

# Role of Remote Sensing Using Topographic Analysis for Wetland breeding sites Encephalitis Disease Vectors in Gorakhpur district, Uttar Pradesh, India.

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**Abstract-** Japanese encephalitis is confirmed to Asia and is almost always associated with rice ecosystems. In India, JE was clinically diagnosed for the first time in 1955 at Vellore, erstwhile North Arcot district of Tamil Nadu. Subsequently, the outbreaks have occurred in 25 states and union territories of India. In the past two decades many tropical countries have experienced several major encephalitis epidemics. Currently there is a renewed interest in exploring the possibility of vector control through additional using technique for environmental management. This study examined the determinants of mosquito larval habitats and usefulness of remote sensing in identifying these habitats in Gorakhpur district. The probability of finding aquatic habitats and habitats with larvae were modelled based on the digital elevation model and land-use types. Remote sensing also can be used for determining factors affecting vector abundance mosquito breeding sites. Remote sensing is a powerful tool for determining the landscape features and climatic factors associated with the risk of vector-borne diseases. The objective of this study was to assess using DEM for identifying larval habitats of vectors and for determining other topographic features.

**Index Terms** - Digital Elevation Model (DEM), Remote Sensing (RS), Topographic analysis, Vector borne disease (VBD)

## 1 INTRODUCTION

Japanese encephalitis (JE) is numerically one of the most important causes of viral encephalitis worldwide, with an estimated 50,000 cases and 15,000 deaths annually (Solomon, 2000). It was first described in Japan from the 1870s onwards. The virus (yellow fever virus) was classed as the genus *Flavivirus* (family *Flaviviridae*) is transmitted naturally between wild and domestic birds, and pigs by *Culex* mosquitoes. Pigs are the most important natural host for transmission to humans, because they are often kept close to humans (Floic *et al.*, 2002). It has been estimated that about 175,000 JE cases would occur annually in children under 15 years of age in the absence of immunization (Hills *et al.*, 2009). Epidemiological studies have shown that after the monsoon rain mosquitoes breed prolifically and as their numbers grow, so do their carriage of JE virus and the infection rate of pigs.

In India, JE was first recorded in Vellore & Pondicherry in mid 1950s (Saxena *et al.*, 2008). JE has been reported from 24 states/ Union Territories so far. Frequently affected states include Andhra Pradesh, Assam, Bihar, Goa, Haryana,

Karnataka, Manipur, Tamil Nadu, Uttar Pradesh & West Bengal.

is monitoring JE in India since 1978. The spread of JE to new areas is probably due to agricultural development and intensive rice cultivation supported by irrigation schemes. It has high mortality and morbidity rates. It is carried by female mosquitoes from infected pigs or water birds like pond herons and ducks to susceptible children. The main vector, *Culex* Mosquito (*Culex tritaeniorhynchus*, *C.vishnui*, *C.pseudovishnui* and others - totally 8 species) lives in rural rice growing and pig-farming regions. The mosquito breeds in flooded rice fields, marshes, and standing water around planted fields. This is the reason; JE is mostly a rural disease. Pigs are the most important reservoirs and the amplifying hosts (Rao, 2000).

In the 2005 Gorakhpur, Uttar Pradesh, India, outbreak spread in area had more severe clinical presentations and poorer outcomes (Halstead and Jacobson, 2007). Remote sensing is a powerful tool for determining the landscape features and climatic factors associated with the risk of vector-borne diseases (Mushinzimana *et al.*, 2006). The use of remote sensing techniques to map vector-borne diseases has evolved significantly over the past 25 years (Kallouri *et al.*, 2007). Various landscape components, such as land cover, hydrologic networks, vegetation characteristics, human and animal population distributions may determine the presence and abundance of immature breeding sites (Cailly., 2011). Wetlands are essential for the free ecosystem services that they provide to the human community. The most important and obvious are the maintenance of water quality, groundwater discharge and recharge, erosion control, flood protection and flow stabilization, storm dampening, healthy ecosystem

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functions, soil building, foodchain production, nutrient cycling and biogeochemical processes, habitat for wildlife, sites for research and environmental education, cultural heritage, open space preservation, aesthetics, tourism and recreation. They are important and give attention to turned and save recently wetland systems. Ramgarh Lake is the largest natural freshwater lake at Gorakhpur, and receives water during the monsoon season through rain. Domestic and sewage water of metropolitan city of Gorakhpur is also being discharged in the lake since many years. Lake water is being used for agriculture and other purposes (Singh et al., 2012). Gorakhpur being an agricultural based district, approximately 80% of its population lives in rural area, the prosperity of its agriculture largely depends upon the rainfall received during its summer monsoon (Arya et al., 2012).

