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Remote Sensing Techniques for Mapping Degraded Land

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ABSTRACT: Land degradation has become a global urgent issue and is now being considered with high priority, especially in the developing countries in order to meet food and fibre demands of accelerated population pressure with the limited available resources. Land degradation by waterlogging and salinization causes decline in production capacity of land. Waterlogging and salinization are two main causes of land degradation in a canal command area. The study was conducted for two distributary comamnds namely, Pansora and Chikhaliya of MRBC (Mahi Right Bank Canal) command area. Remote sensing data of IRS-P6 LISS-III sensor and IRS-1D LISS-III sensor were analyzed for delineation of waterlogged and salt affected area using digital image processing techniques. For waterlogged and salt affected area detection, first K-Means unsupervised classification was carried using the data of Green, Red, NIR (near infrared) and SWIR (short wave infrared) bands as input. However, in the first stage classification water bodies and waterlogged areas could not be separated from each other. So in the second level classification, only the area under water bodies and waterlogged classes were considered and again classified. This could differentiate the water bodies and water logged areas and the areas under waterlogged classes were estimated. In the command area of Pansora distributary, the waterlogged area was found to be 212.6 ha, while in Chikhaliya distributay command area, the salt affected area was found to be 1423 ha.

KEYWORDS: Remote Sensing, Waterlogged, Salt affected, DN.

I. INTRODUCTION

Land degradation is a global phenomenon. The land degradation occurs due to the interactive effects of anthropogenic and biophysical factors on soil properties and leads to adverse alter in soil properties, environmental quality, agricultural productivity and sustainability. Land degradation has been defined in many ways where the prime attention has been given to declining productivity of the soils for example United Nations Environment Programme (UNEP, 1997) defined soil degradation as the rate of adverse change in soil quality resulting in decline in productive capacity of the land induced mainly by human interventions. Also Singer and Munns (2002) defined soil degradation as the loss of soil production by either chemical or physical processes.

Waterlogging and salinization has become a global urgent issue and is now being considered with high priority, especially in the developing countries in order to meet food and fiber demands of accelerated population pressure with the limited available resources. Degradation of land occurs by various ways like soil erosion by wind and water, salinization and or alkalization, waterlogging and chemical pollution from effluents of chemical industries. An estimated 7 million hectares of land in India are affected by salinity and /or alkalinity. These lands are invariably barren. Irrigation systems have always been considered as an effective way of increasing agriculture production since ancient times. Through bridging the gap of water shortage with the help of irrigation systems, the farmers have obtained quite stable productivity. But they started facing an acute problem of water logging and salinity due to seepage from the huge system in most of the countries including India.

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Present-day scenario is much more complex with vast extension of irrigated areas, intensive irrigation practice with multiple cropping, adoption of high water consuming crops and the irrigation management being over-burdened with socio-economical considerations.

Irrigation in arid and semi-arid areas leads to waterlogging and accumulation of salt at soil surface. Waterlogging problem caused due to excessive irrigation, seepage from canals and lack of drainage. Irrigation in arid and semi-arid areas leads to waterlogging and accumulation of salt at soil surface. Water logging in command areas is caused by seepage from unlined canals, Damaged portions of lined channel beds, Blockage of natural drainage due to the network of canals and roads, Poor working of existing surface drainage systems, Very little utilization of groundwater for irrigation and Internal flow of sub-surface water. Waterlogged areas are identified in remote sensing by optical data, microwave data, thermal data or through crop indicators. In optical data, waterlogging is studied by using pre and post monsoon RS data, because of their darker tone compared to the surroundings. Permanent water bodies can also be demarcated from pre monsoon imageries.

Salinization occurs naturally (Fossil salinity) or as a consequence of poor irrigation practices (Secondary salinity). Fossil salinity occurs at margins of natural depressions, where rain and floodwater accumulate. The soil becomes loaded with salts because of capillary rise of water to the surface. The effects of salinity (in order of severity) can be Stunted crop growth, Poor and patchy germination, Crop stress, Death of crop, Encroachment of halophytic species, Bare soils with efflorescence, and Salt crust development. From images of pre-monsoon period agricultural salt affected lands can be delineated based upon high reflectance, lack of vegetation or patches with poor crop growth.

