A Comparative Study of Sodic Wastelands and Water logged Area using IRS P6 LISS- III and LISS IV Data through the GIS Techniques

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Abstract

Sodic land and Water logging are the twin evils for agriculture in arid and semi-arid areas on many continents, which reduce the productivity of agricultural crops adversely. The extent & nature of these problems depend on climatic condition, geologic, topographic, hydrologic factors and human activities, such as population pressure and over grazing. Water logged area is affected by excessive logging of water for quite some period and affects the productivity of land and cultivation pattern. Remote sensing and GIS techniques offer several advantages for management of the salt-affected and water- logged areas by studying various aspects of spatial data on soil, land cover, geology and hydrogeology along with implementing reclamation activities such as site selection, soil monitoring etc. This paper describes a comparative study of sodic wastelands and water logged area using IRS P6 LISS-III (spatial resolution 23.5m) and LISS-IV (spatial resolution 5.8 m) data through the GIS applications This encompasses spatial analysis of sodic land and water-logged area by satellite data. The study area is located in the District of Hardoi in Uttar Pradesh. Waterlogged areas are distinctly seen in satellite image (FCC) as light to dark blue colour of varying size and shapes. Remote sensing and GIS has capability to map & spatially analyse sodic and water logged area in a particular district or region. The satellite images were visually interpreted for three classes, these are sodic wasteland, water logged area and degraded forest.

Keywords: Sodic land, water logging, Remote Sensing and GIS.

Introduction:

Sodic land and water logging areas are widely spread on many continents. Salt affected soils covered about 831 million hactare in the world continents (Martinez-Beltran and Manzur, 2005). The increase sodic and water logging area leads to serious environmental and social problems, such as the reduction of crop yields, degradation soil quality and health related problems. There are two major types of salt affected soils, namely saline and alkali soils. In India about 7 million hectares of land was affected by salinity and alkalinity condition (Abrol and Bhumbla 1971).

One- another problem is related to land in India that is water logging and reported area of water logging land have 2.46 Mha (Anonymous, 1991) and 58.2 million hectares area of wetlands (Prasad et al., 2002) many of which are distributed around the Indo-Gangetic plains. Waterlogged is a land, which is permanently or periodically in undated by water and is characterized by hydrophytes vegetation, which includes water hyacinth and reeds. It is affected by excessive logging of water for quite some period and affects the productivity of land and cultivation pattern.

In the state of Uttar Pradesh, nearly 1.28 million hectares area is under saline and sodic land ('USAR') which is the largest area found in any single state in India. Mostly saline and sodic land areas are covered Aligarh, Allahabad, Etah, Etawah, Fatehpur Hardoi, Mainpuri, Pratapgarh, Raebareli and Sultanpur. These types of problems in soil mostly present in arid and semiarid area of Indo-Gangetic Alluvial Plains. About 40 % of the total affected area is present in Indo-Gangetic Alluvial Plains. On the basis of physico-chemical properties, salt affected soil is divided in to three categories these are saline (pH < 8.5, EC > $4dSm^{-1,}$ ESP < 15), sodic (pH > 8.5, EC < $4dSm^{-1}$ ESP >15) and saline-Sodic (pH > 8.5, EC < $4dSm^{-1}$, ESP > 15).

Remotely sensed and GIS data have been widely used to map salt affected areas (NRSA and RSAC-UP, 1997, Rao et al., 1996; Singh et al., 2001; and Sujatha et al.,2000), different analysis techniques and environmental modeling (Greetman & Toppen, 1990; Fedra & Jamieson, 199;6 Fedra et al., 1996). Remote sensing and GIS applications has been successfully used in studying various aspects of spatial data of soil, land cover, geology , hydrogeology and different reclamation activities such as site selection, soil monitoring, groundwater monitoring in a more scientific method.

The statistics regarding sodic and water logging land is required in order to bring more of the potential land available in the country under agriculture, plantations and a forestation. Therefore, there is an urgent need to prepare latest map of 'sodic and water logging land' showing its location, spatial distribution, pattern and its geographical area at one time period. For this purpose the National Remote Sensing Centre, Department of Space, Government of India has prepared maps showing sodic and water logging wasteland in India based on visual interpretation of IRS P6 LISS-III geocoded satellite imagery on 1: 50,000 scale. In Hardoi district of Uttar Pradesh has large area under sodic wastelands i.e. 159.32 sq. km and degraded forest i.e. 0.12 sq. km out of total geographical area. (Waste Lands Atlas of India, 2010, Ministry of Rural Development, New Delhi and National Remote Sensing Centre, Hyderabad). In Hardoi, water logging i.e. 31.97 sq. km of total geographical area. (Wet Lands Atlas of India, 2010, Ministry of Rural Development, New Delhi and National Remote Sensing Centre, Hyderabad. Remote sensing and GIS application has ability to map sodic and water logged area in a particular district or region and save labour, fine and effort when compared to field data collection, so an effort has been made to compare map sodic wastelands and water logged areas of Sandila Block, district- Hardoi using LISS-III & LISS-IV data.

