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GIS data base design, development and flood analysis: A case study of Olpad Taluka of Surat

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ABSTRACT

Flood is a natural disaster and almost occurs in every part of the world. India has longest rivers passing from high population density area and during monsoon season, river floods are common in India. Most probable conditions causing floods are outdated or clogged drainage systems and rapid accumulation of rainfall. In Gujarat, Tapi river causes flood in Surat and its nearby areas. In this research paper use of remote sensing and GIS in flood analysis is presented. Olpad Taluka of Surat is coastal area and highly vulnerable for flood. Remote sensing and GIS are used for creating required database for Olpad taluka. Parameters like Population density, resources availability and elevation of geographical area are used to categorize villages under high risk zone, moderate risk zone and low risk zone.

Key words: Remote Sensing, GIS Analysis, Types of Flood, Olpad, Risk Zone, Vulnerability

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INTRODUCTION

India is one of the most flood prone countries in the world. The principal reasons for flood are prevailing natural ecological systems in the country and these are heavy rainfall with temporal and spatial variation, highly silted river systems and inadequate capacity to carry the high flood discharge, inadequate drainage to carry away the rainwater quickly to streams / rivers. Many times typhoons and cyclones also cause floods. Flash floods are caused by steep and highly erodible mountains, particularly in Himalayan ranges.

The average rainfall in India is 1150 mm with significant variation across the Country. The annual rainfall along the western coast and Western Ghats, Khasi hills and over most of the Brahmaputra valley amounts to more than 2500 mm. Most of the floods occur during the monsoon period and are usually associated with tropical storms, depressions and active monsoon conditions. Due to the mentioned conditions floods occur in almost all river basins in India. [2]

Vulnerability to floods and other natural disasters is caused by the high population density, widespread poverty, illiteracy, enormous pressure on rural land, and agriculture dominated economy. Children, women, old age and disabled are particularly more vulnerable. Eighty five percent of the deaths during disasters are of women and children (Centre for Research on the Epidemiology of Disasters, CRED 2000). Presently protection in the country against floods is inadequate. Though non-structural measures improve the preparedness to floods and reduce losses, the necessity of structural measures would always remain for minimizing the extent of physical damage caused by floods. In future programmes and development planning of the country, it is required to integrate flood control and management planning along with climate change.[3]

3.1 TYPES OF FLOOD

Flash floods- It gives the least amount of warning time. They are characterized as a rapid and significant rise in water level due to a sudden and intense heavy rainfall event. These floods occur when rainfall rates are so high that the ground cannot absorb the water quickly enough to prevent significant runoff and are especially common in areas with steep slopes. Flash floods can also occur due to a dam failure. These floods can occur in less than an hour and can destroy structures, down trees and wash out roads with little to no warning time. Although flash floods may not last as long or cover as large of an area as other floods, the sudden onset and strength of the water give them the ability to create devastation in a very short period of time.[5]

River flooding- It occurs each year in India and often occurs on a slower time scale than flash flooding. They are caused when water runoff collects in rivers and streams and eventually reaches levels that overflow the banks. When this occurs, the flood can cover an enormous area and affect downstream areas even if they didn't receive much rain themselves. Although river flooding can be predicted, its effects, even over a longer period of time, can cause extensive damage to residents living near rivers and streams.[3]

Coastal flooding- These floods occur when ocean water is pushed inland. Hurricanes and tropical storms can cause large waves and actually raise the sea level, creating storm surge along beaches. Earthquakes can displace large amounts of water and produces tsunami waves which rush to inland and resulted in flooding. On a much smaller scale, extremely high tides associated with a full moon can also cause minor coastal flooding.[4]

Urban floods-These can be caused by flash, river or coastal flooding but most commonly, it is caused by high rainfall rates over developed areas that do not have the ability to absorb the water. Urbanization can increase water runoff as much as 2 to 6 times over what would occur on natural terrain. These floods can cause high economic damages to businesses and homes.[3]

