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Management of Salinity and Afforestation by IRS 1D LISS- III Data in North Bihar, India

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Abstract: Desertification process and loss of agricultural productivity has caused mass migration of rural population to slums of urban areas, causing unwarranted painful demographic changes and strains in social fabric. Integrated management of salinity and afforestation of degraded land at large scale has immense potential to reclaim the soil and mitigate global environmental impact on agricultural practices. In this paper, North Bihar province of India is mapped using remote sensing data from LISS – III satellite for salinity and plate faults. These mapping are done for the design of drainage system and initial afforestation activities. The mapping is further validated by procuring ground data. Ground Positioning System and results of soil samples at 2-3 km ranges are incorporated to determine salinity variation. Results are also extrapolated for the mapping in areas where data could not be obtained.

Keywords: Afforestation, Arid area, Bihar, Remote sensing, Salinity management

1. Introduction

Rural population in India, the second largest populous country of the world (out of 1.2 Billion) is over 60%. Rural population mostly depends upon agriculture for their livelihood. During last few decades, global environmental degradation and unplanned development has sets in desertification process, the effect of which is most visible in recent years. Despite increased use of fertilizers, modern technology and scientific methods, the return from agricultural produce has seen a sharp decline. Besides, natural calamities have increased in their harshness and frequencies. Mass migration of rural population from rural areas and arid region has increased over the years (Kumar *et al*, 2006). Bihar province of India is a typical example of this phenomenon.

Bihar (21˚30'10"N, 27˚31'15"S, 82˚19'50"E and 88˚17'40" W) has a geographical area of 94163 km^2. Once it was the grain house of India due to several rivers criss-crossing the state. Even floods were a boon since it brought fertile soil to the fields. However, the situation has changed drastically in last few decades. Floods and droughts, both have become a regular features here. Their harshness has increased many folds. Extremely low forest cover, manifold increase in salinity and disturbance in natural drainage system are some of the major factors, which has sets in the desertification process in Bihar nearly 2-3 decades ago. Exchangeable sodium in soil complex disperses the system and soil structure is lost which has quite often caused drainage blockade, unfavorable air-water ratio in the root zone and subsequent supply of oxygen.

Integrated management of drought-salinity and flood-drain system both can be achieved by proper mapping of the area using remote sensing data. High level of ground water and ascertaining drainage channel will reduce salinity in the area. Floods can be used for reduction in salinity too. These efforts can be supported by large scale afforestation activities for long term reclamation of the soil. Afforestation has another advantage in mitigating green house effect at global level (Sanjay Kumar *et al.*, 2001). Various methods can be used for afforestation in saline/sodic soil (Sinha *et al.*, 2000), economically feasible manner with least use of fresh water. Remote sensing, by virtue of its synoptic viewing capability, repetitiveness and spectral sensitivity to salt, is a valuable tool for obtaining relevant data on soil salinity even in the irrigated commands due to contrast. The presence of salts at the surface can be detected from remotely sensed data either directly from bare soils, with salt efflorescence and crust, or indirectly through the biophysical characteristics of vegetation as these are affected by salinity. In the present case, salinity is driven by high evaporation rate and therefore, easy to detect.

Hyper-spectral data from LISS–III satellite in mid-infrared range is obtained and analysed for

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determining high salinity areas and plate faults. Ground validation using GPS system and samples are used to validate the analysis. Drainage system along the fault lines is earmarked for drainage and forestation activities.

2. Materials and Methods

IRS 1D LISS- III data is used for the present analysis. Most of the remote sensing research related to the identification of saline or water logging soils has been done by selecting wavelength regions, particularly in the mid infrared, from laboratory spectral data of samples that discriminate between types of soil, and comparing the laboratory results with hyperspectral data. Advance Visible and Infra Red Imaging Spectrometer is used in the present case. Analysis technique follows Kumar (Unpublished data). Further, salt Normalized Difference Salinity Index [(Red-IR)/(Red-IR)], salinity index (Red/IR), soil brightness index and supervised classification were used to differentiate salt affected areas and salinity level. Satellite data registration is followed by classification of probable salt affected areas (pre field) and masking out areas which gives similar signature as salt. This provided land use/cover map. Soil sampling points were located as per sampling needs and collected for laboratory analysis. The probable salt affected areas were integrated with the map and later characterized for severity of salinity, thus forming the final map.

