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REMOTE SENSING AND GIS BASED WATERLOGGED AREAS IDENTIFICATION IN HISAR DISTRICT

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ABSTRACT

Waterlogging is becoming a serious problem plaguing large parts of the country. The present study assessed the waterlogged area in the Hisar district of Haryana State using satellite data of Sentinel 2, LANDSAT 8, and Carto DEM: Version 3 R1. Various thematic layers such as base map, DEM, NDWI, groundwater depth, and waterlogged area have been prepared by using ARC GIS software. Near about 69% area lies under the 10-15 m range of ground water depth while 31% area is under the above 10 m range. NDVI result shows that 68% area is under vegetation-agriculture land and 32% area is under the non-vegetation class. A total 39.99 sq. km (1.01%) area was identified as a waterlogged area. Concluded that remote sensing and GIS techniques are better tools to analyze the waterlogging problem with higher accuracy and timely. And the results prepared by using these techniques will be very helpful for administrators and policymakers.

Keywords: Remote Sensing, GIS, Hisar, Waterlogging.

I. INTRODUCTION

Arid and semi-arid areas with canal irrigation are affected by waterlogging caused by groundwater table rise (Kumar S. & Kumar G., 2019) . In large parts of the country, waterlogging has become a serious problem. A waterlogged soil describes the conditions in which there is a high subsurface water table that dispenses air from the roots, decreasing plant growth and yield. There are two types of waterlogging: surface waterlogging and subsurface waterlogging. The occurrence of surface waterlogging occurs when there is a restriction on natural drainage over depressions (Singh and S.K., 1990). In addition to natural causes such as poor drainage facilities, geological restrictions on natural drainage, and heavy rainfall that leads to flooding, there are also several other factors that contribute to waterlogging. Irrigation practices resulting in loss of water, leakages from unlined canals and artificial storage structures, and construction of roads, railways, and other artificial structures can all contribute to waterlogging due to artificial causes. As a result of blockages in natural drainage and/or higher water levels at outfalls, surface waterlogging occurs over depressed lands, resulting in stagnation of water (Lohani et al. 1999). During subsurface waterlogging, the soil pores become saturated when the water table is extremely high, which causes the air flow to be restricted, the soil to become salinized, oxygen levels to decline, and carbon dioxide levels to rise (Wu et al. 2014; Li et al. 2018; NRSC 2014). The problem of waterlogging has been identified as critical by many researchers in the past. The problem of waterlogging has therefore been studied extensively to find the best remedial and management strategies. Waterlogged areas in irrigated command areas can be mapped very efficiently using IRS data, as Sidhu et al. (1991) demonstrated. According to Dwivedi et al. (1999), satellite remote sensing coupled with a Geographic Information System (GIS) is an efficient means to monitor and map (Kumar S., 2018) surface waterlogged areas in drainage-congested areas. We have used Remote Sensing data in the Visible, Near Infrared (NIR) and Short-Wave Infrared (SWIR) regions of the spectrum to determine the spatial pattern of surface waterlogging. Our results are encouraging based on the information provided. Surface water bodies can be mapped and monitored more rapidly and accurately using remote sensing and geographic information systems (Cao et al. 2013; Kumar S., 2018). Research studies have previously used band ratio-based methods to assess water resources (Lacaux et al. 2007; Campos et al. 2012; Leblanc et al. 2011). As a result of its high absorption and subsequent decrease in reflectance in the visible, near-infrared, and middle infrared (NIR) bands of the spectrum (Ji et al. 2009, Kumar S., 2017), water pixels can be accurately extracted from other terrestrial features in optical remote sensing images.