Study Area

The study area (Sandila Block) is a town in Hardoi District of Uttar Pradesh. **(figure no.1 and 2).** Sandila is lies between, about 27°05′N and 27.08°N latitudes and 80°31′and 80.52°E longitudes. The study area enjoys a pleasant and healthy monsoonal climate with their usual seasons, namely summer, rainy and winter. Generally temperature ranges from 15^0 C (winter's) to 40^0 C (summer's). Annual rainfall in the study area averages up to 116 cms. May and June are the warmest months while December and January the coldest ones. Highest rainfall occurs during the months of July and August.

Satellite data

For delineation and mapping, geo-rectified IRS P6 LISS-III & LISS IV data acquired during Feb 2006 and Dec 2004 (Rabi Season) has been used for on screen visual interpretation. The following data has been used:

- IRS P6 LISS III data Path 99 Row- 52 dated 03 Feb 2006 Rabi Season (FCC) .
- IRS P6 LISS IV data Path 102 Row- 53 dated 03 Dec 2004 Rabi Season (FCC).
- Survey of India topographical Sheet No. 63A/8, 63A/12 on 1:50,000 scale.

Methodology

A very distinctive clear-cut and simple methodology has been adopted in carrying out the study. Preparing the data is a primary requirement before undertaking image interpretation and subsequent analysis. Preparation of database is described hereunder: Satellite data which is available in a raster form needs to be geo-referenced to a map coordinate system so as to generate spatial information to be used subsequently in a GIS environment. The IRS P6 satellite LISS-III & LISS-IV sensors having the resolution of 23.5m & 5.8m simultaneous data has been used to identify and delineate the sodic wasteland using on screen digitization in Arc-GIS software on 1:24000 scale. Digital data has been used for the study area to identify and demarcation various classes like sodic wasteland, waterlogged and forested area.The information exacted from both LISS-III & LISS-IV data has been used for comparison of sodic waste land and waterlogged area. The interpretation work for different categories like sodic land and waterlogged areas carried out on the basis of interpretation key in terms of image element viz., tone, texture, size, shape, association, pattern, shadow and location. The methodology also involves topology built option in the Arc Catelog to find out the non over lap area. Statistics of the study area has been generated of block **-** Sandila for comparative study. Arc GIS 9.2 software has been used for new vector layer, generated by overlaying sodic wasteland, water logging & degraded forest data of year Feb 2006 and Dec 2004, for the purpose of comparative study of IRS P6 LISS III & LISS IV data. (**figure no.3 and 4)**.

Results and Discussion

The sodic wasteland of Sandila block, district-Hardoi **(figure no.8 and 9)** prepared by on screen visual interpretation technique utilizing the Feb. 2006 IRS P6 LISS III and Dec.2004 IRS P6 LISS IV data is 2325 ha. and 2190 ha. of the area was affected by sodicity which is7.6% and 7.24% of the total geographical area of Sandila block 30215 ha. The waterlogged area is the second largest category of wasteland in Sandila block and **(figure no. 10 and 11).**The total area which was interpreted as water logged using IRS P6 LISS III and LISS IV data is 249 ha. & 61 ha. respectively. It is 0.82% & 0.20% of the total geographical area of Sandila block. The total degraded forest area is found to be 7 ha. & 7 ha. using IRS P6 LISS III & LISS IV data which is 0.23% of total geographical area of Sandila block. (**Table 1 and figure no. 5 and 6).**

In this study 225 polygons were interpreted as sodic wasteland using IRS P6 LISS III data & 344 polygons were interpreted as sodic wasteland using LISS IV data. A total of 50 polygons were identified as those polygons which were not overlapping.119 more polygons have been mapped in case of LISS IV data because of much higher spatial resolution of MX data i.e. 5.8 m compared to spatial resolution 23.5 of LISS III data. A large sodic wasteland polygon mapped on LISS III has split into more than one polygon in case of LISS IV, resulting into larger number of polygons. However, there has been misinterpretation also as evident by 50 polygons which are not overlapping when LISS III & LISS IV sodic wasteland data was overlaid. Water logging area that interpreted 52 polygons were mapped as waterlogged in LISS III data while 10 polygons were mapped in LISS IV data. 60 polygons have been found as not overlapping polygons on comparing the IRS P6 LISS III & LISS IV data. There is very small areas under forest category and only one polygon which overlaps has been mapped on comparing the IRS P6 LISS III & LISS IV data. **(Table No. 2 and figure no. 7)**