Areal flooding –These results in standing water in low-lying areas and open fields. They often occur due to heavy rainfall over a larger area in a brief period of time. Additionally, a prolonged period of rainfall can also lead to flooding, often causing dangerous inundation of low lying areas. Agricultural losses can occur with these floods and in addition, stagnant water can serve as a breeding ground for insects and disease.[5]

4. STUDY AREA

Gujarat has seen many damaging floods. Almost all major rivers in the state pass through a wide stretch of very flat terrain (often more than 50 km) before reaching the sea. These flat low lands of lower river basins are prone to flooding. The one-day Probable Maximum Precipitation (PMP) is often higher than the average annual rainfall in most parts of Saurashtra and Kachchh. Occasional cyclones and depressions also cause heavy rainfall in large parts of Saurashtra, Kachchh, central and northern Gujarat. The Flood risks in Saurashtra are lower than the flood risks in the South Gujarat plains. The relatively flat plains in the lower basin areas with hilly catchments in the upper parts of South Gujarat accentuate flood risks. The flood prone river sections were identified by the flood prone village map. The Flood prone river sections in Saurashtra extend to the upper basins. This is due to the presence of dams in the upper basins, which have to resort to emergency discharge during heavy rainstorms. Flood prone river sections of Gujarat are shown in fig 1.

The study area (Olpad Taluka) is bounded by 20° 0' 0" to 21° 7' 48" north latitude and 72° 22' 48" to 74° 13' 48" east longitude region of south Gujarat. During the last decade maximum flood occurrences have been observed in Tapi river basin and the chosen study area of Olpad taluka of Surat district. Heavy rains, sudden discharge from Ukai reservoir, coinciding with high tide in Arabian Sea, drainage congestion and encroachments in natural depression area have seriously affected coastal taluks and specifically Surat city. The major flooding has occurred in 1998, 2005, 2006 and 2007. The flood zone areas for a part of Gujarat are shown in figure 1.The Tapi basin and Surat city are frequently affected zones.

