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Remote sensing and geographic information system techniques were used to map the distribution of barren salt-affected land in the Gomati River basin in India's Indo-Gangetic Plain.

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Abstract

Landscape, hydrology, and fertility of India's strategically vital and ecologically significant Indo-Gangetic plain (IGP) are under siege from climate change and human-caused stress. About 2.6 percent of India's landmass and 6 percent of the world's total are impacted by salt, making them a significant ecological entity. Mapping Salt-Affected Land is a crucial use for remote sensing data. There is a relationship between the salinity/sodicity and the reflectance of salt efflorescence and its surrogate markers. Using a suite of tools provided by Arc GIS 10.0 Software, medium-resolution (23.5 m) LISS-III geocoded FCC satellite pictures were digitally interpreted at a scale of 1:50,000. For the purpose of determining the extent of barren salt-affected land, a survey of the Gomati River Basin and the district encompassed in basin area was conducted. On-screen, we saw a graphic interpretation of the IRS LISS-III data for the Rabi, Kharif, and Zayed seasons of 2005–2006 and 2008–2009. Total barren salt-affected area in the Gomati river basin is 970.41km2 based on visual interpretation of IRS-LISS-III data (2005-06). A total of 891.68 km2 of land was determined to be damaged by salt in 2008-09. As can be seen from the map, the right bank of the Gomati River is dominated by the barren, salt-affected soils.

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Keywords: *Salt-affected Land, Gomati River Basin, Remote Sensing& Hydrology and GIS.*

1. Introduction

The Indo-Gangetic Plain is the extensive alluvial Plain of the Ganga, Indus and Brahmaputra rivers and their tributaries, and separates from Himalayan ranges to Peninsular India. Increasing soil salinity and sodicity are serious worldwide land degradation issues, and may be even increase rapidly in the future (Wong et al., 2009). The problem of salt affected soils is

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pronounced in the many Indo-gangetic plains, arid and semiarid regions of the world and increasingly threatening agricultural expansion and productivity. It is estimated that 1.5 billion hectare of lands, all over the world, are salt-affected (Yuan et al., 2010). Salinity induced land degradation is one of the major obstacles to sustainable agricultural production in many arid and semi-arid regions of the world (Bossio et al., 2007). In India, about 6.9 million hectares of sodic soils are found of which 1.63 million hectares occurs in Uttar Pradesh only (Pandey et al., 2011) which is the largest area found in any single state in the country. Only a negligible portion of soils in UP is saline, the bulk suffering from alkalinity, associated with excess of available sodium, poor porosity, low nutrient content, indifferent drainage and high water-table. The excessive salt accumulation adversely affects soil physical and chemical properties, as well as microbiological processes (Lakhdar et al, 2009). Gomati river basin belongs to Indo-Gangetic Plain. In the basin salinity/alkalinity has developed through natural or human-induced processes that result in the accumulation of dissolved salts in the soil water to an extent that inhibits plant growth. The objective of present study to map the distribution of barren salt-affected land in Gomati river basin in two different years multi temporal data.

2. Materials and methodology

2.1. Description of study area-

The Gomati River Basin is situated between 80° 00' to 83° 10' longitudes and 24° 40' to 28° 40' latitudes Figure 1. The Gomati River is a ground water fed tributary of the Ganga River. It originates near the Madho Tanda in Pilibhit district of Uttar Pradesh. It is a gently sloping drainage basin with a total area of 30,515 km^2. The place of origin is located near Himalayan foothill zone in the Piedmont Zone of the Ganga Plain. It covers a distance of 940 km before meeting the Ganga River in Ghazipur district, Uttar Pradesh.

