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MAPPING OF SALT AFFECTED AREAS OF DISTRICT ALIGARH BY REMOTE SENSING

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ABSTRACT

In India more than 7.0 million hectares are affected by the problem of salinity. The major portion of such areas lies in the Indo-Gangetic alluvial plains. Any attempt of developing such areas for productive activities necessarily needs an accurate information about location and extent of such areas. These days application of remote sensing techniques is becoming more and more popular for such studies. This study was taken up to utilize the capabilities of remote sensing techniques for mapping of salt-affected areas of district Aligarh (U.P.). Visual Interpretation of Landsat MSS false colour composite (scenes 146-041) and 146-040 of 13 Nov. 1984) and Landsat TM false colour composite (scene 146-041 of 13 Oct. 1987) was carried out to delineate salt-affected areas at 1:250,000 scale bare map. Later on, these maps were also utilized for change detection in areal extent and distribution of salt-affected areas.

1.0 INTRODUCTION

India is the seventh largest and second most populous country in the world, with unique physical and cultural diversities. The diversity in physical landscape has resulted in different types of lands which are subjected to different types of utilization to the maximum extent possible. Due to increasing pressure of population there is an excessive demand of more land for agriculture and non-agriculture persuits. This has resulted in uncontrolled exploitation of natural resources and therefore making some piece of lands upproductive or degraded.

Out of the country's total geographical area of about 328 million hectares only about 140.3 million hectares is presently available for cultivation. Various types of soil and land degradation problems have rendered about 175 million hectare or 53 percent of geographical area either completely or partially unproductive. In which about 150 million hectares of land is affected by erosion, and another 25 million hectares is affected by water logging, ravines, and alkaline and saline soils and shifting cultivation etc.

It is estimated that about 7 million hectares of land is affected by salinity/alkalinity conditions in India. The problem is particularly acute in the arid and semiarid tracts of the Indo-Gangetic alluvial plains, where alone about 40 per cent of the total affected area is encountered. According to the available information the

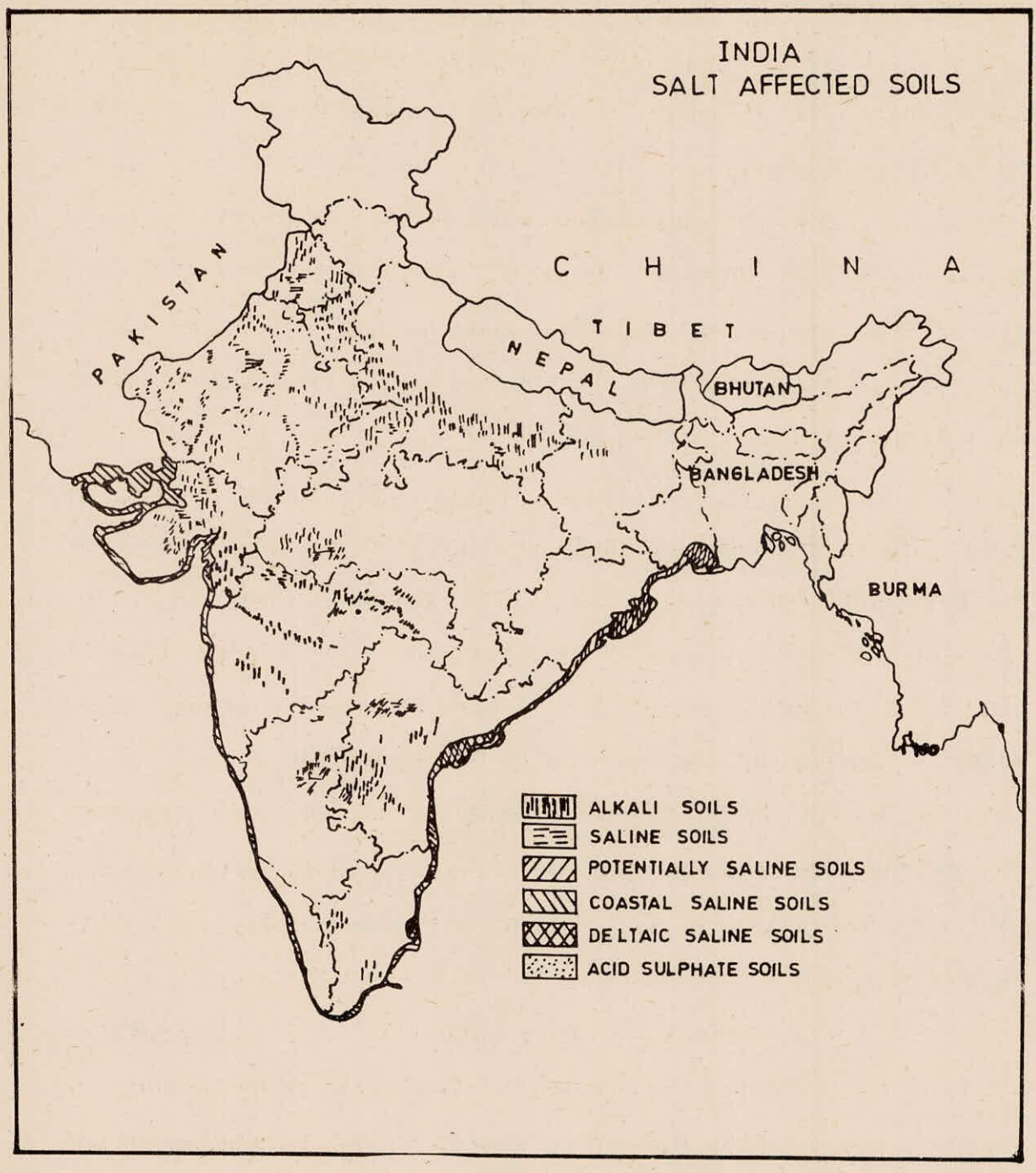

FIG.1: Spread of Salt Affected Soils in India

major problem there is of soil alkali. However, in Agra and Mathura districts of Uttar Pradesh, Hissar and Rohtak districts of Haryana, Ferozepur, Faridkot and Bhatinda districts of Punjab, Muzaffarpur and Shahbad districts of Bihar and some parts of Delhi, the presence of mainly salinity with or without alkali poses the problem. The estimates of such area in different states, as complied by the Central Soil Salinity Research Institute, Karnal are given in Table 1.