Landsat is a low orbit satellite data whose TM sensor records data in 6 spectral channels at 30m X 30 m spatial resolution, and one at 120m X 120 m, with a repeat time of 16 d (Hay et al., 1997). Mosquito larvae are purely aquatic and develop in water bodies, the type of which is more or less specific to each species. Land cover delineates habitat suitability for vectors and land use determines the spatial distribution of humans. Vectors and hosts depend on spatially diverse environmental conditions, including land cover. Different land uses modify contact of susceptible humans with infectious vectors (Vanwambeke et al., 2007) and modify human cases distribution (Tran et al., 2007).

A disease spread is influenced by many environmental variables including temperature, precipitation and soil moisture. Flooded area is land of soil water drainage; a mosaic of interspersed human and the habitat of vector mainly swamps, ditches, and canals. Through the use of remote sensing, these habitats can be mapped and dynamic environmental variables can be measured and used to predict the habitat suitability of a particular area (Cleckner et al., 2011). Using terrain model derived from 90 meter Shuttle Radar Topography Mission (SRTM) digital elevation data (DEM) were performed better at predicting water drainage patterns and characterizing the landscape. These models were especially successful at ruling out potential locations, but had limited ability in predicting which species inhabited aquatic sites. Hence, satellite remote sensing and GIS tools have been used to demonstrate the utility space technology for rapid assessment of landuse/landcover and model the elevation and their relation with the incidence of JE leading to the mapping of risk prone areas.

## 2 STUDY AREA

The majority of the cases of VBD came from eastern Uttar Pradesh (Gorakhpur), which is the paddy growing "Terai area." Uttar Pradesh (a northern state of India) lies between latitudes 24° and 31° north and longitudes 77° and 84° east. An epidemic of viral encephalitis was reported from July through November in 2005 Gorakhpur, Uttar Pradesh, India (fig.1.). 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 (Saxena et al., 2009).

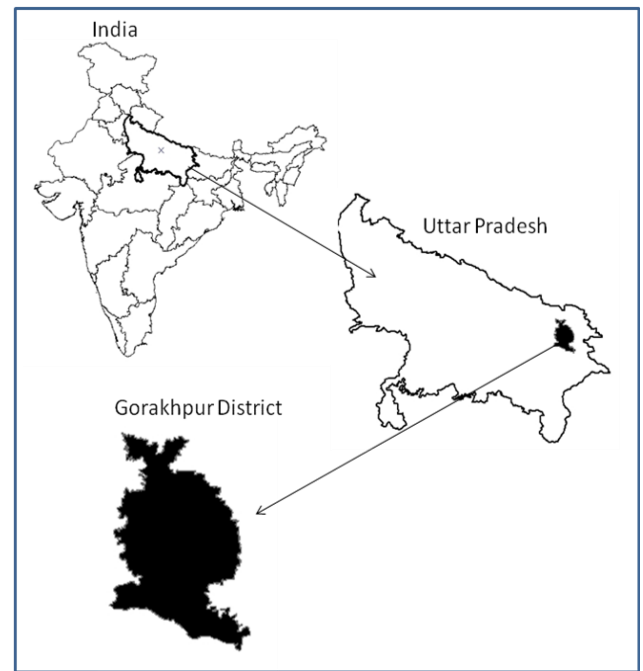


Fig. 1. Location Map of Study Area

## 3 DATA USED

The statistical data were collected from district hospital of study area. The topographical maps were collected from Survey of India (Dehradun). Multitemporal LANDSAT ETM data were acquired from USGS. The data is freely downloaded with a nominal spatial resolution of 30 m and swath coverage of 185 km<sup>2</sup>. The selection of imagery was limited due to difficulties in finding relatively cloud-free data. The LANDSAT ETM images were acquired for both the dry season may 2006, april and november 2010. In this region of study area, the Shuttle Radar Topography Mission (SRTM) version 3 DEM (<http://glcfapp.glcf.umd.edu:8080/esdi/>) with 90 m pixels.

