natural or anthropic factors. In the context of productivity, land degradation results from a mismatch between land quality and land use. Mechanisms that initiate land degradation include physical, chemical and biological processes. Land degradation is a biophysical process driven by socioeconomic and political causes (Eswaran *et al.*, 2001). Soils are a vital natural resource on whose proper use depend the life-supportingsystems of a country and the socioeconomic development of its people. Being a componentof the lithosphere and biosphere systems, soils provide food, fibre, fodder and fuel-Wood formeeting the basic human needs. However, the capacity of a soil to produce is limited andthe limits to production are set by its intrinsic

characteristics, agro-ecological settings and use and management (FA0 1993). With the ever-increasing human and animal population, demand on soils for foodproduction has been increasing. The significant growth of agriculture has been at the cost of decline in soil quality andrisk of soil degradation (Abrol and Sehgal 1992). Todaythere are increasing evidencesto support that a majority of our soil resources are under different degrees of degradationand are getting further deteriorated at an alarming rate with risk of jeopardising food security system (Sehgal and Abrol 1994). Though conventional soil surveys provide information on land degradation, they are slow, time consuming and expensive. Among the newly emerging technologies emerged for studying natural resources, remote sensing technology proved to be powerful, because of repetitive coverage of the same area at regular time intervals, collection of data invisible through near infra-red, thermal to microwave regions and availability of data to computers for quick analysis. The need to maintain sustainable use of these lands requires that they ought to be monitored for the onset of land degradation so that the problem may be addressed in its early stages. In order to develop technologies to combat with the problem, it is imperative to know the extent and degree of land degradation.

## Materials and Methods

The Belgaum district is located east of the Western Ghats and agro-climatologically the district is divided into three zones i.e. high rainfall "Hilly zone" (zone 9), "Northern transitional zone" (zone 8) and "Northern dry zone" (zone 3) from southwest to northeast, respectively. Three micro-watersheds were selected representing the three agro-climatic zones of the district. Yadawad micro-watershed (4D7D3J1a) has represented zone-3, Hukkeri micro-watershed (4D7D7D2a) has represented zone 8 and Khanapur micro-watershed (4D7C9L1c) has represented zone 9 and belong to Gokak, Hukkeri and Khanapurtaluks, respectively of Belgaum district**.** The Yadawad micro-watershed is located between $16^0$11'20" and $16^0$20'50" N latitudes and $75^0$07'50" and $75^0$09'20" E longitudes with an average elevation of 613 m above Mean Sea Level (MSL). The Hukkeri micro-watershed is located between $16^0$13'0" and $16^0$14'40" N latitudes and $74^0$34'10" and $74^0$35'10" E longitudes with an average elevation of 654 m above MSL. The Khanapur micro-watershed is located between $15^0$36'30" and $15^0$38'0" N latitude and $74^0$31'10" and $74^0$32'30" E longitude with an average elevation of 682 m above MSL. The geographical area of Yadawad, Hukkeri and Khanapur micro-watersheds is 572.9, 498.4 and 586.2 ha, respectively. The climate of the Yadawad and Hukkeri micro-watersheds is semi-arid with mean annual rainfall of 507.6 and 658.4 mm and that of Khanapur micro-watershed is sub-humid with mean annual rainfall of 1859.1 mm.

### Land Degradation Mapping using Remote Sensing and GIS

Satellite image multi-temporal geo-rectified Resourcesat-1(IRS-P6) LISS-III data acquired during *kharif*, *rabi* and zaid seasons of 2005-06 were used to address spatial and temporal variability of land degradation. In the preparation of land degradation map the ancillary data in the form of topographic maps (1: 50,000 scale) and existing wasteland data were used. Sample points were identified for various land degradation classes for ground truth collection and accuracy assessment through on-screen visual interpretation of satellite FCC data by adopting standard visual interpretation techniques. Soil samples were collected from 0-15 and 15-30 cm depths using GPS device for lat-long position of the sample points and analysed in the laboratory. During the field work, the relationship between image elements and tentatively identified land degradation classes that are delineated during preliminary interpretation were established. The flow chart of methodology is given in Fig. 2.