Haryana is home to approximately half a million hectares of irrigation-induced waterlogged saline areas in northwest India (Kumar S. & Singh R., 2021; Arvind et. Al., 2022). There is no doubt that Haryana is one of the worst affected states in the country, suffering acutely from this issue. Nine districts of Haryana are affected by soil salinity and waterlogging, according to a study conducted by Central Soil Salinity Research Institute (CSSRI) (The Tribune, 16 January, 2016). Because of its geology, Haryana has predominantly inland drainage conditions and an extensively closed basin due to the Himalayan Mountains to the north and Thar Desert to the south. A rising water table, waterlogging, flooding after heavy rainfall, and soil salinization can result from both surface and subsurface water flowing towards this depression. Using an integrated RS and GIS approach, this study aims to assess waterlogged areas. An analysis of the overall waterlogging conditions in the study area was conducted using remote sensing data incorporated into a GIS platform.

II. STUDY AREA

The district of Hisar occupies a total area of 3983.00 square kilometres in the state of Haryana. This area lies between North latitudes 28o 56'00" and 29o 38'30" and East longitudes 75° 21'12" and 76° 18'12". Fig. 2.1 shows the location map of the study area. The district area falls in Yamuna sub-basin of Ganga basin. There is no natural drainage in the district area. The climate of Hisar owes to its continental location on the outer margins of the south-west (SW) monsoon region. The SW monsoon, also known as the summer monsoon, brings heavy rains. Rain during the last week of June to mid-September. From October until next June, the weather is almost dry except for a few light showers brought on by westerly depressions/western disturbances (WDs). The normal annual rainfall of the district is 330 mm which is unevenly distributed over the district over a 22-day period. The average monthly rainfall during September is 54.5 mm and June 49.8 mm. The average rainfall received during the normal monsoon season is 283 mm. Generally, rainfall in the district increases from the southwest to the northeast. The district area forms part of the Indo-Gangetic plain. The area as a whole is an almost flat alluvial plain dotted with sand hummocks and sand dunes. The general altitude of the area is between 203 and 225 m msl, with a gentle slope toward the south. The soils of the district are of three types i.e., Arid brown soil, Sierozem soil, and desert soil. The water-logged area accounts for 37.65 sq km (0.93 %) of the total district area during Pre-monsoon and 264.55 sq km (6.55 %) during the post-monsoon period. However, the area under water logging conditions increases almost 7-fold in the post-monsoon period. Ground Water Flow The elevation of the water table in the district varies from 188.82 to 224.42 m msl. The average gradient of the water table for the district was 0.09 m/km.