Elevation values in DEM corresponded to the reflective surface on the Earth that could include soil surface, vegetation (including tree tops) or man-made structures (Clennon et al., 2010). From 2000 year, SRTM imagery was collected during space shuttle mission using multi-frequency, multi-polarization radar system. Each pixel represented a 30 m average of elevation around each pixel's center. The relative horizontal accuracy is ±15 m (90% circular error) with a relative vertical accuracy of ±6 m (90% vertical error) (Moss et al., 2011). The purpose of DEM construction was to extract topographic parameters that may be associated with mosquito larval habitat formation, such as elevation, flow distance to stream and aspect of land-surface. Elevation is directly related to temperature, which affects mosquito survivorship (Mushinzimana et al., 2006).

## 4 METHODOLOGY

Various factors can be determined by remote sensing which give the knowledge of mosquito breeding sites. Landscape elements were most important for explaining the vector

abundance. Using Landsat images found the water pools, swamps, ditches and unmanaged agriculture, which are important determinant of encephalitis in the area located low elevation. To demonstrate this, studies will conclude the assessment of monitoring the area.

The relationship between landscape the area and shape of land, their elevation and corresponding the spread of disease (fig.2).

Fig .2. Theoretical relationship between elevation, land-shape, and disease

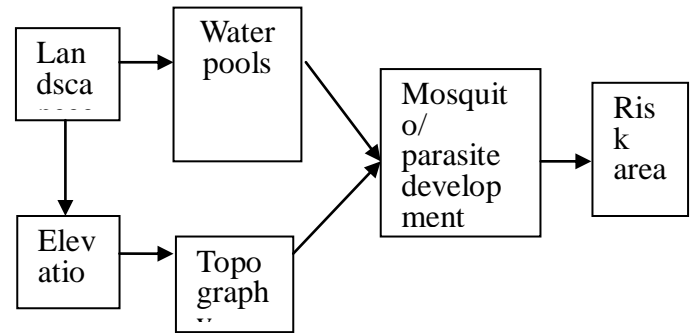
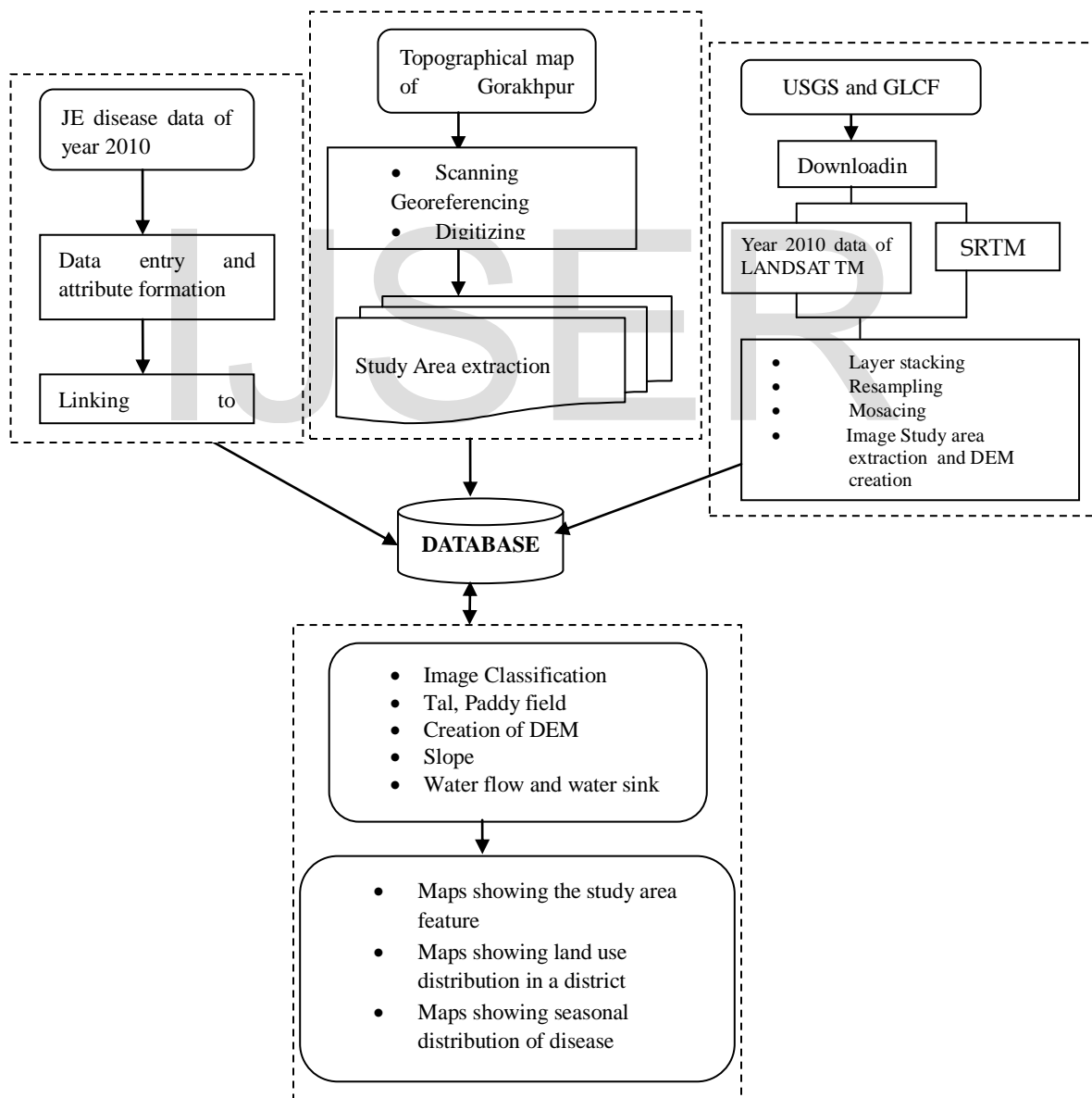


