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RS-GIS based mapping of an impact of flood inundation on cultivated lands: A case study of *Tal* and *Diara* lands of Bhagalpur district (Bihar), India

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Abstract
In the present investigation, the multi-spectral satellite data viz. IRS LISS III(Pre Monsoon), MODIS V6 and SRTM DEM were used for visual interpretation and mapping of flood affected *Tal* and *Diara* lands. However, on screen visualization of the cultivated lands were also visualized for the delineation of the cultivated lands. Hence, data of NDVI, water bodies and relief were superimposed to find out area where water logging was remained impact on the cultivated lands. Results revealed that 45.21% of cultivated lands of Sabour, Sultanganj, Nathnagar, Kahagaon and pirpainti block were highly affected due to flood. However, > 85% of the cultivated lands of Ismailpur, Rangra Chowk and Gopalpur block was damaged due to flood. In these blocks, appurtenance of NDVI (value 0.0-0.1) shows the negligible standing crops (except tree). However, there was negligible appearance of the flood was observed in southern part of Sanhaula, Pirpainti and Sahkund block. The present investigation provided an overview, how the geospatial technology can be used to map the cultivated lands of *Tal* and *Diara* lands (low land Physiography) in lower Gangetic plain of Bihar.

Keywords: GIS, NDVI, remote sensing, satellite data

Introduction
An upper crust on the earth surface has been recognized as land, and the lands known as the land, as natural resources. However, in terms of land use, the cultivated is a part of man- made resource. Hence, it is an important to develop site specific strategies for the management of the cultivated lands. In this context, *Tal* and *Diara* lands are the valuable natural resources which have been used as for the agricultural practices in lower Gangetic plain s of Bihar. (Panigrahy *et al*., 2008) [13] reported that the Remote Sensing (RS) and Geographical Information System (GIS) can be employed to prepare site specific based management of horticultural land use pattern. (Neteler *et al*., 2011; Lenk *et al*., 2007) [9, 5] reported that the GIS is a powerful tool used to monitor the land use land cover over pattern over the large areas, and to deploy location specific based strategies for land use planning. In terms of creating a geographical analysis, various types of information *viz*. topography, drainage pattern, water-logging, low land physiography, climatic condition, and soil type have been considered. (Durana and Helms, 2002) reported that GIS can be involved for the development of natural resources viz. soil, water and vegetation towards make a land use plan in digital domain. (Manchanda *et al*., 2002) [6] reported that survey data provided adequate information in terms of land forms; natural vegetation as well as characteristics of land use pattern which can be utilized for the management of land resource management. Hence, responses of the spectral reflectance are the results of numerous soil properties and other land use pattern, and that the spectrally-derived maps may be helpful to delineate the important information. (Kristof *et al*., 1980) [4]. In order to obtain a more accurate interpretation using satellite data, several empirical radiometric indices such as NDVI, SAVI, PCA etc. have been proposed and apart from these indices, such as, a "redness index:", a "colour index" and a "texture index" have also been developed (Pouget *et al*.,1990) [11].
(Venkatratnam, 1980; Patel *et al*. 2001) [14, 10] reported that remote sensing has proved to be the most efficient, economical and reliable technique to prepare a comprehensive inventory of soil resources and land use pattern of an area. The topography of *Diara* land is the most the important resource which intersected with numerous dead and alive streams forming complex type of physiography, distributed in an area of more than 11 lakh hectares on both sides of

river Ganga, Gandak, Kosi, Sone and subsidiary rivers in Bihar. (ICAR, 2005) [2, 3].

Flood mapping under low land ecology of Bhagalpur district has a great concern and these reviews provided an opportunity how to use the RS-GIS for flood mapping. In this context, the present study was carried for the mapping of an impact of flood on cultivated lands of *Tal* and *Diara*.