III. MATERIAL AND METHODOLOGY

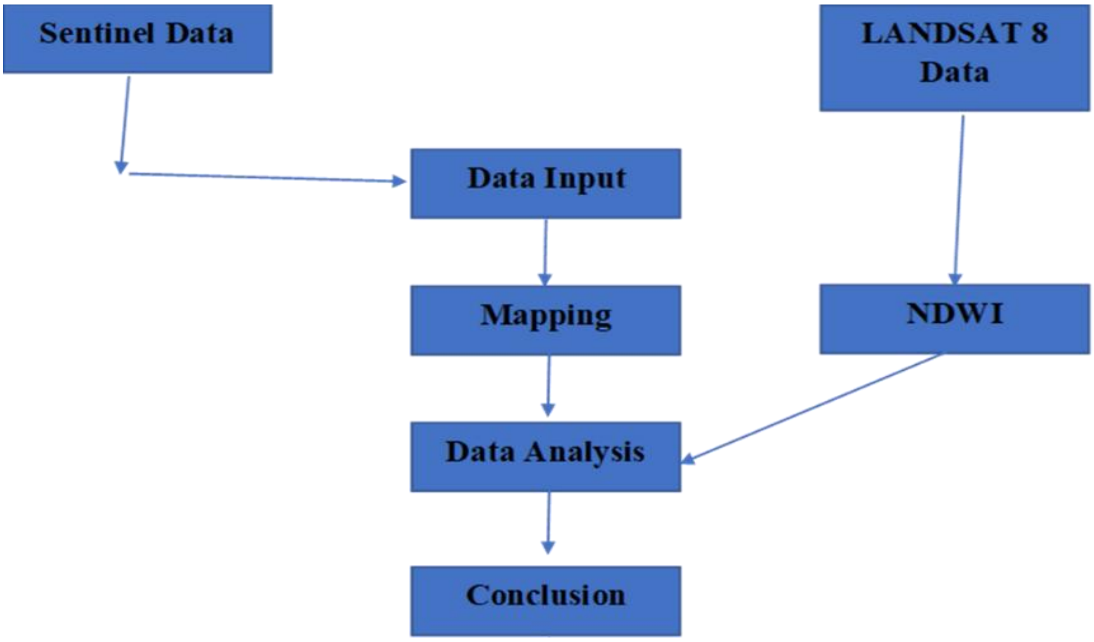

Fig 3.1: Flow Chart of Methodology

Sentinel 2 data have been used for preparation for thematic maps. Carto DEM: Version-3 R1 and LANDSAT 8 data have been used for DEM (Digital Elevation Model) and NDWI (Normalised Differentiate Water Index). Water depth level map have been prepared from scanned map which had been prepared by HARSAC. LANDSAT

8 data have been used for water index calculation. From the Landsat 8 imagery, following Mc Feeters (1996), NDWI can also be calculated using the formula as follows: NDWI = (Band 3 – Band 5) / (Band 3 + Band 5), following the formula for TM and ETM+ bands. Water logged area have been identified from sentinel data. Mottled black pixels indicate waterlogged pixels. All the mottled pixel were digitized in ARC GIS software. The data for Carto DEM: Version-3 R1 is downloaded from Bhuvan Portal for DEM and slope mapping in Hisar District in Haryana. The DEM data has a resolution of 30 meters. Data downloaded in multilayers were merged into one raster dataset. It is then necessary to generate DEM and slope maps. The fig. 3.1 shows the flow chart of methodology.