A frequency distribution for sodic land has been prepared and is given in **graph no.1** shows that maximum number of polygons not overlapping (32%) are between 2 ha. – 4 ha., followed by 4 ha. – 6 ha. (30%) range of area. There is one polygon falling in the range of 14 ha. – 16 ha., which is indicative of misinterpretation. Frequency distribution indicate 82% polygons not overlapping are of < .08 km^2 area and 18% polygons not overlapping are of 8 ha. – 20 ha size.

A frequency distribution for water logged area has been prepared and is given in **graph no.2** shows that maximum numbers of polygons (40%) are in the area range of 4 ha. – 6 ha., followed by 6 ha. – 8 ha. (28%) area range, very less number of polygons could be mapped in case of LISS IV data because of the reason that the two satellite data set used are of different periods. Therefore, large numbers of polygons are not overlapping.

Sandila block has large areas affected with sodicity which can be reclaimed by using the proper amount of Gypsum, to bring them under vegetative cover. Water logging problem was found to be more along the canals so proper method was to be adopted to avoid the water seepage from the canals. At the same time, drainage needs more attention to save the cultivated areas from water logging. The difference in the interpretation of waterlogged area could be due to the change in spatial resolution of the data the area which was identified as waterlogged in the LISS III data was found normal in LISS IV data.

Conclusion

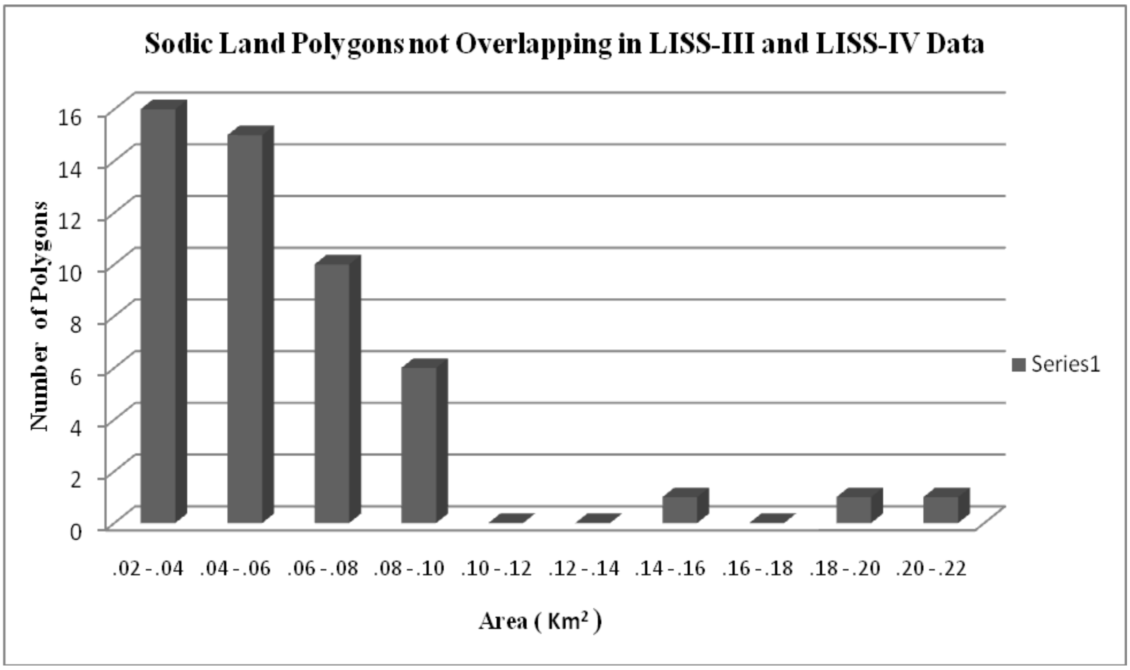
The results of the study area in Sandila town in Hardoi district of Uttar Pradesh are more precise to interpret sodic wasteland using IRS P6 LISS IV data as compared to the LISS III data. 7.6% of area was interpreted as sodic using LISS III data while 7.24 % of area was interpreted as sodic from LISS IV data. There is no significant difference in the overall area mapped using LISS III & LISS IV data while only 61 ha. area was interpreted as waterlogged in LISS IV data. It is noticed that the areas having sodic problem and water logging problem within its vicinity. 2.4 % km^2 area was interpreted as waterlogged in LISS III data while only 61 ha. area was interpreted as waterlogged in LISS IV data. The difference in the area is because of the two different periods of data used. In another way if we can see the frequency distribution of sodic water logging polygons interpreted in LISS III & LISS IV data. These interpreted data indicate that maximum not overlapping sodic wasteland polygon are in range of 2 ha. - 4 ha. which can take 32% of total not overlapping polygons. Water logging frequency distribution also show in interpreted data that indicate maximum not overlapping water logging wasteland polygon are in range of 4 ha. – 6 ha. which can take 40% of totals not overlapping polygons. The reason for these difference in area statistics and polygons not overlapping when two interpreted layer data set (IRS P6- LISS - III & LISS - IV) are overlaid are mainly the better resolution of IRS P6 LISS - IV sensor, shift in the registration of two data sets used, misinterpretation and two different periods of IRS data sets used in the study.

