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Spatial and temporal variation in NDVI and NDWI of the Ukhma River Basin, Central India

S. Singh[a,b], S Kanhaiya[c]*, Susheel Kumar[d], S. K. Yadav[c]

[a] Department of Earth Sciences, Indian Institute of Science Education and Research, Kolkata, India
[b] Department of Geology, Institute of Earth and Environmmental Sciences, R.M. L. Awadh University, Ayodhya, India
[c] Prof. Rejendra Singh (Rajju Bhaiya) Institute of Physical Sciences, V. B. S. Purvanchal University, Jaunpur, India
[d] Centre for Petroleum Exploration, Mizoram University, Aizawl, India

*corresponding author, Email: shyamkanhaiya44@gmail.com

Abstract: **The present study is a reasonable step on quantitative approaches of water management and advancement of groundwater potential for watershed development of the Ukhma River Basin with the help of remote sensing and GIS techniques. The Ukhma River is one of the significant NW (north-west) flowing tributaries of the Tons River in Central India occupying a 745 sq km area within the Kaimur and Rewa Group of rocks in the Son valley sector. It originates from Ledari Village and joins the Tons River near Deokhar village, Satna District, Madhya Pradesh, Central India. In the present study variations in NDVI and NDWI of the Ukhma River Basin has been measured significantly from 2006-2019. The NDVI and NDWI provide turbidity estimations of the basin's vegetation cover and water resources. The change in NDVI and NDWI detection from 2006-2019 indicates that the area susceptible to erosivity increases the surface runoff reduces the infiltration rate.**

Index Terms: **Ukhma River, Central India, Surface runoff, NDVI, NDWI**

I. INTRODUCTION

Land degradation is a continuous process caused by various factors, primarily climatic changes and human activities. Factors responsible for the significant changes in the Earth's surface may be effective globally (Tran and Campbell, 2015). In the present scenario, delineation of the rate of land degradation and desertification causing the alteration of geomorphic changes received significant attention globally. The standard ground survey methods through satellite-based and airborne remote sensing systems emerged as an efficient tool to access the changes in geomorphic features at micro-scale. Geospatial data at various scales from the satellites ominously support analyzing alteration in land surface, desertification processes, climate changes and retrieving the relationships among them.

Additionally, satellite images are also imperative in assessing land cover (Alphan and Yilmaz, 2005). Vegetation is the primary element of ecosystems on the Earth's surfaces and plays a vital role in the atmospheric fluctuating and soil-water conservations. Moreover, vegetation plays a dominant role in justifying the increase in greenhouse gas absorptions (Sun et al., 2015). Therefore, variations in the vegetation cover may considerably impact the environment on a global scale and may guide scientifically for expressing balanced land-use patterns (Zhang et al., 2008). NDVI, an effective tool derivative from satellite image data in the red bands and near-infrared, has been used to access the rate of vegetation alterations at a large scale (Piao et al., 2006). At present, the NDVI technique is extensively used in various fields, including environmental research, monitoring restoration projects, and agriculture studies (Magney et al., 2016).

The present study focused on the Ukhma River Basin (Fig.1). The Ukhma River is one of the principal tributaries of the Tons River and flows through vital districts like Rewa and Satna of Madhya Pradesh, Central India. Ukhma River is an average seasonal river originates from Ledari Village and joins Tons River near Deokhar Village of Satna District, Madhya Pradesh. The basin area of the Ukhma River covers Vindhyan rocks, having a maximum elevation of about 449m and a minimum of about 95m, covering an area of about 745sq km. The groundwater available for drinking and irrigation purposes is shallow dug wells or surface rainwater mainly concentrated in small patches of alluvium or highly fractured/jointed rocks.