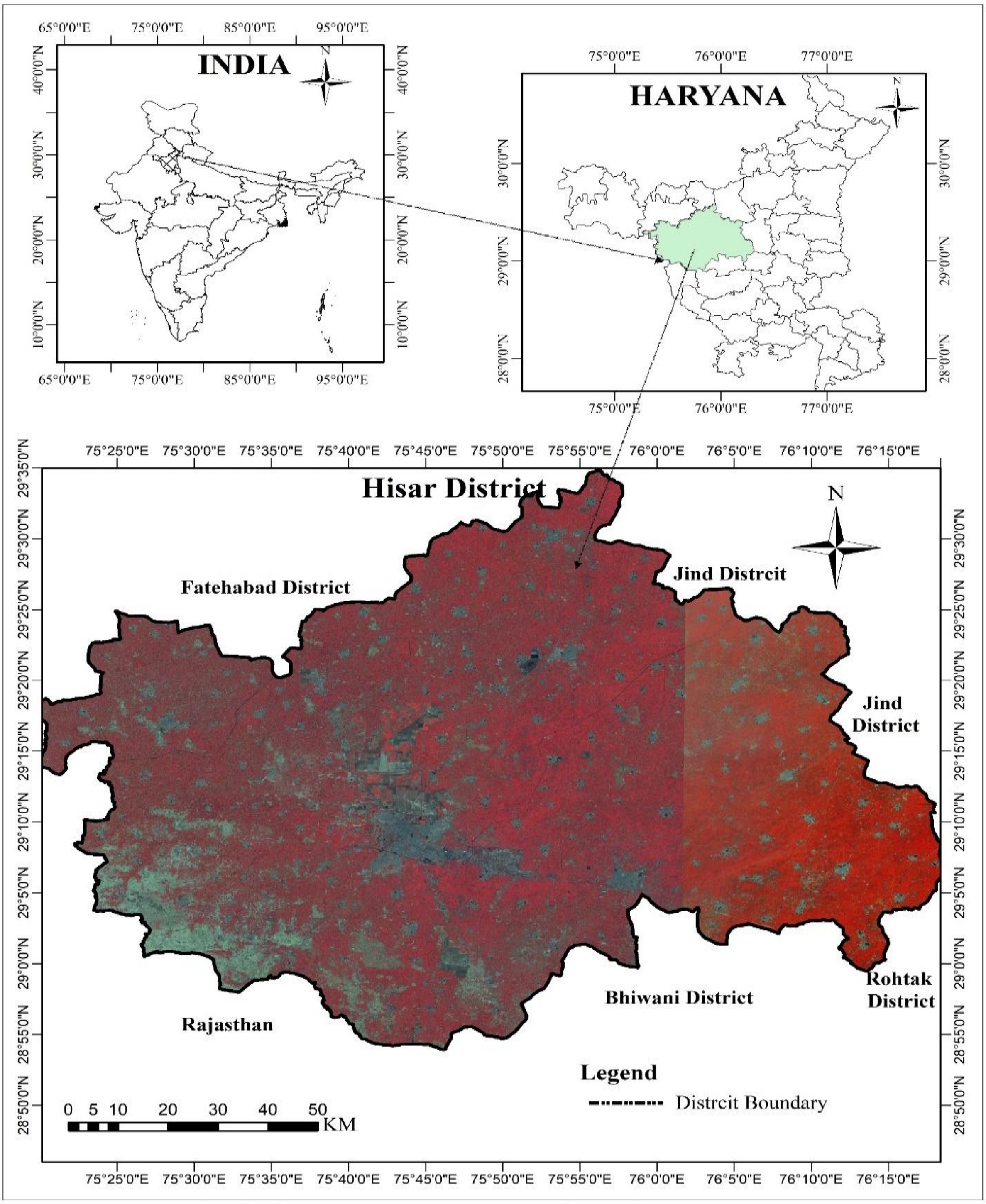

Fig 3.2: Location map of the study area

IV. RESULT AND DISCUSSION

In this section is talk about what I have found in the study area. After finalizing the spatial database and collecting the relevant information detailed analysis was carried out to demarcate waterlogged area in Hisar district. Base map, NDWI and groundwater depth map were prepared.

4.1 Base map

On the basis of satellite data base map is prepared out of the study area (Fig. 4.1). In this map linear and polygon features like as roads, railway line, built up area and waterbody.

4.2 Groundwater Depth map

The table no. 4.2.1 and Fig. 4.2.1 shows the groundwater depth under different classes of Hisar district. The area under class of 0-5 m covers 11%, 05-10 m covered 58%, 10-15 m covered 26% and 5% area have above 15m water table depth.

Table no 4.2.1: Water depth area analysis

Water Depth Level (m)	Area in %
< 5.00	11
5.00 – 10.00	58
10.00 – 15.00	26
>15	05