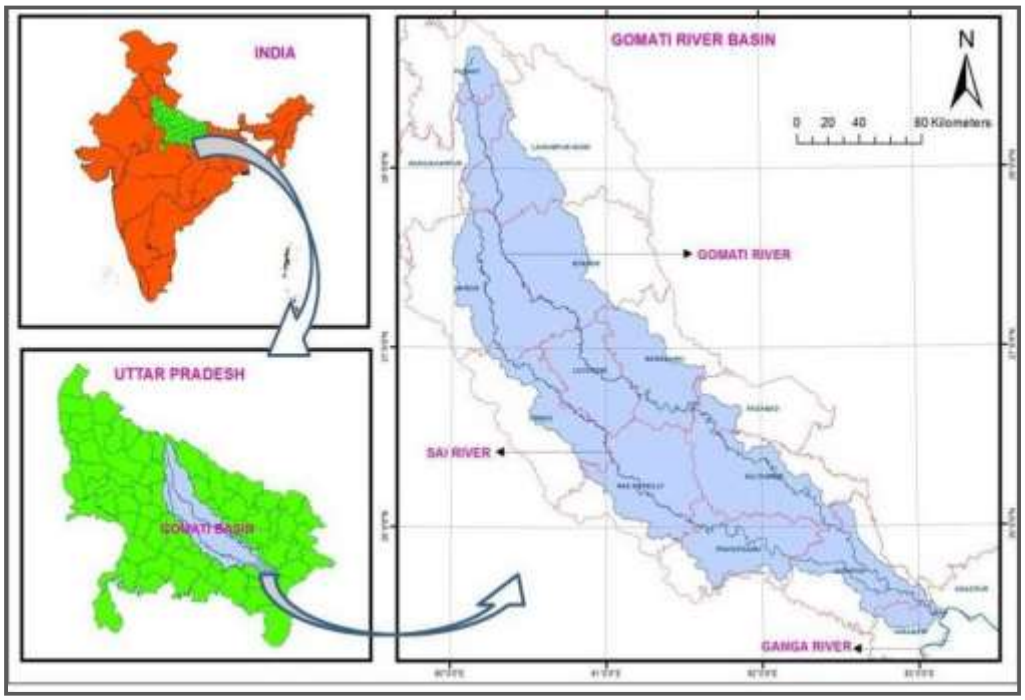

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Figure1: Location map of study area.

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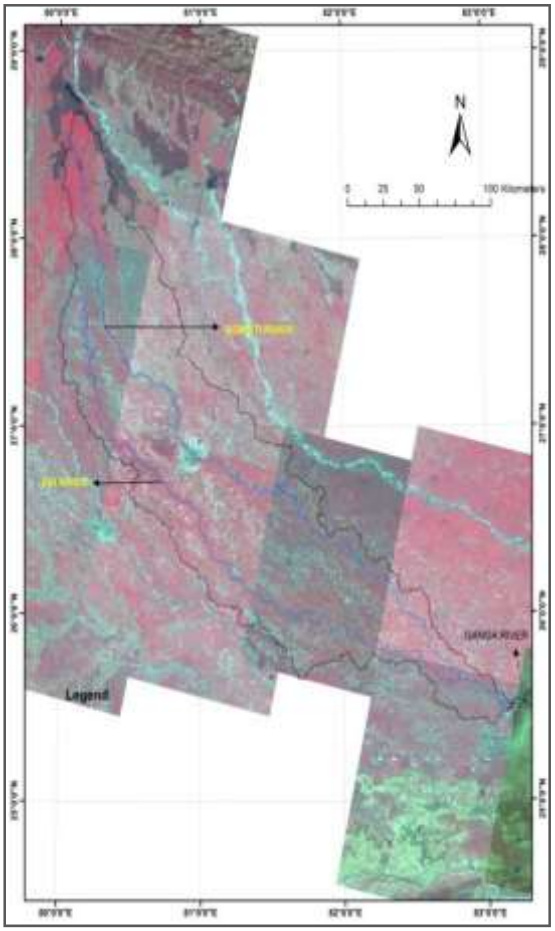

Figure 2: View of Gomati River Basin on IRS LISS III (2005-06) Satellite Data.

2.2 Data collection

The Gomati River Basin has been traced on 1: 50,000 scale topographic maps to delineate its basin boundary and drainage. For the verification of salt-Affected land in Gomati River Basin several field visits were done. These investigations have helped to confirm the occurrence of salt-affected land in doubtful area of Gomati River Basin. As major influencing factors is based on rainfall, terrain and soil characteristics, nine agro climatic zones have been recognized in the state of Uttar Pradesh (NBSSLUP). Gomati River basin falling in three agro-climatic zones-

i. Semi-Arid South Western Plain
ii. Central Plain
iii. Eastern Plain

2.3 Data and software used

IRS P6 LISS III (2005-06) and (2008-09) satellite data and Geographical information system Arc GIS 10.0 was used for georefrencing, delineation, area statistics generation and map composition.

2.4 Methodology

Standard FCC band combination of 3(Near Infrared) 2(Red) 1(Blue) imagery on of IRS-LISS-III data of Jan-Feb, Sep-Oct, and May-June of year 2005-06 and 2008-09 Satellite data generated on screen visual image interpretation. The boundaries of salt affected classes delineated in GIS environment. The dynamics of salt -affected land was observed from its data covering variable extent in different seasons. Figure 3 shows the flow chart of methodology.