Materials and Methods

Study Area

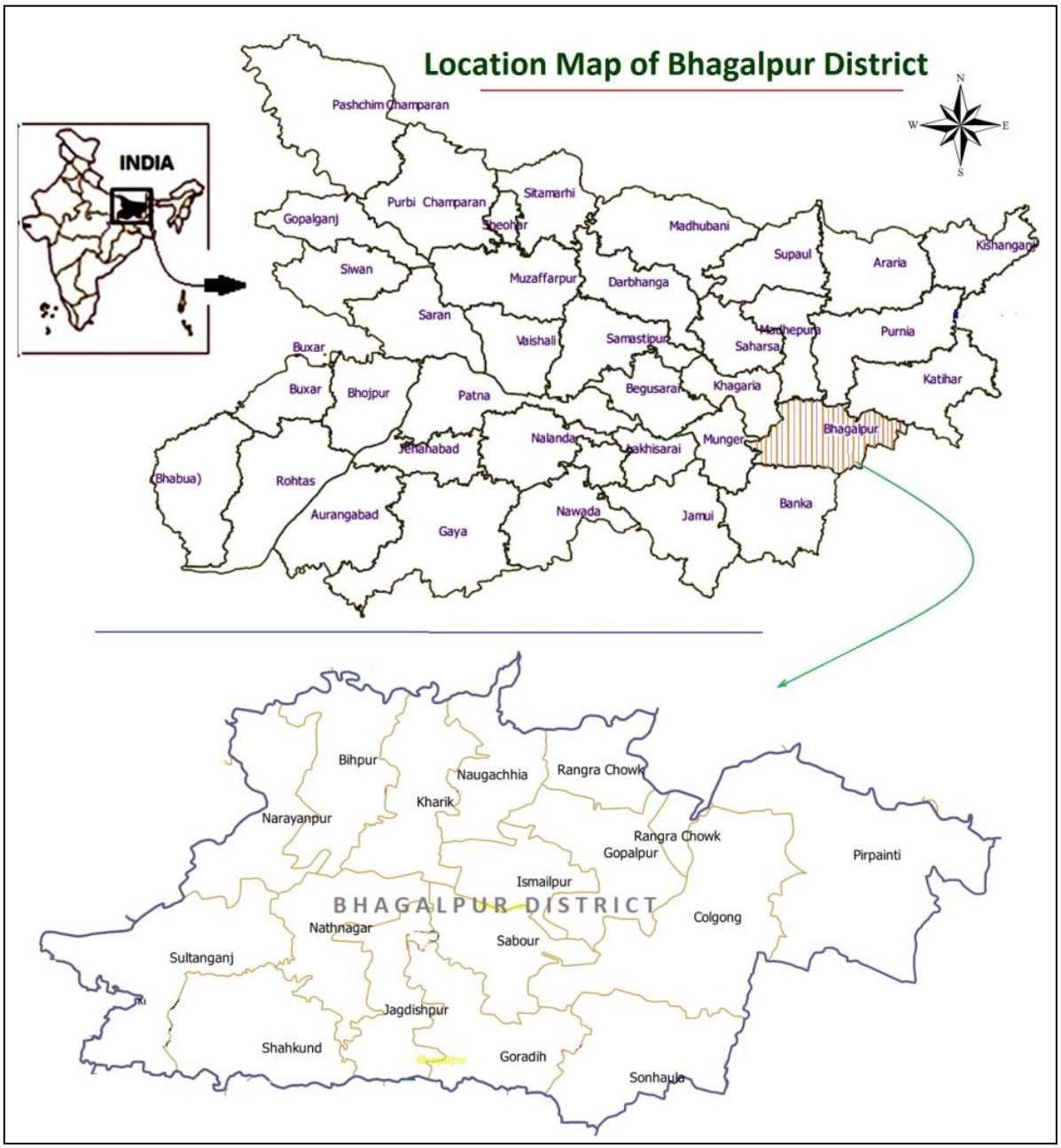

Fig 1: Location map of study area

Bhagalpur district (Fig.1 location map) of Bihar consists 2612.55 $km^{2,}$ near the river Ganges under vast alluvial plain influenced by a number of small streams viz. Kadua and Chanan. The physiographic pattern *Tal*, *Diara* and *Ox-Bows* found in both sides of river Ganges.