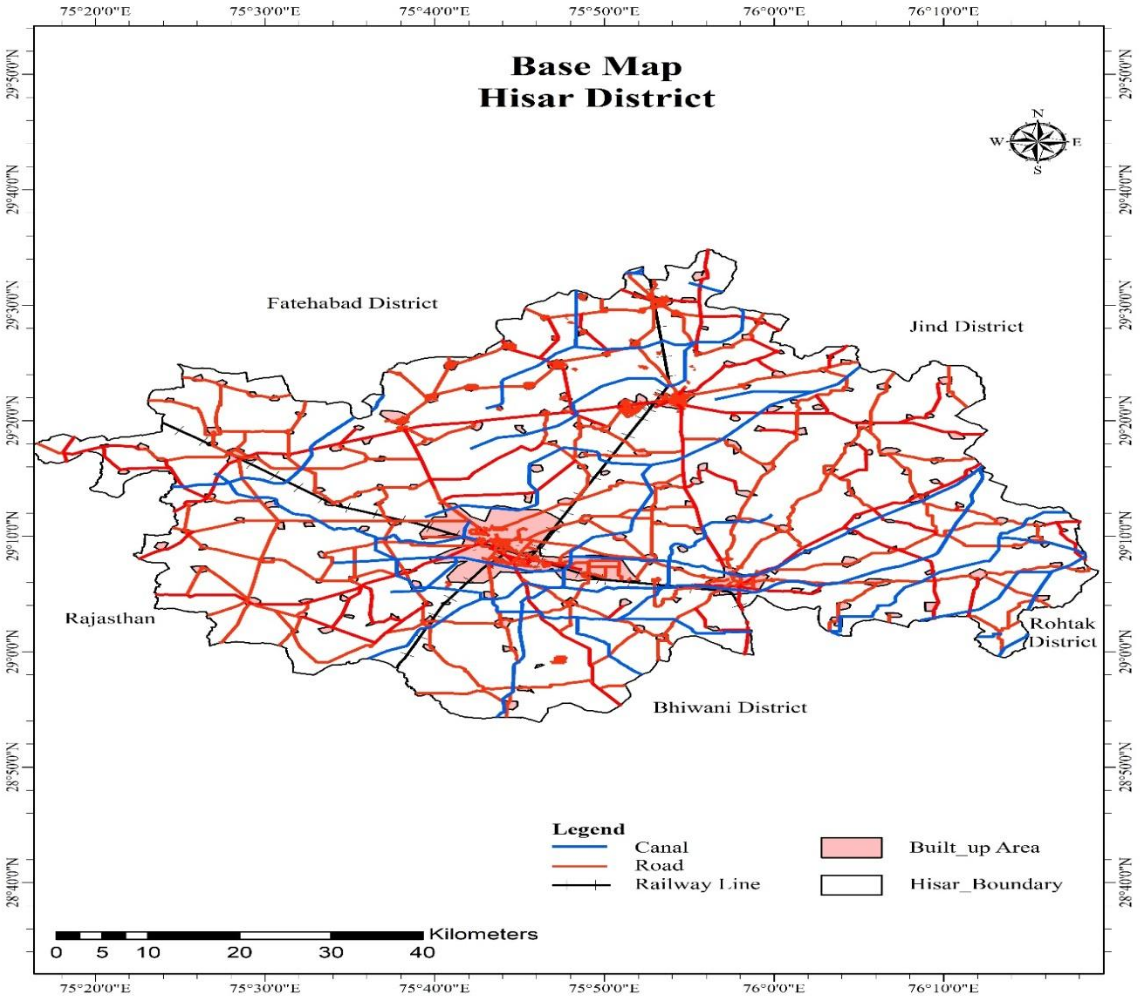

Fig.4.1: Base map of the study area

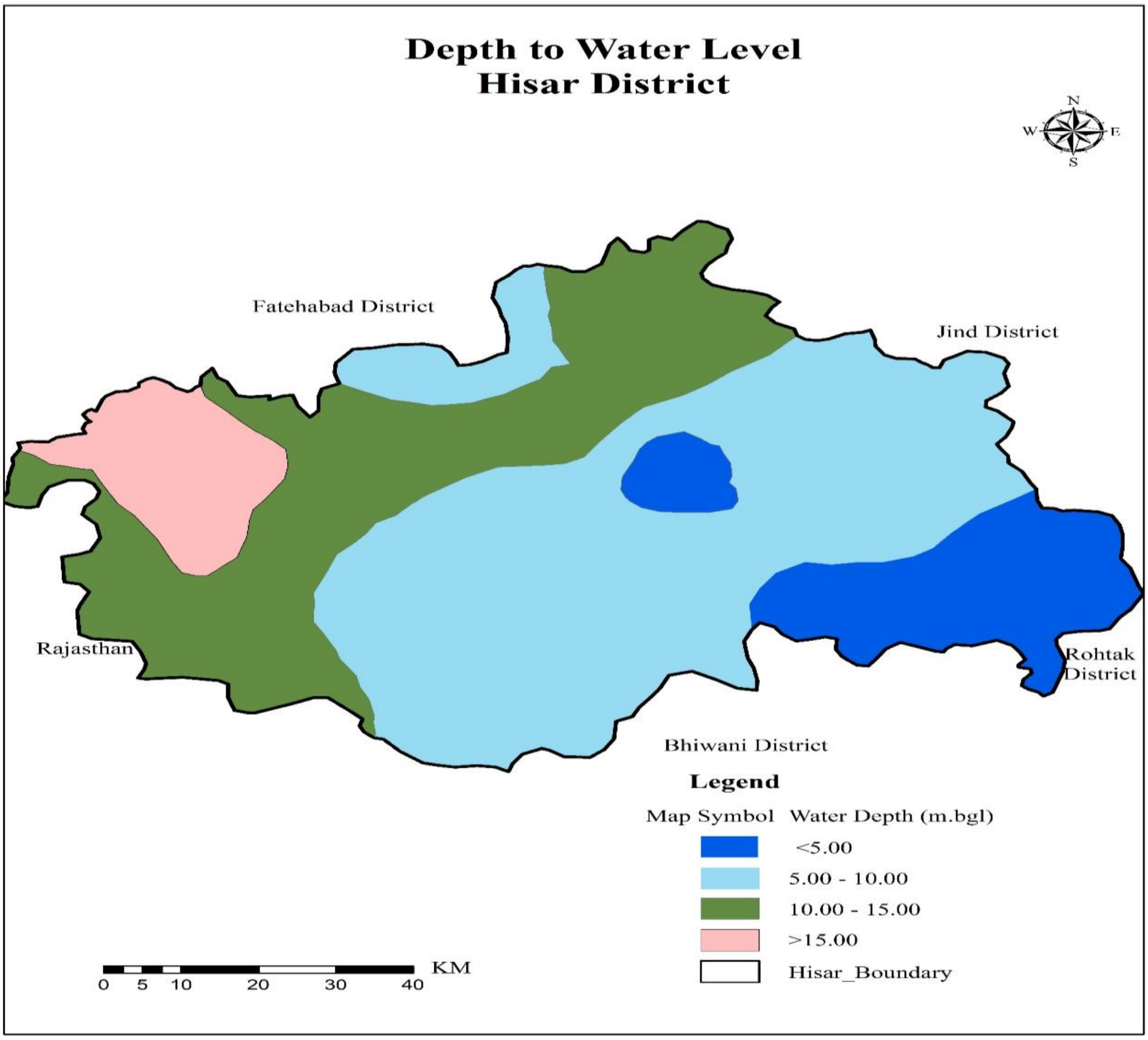

Fig. 4.2.1: Water depth map

4.3 NDWI map

The formula of NDWI calculation for different band combinations of the Sentinel Satellite. values vary -1 (negative) to 1 (positive) in which above 0.5 value for water bodies, 0-0.2 value for built-up area, soil and vegetation have 0 or negative value. Table 4.3.1 and Fig. 3.3.1 shows the NDWI area and map. Clear and turbid ware reflects in only visible portion (0.4 -0.7 μm) of EM spectrum after visible band no reflectance has been found (Kshetri, 2018). The formula of NDWI calculation for different band combinations of the LANDSAT series is given in Table.3. Calculated values vary -1 (negative) to 1 (positive) in which above 0.5 value for water bodies, 0-0.2 value for built-up area, soil and vegetation have 0 or negative value.

Table no. 4.3.1: NDWI area analysis

Class	Area in %
Vegetation-Agriculture Land	68
Built-up Area	28
Water content	04

Above table shows Vegetation-Agriculture Land covers highest area of Hisar district. Water content and built-up areas covers lowest area.

4.4 Waterlogged Area

Waterlogged area is delineated by using sentinel data. Table no 4.4.1 and Fig. 4.4.1shows the water-logged area and map.

Table no. 4.4.1: Waterlogged area calculation

Class	Area in km²	Area in %
Waterlogged Area	39.99	1.01

According to the table waterlogged area in Hisar district is 1.01%. The satellite data was pre monsoon season.