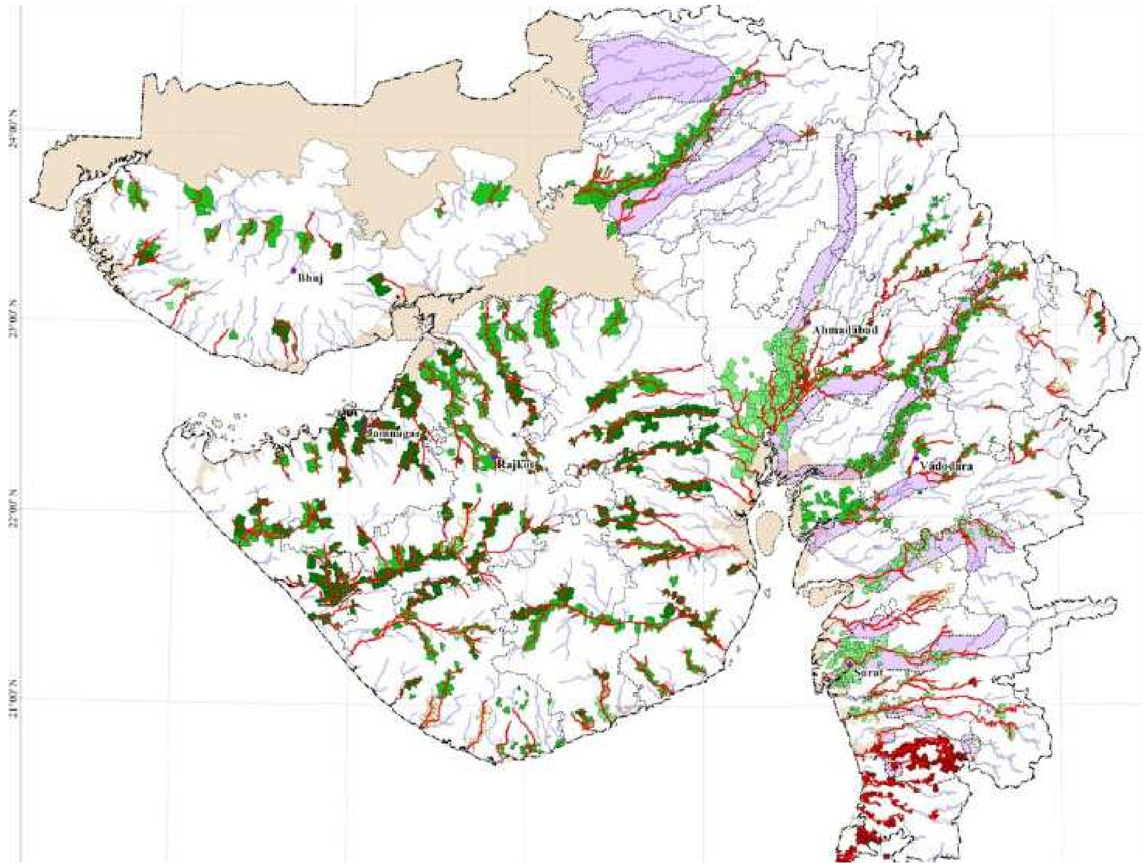

Figure- 1: Flood zones in Gujarat (www.gsdma.org)

5. DATA BASE DESIGN

Database design involves major database elements, naming convention, attributes schema, data model, datum /projection, coordinate precision and the tolerances.

Thematic layer	Land Use, Drainage System, Water Bodies
Administrative layer	District Boundary, Taluka Boundary, Village Boundary, Land Parcel, Watershed Boundary
Topographic	Road, Railway , Digital Elevation Model, Canal
Facilities	Relief Centers, Schools, Temples, Angan wadis, Bus Station, Health Centers, Panchayat, Mosque etc.

Multi-layer GIS database for the study Area has been created using IRS data, SOI topographic data, Census data, field observations etc. and organized properly for efficient query, analysis and retrieval.

6. METHODOLOGY OF DATABASE CREATION

GIS database creation mainly involves data collection, mapping, digitization, GIS error handling, attaching attributes data and making GIS data usable. The major tasks involved in database creation are:

1. Collection of satellite data, maps and tables
2. Analysis of satellite data for generating thematic maps using GPS field observations for generating ground control point's library, Creation of spatial registration framework.
3. Geo-referencing of satellite image data and scanned map data. Environment setting and point, line and polygon database creation using onscreen visual digitization.
4. Converting / formatting of socio-economic and demographic tabular data and linking to village layer.