Table 1 - Statewise Estimated Area Affected by Saline and Alkali Conditions in India.

State	Area (million hectare)	State	Area (million hectare)
Uttar Pradesh	1.295	Maharastra	0.534
Gujrat	1.214	Orissa	0.404
West Bengal	0.850	Karnataka	0.404
Rajasthan	0.728	Madhya Pradesh	0.224
Punjab	0.688	Andhra Pradesh	0.042
Haryana	0.526	Other States	0.040

These salt affected areas in India have been grouped on the lines of broad based soil classification as per Table 2. The spread is also shown in the map of India in Fig.1.

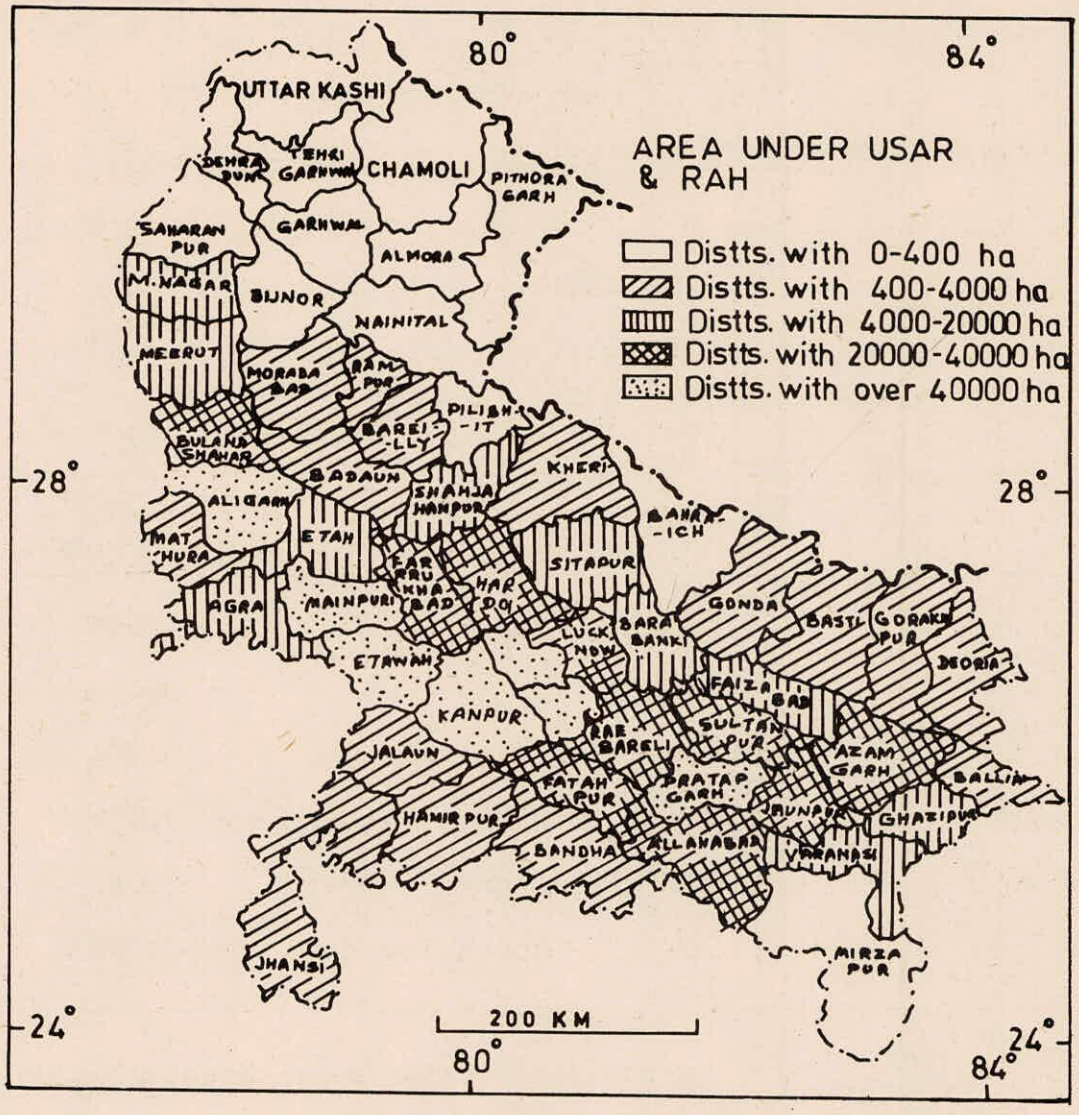

FIG. 2: Acreage Distribution of USAR in Different Districts of U.P.