The *Diara* land, a natural behavior formed due to periodical erosion and deposition of sediments (alluvium) in flood prone area, recognized as one of the most valuable natural resources in Bihar and Orissa. (ICAR, 2005) [2, 3]. However, as a saucer shaped structure develops due to accumulation of backwater of flood in low lands found in southern part of river the Ganges is locally known as *Tal*. The *Oxbow* as a semi-circle or curve shaped, low land physiographic structure found in lower Ganga basin which is formed when a wide meander from a stream or river is cut off from the main channel to form a lake. (Manish *et al*. 2013) [7]. It is locally known as *Moun* in the Gandak river basin in Bihar. Oxbows with plenty of water were found in Sabour, Gopalpur, Narayanpur, Bihpur, Kharik, Naugachhiya, Ismailpur and Rangra Chowk block.

Summer season starts from March to early June followed by rainy season starts from mid-June to September end and winter starts from November to February. Rainfall is mainly by south west monsoon active from mid-June to September end. The average annual rainfall for the year 2018 is 2194 mm and 1600 mm in 2019. However, the relative humidity is generally above 80% during monsoon period from July to September.

Satellite images, hard ware and software used

In the present study, the multi spectral satellite image of eVIS (2021) was used for the visual interpretation of vegetation, water bodies and streams. However, topographical sheets at the scale of 1:250000 and 1:50000 were used to trace out the administrative boundaries of blocks of Bhagalpur district and used as a shp. file to map the flood impact on cultivated lands. Computer system HP (Intel® Core (TM) i5- 4210U CPU (4 cores) running at 1.70GHz, a RAM (Random Access Memory) of 12GB with an operating system of Microsoft Windows 10. and QGIS software (Version 2.8) were used for the visual interpretation of satellite images, digitization, Digital Image Processing (DIP) and mapping.

Methodology

Field survey was done during the month of August, 2021 with GPS reading of water logging area, river and other land use pattern. In this context, sampling sites were selected by using visual interpretation of satellite images and delineated the cultivated lands. (Fig.3) Documented soil survey reports and ancillary data were also used as reference purposes during the field survey and validation of research findings. However, shape files (shp. file) of different blocks by using topographical sheets were traced to fill the necessary information in attribute table and the Normalized Difference Vegetation Index (NDVI) was used to measure the vegetation and water resources of the low land area. (Fig.3). The NDVI introduced in the early seventies by (Rouse *et al*., 1974) is expressed as the difference between the near infrared (NIR) and red bands (RED) normalized by the sum of those bands. It helped to characterize the agricultural and horticultural land units. (Zhang *et al*., 2014) [5] reported that mapping of land units by using visual interpretation than by digital classification is more accurately. Hence, other land units were also characterized by visual interpretation keys using IRS LISS III satellite data. These steps were summarized in the methodology which is in flow chart. (Fig2).