Table 1 - Area under Sodic Wastelands, Water logging & Degraded Forest in Sandila block, District – Hardoi

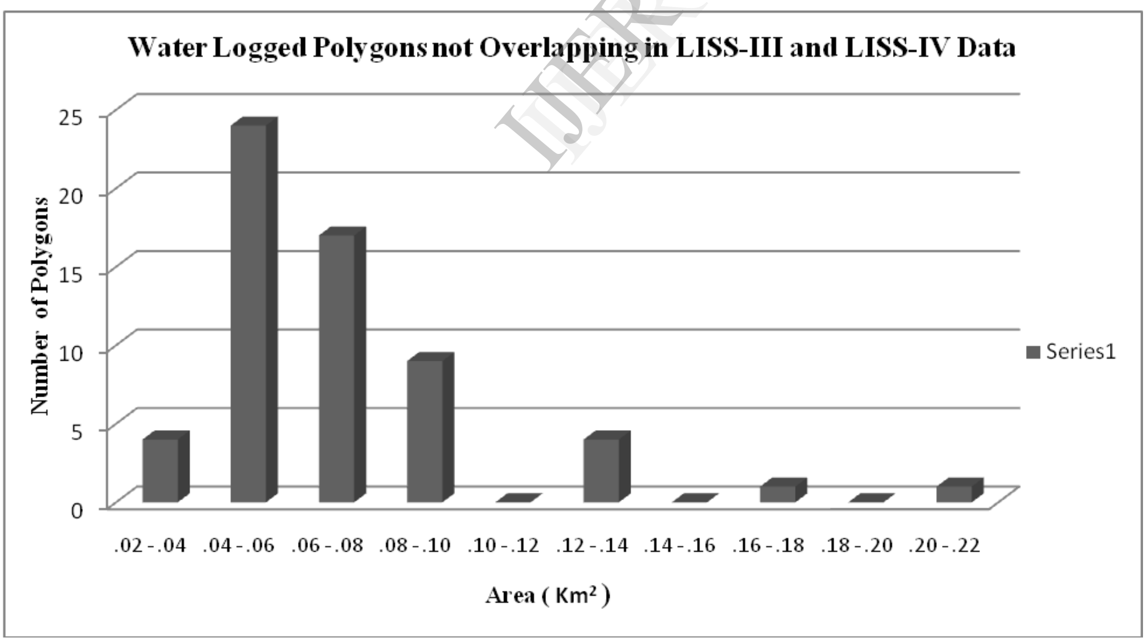
Land Use Class	Based on IRS P6 LISS III data		Based on IRS P6 LISS IV data		Total Geog. Area of Sandila block (ha)
	Area (ha)	%	Area (ha)	%	
Sodic Wasteland	2325	7.6	2190	7.24	30215
Water logged	249	0.82	61	0.20	
Degraded Forest	7	0.23	7	0.23	
Total	2581	8.65	2258	7.67	30215

Table 2 - Total number of Polygons delineated using IRS P6 LISS III & LISS IV data

Number of Polygons					
Land Use Category	LISS III	LISS IV	Total Poly. of LISS III & LISS IV	Overlapping	Not Overlapping
Sodic Wasteland	225	344	559	509	50
Waterlogged	52	10	62	2	60
Degraded Forest	1	1	2	1	0
Total	278	355	623	512	110