Table 2- Geographical Distribution of Salt-affected Soils

Problem	States in which the soils occur	Approx. area (million ha.)
1. Coastal salt-affected soils		
a) Coastal salt-affected soils of arid region	Gujarat	0.714
b) Deltaic coastal salt-affected soils of the humid regions	West Bengal, Orissa Andhra Pradesh, Tamil Nadu	1.394
2. Salt-affected soils of the medium and deep black soil regions	Karnataka, Madhya Pradesh, Andhra Pradesh, Maharashtra Rajasthan	1.420
3. Salt-affected soils of the	Gujarat, Rajasthan Punjab Haryana Uttar Pradesh	1.000
4. Salt-affected soils of the Indo-Gangetic plains	Haryana Punjab Uttar Pradesh Bihar Rajasthan Madhya Pradesh	2.516

The area under saline-alkali soils in Uttar Pradesh is perhaps the largest area found in any single state in India. The saline and alkali lands are mostly localized in the semi-arid heart of the state and in the region lying south-west of the Ganges. The district worst hit by the ravages of salt infestation are Mainpuri, Aligarh, Etah, Farukhabad, Etawah, Agra, Mathura, Meerut, Kanpur, Unnao, Fatehpur, Allahabad, Rao-Bareli, Lucknow, Hardoi, Faizabad, Pratapgarh and Sultanpur (Fig.2). There is also a stretch of low-lying tract extending to the sub-humid parts of the

state, comprising the district of Azamgarh, Western part of Ballia, Northern part of Ghaziapur and the Bhadi tehsil of Varanasi district where water-logging conditions prevail and salt-affected soils are quite common. These soils are collectively called Usar and some times Kallar or Reh. The most common feature of such lands is the appearance at the surface of extensive quantities of the white, greyish-white or ash-coloured, salt encrustations during dry periods. Besides, these present sterile and barren look with hard rock-like surface devoid of any vegetation or only in patches, and poor or impeded drainage with muddy water stagnating over long periods during the rains. The surface is quite often impermeable to water and there may be a hard kankar layer (calcium carbonate nodule) or clay pan at some depth in the profile.

Because of lack of efforts on the part of land records departments of the different states of India, the correct statistics of the total land affected by salinity are at present not available. Salty lands lying uncultivated are collectively classified as 'culturable waste lands'. Thus all types of culturable wastelands are put together and separate categorisation is not attempted for saline and alkali lands. In the absence of correct statistics, no total assessment of the extent or magnitude of the problem is possible. Moreover, even the estimates for culturable wastelands if separately maintained for lands affected by salinity will include large tracts of the arid regions in the country which are not completely sterile, but are on

the verge of saline or alkali conditions where crop yields are low and plant growth perceptibly retarded. Further soil surveys in the different states, if properly organised, may bring out many more areas of such lands not visibly affected by salts, but producing hardly any crop worth the name. Besides, impact of ill-planned big irrigation or impeded drainage are already adding to the existing extent of the salline-alkali soils in the country.

A rapid and accurate assessment of the extent of salt-affected lands can be made through the help of aerial photographs and satellite imagery. Salt-affected areas appear as white, greyish-white or ash-coloured on the surface, as discussed earlier, are easily identified on satellite imagery. Also satellite imagery provide a synoptic coverage of the area which helps in studying the integrated effects of various aspects of ecosystem and it is often possible to correlate the cause and effect of salinity and its spatial variations. Due to availability of repetitive data it is possible to monitor the change in spread of salt-affected areas and update existing data base.

2.0 REVIEW OF LITERATURE

Scientific study of saline soils in India started in the second half of the nineteenth century. However, these investigations were concentrated towards the study of origin and composition of such soils. These studies were mainly based on ground survey methods. Later on, with the advent of aerial photo interpretation techniques attempts were made by many researchers to use aerial photographs for mapping of salt-affected areas.

The utility of black and white photographs was demonstrated by Shrinivasan (1976) and Bhargava and Sharma (1977). Further studies were reported by Bhargava et.al (1978), Sharma and Bhargava (1987), Manchanda and Khanna (1981) and others. These investigators found that aerial photographs can be successfully used for semi-detailed soil map with efficiency, accuracy and low cost. In the saline soil studies conducted in Haryana and Punjab three levels of soil salinity could be identified and mapped by photo interpretation techniques (Shanwal et.al. 1980, Bhargava & Sharma, 1980).

A.K. Kolarker et.al. (1980) analysed aerial photographs at 1:25,000 scale to delineate salt affected areas (patches) in south-east arid Rajasthan, their distribution, and genesis. The distribution and pattern of occurrence of salt affected areas (patches) in the landscape as studied on satellite imagery and aerial photographs, and then in field suggested a mechanism of genesis of the problem and

contemporary changes.

In 1982, Beldev Sahi et al. attempted to delineate water logged and salt affected areas near Kakrapar weir by studying multiband Landsat imagery. The study was supplimented by colour infrared photography over centrally located areas of 1200 sq.km. The comparison of ground truth data and remotely sensed data showed that water logged and salt affected lands are identifiable within the limits of spatial resolution of remotely sensed data.

A study was carried out by M.H. Kalubarme (1983) in Mahi right bank of command area in state of Gujrat to operationalize the technology of delinating the water logged and salt affected soils using multi season landsat imagery. It was observed that quite a few areas which were not indicated by the sub soil water logged observations as water logged, could be identified on satellite imagery. He concluded that satellite imagery provide a quick and more reliable delineation and mapping of water logged and salt affected areas, if extent of such areas is at least 4-5 hectare.

Venkataraman (1983) studied the use of multidate landsat date for monitoring of soil salanity in Indo-Gangatic plain of North-West India. A small part of area pertaining to Sangrur Distt. (Punjab) had been selected for this study and landsat MSS data at different dates and season were analysed on MIDAS. He concluded that the methodology developed in this study for monitoring of soil salinity could be extended to other areas also in the Indo-Gangatic plains where several

thousands of acres of areas had been affected by salinity/ alkalinity.