The problem faced in MRBC command is of staggering proportions and is the major factor preventing agriculture productivity increase. In the present study, satellite imageries of IRS-P6/1D with LISS-III Data of 26, November 2002 and 8, February 2004, have been used for mapping water logged and salt affected areas.

For mapping salt affected soils in Punjab, Pakistan, Khan et al. (2001) used IRS-LISS II digital data and different remote sensing derived indices such as salinity index (SI), Normalized Difference Salinity Index (NDSI), Brightness Index (BI), Normalized Difference Vegetation Index (NDVI). Sahai et al. (1985), studied the impact of canal irrigation on ecosystem of Ukai-Kakrapar command area in Gujarat due to waterlogging/salinity using multitemporal, multispectral Landsat imagery of pre and post monsoon period for 1972-82. Sharma and Bhargawa (1988), followed a collective approach comprising the Landsat 2 MSS FCC, Survey of India Topographical maps and limited field checks for mapping saline soils and wetlands. Their results showed that because of their distinct coloration and unique pattern on FCC imageries the separation of saline and waterlogged soil was possible. Dwivedi(1996), Rathore and Jain(2001), Sharma and Bhargawa (1988); found that the development of aerial photographs and the subsequent advances in satellite remote sensing and image processing techniques have enabled the detection, mapping and monitoring of waterlogged areas. Mutlaq (2002) assessed degradation in Mathura district, Uttar Pradesh, India through visual interpretation and digital image processing. He could identify different types, extent and degree of degradation. Bai and Dent (2006) reported on a pilot study done in Kenya during the global assessment of land degradation in dry lands. Ajai et al. (2009) successfully identified different types of degradation in India through remote sensing techniques. Many approaches used for mapping land degradation such as visual interpretation, unsupervised, supervised classification and remote sensing derived indices (Gupta et al. 1998 ; Saini et al. 1999 ; Porarinsdottir, 2008 ; Jafari et al. 2008 and Koshal, 2010).

II. STUDY AREA AND DATA BASE

The Pansora and Chikhaliya of Mahi Right Bank Canal (MRBC) command area selected for waterlogged and salt affected area detection (Figure1). The MRBC command area in Kheda district of Gujarat state lies between 22°26' N to 22°55' N and 72°49' E to 73°23' E.

For detection of waterlogged and salt affected area, the digital IRS-P6/1D LISS-III sensor data were used as given in (Table 1.)

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Table 1: Details of Remote Sensing Data Used

Satellite	Sensor	Path/Row	Date
IRS P6	LISS-III	93/56	January 15,2004
IRS P6	LISS-III	93/56	February 08,2004
IRS 1D	LISS-III	93/56	November 26,2002