## Results and Discussion

### Land degradation under different classes in agro-climatic zones of Belgaum district:

The Belgaum district includes three agro-climatic zones - zone 3, 8 and 9 occupying 54.0, 30.1 and 15.9 per cent of TGA. Among the three zones, the extent of land degradation was highest in zone 3 constituting 33.36 per cent of TGA followed by 28.86 per cent in zone 8 and 17.43 per cent in zone 9. Water erosion of soil was found to be dominant type of soil degradation in all the zones. The data supports the hypothesis that soil erosion is more intense in semi-arid regions than sub humid and humid regions (Hudson, 1971). Zone 3 predominantly has Vertisols and vertic sub groups of Inceptisols and hence is vulnerable to erosion as the soils are exposed most of the period due to single cropping, especially due to the very intense pre-monsoon rains during May. Sheet erosion is observed in 22.68, 27.19 and 16.96 per cent of area in zone 3, 8 and 9, respectively. Rill erosion is observed in 10.03 and 1.15 per cent of area in zone 3 and 8. The area mapped under gullies constituted 0.04 per cent of TGA of zone 3 and in other two zones it was nonexistent. Saline and sodic soils are observed in 0.02 and 0.07 per cent of TGA in zone 3. Zone 8 had 0.02 per cent of

TGA under slightly saline condition. The salt affected soils are understandably confined mostly to zone 3 and to some extent to zone 8 due to lesser rainfall as also due to faulty irrigation. The area affected through mining is 0.03, 0.07 and 0.04 per cent of TGA in zone 3, 8 and 9, respectively (Table 1). Degradation due to mining affected all the zones and can be considered minimal. However, the environmental damage of mining activity has been a menace due to transport of ores and dust.

**Land degradation in the selected micro-watersheds in agro-climatic zones 3, 8 and 9 of Belgaum district**

The location of the selected micro-watersheds (Yadawad, Hukkeri and Khanapur) is depicted in fig. 1. The extent and type of land degradation in the selected micro-watersheds of the three agro-climatic zones (3, 8 and 9) in Belgaum district is presented in Table 2 and fig. 3, 4, 5. The Yadawad micro-watershed (Zone-3) is affected by sheet and rill erosion in 332.63 and 53.81 ha of land area contributing to 58.06 and 9.39 per cent of the total geographical area (572.93 ha), while the remaining area was normal. Sheet and rill erosion of Yadawad micro-watershed is presented in Plate 1. The sheet erosion in Yadawad micro-watershed was mainly observed in the catchment areas along the streams whereas, rill erosion observed was due to concentrative flow of surface water because of continuous high intensity rains occurred for 2-3 days. Sheet erosion predominated in Hukkeri micro-watershed (Zone-8) to the extent of 198.53 ha area constituting 59.9 per cent of TGA (498.38 ha) and observed mostly in open scrub land because of poor vegetative cover. Slightly saline patch extended in an area of 28.85 ha constituting 5.8 per cent of TGAwas observed in lowland area of Hukkeri micro-watershed. This might be due to low rainfall and faulty irrigation practices followed in the micro-watershed. Khanapur micro-watershed (Zone-9) was subjected to degradation mainly by sheet erosionto the extent of 151.19 ha comprising 25.79 per cent of TGA. Sheet rock was exposed in an area of 28.57 ha accounting for 4.87 per cent of TGA. Among the three micro-watersheds, Khanapur (zone 9) was least affected by land degradation compared to Hukkeri (zone 8) and Yadawad.

**Table 1:** Extent of land degradation under different classes in agro-climatic zones of Belgaum district

| Land degradation class | Zone 3 | | Zone 8 | | Zone 9 | |
|---|---|---|---|---|---|---|
| | Area (ha) | % of TGA | Area (ha) | % of TGA | Area (ha) | % of TGA |
| Sheet –erosion | 164567.8 | 22.68 | 109981.9 | 27.19 | 36298.3 | 16.96 |
| Rills | 72793.8 | 10.03 | 4647.7 | 1.15 | 27.9 | 0.01 |
| Gullies-severe | 259.7 | 0.04 | | | | |
| Surface ponding-slight | 108.1 | 0.01 | | | | |
| Saline-slight | 92.1 | 0.01 | 72.1 | 0.02 | | |
| Saline-Moderate | 9.7 | 0.001 | 7.1 | 0.002 | | |
| Saline-Severe | 58.1 | 0.01 | | | | |
| Sodic-Slight | 214.0 | 0.03 | | | | |
| Sodic-Moderate | 269.5 | 0.04 | | | | |
| Sodic-Severe | 30.9 | 0.004 | | | | |
| Saline Sodic-Moderate | 98.7 | 0.01 | 5.3 | 0.001 | | |
| Saline Sodic-Severe | 80.8 | 0.01 | | | | |
| Mining | 216.3 | 0.03 | 262.9 | 0.07 | 84.7 | 0.04 |
| Barren rocky/stony waste | 3236.7 | 0.45 | 1731.6 | 0.43 | 891.2 | 0.42 |
| Industrial effluent affected area | 12.5 | 0.002 | | | | |
| Total Degraded land | 242048.7 | 33.36 | 116708.5 | 28.86 | 37302.2 | 17.43 |
| Total Geographical Area | 725645.9 | 100.00 | 404461.4 | 100.00 | 213977.2 | 100.00 |

