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The Use of Satellite Data for Identifying the Risk of JE Disease in District Gorakhpur, Uttar Pradesh, India.

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ABSTRACT

The tropical environment is highly conducive to the propagation of vector borne disease all over world. Such as dengue, plague, lymphatic filariasis, malaria and Japanese encephalitis (JE) have long been cause of severe problem. In whole world a new trend of vector disease i.e. JE is the more killer of human beings in the northern states of India. Over the past 60 years, it is estimated that JE has infected approximately 10 million children globally, killing 3 million and causing long-term disability in 4 million. JE virus is transmitted by Culex mosquito, particularly, Culex vishnui. Pig is the amplifying host of JE virus, and suitable reach to shallow surface water. The factors can be detected using satellite data which provide high spatial and temporal coverage of most of earth surface. It is mainly tropical disease, so using temporal satellite image can provide strong tool for monitoring disease around affected sites. The present study combines the use of remote sensing and GIS to provide a strong tool for monitoring environmental conditions, and mapping the disease risk to human populations. Landsat ETM data were initially classified into spectrally distinct water and vegetation classes, GIS has been used in turn to identify suitable presence and proximity to habitat sites. The study shows that the mosquito habitat area increases with seasonal change and due to increase in rice cultivation land cover type.

Keywords: Japanese Encephalitis (JE), Landsat ETM, Land use map, GIS, Remote Sensing.

1. INTRODUCTION

Vector-borne pathogens cause enormous suffering to humans and animals. Many are expanding their range into new areas. Malaria, Dengue, West Nile, Chikungunya and Japanese

Encephalities (JE) have recently caused substantial human epidemics. Arthropod-borne animal diseases like Bluetongue, Rift Valley fever and African horse sickness pose substantial threats to livestock economies around the world (Tabachnick 2009, Vanwambeke *et al*., 2008). Changes in climate will influence arthropod vectors, their life cycles and life histories, resulting in changes in both vector and pathogen distribution and changes in the ability of transitions of pathogens. Climate can affect the way pathogens interact with both the vector and the human or animal host. The spatial and spectral resolutions of satellite image data are increasing, suggesting opportunities to apply such data to problems in which contact patterns, distances or environmental factors are important. Various reports, including many in this issue, have suggested that higher resolution data when combined with more powerful tools for data manipulation and analysis should enhance efforts to identify time-space patterns that underlie the etiology and risk of many diseases (Hey *et al*., 1998).

Satellite-derived information considered useful in understanding these diseases include patterns of vegetation (crop type, deforestation, rate of green-up), habitat type (forest patches, ecotones), fresh water sources (permanent water, wetlands, flooding, soil moisture, canals), housing (human settlements, urban features) and ocean conditions (ocean color, sea surface temperature, sea surface height) (Kallouri *et al*., 2007; Stoops *et al*., 2008). Interestingly, it appears that there are no simple associations among disease type, source of infection or transmission and environmental features considered. None of the microbes causing these diseases depend directly on vegetation for their survival or transmission. Despite enormous differences among this wide range of pathogens whose transmission cycles involve assorted animals and/or vectors, each was studied using characteristics of local vegetation. Similarly, water-related characteristics (e.g. extent of wetlands, flooding, and presence of canals) obtained from satellite images also were used to study many of these same diseases, as well as cholera, filariasis, onchocerciasis and St. Louis encephalitis.

Self *et al.,* (1973); have analyzed the assessment of JE in Korea from the collection and monitoring of cows and pig with seasonal abundance. The main breeding sites in the study area were swamps, marshes, and ricefields. The overall adult densities were the lowest at the rice-growing site where agricultural pesticides were extensively used. Remote Sensing and GIS enhance the understanding of the relationship between vegetation and vector-borne disease and prepare health professionals for changes in the distribution of important infectious pathogens (Wilson, 2001; Chaung *et al*., 2012). An important step in understanding their ecology for the purposes of intervention is to determine the environmental causes of the spatial and temporal variation in the disease (Beck *et al*., 2000).