Figure- 2 below shows different villages of Olpad taluka, Surat

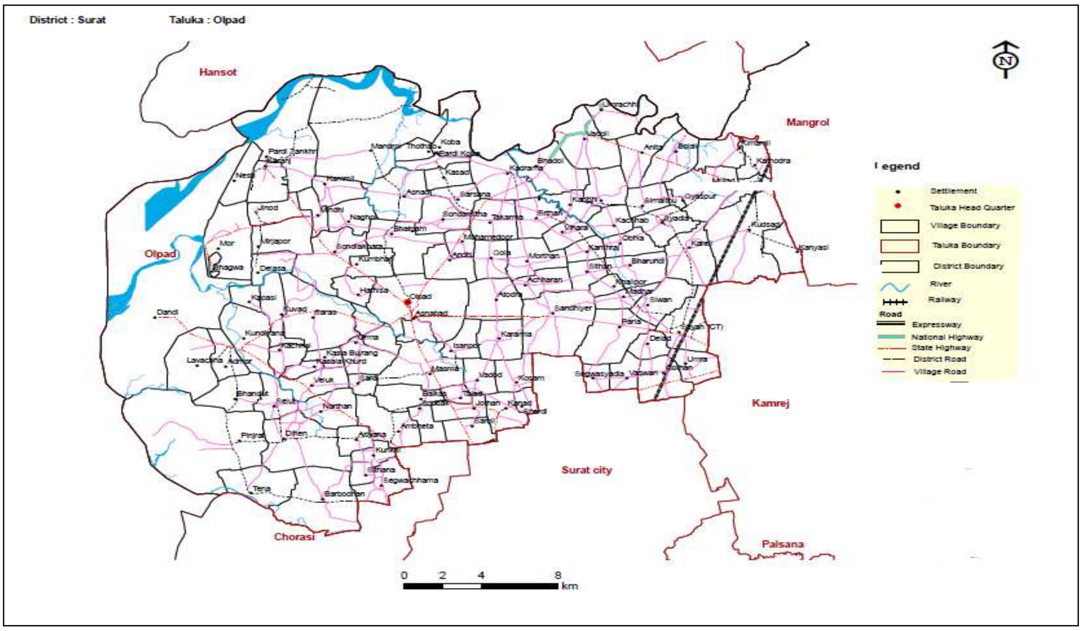

Figure-2: Villages of Olpad with Taluka Boundary (Source-BISAG)

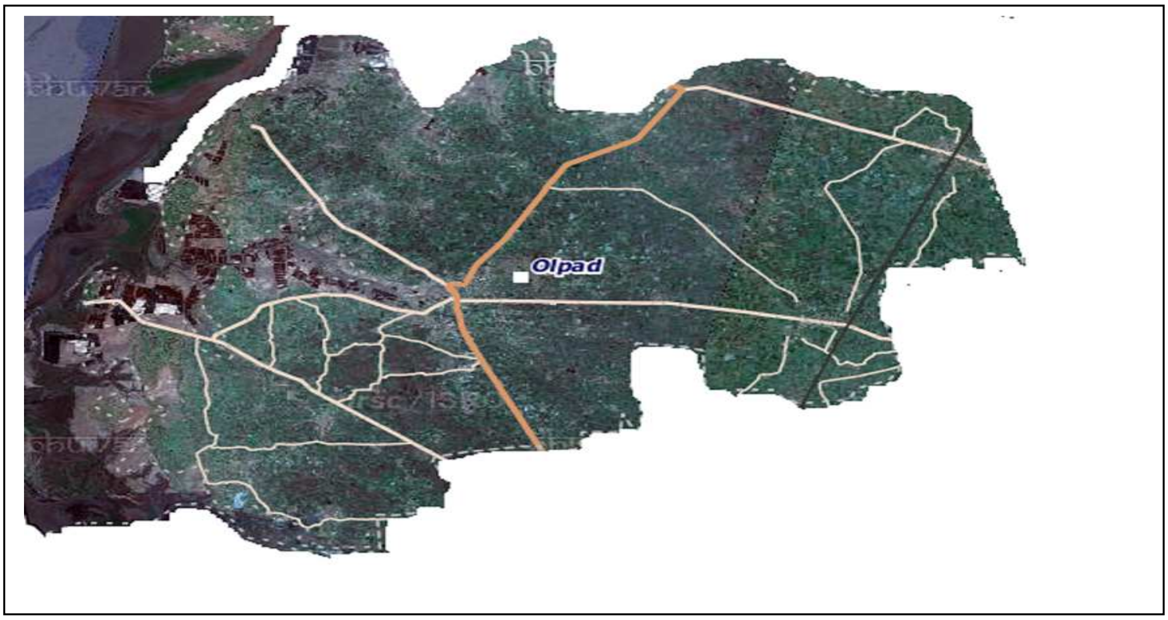

Figure-3: Satellite Image of Olpad Taluka (Source-Bhuvan Portal)

Village layer shown in figure 4 is created using 2011 census reports and QGIS. This layer contains information pertaining to population density, elevation, rescue facility etc.