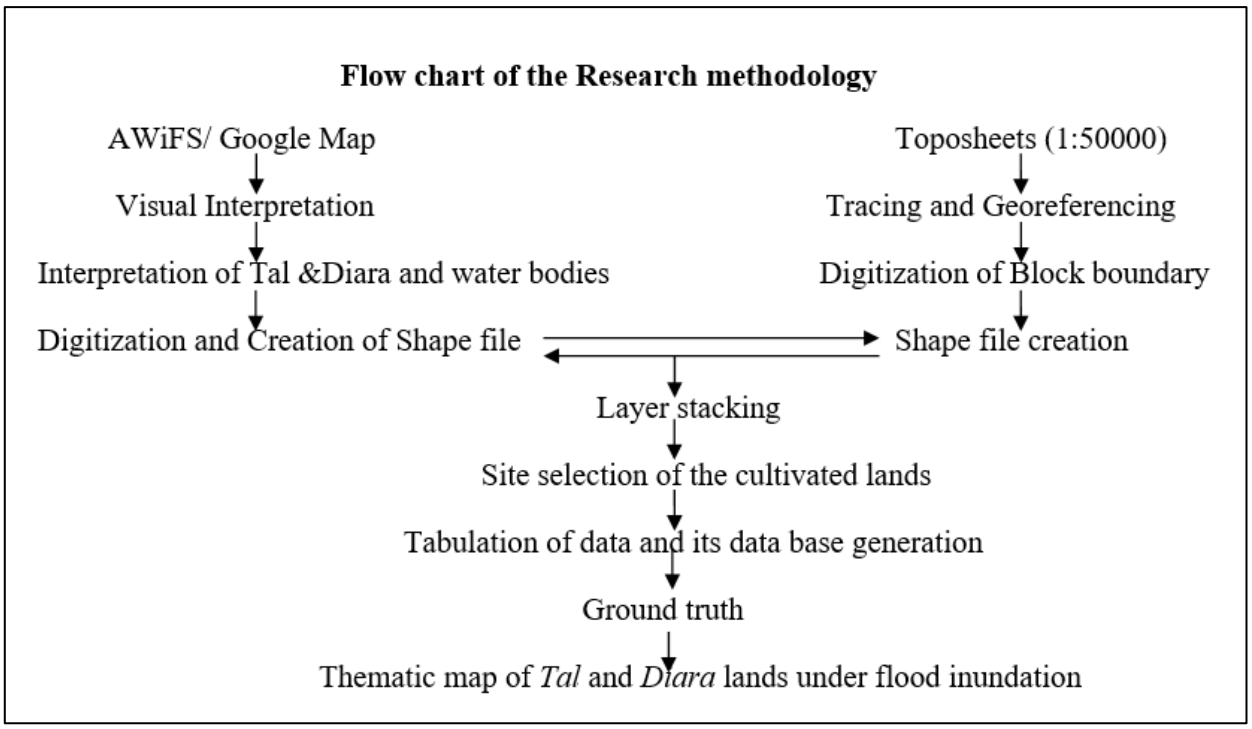

Fig 2: Flow chart of Methodology

Results and Discussion

Out of the total geographical area 261255 ha, only 7521.69 ha land was cover with flood affected in Diaralands of Narayanpur, Kharik, Bihpur, Naugachhiya, Rangra Chowk, Gopalpur and Ismailpur blocks of Bhagalpur district. Hence, cultivated lands under *Diara* lands of Gopalpur and Ismailpur block were highly affected due to flood. (Fig.1). However, the maximum coverage of affected *Tal* lands due to flood inundation was traced in Sabour, Sultanganj and Nathnagar blocks (Fig. 3). However, cultivated lands of Sahkund, Goradih, Kahalgaon block were also affected due to flood caused congenial environment.

Based on interpretation of satellite images and weather data, it was observed that the graph of rainfall during the months of July, August and September was comparatively in maximum peak may be caused water logging in lowlands of northern part of river Ganges, and the plenty of water was observed in *Tal* and *Diara* lands in the month of September (Fig. 4). In pre monsoon, the appearance of red tone in false colour composite image (layer stacked of NIR, red and green bands) represented as tree cover as well as croplands in the satellite data of the study area (Fig.1).