Fig. 3. The broad methodology adopted is shown



The overall broad methodology was discussed in fig. 3.

From the collection of disease data, downloaded Landsat satellite data including SRTM, the methodology has been setup to carry out the work towards. 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.

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, dependent on the spectral pattern recognition (Liliesand, 1994). Some area was also classified as polygons extracted as GIS layers for generation of disease risk map generation. The paddy field class and there surrounding low lying area was considered to be most conducive to larval breeding (Beck *et al.*, 2000). Digital Elevation Model and irrespective slope, aspect, water sink area was corresponding to delineating vector growth. With this information, a risk map was generated to show the most affected areas.

### 5.0 Results and Discussions

The characterizations of wetland area using the remote sensing data are evaluated the presence of breeding sites. The district comprised mainly Ramgarh, Chilloa Tal, Jacia, Kandaila and Jahda tal. Ramgarh wetland covered 8.137 km<sup>2</sup>, present near urban area the most focused area of study. The areas covered by settlement, paddy field, water bodies, with agriculture were which are more extensive in November 2010 than in April 2010 (Table. 1). JE cases in year 2010 were found in the urban area more than 56 cases. (fig.4-6).

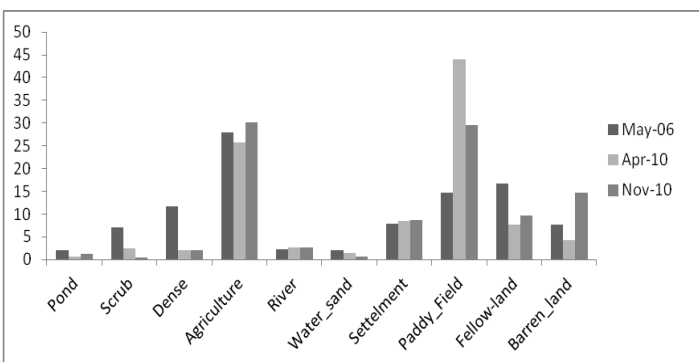


Fig. 4. Distribution of classes in year May 2006, April 2010 and November 2010 of study area