Further in 1985, Ahuja et al. used landsat flase colour composite at 1:1 million scale for preparation of soil degradation map in a part of Haryana. Broad units and sub units of soil hazards (mainly salinity and associated features) were identified and delineated using existing geological and topographical information along with field checks and experiences. MSS false colour composites and TM false colour composite were visually analysed by Kankne (1987) for mapping of wastelands in a part of western U.P. This study indicated that satellite data can be successfully used for mapping and monitoring of salt-affected areas. It was also found that visual interpretation of TM imagery is sufficient for compiling spread of salt-affected areas. However, a detailed study could be made by aerial photo interpretation and field visits.

3.0 STATEMENT OF THE PROBLEM

The area under saline-alkali soils in Uttar Pradesh is the largest area found in states of India. District Aligarh is one of the most severely affected district. Any attempt of developing such areas of the district for productive activities necessarily needs an accurate information about the location and extent of such areas. This study has been undertaken to map the salt-affected areas of the district and to detect the change in areal extent between the period 1984-87.

4.0 DESCRIPTION OF STUDY AREA

4.1 Geographical Location

The study area lies within the administrative boundaries of district Aligarh of Uttar Pradesh. This area is a part of the Indo-gangetic alluvial plain lying between the latitudes $27^{o}30'$N to 28^{o} 15' N and longitudes 77^{o} 30 E to $78^{o}40'$E. The total geographical area of the district is about 4917 sq.km. The northern boundary of the district is formed by district Bulandshahar whereas district Mathura and Etah form its southern-western and southern-eastern boundaries respectively. District Budaun is in north-east of the district Aligarh and the western boundary is marked by Haryana (figure 3).

4.2 Agricultural and Natural Vegetation

Over 79% land is under cultivation in the district. The wheat is the major rabi crop. The other crops of rabi are gram, peas and masur. The Kharif crops include urd, moong, arhar and moth. In some parts oil seeds are also grown.

Shisham, babul, khair and semal are the main tree species found in the district. In some parts grasses like elephant grass, kans and munj are found in scattered patches.

4.3 Soils and Geology

An almost imperceptible change in elevation and uniform surface materials are the two noteworthy features of the area. The alluvium consists of unconsolidated beds of clay, sand, gravel and their mixture in varying proportion. The