2. STUDY AREA:

Gorakhpur occupies the North Eastern part of the State of Uttar Pradesh, and is located to the North of the river Ghaghra. Gorakhpur is located between Latitude 26º 13’ N and 27º 29' N and Longitude 83º 05' E and 83º 56’ E (Fig. 1). Based on its geographical area, the district occupies the 15th position in the state in terms of size. The majority of the cases of vector borne disease came from eastern Uttar Pradesh (Gorakhpur and adjoining areas), which is the paddy growing Terai area. Uttar Pradesh (a northern state of India) lies between latitudes 24º and 31º north and longitudes 77º and 84º east. An epidemic of viral encephalitis was reported from July through November in 2005 Gorakhpur, Uttar Pradesh, India. It was the longest and most severe epidemic in 3 decades; 5,737 persons were affected in 7 districts of eastern Uttar Pradesh, and

1,344 persons died. Emergence or resurgence of numerous infectious diseases are strongly influenced by environmental factors such as climate or land use change (Patz *et al*., 2008).

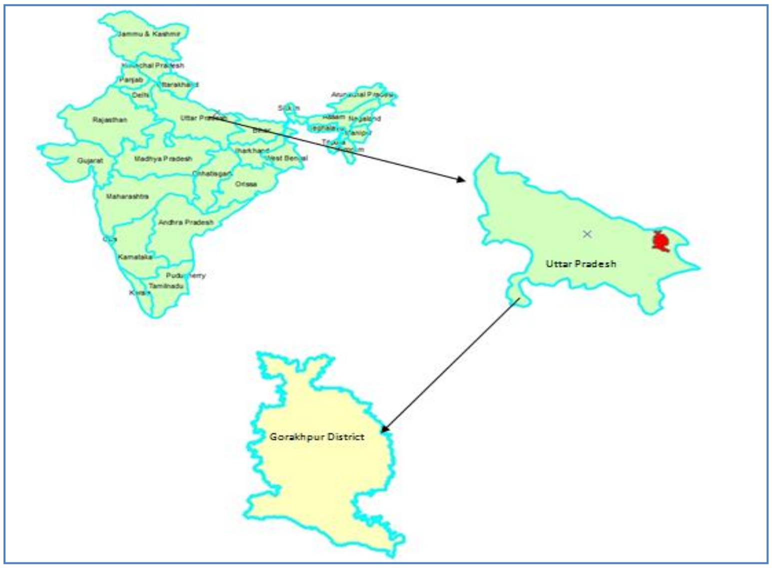


Fig. 1: Location of Study Area

3. DATA Used

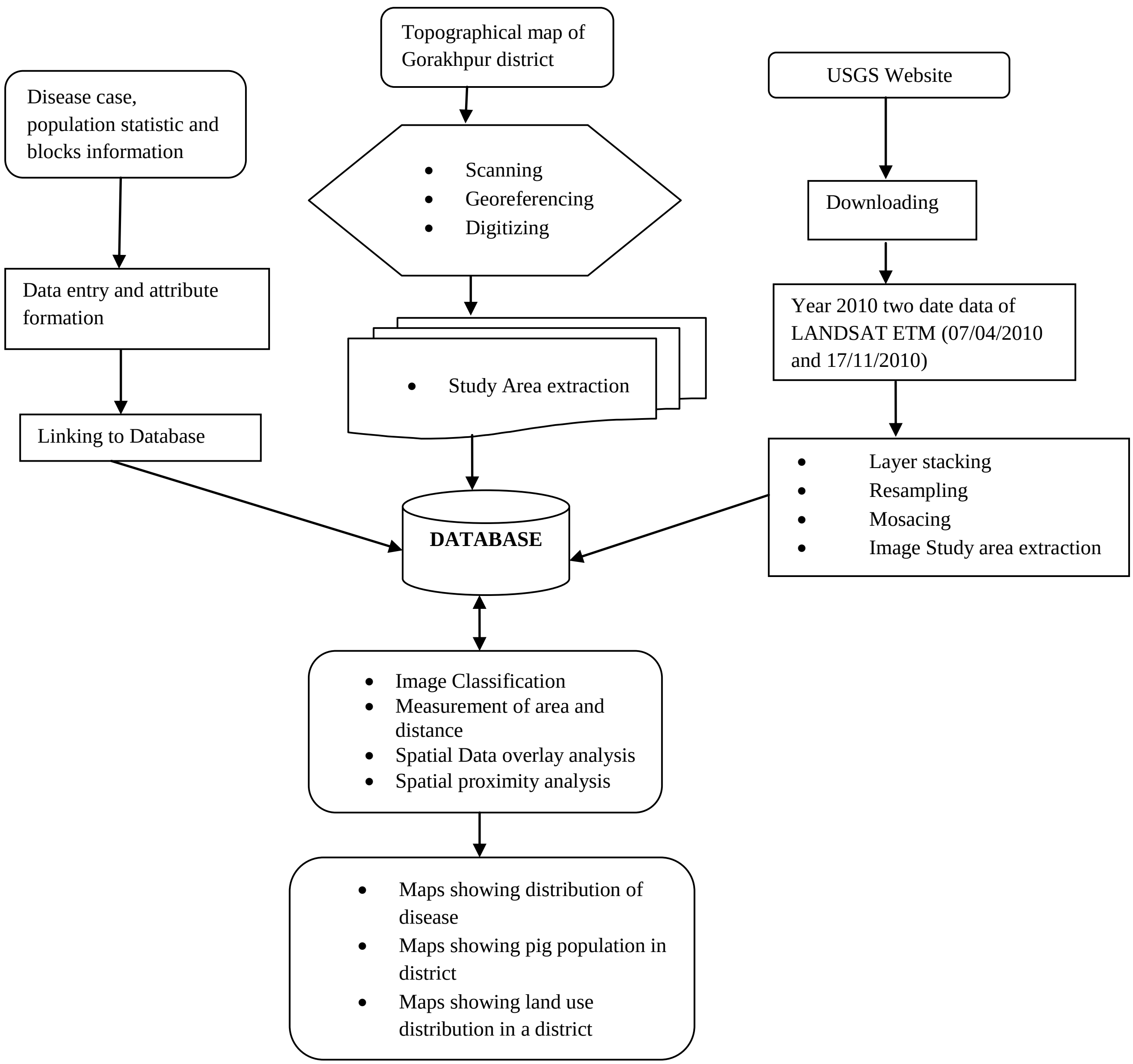
The ancillary data were collected from study area, district hospital and district statistical book of Gorakhpur district. The topographical maps were collected from Survey of India (Dehradun). Landsat ETM data was downloaded free of cost from USGS. The USGS developed new image products to fix the striping problem by combining two separate dates or by interpolation to fill in the data gaps. Multi-temporal standard mode ascending pass of LANDSAT ETM were acquired, with a nominal spatial resolution of 30 m and swath coverage of 185 km^2.

The LANDSAT ETM images were acquired for both the dry season 7th April 2010 and for the wet season i.e. 17th Nov 2010. In this region of study area, April 2010 marks the end of the dry season while; November 2010 images were acquired during the starting winter season. The selection of imagery was limited due to difficulties in finding relatively cloud-free data.