The analysis is done only for Muzaffarpur and adjoining districts due to limited resources and scope of study. Over 100 samples of soil were collected, mainly in Muzaffarpur and results are extrapolated statistically using cubic spline to other areas. The maps generated from satellite data were corrected using topography maps and Ground Positioning System (GPS). False colour composite maps were prepared and analyzed for salinity determination, earmarking drainage channel possibility and first stage of afforestion activity.

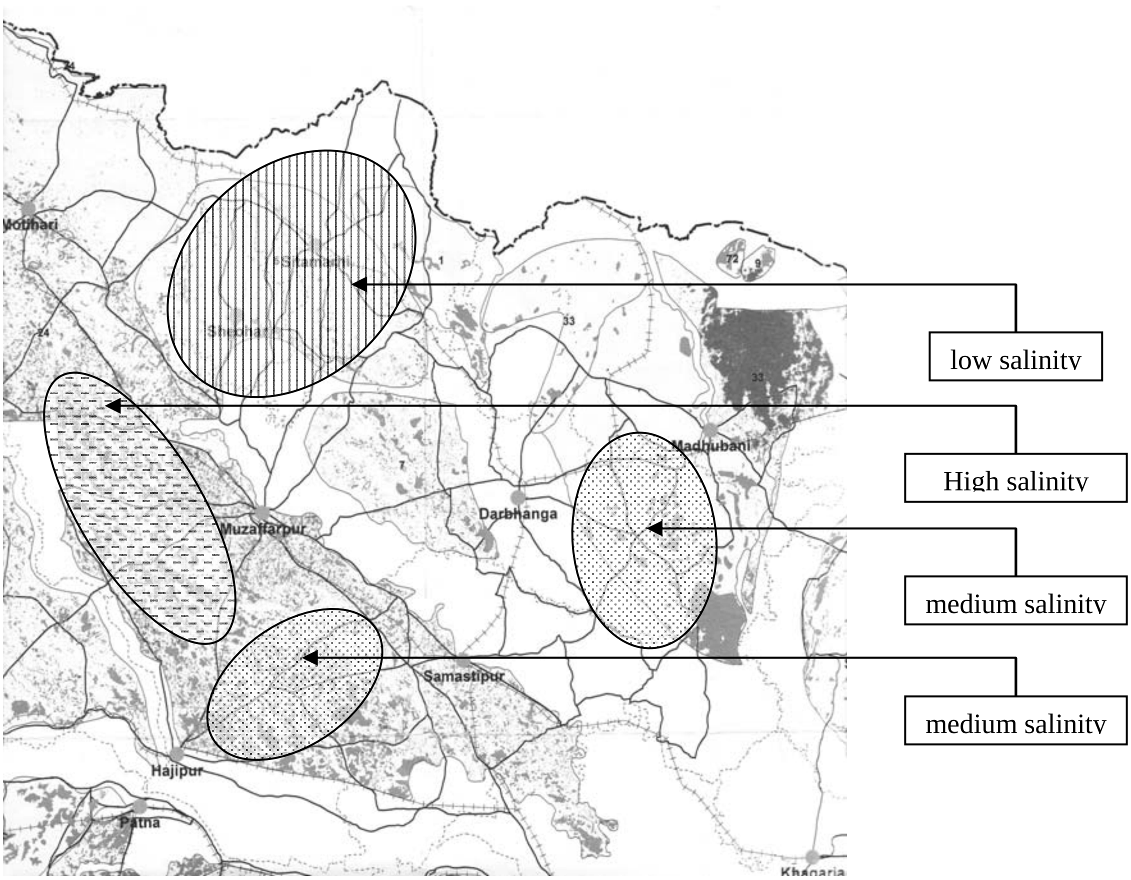

Fig. 1. Salinity classification of areas around Muzaffarpur.

Soil samples for salinity analysis in the vicinity of water logged areas and moist areas are further carried out on the basis of visual appearance. Sampling frequency per 2-3 km^2 was done in 0-30 cm depth. The samples were oven dried and analyzed with the help of automatic pH and EC analyzer. The process was repeated twice to eliminate any error. The pH and EC values were further subjected to temperature correction against reference 25 ˚C. Exchangeable sodium percentage (ESP) was determined by double flame spectrophotometer for samples having pH above 8.5. Measurement of Cation Exchange Capacity (CEC) and exchangeable sodium is calculated to compute ESP.