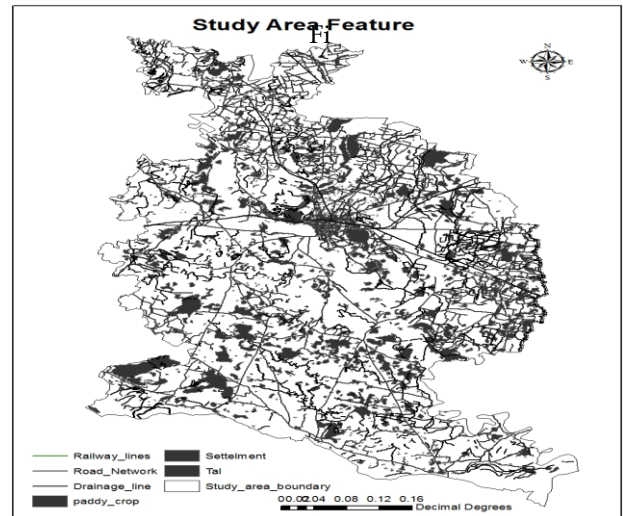


Fig. 5. Study Area Features

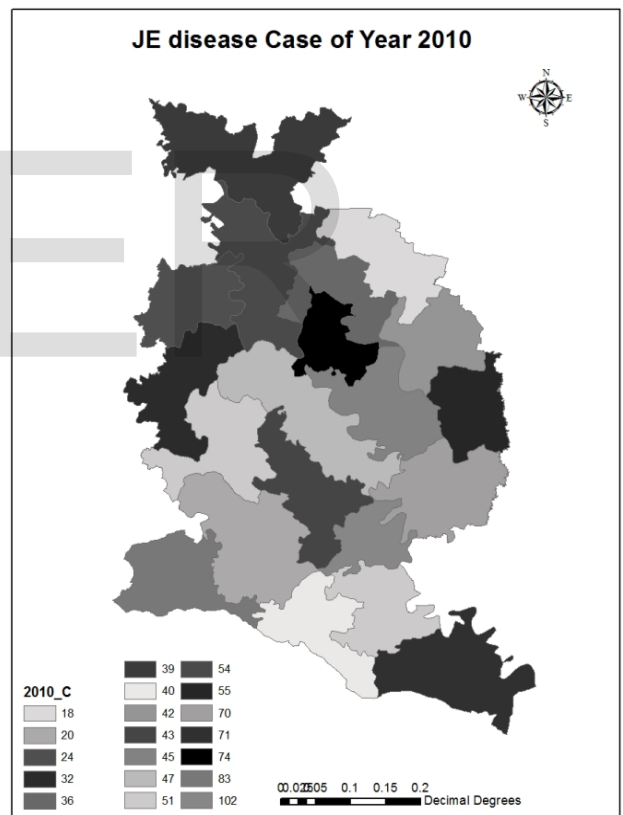


Fig. 6. JE Cases in year 2010

The land use type identified and demonstrated using LANDSAT ETM images were associated with disease-carrying mosquito breeding site. 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 (fig 4).

The generated DEM from SRTM to characterize the landscape, the majority of the area was composed of plains area. The slope of the area was generated from the spatial



analyst tool of using ArcGIS 10. DEM is used to calculate derivatives such as slope (fig 7 - 10). Slope is a measurement of how steep the ground surface is considered an approximate measure of predicted water accumulation (fig. 9).