4. METHODOLOGY

The focus of this research is to demonstrate the usefulness of LANDSAT ETM data for monitoring and mapping JE in Tarai area of Gorakhpur district.

The broad methodology adopted is shown in Fig. 2.



The methodology has been developed to carry out the work towards collection and creation of base study area, block boundary, disease data, pig-population data were integrate in GIS environment. The satellite data from seven band, spectral band 6, thermal infrared band, was removed from all dates of imageries. The thermal band was not included as it measures the amount of infrared radiant flux emitted from surfaces (Jensen, 1996). While other bands provide a measure of reflected energy, band 6 measures transmitted energy. The remaining bands, 1-5 and 7 were subset from each individual scene and were layer stacked to create imagery. Originally, all the remotely sensed data are geocoded to the Universal Transverse Mercator (UTM) projection but to attain precise result all the satellite imagery were rectified using ground control point (GCP). Satellite scenes were loaded in to Erdas Imagine software (2010) then geometric correction was run to rectify the satellite scenes to Universal Transverse Mercator (UTM) map projection. Rectification would correct the distortion within the scene as well as georeference the scene to UTM co-ordinate system. The first and second scene to be geocoded by using base map data with Root Mean Square (RMS) equal to ± 0.3 and ± 0.8 for which map co-ordinates were known. The points were precisely collected on the road network intersection points. Polynomial transformation model was adopted due to its simplicity and because such a model is highly recommended for flat areas.

Satellite data is classified based on signature of pixel, created using an AOI tool to separate significantly contrasted adjacent regions in an image based on image brightness values, and extracts the homogeneous regions as individual objects.