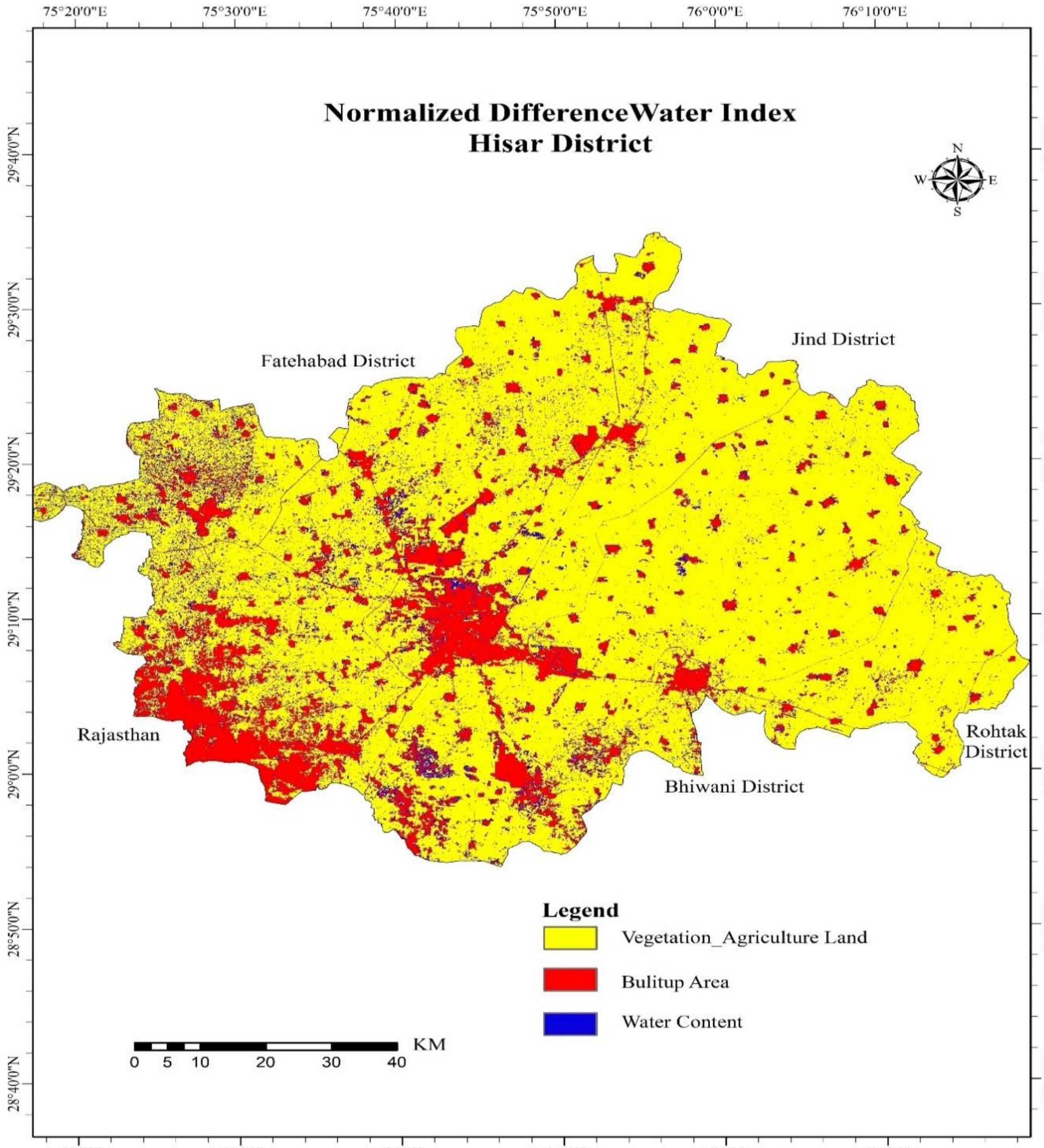

Fig. 4.3.1: NDWI map

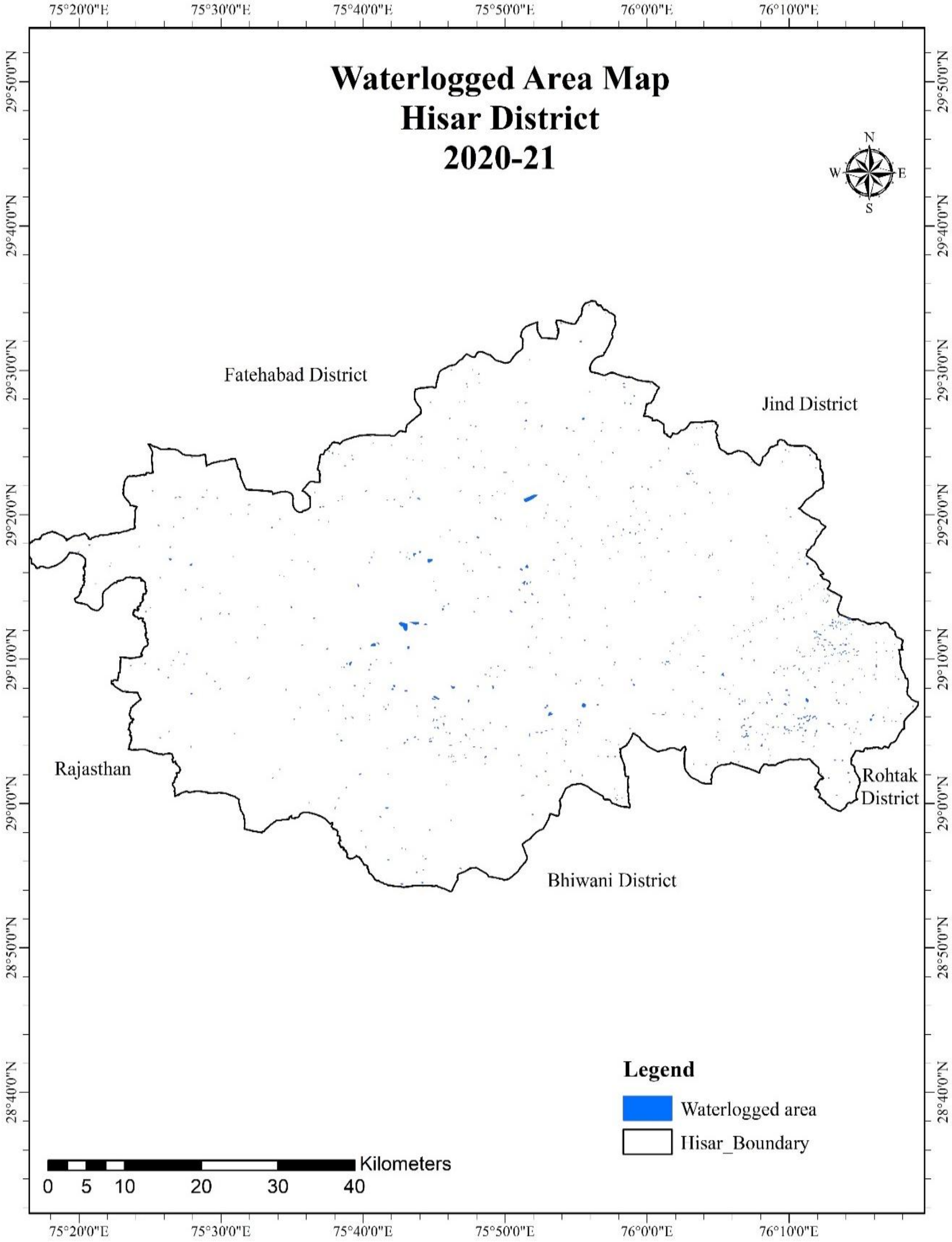

Fig.4.4.1: Waterlogged area in Hisar

V. CONCLUSION

The study establishes the role of remote sensing and geographical information system for waterlogged area in an integrated way. The major findings of the study are: (1) Based on pre monsoon satellite data, waterlogged area in the Hisar district was 1.01%. (2)According to NDWI, 68% area under vegetation and agriculture land, 28% area is built up area, 04 % area is water content. (3) Maximum area near about 58% lies under 05 to 10m, while above under 15 m depth only 05% area falls (4) Maximum area of the Hisar district is to be prone as waterlogged.

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