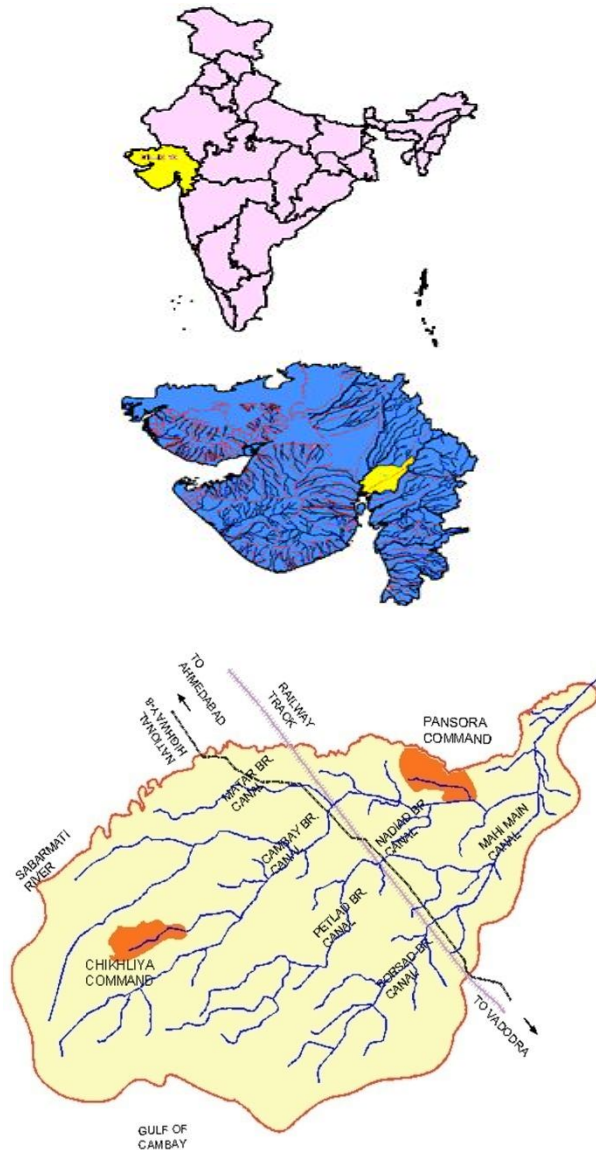


Figure 1: Location of the study area in India

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The ancillary data includes statistical information and spatial data of canal network, command boundary, and topographical maps. The MRBC command area is spread over nine 1: 50,000 Survey of India (SOI) toposheets, namely, 46 B/6, B/7, B/10, B/11, B/14, B/15, 46 F/1, F/2 and F/3. Out of these, there are four main sheets (46 B/10, B/11, B/14 and B/15), which are completely covered by the command area.

III. METHODOLOGY

The digital remote sensing data were processed and analyzed using the PCI Geomatica V9.1 image processing software. Initially, the digital data of all scenes were geo-referenced. The 15 Jan 2004 image was considered as the master image since the ground control points (needed for geo-referencing) were very clear. This image was first geo-referenced by taking various controls points from the SOI (survey of India) toposheets. The projection type used was "UTM" with the Everest spheroid. Subsequently image to image registration was performed in order to register the other images. Some sharp and easily identifiable features like crossing of roads, railways, canal etc. were located on all images and were selected as GCP's (ground control points). Some GCP's with RMS (Root mean square) errors beyond threshold were deleted and replaced by others points so as to maintain acceptable positional accuracy.

The water logging classification was carried in Pansora Distributory command. For this LISS III data of 26 November, 2002 (post Monsoon) was used. First K-Means unsupervised classification was carried using the Green, Red, NIR (Near Infra Red) and SWIR (Short Wave Infra Red) band as input. However, in the first classification water bodies and waterlogged areas could not be separated from each other. So in the second level classification, only the area under water bodies and waterlogged classes were considered and K-Means classification approach was followed. This could differentiate the water bodies and water logged areas. The area under waterlogged class was estimated. and compared with the area given by Brahmabhatt et al. (2001), to monitor the change from 1997 to 2002.

IV. RESULTS AND DISCUSSIONS

A. *Waterlogging*

The visible, NIR (Near infra red) and SWIR bands provide encouraging results on pattern of waterlogging. For separating water body from water logged area, FCC of NIR, Red, green shown in Figure 2 and FCC of NIR, SWIR, Red shown in Figure 3 can be compared together. Prominent waterlogging are identified from the image elements as dark blue to blue/black tone shown in Figure and mostly found along canal.

The comparison of digital number values for water body and waterlogged area for various band show that difference is more apparent in 26th November data shown in Figure 4. In 26th November data the difference is more remarkable in SWIR band followed by NIR band. DN values of waterlogged areas are higher than water bodies.