A supervised classification was performed on both two season dataset of year 2010. This approach is totally dependent on the spectral pattern recognition (Liliesand, 1994). The training areas were delineated from false color composite image. Resulting classification was validated using qualitative accuracy assessment technique.

Classified polygons were extracted as GIS layers for use in the disease risk map generation procedure. The premise for assessing areas at risk of JE infection is based on the maximum distance a vector-carrying mosquito can travel from its breeding ground to infected human hosts. For this study, a 2 km buffer zone around the classified larval breeding grounds was used (Kaya *et al*., 2001) the paddy field class was considered to be most conducive to larval breeding (Beck *et al*., 1994). With this information, a risk map was generated to show the populated areas that lie within the 2 km buffer zone.

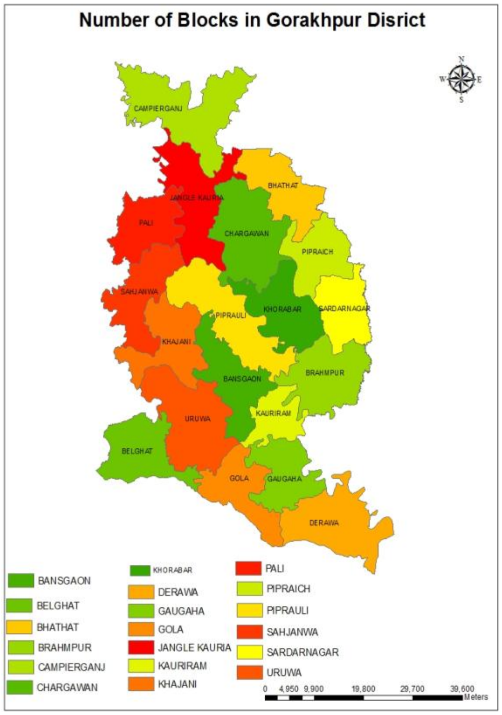
5. RESULTS AND DISCUSSIONS

The larval habitats of mosquito are depending on change with season. During the dry season, some rivers and streams become completely dry, while others have reduced flow and numerous isolated, residual pools of water in the main riverbed. The pond area of some places stay permanently flooded throughout the whole year. Seasonal cultivation is also present and some are used for rice cultivation during the rainy season.

The Table 1 are showing the area which is extracted from each class using training site sample. Ten classes were classified in studies. The proportion of area comprised the both image data.

Table 1: The total area covered by each land cover type of month April and November, Year 2010

Class Name	April - 2010		November - 2010		Suitability for disease
	Area (km^2)	Proportion (%)	Area (km^2)	Proportion (%)	
Pond	44.50	1.32	39.58	0.74	Not - Suitable
Scrub	12.11	0.361807	85.14	2.46	Very Suitable
Dense Forest	71.50	2.135868	71.06	2.06	Not Suitable
Agriculture	1007.65	30.09983	884.87	25.66	Very Suitable
River	91.92	2.745924	94.23	2.73	Not Suitable
Water_sand	24.34	0.727163	49.95	1.44	Not Suitable
Settelement	292.20	8.728518	292.71	8.48	Suitable
Paddy_Field	986.36	29.46402	1531.52	44.41	Very Suitable
Fellow_land	324.85	9.703697	266.88	7.74	Not Suitable
Barren_land	492.23	14.70362	145.92	4.23	Not Suitable
Total	3347.69	100	3347.69	100	