3. Results and discussion

Salt affected soils are shown in **Figure 1** with classification of low, medium and higer salinity as per following criteria,

(1) Low salinity (EC < 4 ds/m at 25 ^{o}C, pH < 8.5 and exchangeable sodium percentage < 15)
(2) medium salinity (EC < 4 ds/m at 25 ^{o}C, pH > 8.5 and exchangeable sodium percentage > 15)
(3) high salinity (EC > 4 ds/m at 25 ^{o}C, pH > 8.5 and exchangeable sodium percentage > 15)

The reasons of salinity in North Bihar are, (a) higher level of ground water; (b) water logging; and (c) traditional agricultural practices, such as flood irrigation etc. Under these conditions, it was found appropriate to earmark the two River basins in the area, Brahmpura River basin and Gandak River basins. Since, movement of surface water is decisively affected by the fault lines, these are considered in the present analysis. **Figure 2** shows the two basins and the fault lines determining movement of surface water. The area between the fault lines and falling under the river basin are most vulnerable to salinity, such as those falling between East Patna fault line and West Patna Fault line. Water movement across the fault line during rainy season is considerably small. On the other hand, flash floods, such as those from Baghmati River across the fault lines, decisively affects the soil condition. High evaporation rate and stagnant water contributes to salinity problem. Absence of large water bodies, also aggravates the problem.

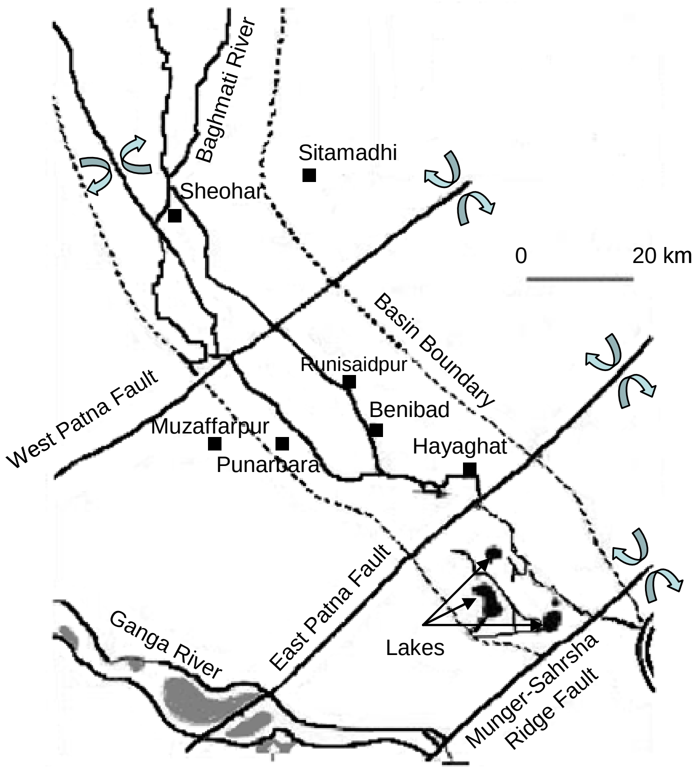

Fig. 2. Fault lines and river basin arround Punarbara Village of Muzaffarpur District.

Areas lying between East Patna fault line and Munger Saharsha ridge fault line has an advantage to have large water bodies and therefore, natural buffering effect occurs. Muzaffarpur lies near to the west Patna fault line and the research site, Punarbara village within the basin boundary. Soil of Punarbara village and its vicinity are likely to turn saline sodic if proper drainage system is not made across the fault lines or otherwise. The area has very high water table and surface salt deposition due to high evaporation rate. High salinity has already started adversely affecting the area in terms of reduction of agricultural produce, mainly by damaging the drainage system till now. Proper drainage system across the fault line and creation of water bodies will help in mitigating the effect from salinity.

Punarbara village is also affected by drought condition quite often atleast once in four years due to scanty rain fall. Integrated management of the flood, drought and salinity can be best made by large scale afforestation in the area. Afforestion activity along the fault lines has better initial chances of survival. At the same time, this would help in controlling flash floods and reducing the harshness of the flood in case of high rain fall. Besides, drainage system across the fault lines and creation of water bodies are other parallel options to be exercised.

4. Conclusion

Mass migration of rural population to urban slums in search of livelihood can be stopped if integrated management of salinity, floods and droughts are made. The severity of salinity problem shows that agricultural system is likely to collapse if the present state of affairs continues without corrective measures. The most important among them are putting in proper place drainage systems and afforestation on a large scale. Satellite data provides ample opportunity for integrated management of the system and likely reclamation of soil.

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