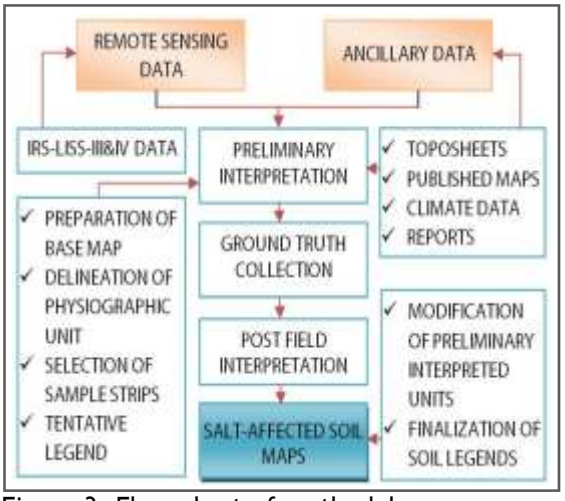

Figure 3: Flow chart of methodology.

3. Result and Discussions

Mapping of barren salt-affected land in Gomati River Basin based on multi-temporal LISS-III (2005-06) satellite data, the total salt affected land area found 970.41 km^2 which is 3.18% of total geographical area of basin (Table-1). Based on multi-temporal LISS-III satellite data of 2008-09 total salt affected land reduced to 891.68 km^2 which is 2.92% of total geographical area of basin (Table-2).

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Total 78.33km^2 salt affected land decreased out of which 47.37km^2 area of salt affected land decreased in Lucknow district. Distribution of salt-affected land is higher in central zone out of total salt-affected land in Gomati river basin 91.77% salt-affected land in this zone. 8.23% salt-affected land in eastern plain and only 0.01% in semi arid south western plain as based on IRS LISS-III (2005-06) data (Figure 4).

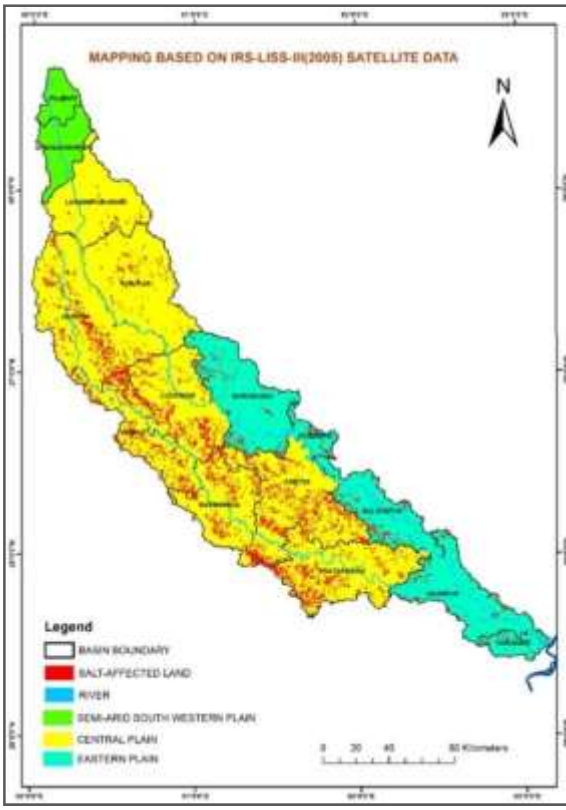

Figure 4: Distribution of salt-affected land in Gomati River basin (IRS-LISS-III-2005).

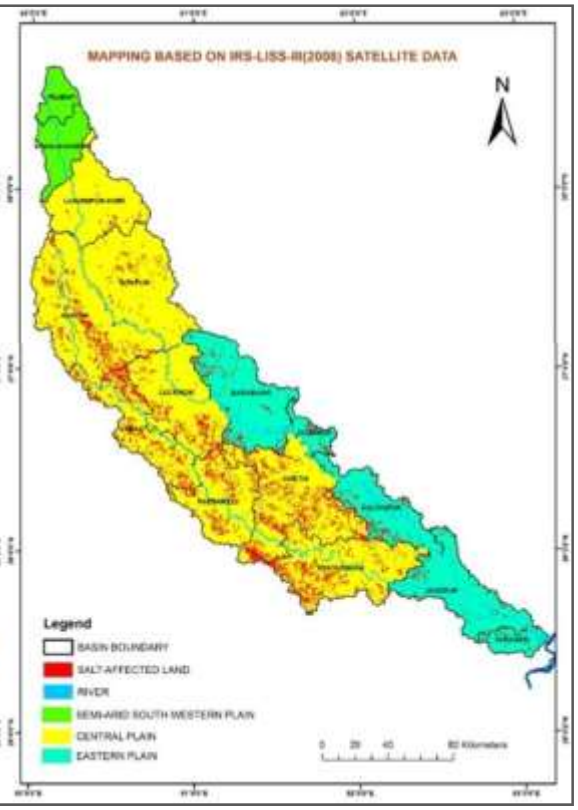

Figure 5: Distribution of salt-affected land in Gomati River basin (IRS-LISS-III-2008).