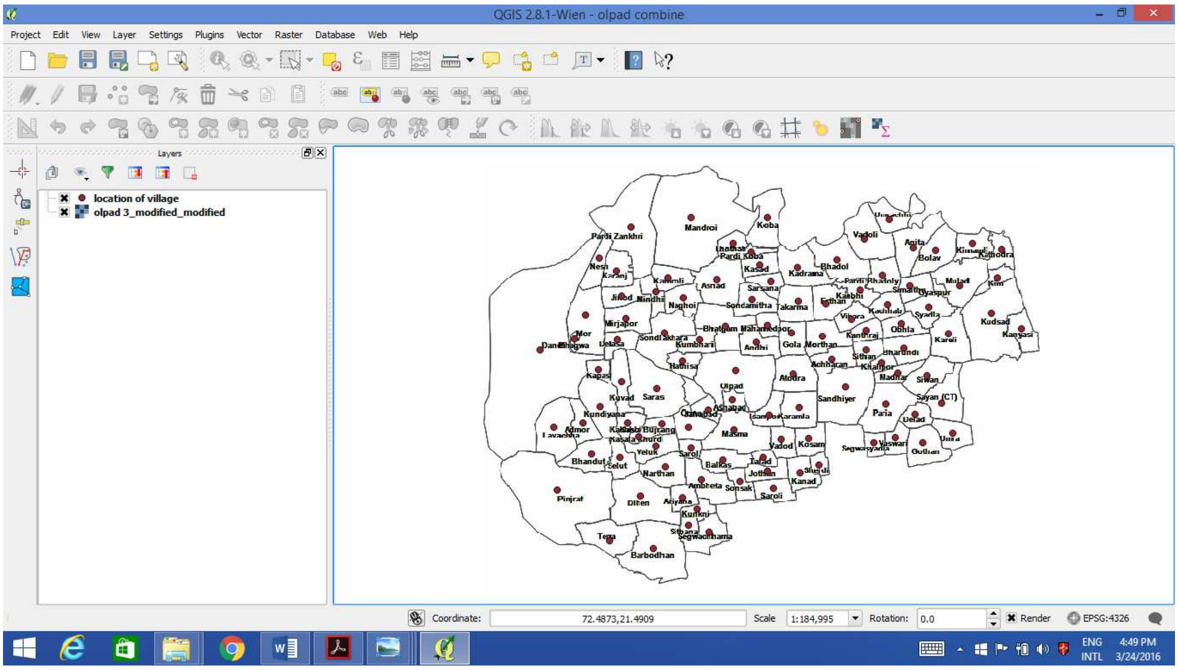

Figure 4: Village Layer in QGIS

SRTM DEM for the study area was downloaded from website and elevation ranges were computed. Higher elevation range area is not important and hence single wide range class is prepared for elevation ranges 50 and above meters. The DEM (digital elevation model) of the study area is shown in figure 5.

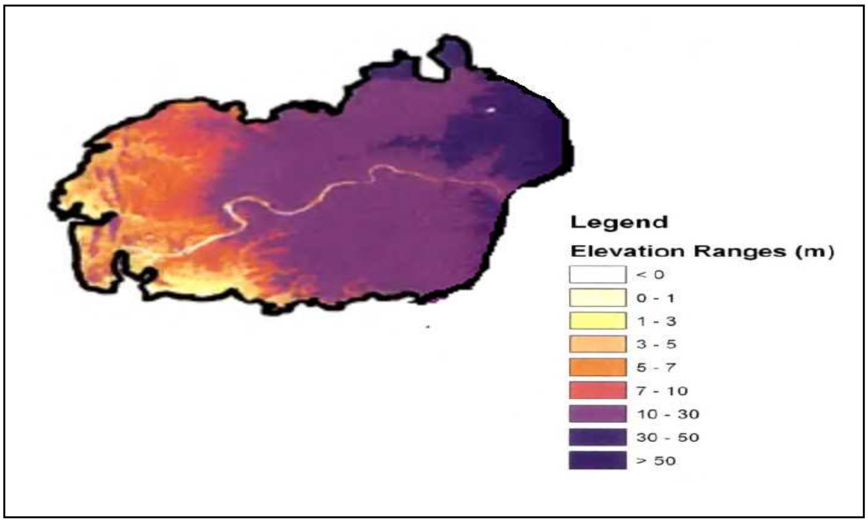

Figure- 5: Digital Elevation Model (Source-SRTM DEM)