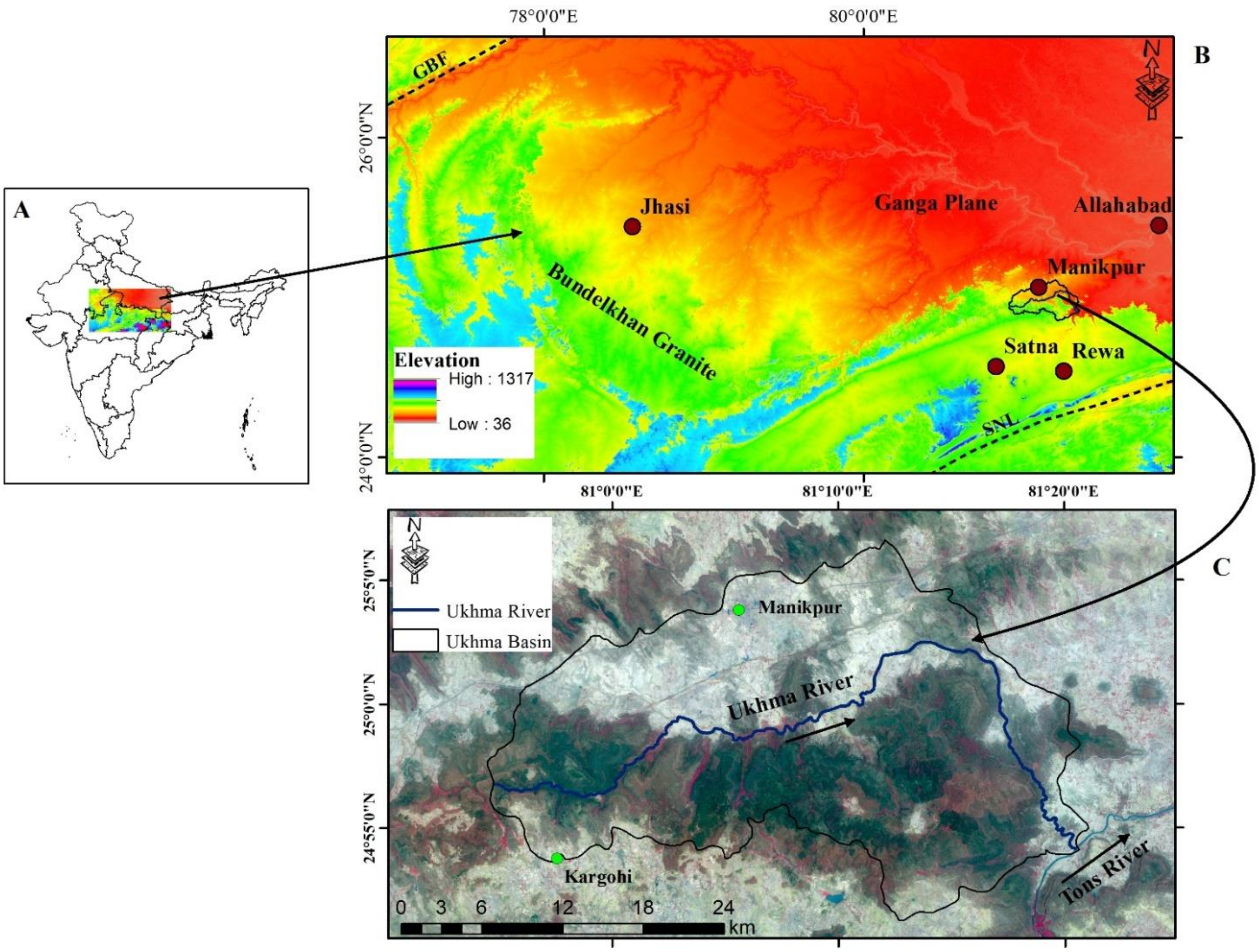

Fig. 1. Map showing the position of the Ukhma river basin in central India.

II. Geology

The Ukhma River Basin is spread over Vindhyan Super Group. The Vindhyan Supergroup is separated into two groups the Semri Group (Lower Vindhyan) and Kaimur, Rewa, Bhander Groups (Upper Vindhyan consist) (Auden 1933, Bose et al. 2015). The Ukhma basin is covered by the Rewa Group of rocks. Rewa Group consists of sandstone and shale. Kaimur Group, having quartzite, sandstone, and shale. Rewa Group, one of the significant horizons, covers 77% of the basin area, and the Kaimur group includes 23% of the basin area.

III. Methodology

NDVI is an index that defines the ratio between the Red and near-infrared bands (Weier and Herring, 2000). NDVI can be used to estimate the density of vegetation on Earth's surface (Weier and Herring, 2000). NDWI is an index ratio to the Short Wave Infrared and Near-Infrared bands (Gao, 1996). NDWI is used to detect moisture contained in plants and soil.

The Shuttle Radar Topography Mission acquired elevation worldwide to create Earth's surface's entire 90 and 30m resolution advanced topographic database. The SRTM DEM was used for delineating the Ukhma river basin boundary.

IV. Results

(A) Normalized difference vegetation index (NDVI): The Spatio-temporal variation of The NDVI was