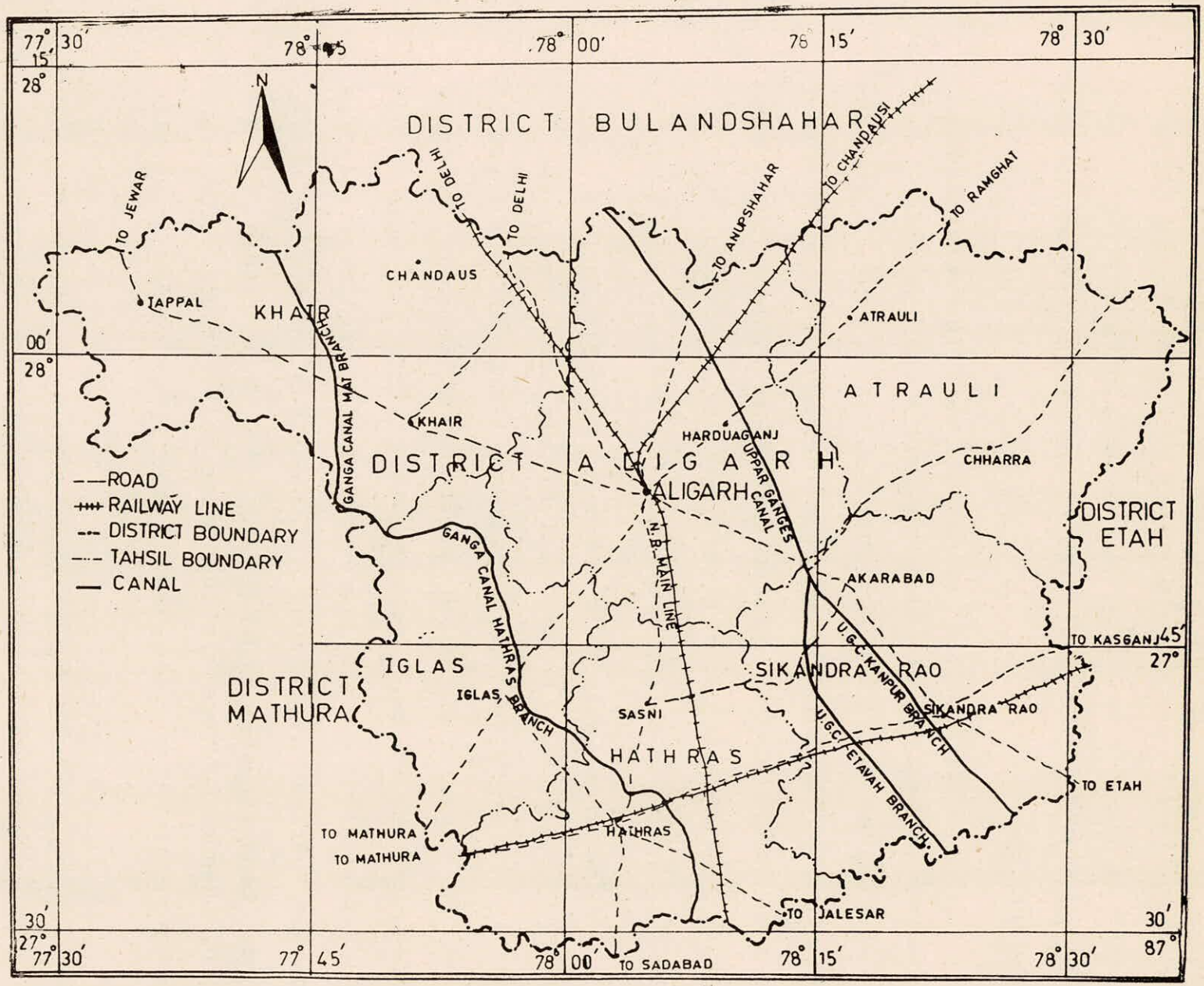

FIG.3: Geographic Location of Study Area

depth of the alluvium is less than 1500 meter which gradually thins out in the south. One distinct character of the alluvial plains is the formation of Kankar pans in the sub-soil zone through capillary action owing to the alternating calcareous sand and clay beds.

The Khadar soils lying in the flood-plains have immature profiles with sandy to silty loam texture, fair proportion of lime and are alkaline in reaction with poor drainage. The Bhagar soils are more extensive in areal spread, occupying the interfulvial zones. These soils have mature profile with varying colours.

4.4 Climate

The area falls in a sub-humid climatic region. There are four well marked seasons i.e. the hot summer, the wet summer, the pre-winter transition and the winter. The gradual rise in temperature which starts from February, becomes more rapid by March. The scorching effect of loo(the hot and dry westerlies) are aggravated due to the lower relative humidity during May and June. The maximum and minimum average annual temperatures are 40°C and 7.9°C respectively. The rainy season commences in the later half of June. The rainy months account for over 90% of the total annual rainfall.

5.0 DATA USED

The study was carried out by visual interpretation of landsat imagery in false colour mode. Landsat MSS false colour composite of year 1984 and Landsat TM false colour composite of year 1987 were used for identification of salt affected areas. A detailed description of the landsat data is given in Table 3.

Table 3 : Description of Landsat Data Used

Sl.No.	Path&Row	Data	Satellite	Sensor	Data type
1.	146-040	13 Nov.1984	L4	MSS	FCC 1,2,4
2.	146-041	13 Nov.1984	L4	MSS	FCC 1,2,4
3.	146-041	13 Oct.1987	L5	TM	FCC 2,3,4

The area is covered in two scenes for MSS and one scene for TM. Survey of India topographic maps at 1:250,000 scales were used for preparation of a base map of the area. The index for toposheets and imagery is shown in Fig.4.