Most of the villages of study area are connected by roads. Major road network in olpad consists of National Highway, State Highway and District Roads. The road network of Olpad taluka is shown in figure-6. In-situ field observations were taken for every village and facilities data collected is shown in figure-7. Water features in study area is shown in figure-8.

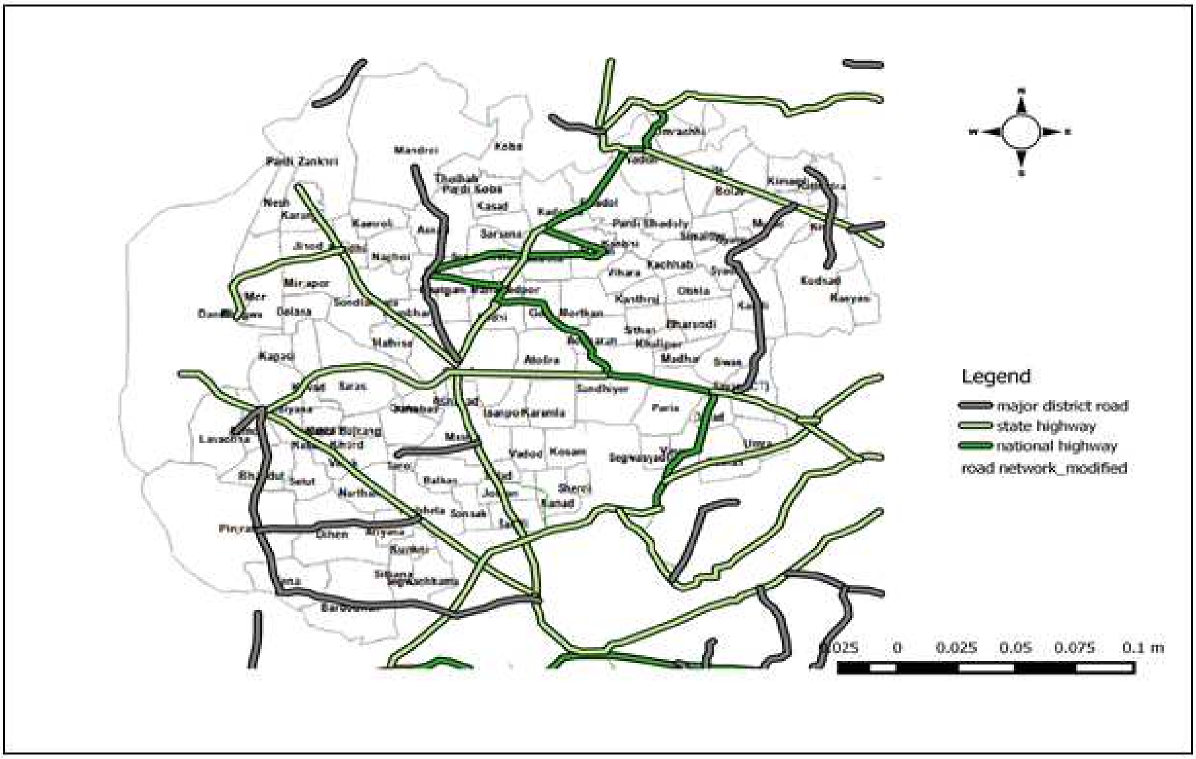

Figure -6: Road Network of Olpad Taluka

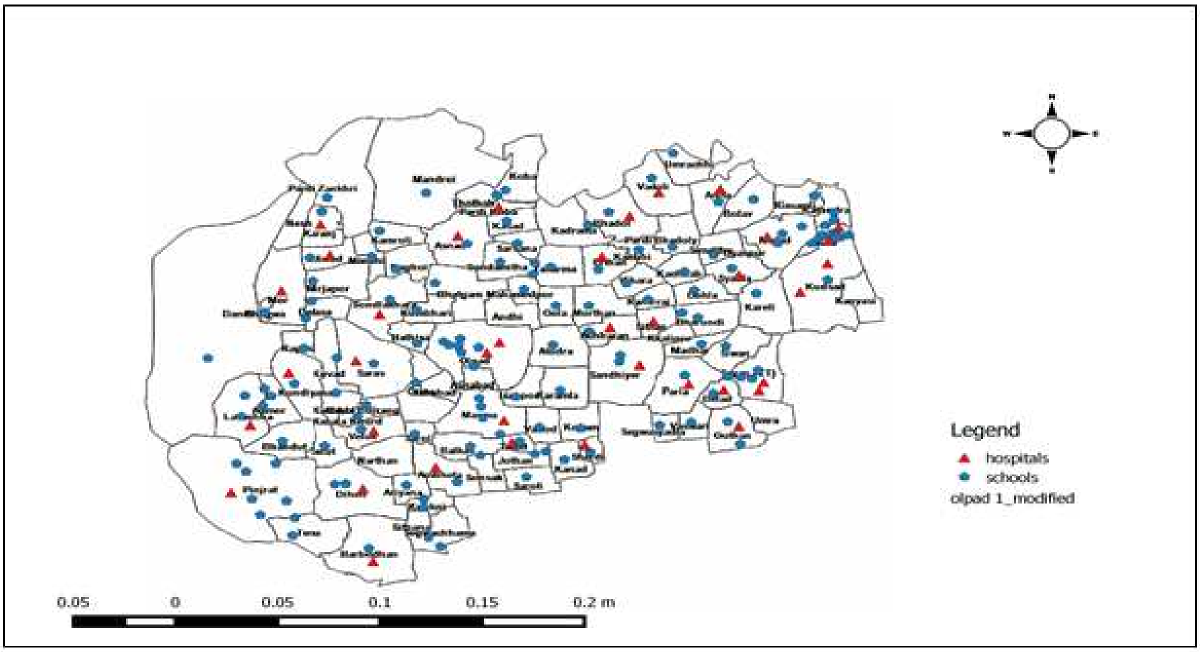

Figure -7: Facilities Data for Study Area

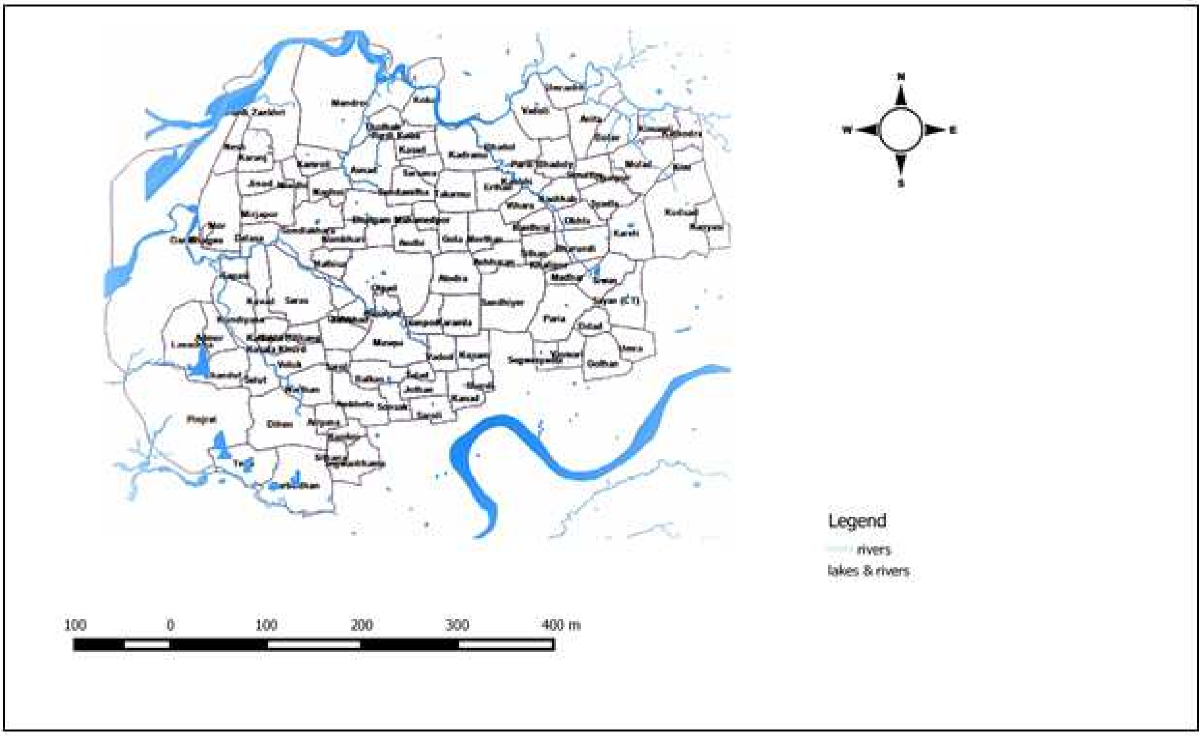

Figure- 8: Water Features of Study Area

7. GIS ANALYSIS and RESULTS

GIS analysis was done and based on population density of villages, SC/CT populations, Elevation data and available facilities / shelter data villages of Olpad were are classified under three categories viz. High Risk Zone, Medium Risk Zone and Low Risk Zone villages