Mapping based on IRS-LISS-III (2008-09) multi temporal satellite data 92.30%. Salt-affected land in central plain, 7.69% in eastern plain, 0.01% semi arid south western plain noticed. In both year satellite data sodicity problem is much higher in central plain which cover maximum area of Gomati river basin (Figure 5).

Table 1: District wise statistics of Salt Affected Land in Gomati River Basin based On IRS-LISS-III (Feb-Mar) 2005-06 Satellite data.

S. N	District	District Area (km^2) in Gomati River Basin	Sodic Land Area(km^2) based on (2005)Data		% of Total Sodic area
			Sodic Area (km^2)	% of Area	
Semi-Arid South Western Plain Zone					
1	Pilibhit	578.15	0.00	0	0.00
2	Shahjahanpur	1004.71	0.07	0.006	0.01
	Total	1582.86	0.07	0.006	0.01
Central Plain					
1	Lakhimpur-Khiri	2201.28	10.59	0.48	1.09

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2	Hardoi	3643.53	151.62	4.16	15.62
3	Sitapur	3018.33	32.37	1.07	3.34
4	Lucknow	2526.1	124.69	4.93	12.85
5	Barabanki	2645.17	41.57	1.57	4.28
6	Unnao	1905.37	132.03	6.92	13.61
7	Amethi	3311.86	181.28	5.47	18.68
8	Raebarely	2032.8	95.17	4.68	9.81
9	Pratapgarh	2825.73	121.2	4.28	12.49
	Total	24110.17	890.52	33.56	91.77
Eastern Plain					
1	Faizabad	440.97	10.04	2.27	1.03
2	Sultanpur	1665.82	35.40	2.12	3.65
3	Jaunpur	2178.24	27.30	1.25	2.81
4	Ghazipur	32.27	0.26	0.80	0.03
5	Varanasi	477.59	6.82	1.42	0.70
	Total	4794.89	79.82	7.86	8.23
	Grand Total	30487.92	970.41	3.18	

Table 2: District wise statistics of Salt Affected land in Gomati River Basin based On IRS-LISS-III (Feb-Mar) 2008-09 Satellite Data.

S.No	**District**	**District Area (km^2) in Gomati River Basin**	**Sodic Land Area(km^2) based on (2008)Data**		**% of Total Sodic area**
			Sodic Area (km^2)	**% of Area**	
Semi-Arid South Western Plain Zone					
1	Pilibhit	578.15	0	0	0.00
2	Shahjahanpur	1004.71	0.047	0.00	0.01
	Total	**1582.86**	**0.047**	**0.003**	0.01
Central Plain					
1	Lakhimpur-Khiri	2201.28	10.23	0.46	1.15
2	Hardoi	3643.53	152.40	4.18	17.09
3	Sitapur	3018.33	31.90	1.06	3.58
4	Lucknow	2526.1	77.32	3.06	8.67
5	Barabanki	2645.17	41.06	1.55	4.60
6	Unnao	1905.37	127.28	6.68	14.27
7	Amethi	3311.86	177.43	5.36	19.90
8	Raebarely	2032.8	95.07	4.68	10.66
9	Pratapgarh	2825.73	110.35	3.91	12.38
	Total	**24110.17**	**823.04**	**30.94**	92.30
Eastern Plain					
1	Faizabad	440.97	9.96	2.26	1.12
2	Sultanpur	1665.82	32.58	1.96	3.65
3	Jaunpur	2178.24	20.68	0.95	2.32
4	Ghazipur	32.27	0.00	0.00	0.00
5	Varanasi	477.59	5.38	1.13	0.60

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	Total	**4794.89**	**68.6**	**6.3**	**7.69**
	Grand Total	**30487.92**	**891.68**	**2.92**	

4. Conclusions

In the present study database of agro-climatic zone wise barren salt affected soils for the Gomati river basin in India was generated based on the satellite data of IRS-LISS-III (2005-06), and (2008-09) using GIS 10.0 software. The salt affected soil was significantly higher in central plain zone followed by eastern plain and semi-arid south western plain. Maximum salt accumulation noticed in Gomati-Sai interfluve followed by left bank of Sai River and left bank of Gomati River. Such databases were very important and useful in decision making and planning for reclamation and management of salt-affected soils in Gomati river basin and other similar regions in India.

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