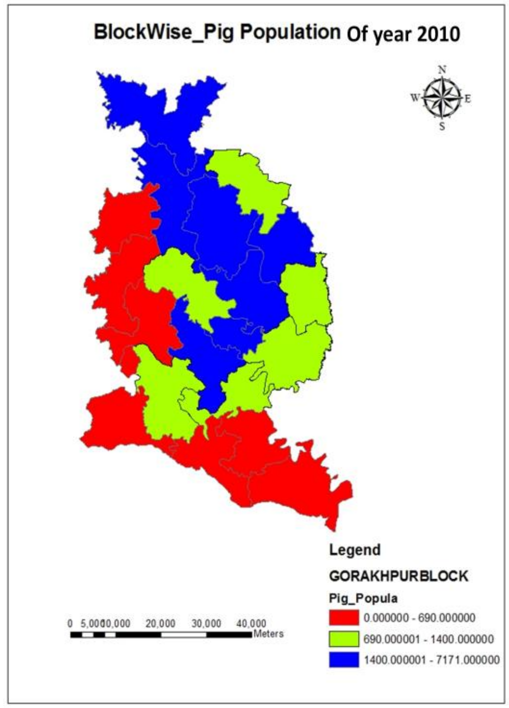
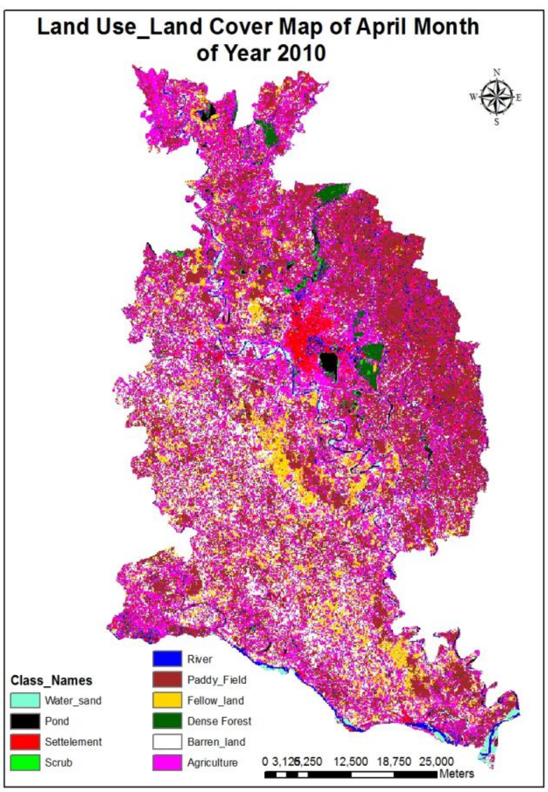


Fig. 4: Number of Blocks in Gorakhpur District

Fig. 5: Number of Pig Population in Blocks



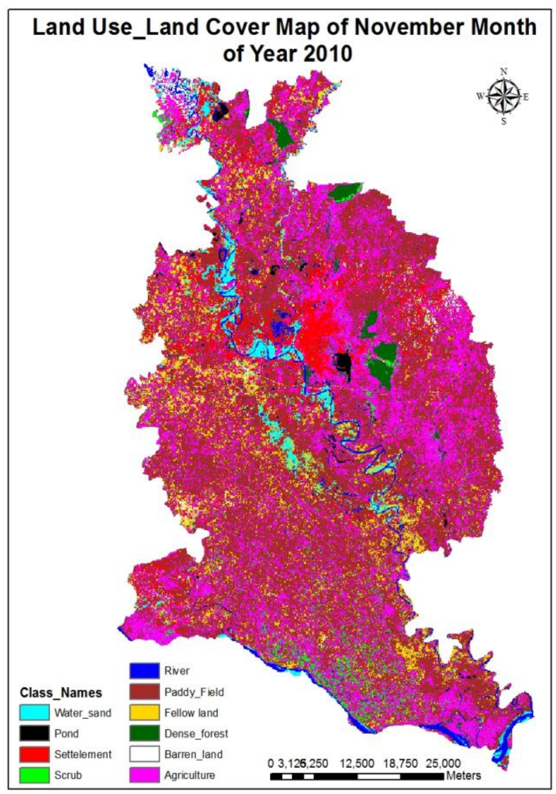
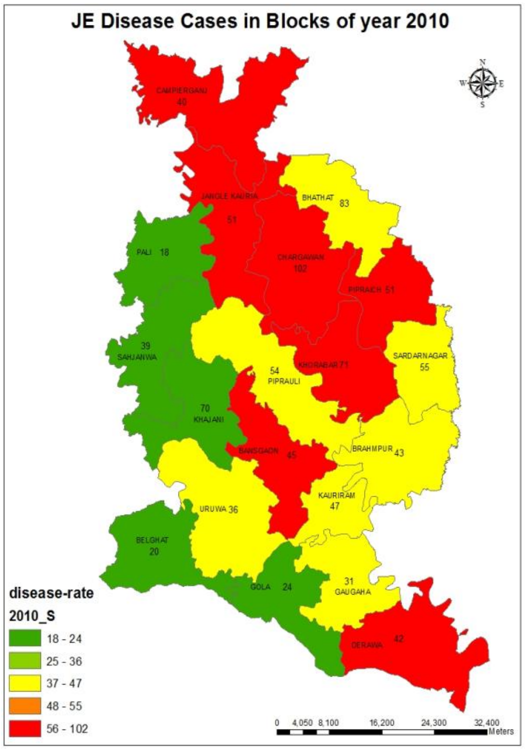