Higher Risk Zone Villages		**Medium Risk Zone Villages**		**Lower Risk Zone Villages**	
Admor,	Mirjapor,	Ambheta,	KasalaKhurd,	Kanad,	Paria,
Ariyana,	Mulad,	Barbodhan,	Kosam,	Karamla,	Mandroi,
Asnabad,	Narthan,	Bhadol,	Kunkni,	Kachhab,	Sandhiyer,
Balkas,	Olpad,	Bhandut,	Kuvad,	Kareli,	Andhi,
Bhagwa,	Orma,	Dandi,	Lavachha,	PardiZankhri,	Kanad,
Delad,	PardiKoba,	Delasa,	Mahamedpor,	Khalipor,	Sondlakhara,
Gothan,	Sarol,	Erthan,	Mor,	Kimamli,	Sithana,
Hathisa,	Saroli,	Isanpur,	Naghoi,	Vaswari,	Obhla,
Jafrabad,	Sarsana,	Jinod,	Nesh,	Veluk,	Sithan,
Kadrama,	Selut,	Kachhol,	Saras,	Vihara,	Syadla,
KaslaBujrang,	Sherdi,	Kamroli,	Sayan,	Thothab,	Takarma,
Kathodra,	Sonsak,	Kanyasi,	Segwasyadla,	Vadoli,	Tena,
Kim,	Umra,	Karanj,		Talad,	
Kudsad,	Umrachhi,				
Masma,					

CONCLUSION

Remote sensing and GIS inputs are useful for relief and rescue operations as well as for impact assessment to infrastructure and properties. Remote sensing and GIS inputs are used operationally for early warning and decision support by authorities during disaster. Cyclones, tsunami, heavy rain fall, storm surge are often resulted in flood. For better disaster preparedness planning and post disaster impact assessment, it is required to use RS data with required spatial and temporal resolution for information extraction. GIS framework provides facility for data integrating, query, analysis and decision support. This paper has provided insight about the possible applications of remote sensing and GIS in flood management.

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