Graph 1 - Frequency distribution of Sodic Polygons not Overlapping



Graph 2 - Frequency distribution of Waterlogged Polygons-not Overlapping

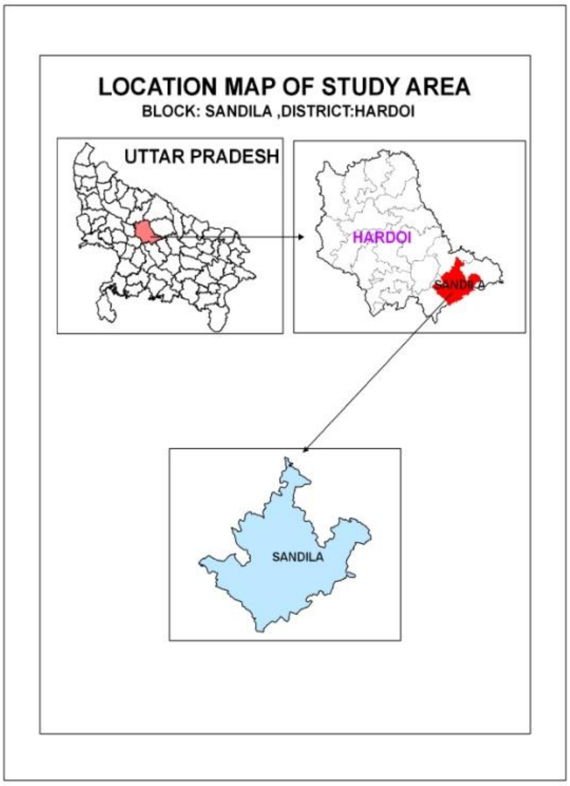


Fig.-1

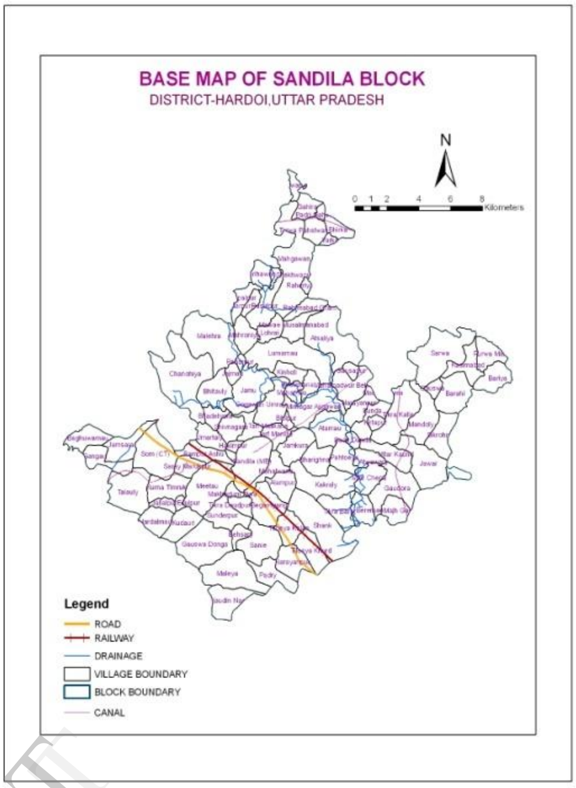


Fig.-2