The area affected by waterlogging falls mainly along the canal. Brahmabhatt et al. (2000) had found that the waterlogged area in Pansora command had increased from 285 ha in 1991 to 586 ha in 1997. In 2002, from our study, it was found that waterlogged decreased from 586 ha in 1997 to 212.6 ha in 2002 in pansora distributory. The increase in waterlogged area from 1991 to 1997 had caused a decrease in agricultural area from 5076 ha to 4888 ha as observed by Brahmabhatt et al. (2001). Further in 2002, we found agriculture area has increased from 4888 ha to 5148.4ha. The output of IRS data is shown in Figure 5.

B. *Salt Affected Area*

Figure 6 and Figure 7 show the FCC (NIR, Red, Green and NIR, SWIR (MIR), Red) of 8th February 2004 for Chikhaliya command. Features, which are associated with gray to yellowish white indicating salt efflorescence. The light gray to grayish red with red molting indicated saline area with patchy crop, as shown in FCC of NIR, Red, Green and also FCC of NIR, SWIR, Red.

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The digital number value of different bands for various salt affected classes in 8th February and 26th November data are shown in Figure 8. All salt affected area have high digital number ranging between 70 to 170; the areas with salt encrustation has higher DN values in all bands followed by mudflats and salt affected land with patchy vegetation. Between 1993 to 1997, the increase in salt affected area, observed by Brahmabhatt et al. (2000), was 195 ha (1221 to 1416 ha) in Chikhaliya Distributary command. However, in 2004, there are minor changes in salt affected area observed in this study. The salt affected area increase was only 7 ha (1416 to 1423 ha) from 1997 to 2004. The study of Chikhaliya Distributary for salt affected area showed that in the last seven to eight years the menace of salinisation in MRBC command area was mostly under control. The output of IRS data is shown in Figure 9.



Figure 2: FCC of NIR, Red, Green (Pansora Distributary)

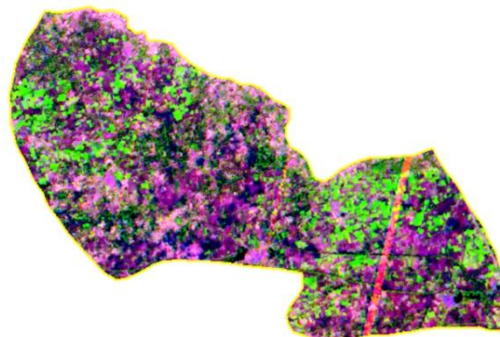


Figure 3: FCC of NIR, SWIR, Red (Pansora Distributary)

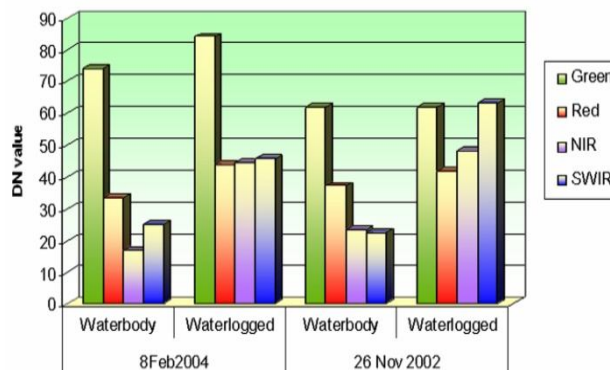


Figure 4: Comparison DN value of different bands for waterbody and waterlogged area

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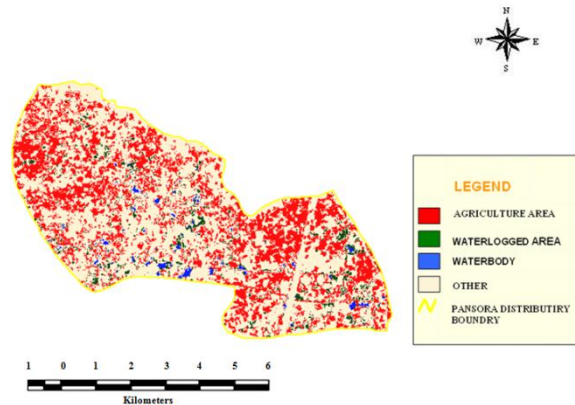