*TGA- Total geographic area

**Table 2:** Extent of land degradation under different classes in the selected micro-watersheds of three agro-climatic zones in Belgaum district

| Land degradation class | Area (ha) | % of TGA |
|---|---|---|
| **Yadawad (4D7D3J1a)** | | |
| Sheet erosion | 332.63 | 58.06 |
| Rill erosion | 53.81 | 9.39 |
| Normal land | 186.49 | 32.55 |
| Total geographical area | 572.93 | 100.00 |

| | | |
|---|---|---|
| **Hukkeri (4D7D7D2a)** | | |
| Sheet erosion | 298.53 | 59.90 |
| Slight salinity | 28.85 | 5.79 |
| Normal land | 171.00 | 34.31 |
| Total geographical area | 498.38 | 100.00 |
| **Khanapur (4D7C9L1c)** | | |
| Sheet erosion | 151.19 | 25.79 |
| Barren Rocky/stony waste | 28.57 | 4.87 |
| Normal land | 406.48 | 69.34 |
| Total geographical area | 586.24 | 100.00 |

*TGA- Total geographic area

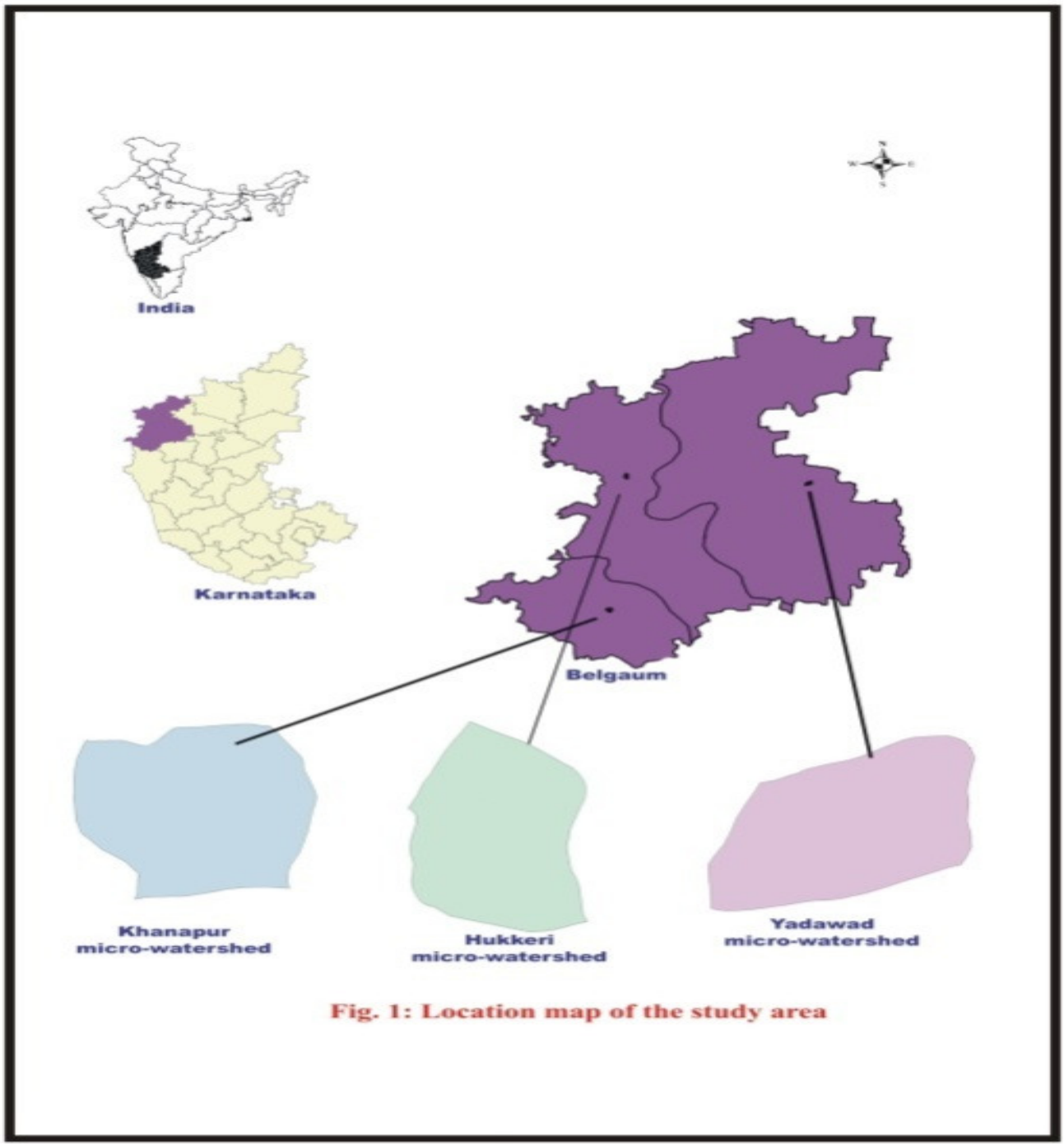


Fig. 1: Location map of the study area

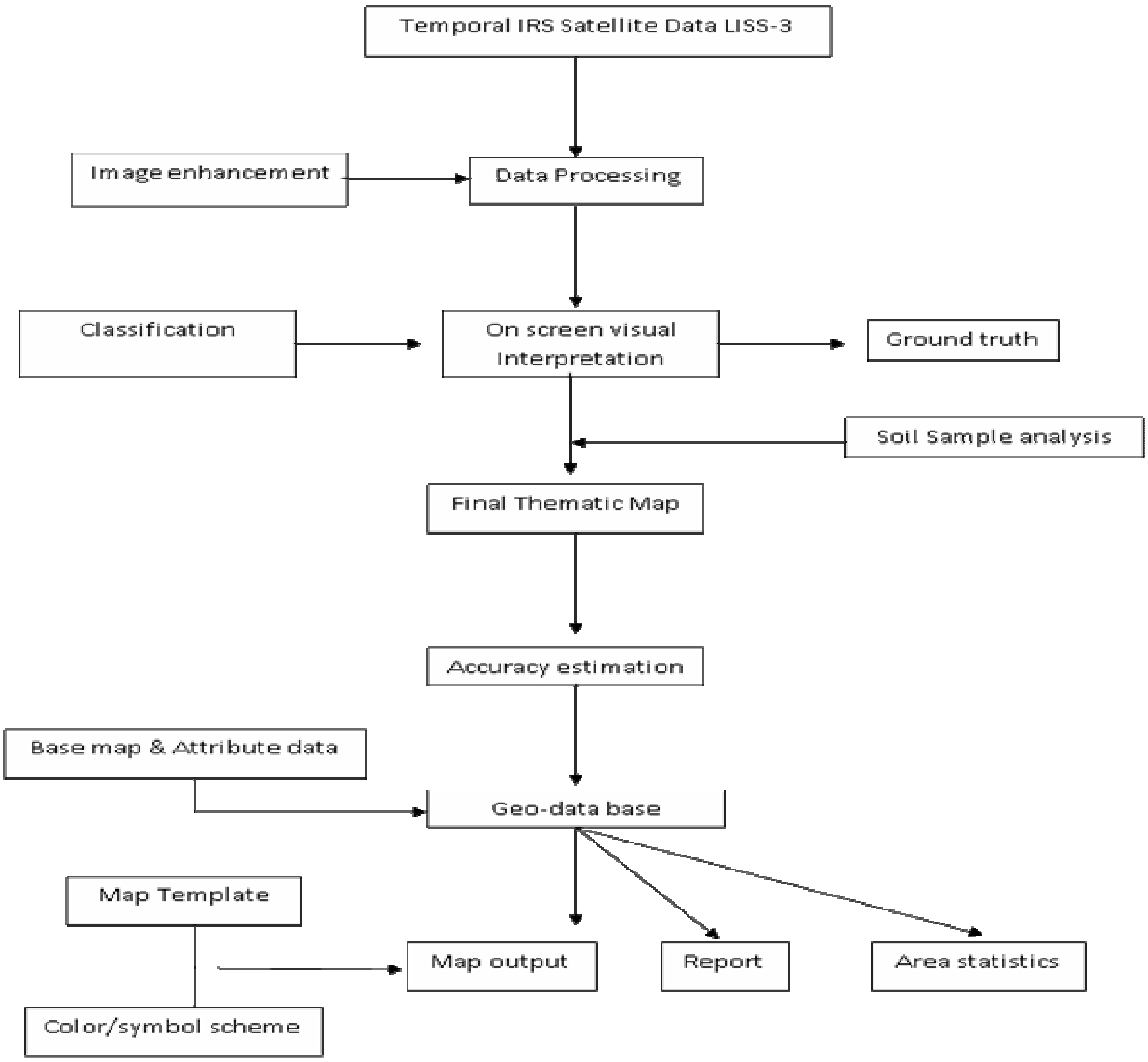


**Fig. 2 :** Flow chart of methodology for mapping land degradation

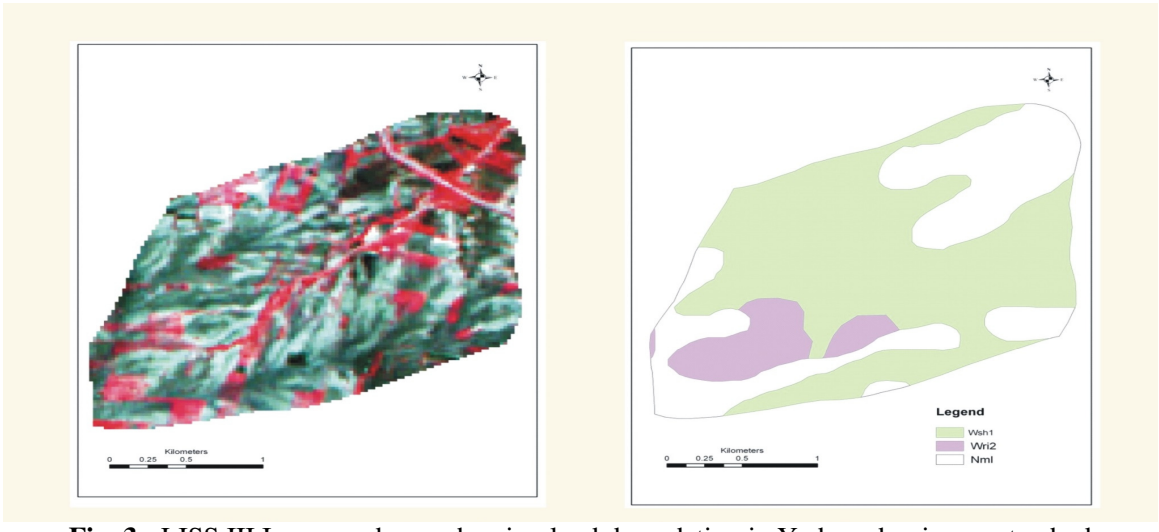


**Fig. 3 :** LISS III Image and map showing land degradation in Yadawad micro-watershed

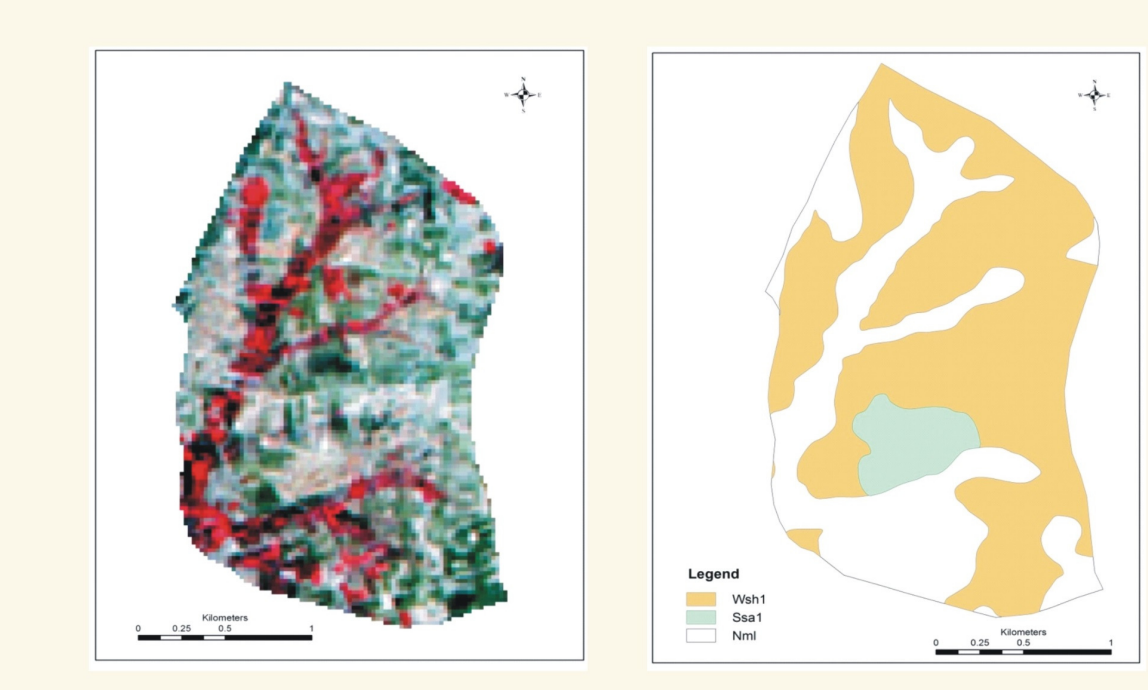