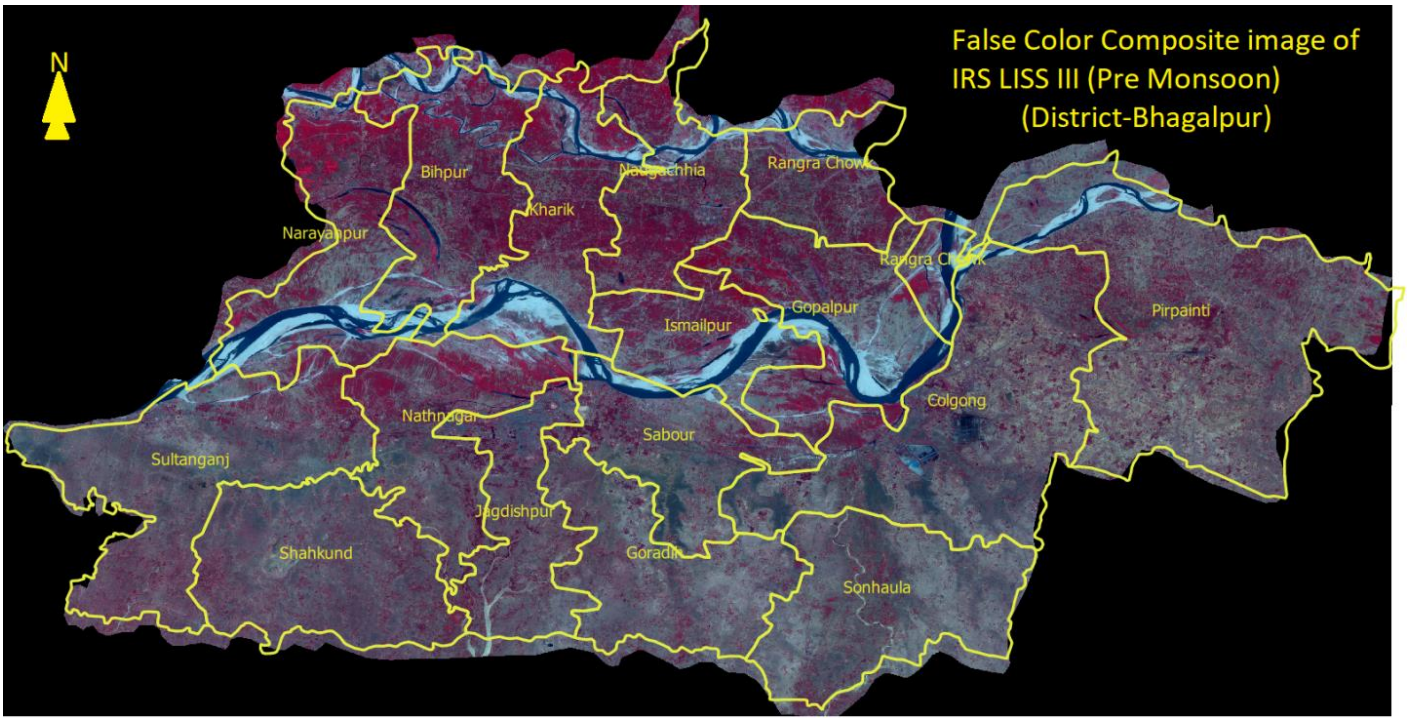

Fig 3: Map showing FCC image of the study area

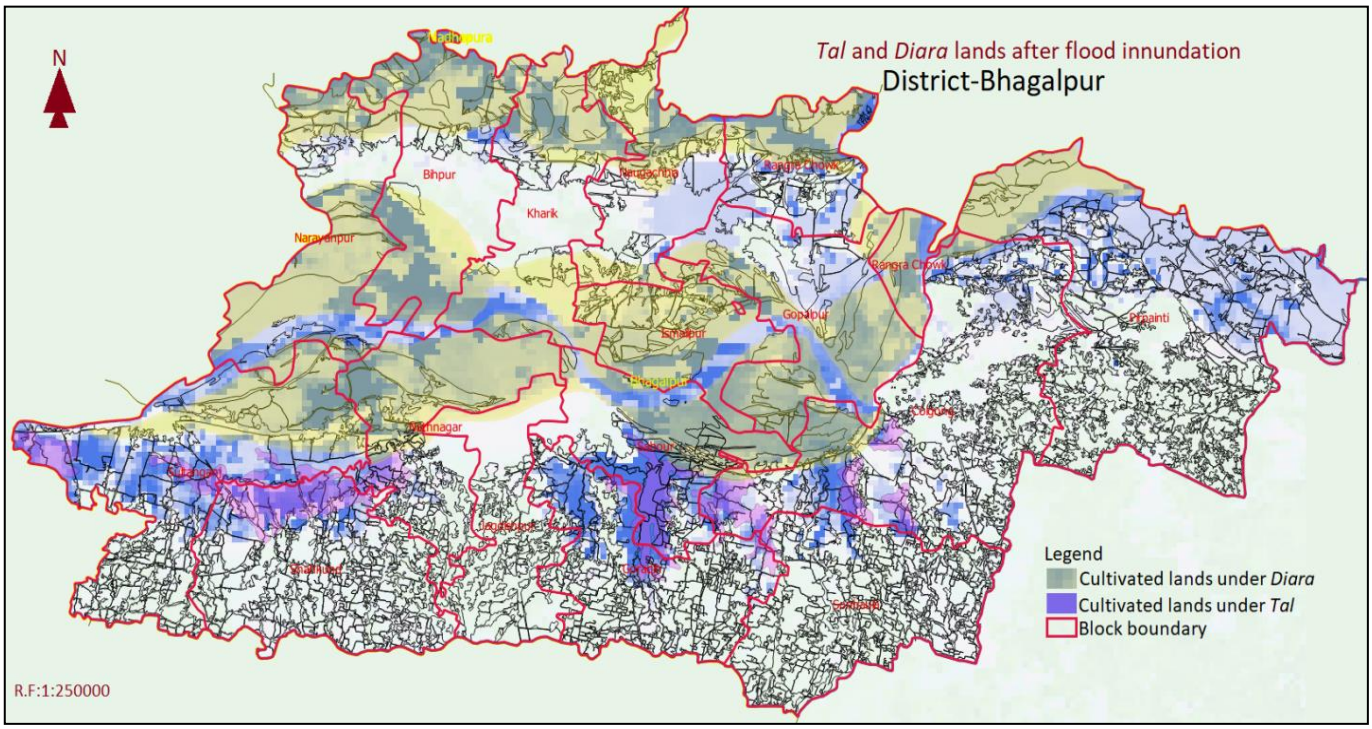

Fig 4: Map showing Flood impact on the cultivated lands of *Tal* and *Diara*

Hence, interpreted NDVI of eVIS (2021) of *Tal* and *Diara* lands helped to observe the least cropping pattern near adjoining of the Ganges. (Fig. 2).

Waterlogged and moist lands were also analyzed by the visual interpretation of satellite images of IRS LISS III and eVIS images.Hence, preliminary analysis using IRS LISS III data supported the feasibility of discriminating fully damaged late blight potato fields from healthy ones (Arora *et al*. 2004). Similarly, successful evaluation of remotely sensed data (IRS-1-C) was conducted for detection, mapping and monitoring of rubber plantations affected by Corynespor and Gloeosporium fungi which causes leaf spot and leaf fall disease. (Ranganath *et al*. 2004) [12].

Based on interpretation of the NDVI image of the study, the distinct tone (blue) over *Tal* and *Diara* lands was appeared as hot spots and high vulnerable zones for least growing of plantation. (Fig.2). Southern part of Khalgaon, Goradih, Nathnagar, and Sahkund block were traced as free water logging caused by far from the low land topography. Results also revealed that the northern part of the Ganges is highly susceptible during flood may caused congenial environment.

Conclusion

In context of outcome of the research work, the modern technology (remote sensing and GIS) was used to assess the flood affected *Tal* and *Diara* lands, and it was found that the

Diara lands were highly affected due to flood. However, remotely sensed data helped to monitor the water logged cultivated lands. However, in the context of managerial point of view, approx. 80% of the cultivated lands were highly affected due to flood, which was fallen in adjoining of the river Ganges and the Kosi was traced as the congenial environment during monsoon.

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