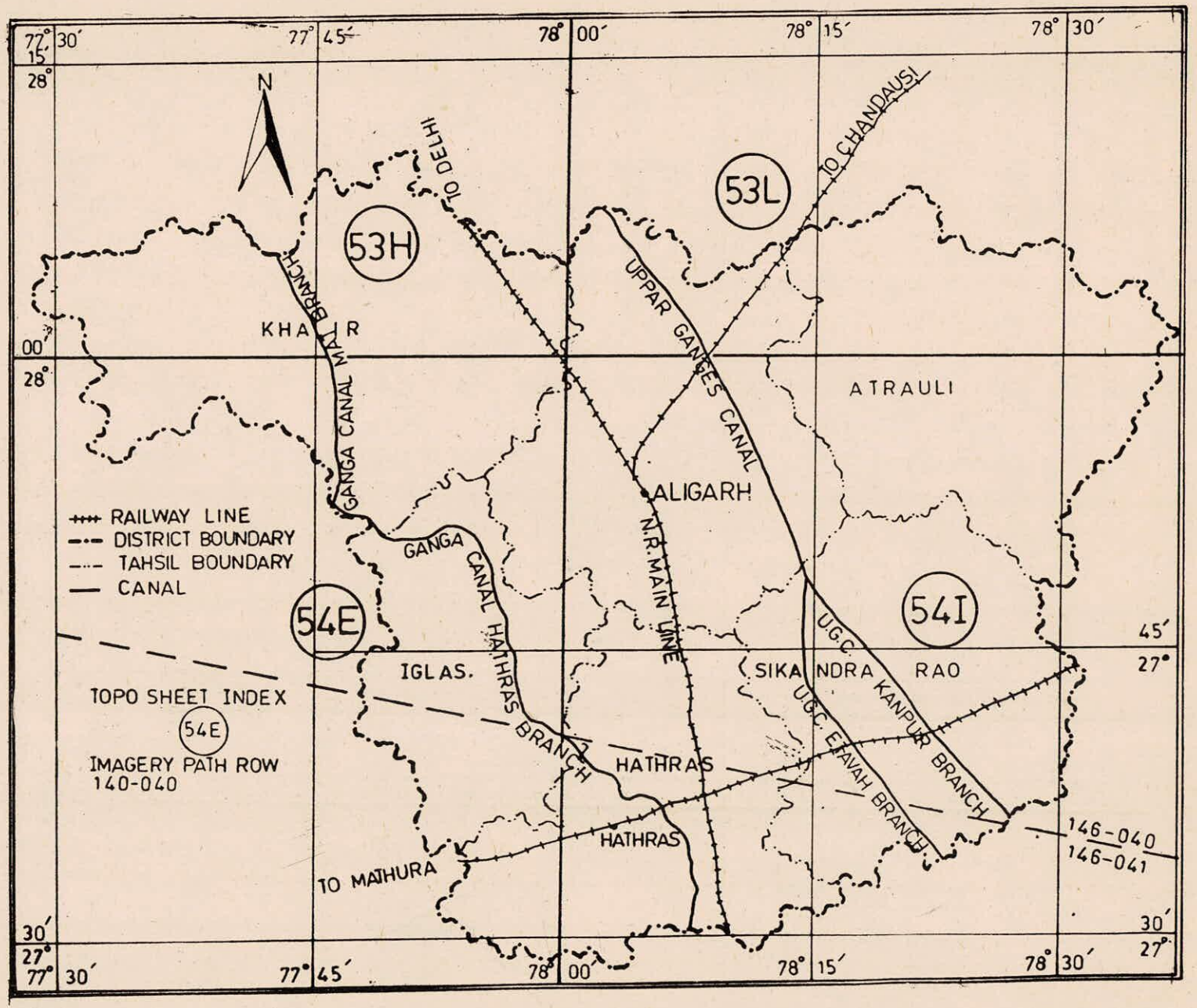

FIG.4: Landsat Images and Toposheet

6.0 METHODOLOGY

Landsat false colour composites were visually analysed to delineate salt-affected areas. These areas appear as white to greyish white on imagery. During the superimposition of interpreted maps over base map at 1:250,000 scale it was observed that imagery are slightly distorted. Hence interpreted maps were corrected for distortions. An interpretation key which was used during interpretation is given in Table 4.

Table 4 : Interpretation key for Identification of Various Features

Description	Appearance on FCC
Salt-affected areas	white-greyish white
Water bodies	dark blue
plantations	dark red
sandy areas	bluish-white to white
water logged areas	dark grey to black
agricultural areas	pink to light blue with scattered clusters of pink.

7.0 ANALYSIS OF RESULTS

On the basis of visual interpretation of Landsat MSS imagery of year 1984 and Landsat TM imagery of year 1987, salt-affected areas of district Aligarh have been shown in Figure 5 and Figure 6. The areal extent of these salt-affected areas have been determined by using a .01 cm^2 grid for each of the six sub-divisions of the district (Table 5).

From the table it is clear that there has been an increase of about 57.34 sq.km in the total estimate of salt-affected areas for the district. In year 1984 total salt-affected areas were about 5.36% of the geographical area of the district which increased by 1.17% in year 1987. Thus, the salt-affected areas has been spreading at a rate of about 0.39% per year which amounts to 19.18 sq.km.

The problem is more acute in three sub-divisions; Aligarh and Sikandrarao wherein the percentage of salt-affected areas is quite large when compared with total percentage of salt-affected areas of the district. Interestingly, a major part of these sub-divisions are in the vicinity of Upper Gang Canal. From the map it is also clear that a majority of salt-affected patches are concentrated around Nanu where UGC splits in two branches. This clearly indicates that seepage from UGc and its branches has been a major cause of salinity ingress in the area.

The salinity problem is least in Hathras and Iglas sub-divisions whereas in Khair and Atrauli salt-affected areas lie between 4-7 percent of total graphical areas of