**Fig. 4 :** LISS III Image and map showing land degradation in Hukkeri micro-watershed

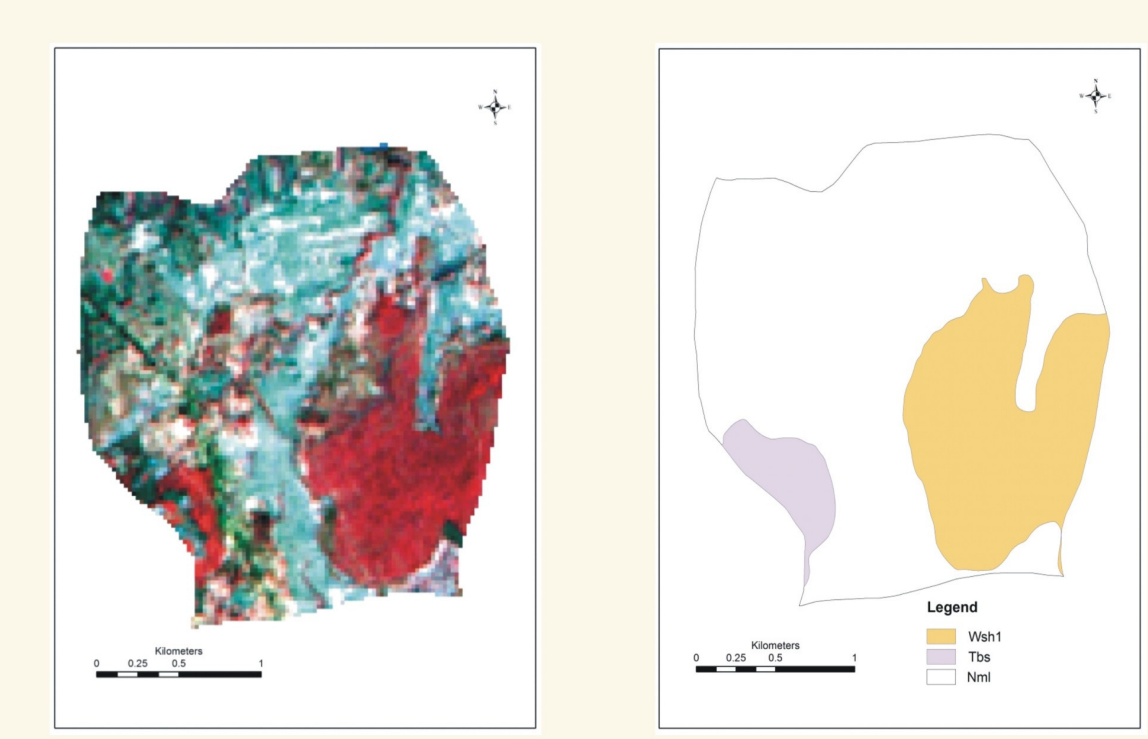


**Fig. 5 :** LISS III Image and map showing land degradation in Khanapur micro-watershed

Sheet erosion

Rill erosion

Plate 1: Sheet and rill erosion in Yadawad micro-watershed

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