Fig. 6: Land Use_Land Cover map of 2010 April

Fig. 7: Land Use_Land Cover map of 2010 November



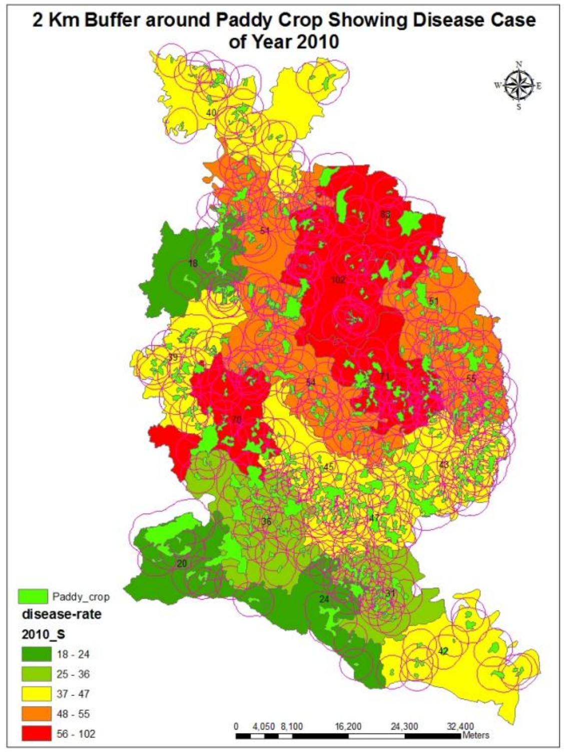


Fig. 8: JE disease case in Blocks

Fig. 9: 2 Km buffer around paddy field in more susceptible Blocks

The study area constitutes 19 blocks (fig. 4). Comparing the gradual increase of pig habitation in blocks (fig. 6) there was generally slight increase the pig population habitats in blocks in range above 1400 (Campierganj, Jungle Kauria, Khorabar, Chargaon, Piparaich, Bansgaon, Derwa). JE cases were also found in this area more than 56 cases in this areas. The areas covered by settlement, paddy field, water bodies, with agriculture were which are more extensive in November 2010 than in April 2010 (fig. 6 & 7). Conversely, the forests, and barren land were more extensive in April 2010 than in November 2010. So the most increase habitation of in this area overlay the disease cases are more in this blocks in range above 60 cases (fig. 8). The paddy field was more in these blocks increase in the months November 2010. Conversely there was an increase in the fresh water swamps and a decrease in the water bodies because of the increased growth of fresh water weeds and plants which are known to be moderately favorable for JE habitats.

6. CONCLUSIONS

This study demonstrates the methodology of using LANDSAT ETM images for identification of land cover variables that may be associated with disease-carrying mosquito breeding. The use of software demonstrated the importance of classification for LANDSAT data, which allows for quantification of surface patterns that are not adequately done with per-pixel approaches. LANDSAT imagery was used the proximity approach to find out the area which is located around paddy field area and most sensitive to disperse the disease. The two season data and timely data have given main advantages of the data for disease monitoring applications.

Gorakhpur and other tropical areas, should be needed a strong operational disease surveillance tool. This research demonstrates how LANDSAT remote sensing could plays critical role in addressing this need. 89.00% and 91.00 % accuracy was found to overall classified map. The large areas covered by paddy field in April to November relatively homogeneous area and were classified in between 78.59 % to 89.29 %. For the tarai region near to district are tending to high increase rice cultivation seasonally. This land would be favorable to habitation of piggistic population which is host of JE vector. The digital data processing using satellite data has given prospects results on spatial distribution of disease. Additionally the role of this technology remains to be explored for supporting the implementation of endemic surveillance activities.

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