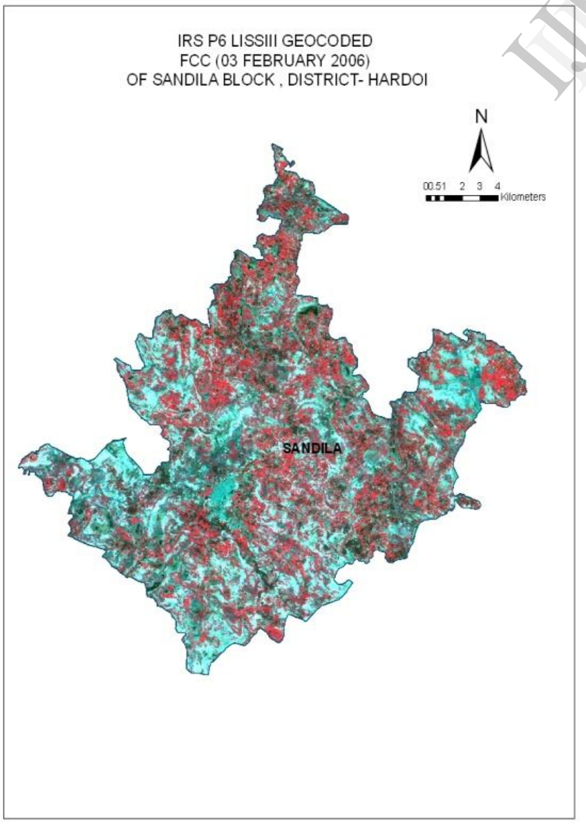


Fig.-3

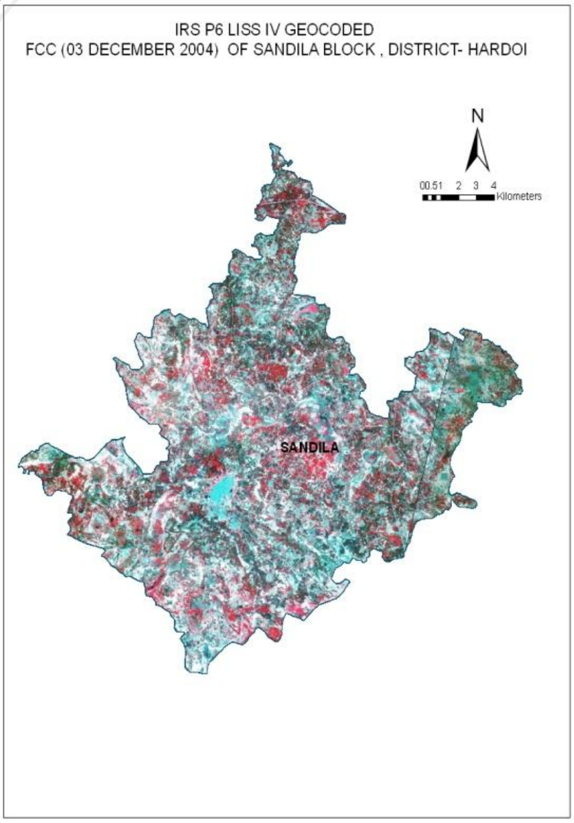
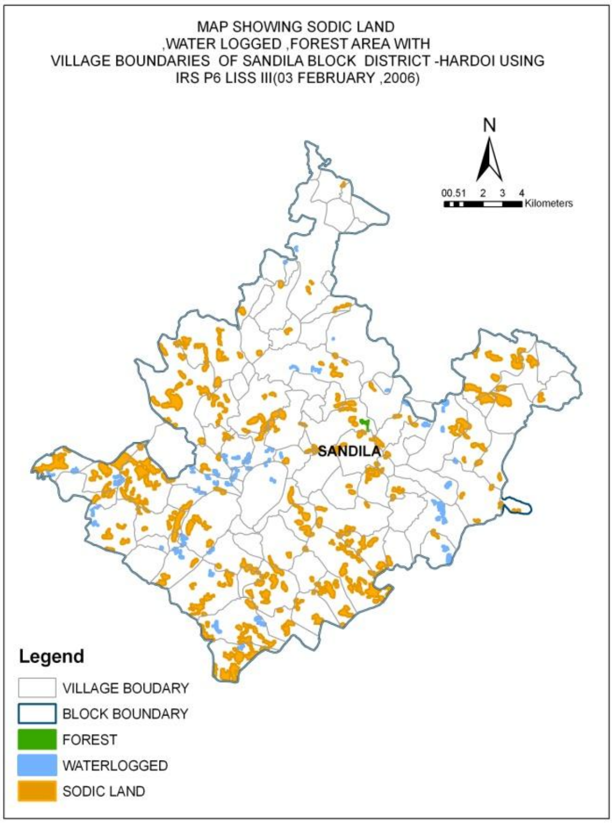


Fig.- 4



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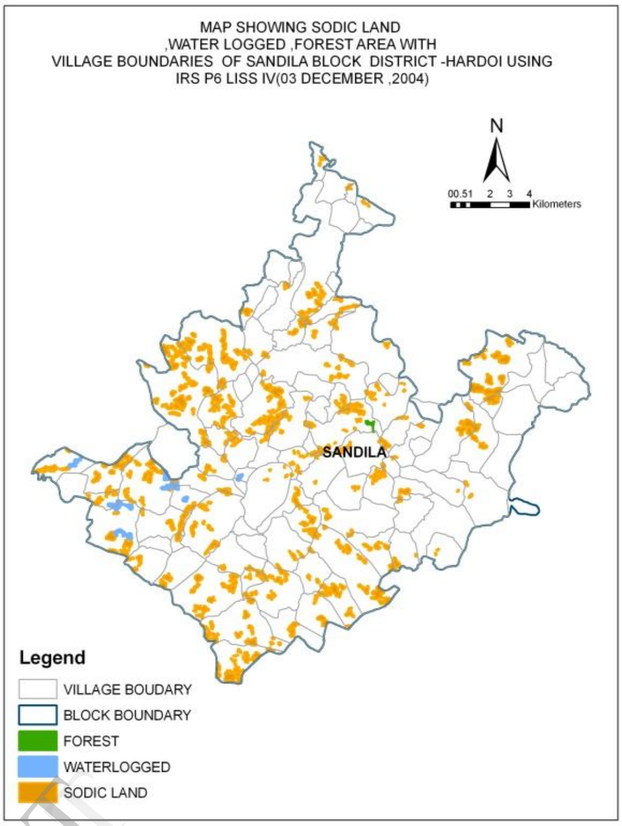