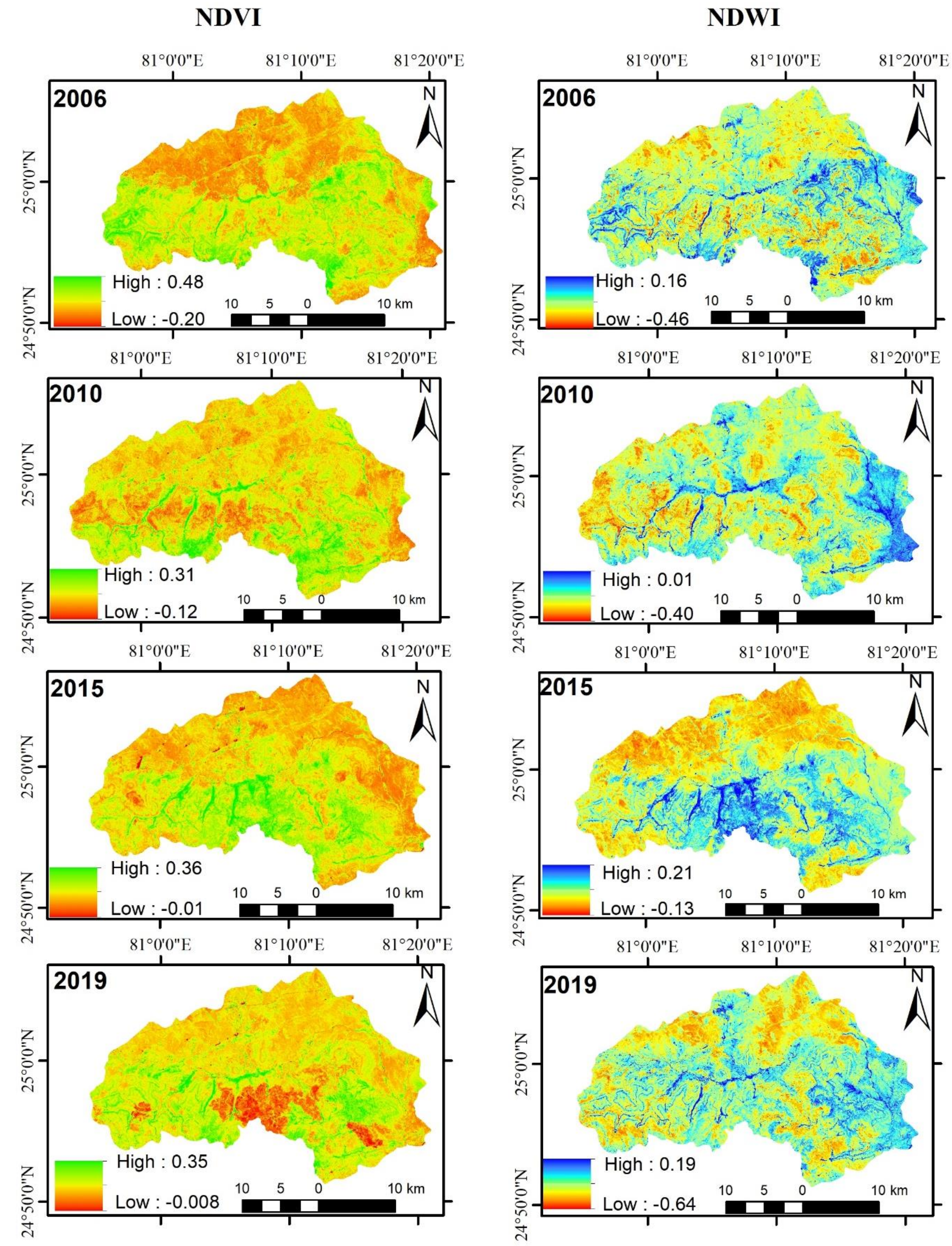

Fig. 2. From 2006-2019 the spatial distribution of higher NDVI decreases, and the lowest NDVI increases. The minimum value of NDWI is increased continuously from 2006-2019.

high in the southern part of the Ukhma Basin while decreasing towards the northern region of the basin. The rainfall variation plays a dynamic role in the changes in vegetation. The value of NDVI shows the vegetation change in the lower and middle parts of the Ukhma basin, which was severe for the ecological constancy of the basin. The principal vegetation types were grassland and agricultural land, which can strongly regulate the eco-environmental position of the Ukhma basin. On a comparable basis (2006-2019), maximum NDVI occurs in the south-eastern and southwestern parts, and minimum happens in the Ukhama Basin's southern region. The areas are covered with settlements, agricultural practices, rocky, barren lands, indicating imperviousness (Fig. 2). As per change detection from 2006-2019, the spatial distribution of the highest NDVI decreases, and the lowest NDVI increases, indicating that the area susceptible for erosivity increases the surface runoff, reduces the infiltration rate, and surface runoff, etc. (Fig. 2). This variation influences by the rainfall variations between the years 2006 to 2019.

(B) NDWI (Normalized difference water index): NDWI is suitable for water body mapping. NDWI uses the near Infrared band and green band of images (Gao 1996). The NDWI can improve the water body or water contained information successfully in most cases. Maximum NDWI occurs in the south-eastern and southwestern portions and minimum in the northern part of the Ukhama basin. The spatial distribution of minimum NDWI has been increasing from 2006-2019. As per change detection, the minimum value of NDWI increases continuously from 2006-2019, indicating that open surface water or vegetation may be underwater stress conditions, which is the sign of drought or low vegetation cover, etc. (Fig. 2).

CONCLUSION

The NDVI and NDWI also provide turbidity estimations of the basin's vegetation cover and water resources. As per change detection from 2006-2019, the spatial distribution of the highest NDVI decreases, and the lowest NDVI increases, indicating that the area susceptible for erosivity increases the surface runoff, reduces the infiltration rate, and surface runoff, etc.. As per change detection, the minimum value of NDWI increases continuously from 2006-2019, indicating that open surface water or vegetation may be underwater stress conditions, which is the sign of drought or low vegetation cover, etc.

The change in NDVI and NDWI detection from 2006-2019 indicates that the area susceptible to erosivity increases the surface runoff reduces the infiltration rate and surface runoff.

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