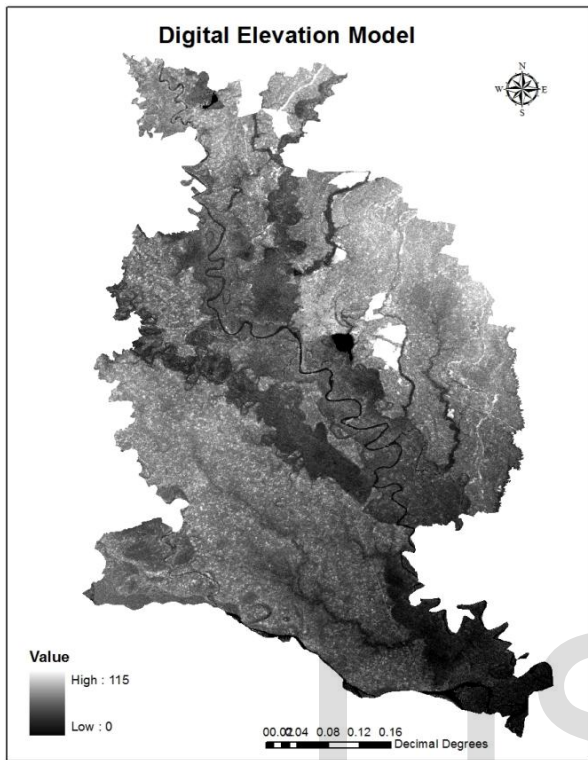


Fig. 7. Digital Elevation Model

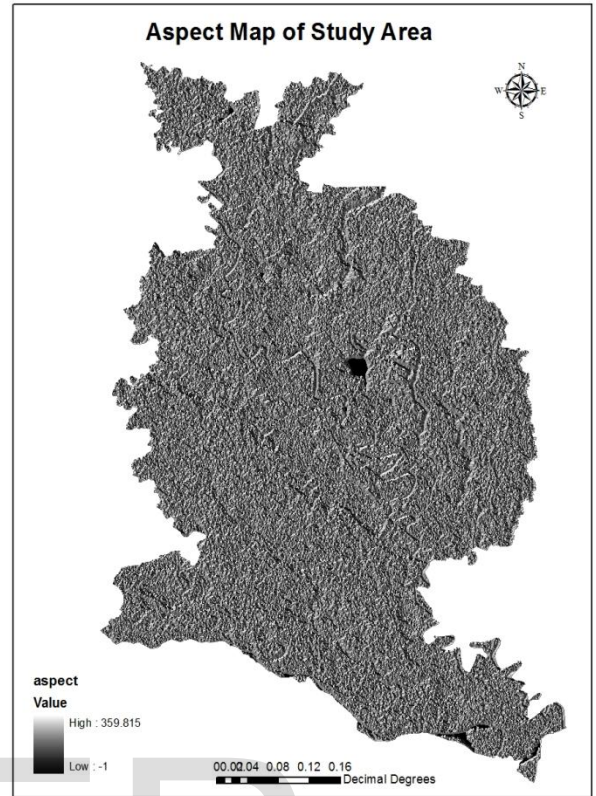


Fig. 9. Aspect

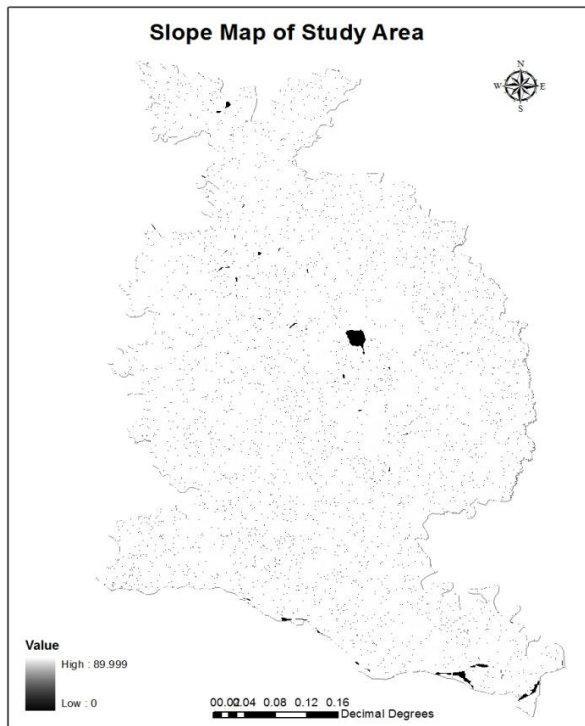


Fig. 8. Slope

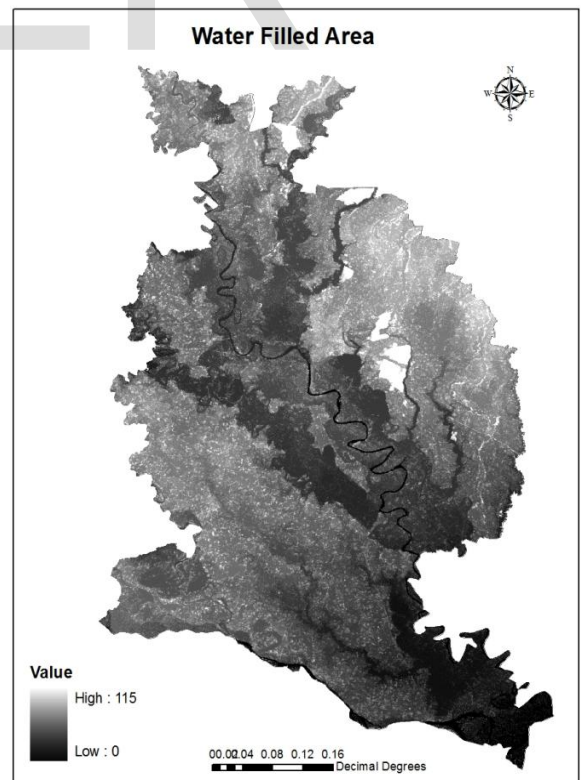


Fig. 10. Water Filled Area

Topography is an important factor in understanding the JE habitat at local scale and helped to identify down slope flat areas of JE risk illustrating how topography could help to identify the local areas which are prone to epidemics. Strong correlation was between elevation and the predicted area taking topography (fig.11 and fig. 12). The variables were associated with disease near settlement and water filled area. Elevation including slope, aspect, water sink and accumulation were found significantly the area of surrounding the breeding sites.