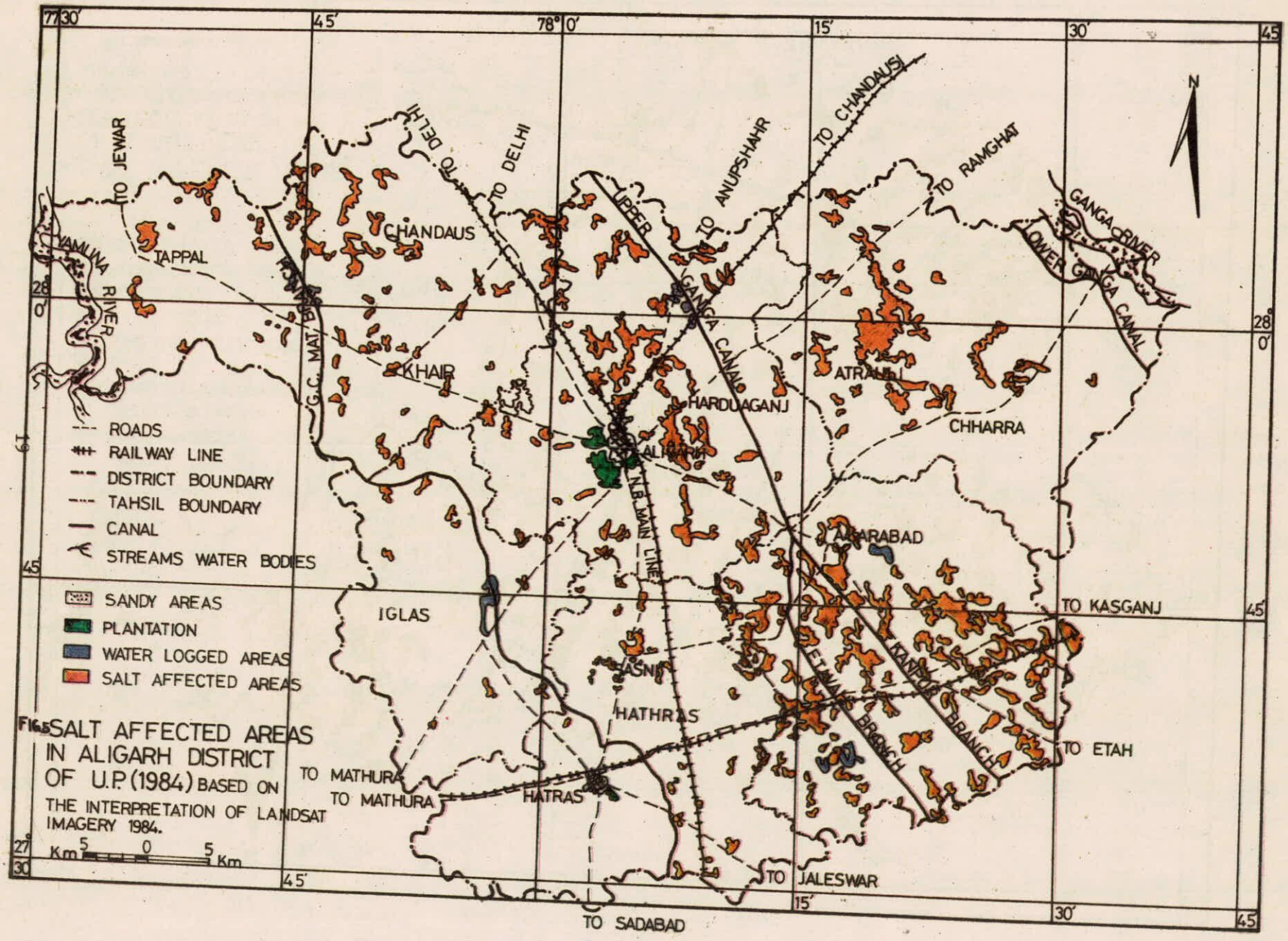

FIG.5 SALT AFFECTED AREAS IN ALIGARH DISTRICT OF U.P. (1984) BASED ON THE INTERPRETATION OF LANDSAT IMAGERY 1984.