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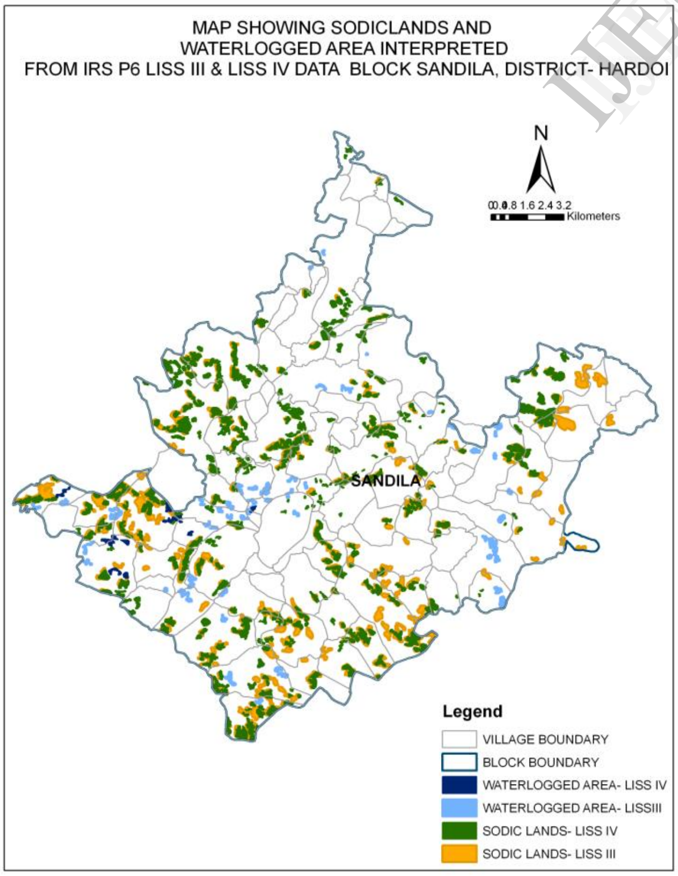