Figure 5: Output of IRS data for Pansora Distributary

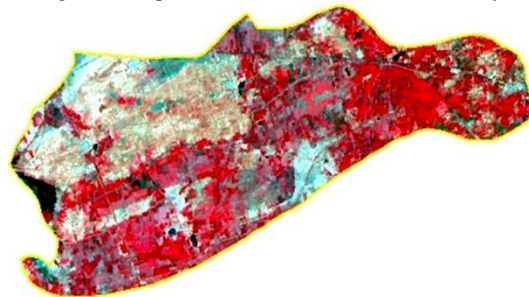


Figure 6: FCC of NIR, Red, Green (Chikhaliya Distributary)

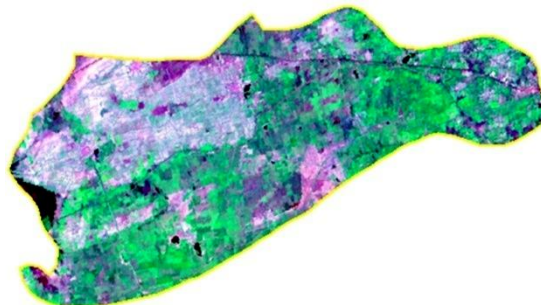


Figure 7: FCC of NIR, SWIR, Red (Chikhaliya Distributary)

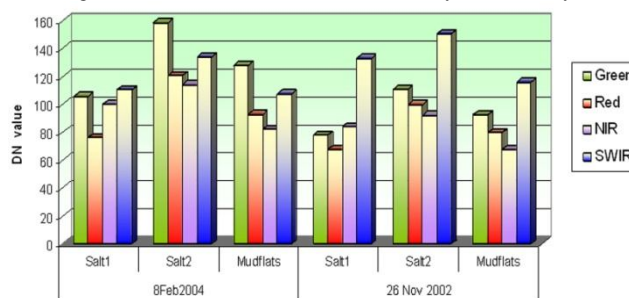


Figure 8: Comparison DN value of different bands for various salt affected classes

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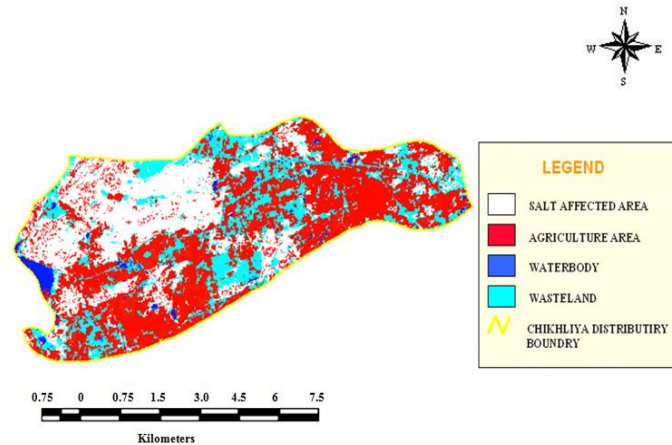


Figure 9: Output of IRS data for Chikhaliya Distributary

V. CONCLUSION

In this study land degradation of two distributaries of MRBC command were delineated using LISS-III data for year 2002/2004 using digital image processing techniques. The analysis has shown that land degradation in MRBC command was mainly due to waterlogging and salinization.

A remote sensing based study could show the aerial extent of these degraded lands, which would be helpful for planning proper reclamation measures. Hence, a regular monitoring command area using satellite-based remote sensing data is essential for improving the performance of canal irrigation systems.

The analysis has shown that waterlogged area has decreased in the Pansora Distributary command area, and the water logged area was identified mostly along the canal. There were minor changes in the spread of salt affected area during last five to six years in the Chikhaliya.

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