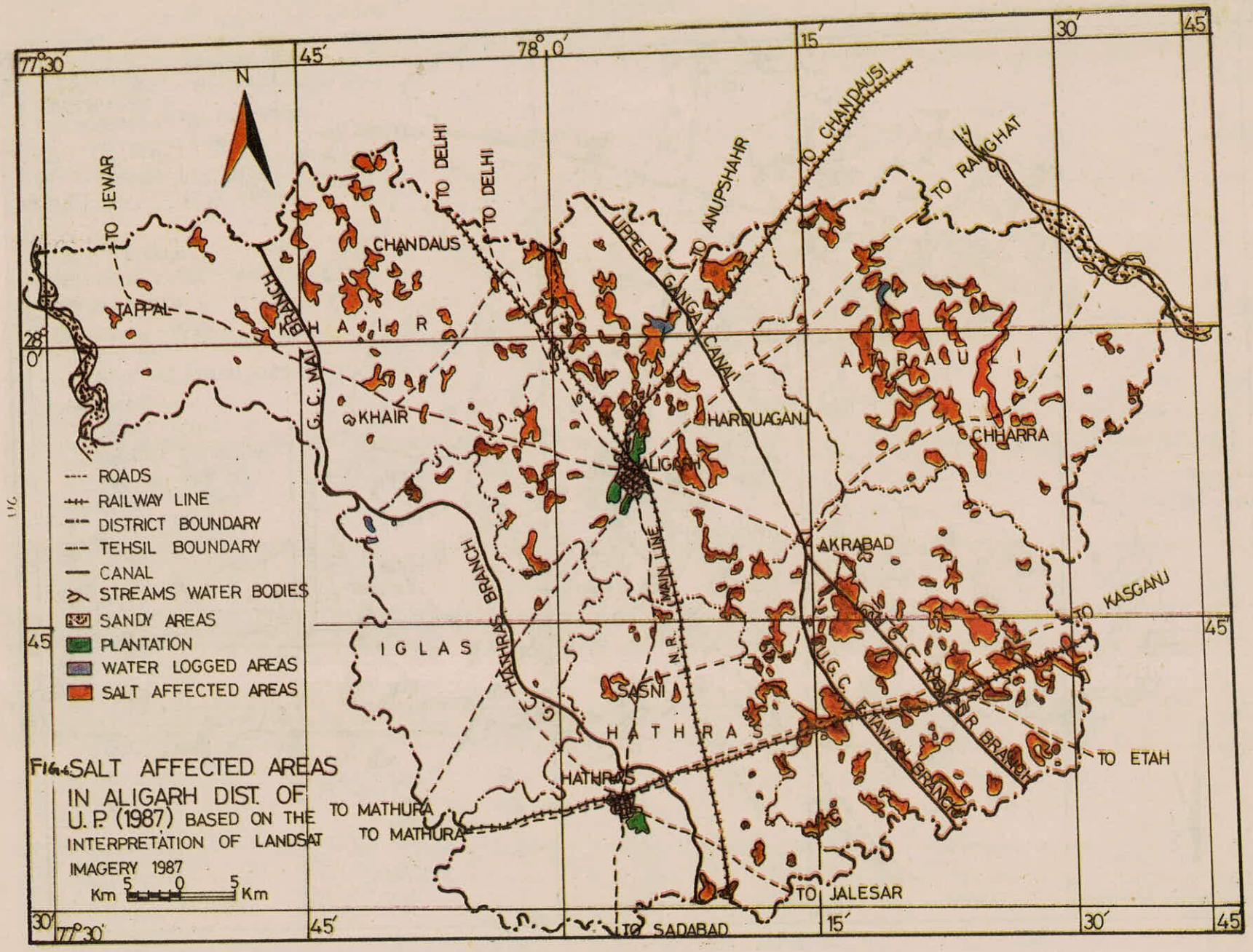

FIG. SALT AFFECTED AREAS IN ALIGARH DIST. OF U.P. (1987) BASED ON THE INTERPRETATION OF LANDSAT IMAGERY 1987

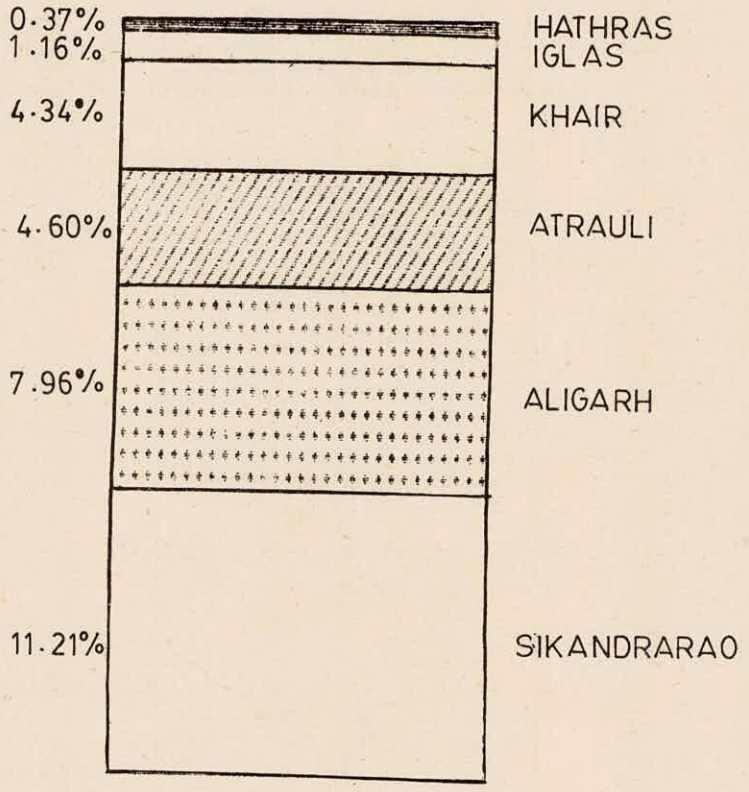

FIG. 7: Acreage Distribution of Salt Affected Areas in 1984

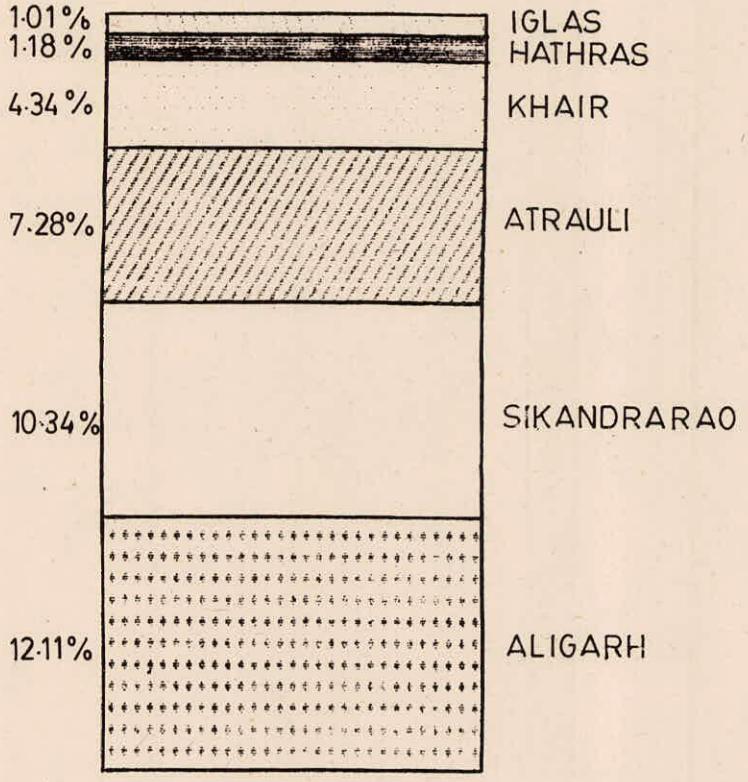

FIG. 8: Acreage Distribution of Salt Affected Areas in 1987

Table 5. Sub-division wise Estimated Area Affected by Salinity

Sub-division	Geographical Area(sq.km)	Salt-affected area(sq.km)		Salt-affected area(%)		Change in salt-affected area	
		1984	1987	1984	1987	+ve	-ve
Hathras	703.13	2.63	8.21	0.37	1.16	0.79	-
Iglas	512.5	5.24	5.16	1.16	1.01	-	-0.15
Khair	1062.5	46.13	46.12	4.34	4.34	-	-
Atrauli	881.25	40.45	64.00	4.60	7.26	2.66	-
Aligarh	885.00	70.44	107.18	7.96	12.11	4.15	-
Sikandrarao	873.40	97.94	90.31	11.21	10.34	-	-0.87
Total for the district	4917.78	263.64	320.98	5.36	6.53	1.17	-

the sub-division.

Usar Land Reclamation Committee set up by U.P. Government in 1938-39 has estimated the total salt-affected land inU.P. about eight percent on the basis of ground survey methods or records available with Revenue Department. The estimate from Landsat imagery interpretation lies between five to six percent. This discrepancy between the figures may be attributed to the following reasons:

1. The Usar Land Reclamation Committee estimates are based on data collected during 1938-39. During the last fifty year many land reclamation measures have been taken up due to this salinity problem has been controlled to a large extent.

2. Only severly salt-affected areas, completely devoid of vegetation, could be mapped on satellite imagery from visual interpretation, whereas Usar Land Reclamation Committee estimates include all types of salt-affected areas.

8.0 CONCLUSION

As discussed earlier salinity problem has rendered vast areas of this country unproductive. A rapid assessment of extent of such areas is the foremost task to develop such areas for agricultural purposes. This study indicates that remote sensing techniques give quite reasonable estimates with time and cost effectively. However, correct estimates could be made by supplementing satellite data interpretation with aerial photo-analysis and a well planned ground truth verification. Visually it is difficult to map slight to moderate salt-affected areas due to the poor distinction between total values. However, digital analysis can distinguish many such levels.

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