Fig.-7

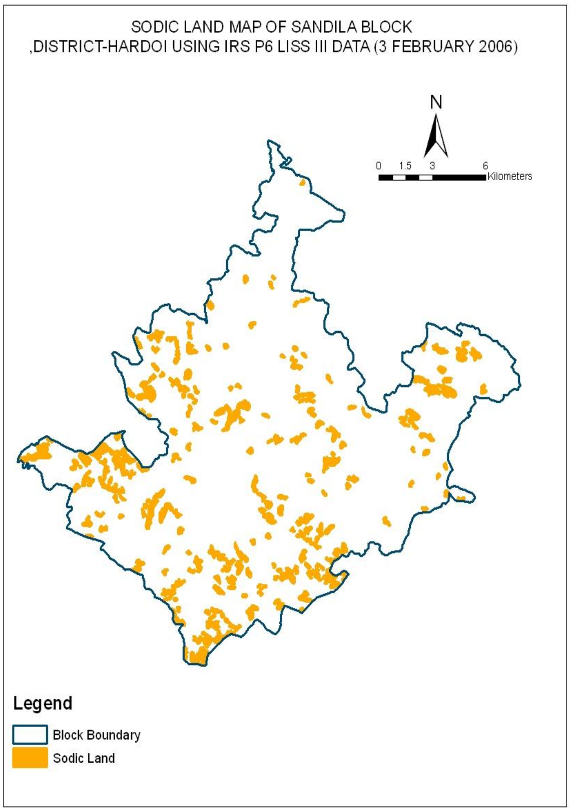

Fig- 8

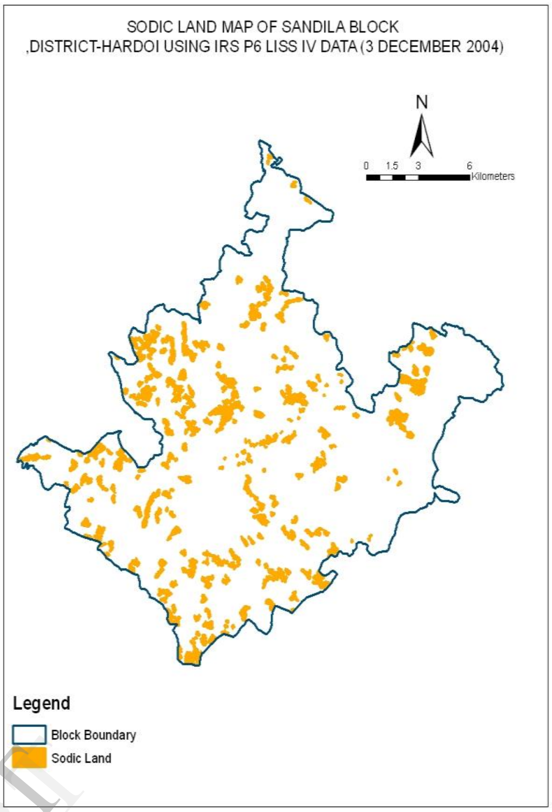

Fig.-9

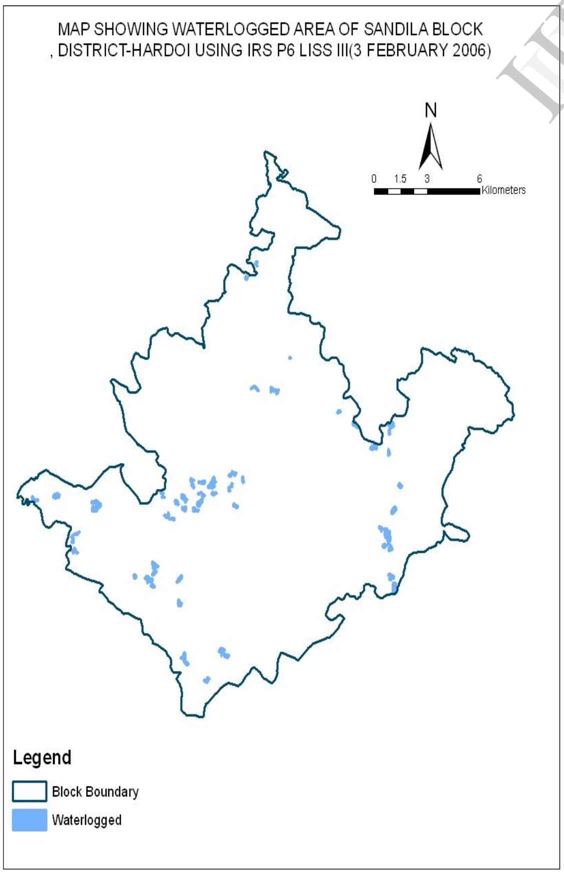

Fig.-10

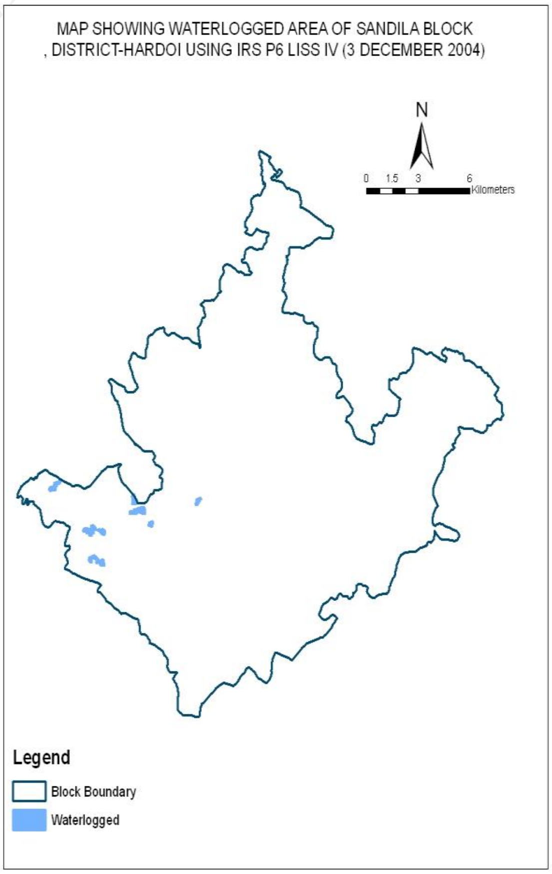

Fig.11

Acknowledgement

The author is grateful to Director, Remote Sensing Applications Centre, Uttar Pradesh, Lucknow, to allow me and to carryout the work at the centre. The author is also very thankful to scientists of the Remote Sensing Applications Centre, Uttar Pradesh, Lucknow for providing their guidance and invaluable comments.

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