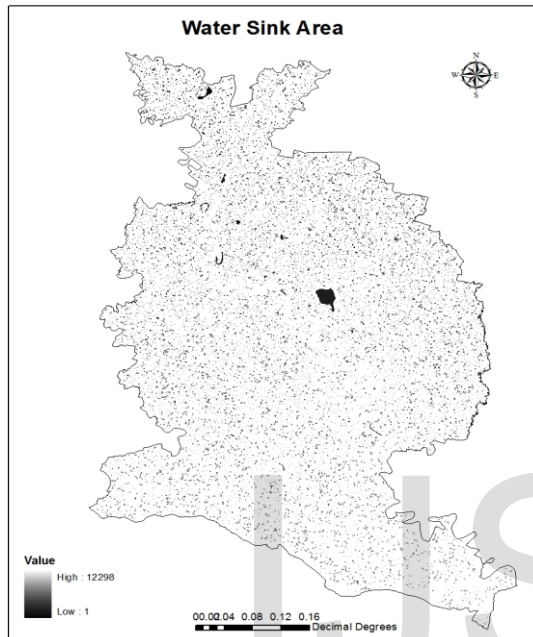


Fig. 11. Water Sink Area

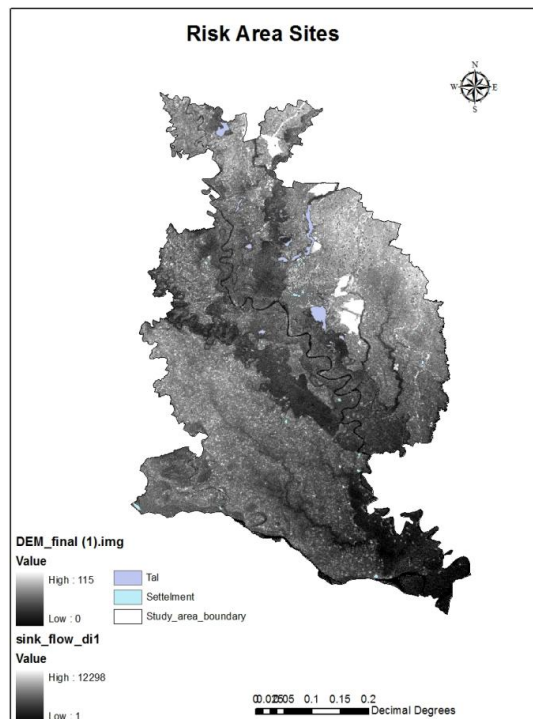


Fig. 12. Risk Area Sites

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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 <sup>2</sup> )	Proportion (%)	Area (km <sup>2</sup> )	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
Settlement	292.20	8.728518	292.71	8.48	Suitable
Paddy_Field	986.36	29.46402	1531.52	44.41	Very Suitable
Fallow_land	324.85	9.703697	266.88	7.74	Not Suitable
Barren_land	492.23	14.70362	145.92	4.23	Not Suitable
<b>Total</b>	<b>3347.69</b>	<b>100</b>	<b>3347.69</b>	<b>100</b>	



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