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Identification of critical soil erosion prone areas and prioritization of micro-watersheds using geoinformatics techniques

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ABSTRACT

Soil and water come under the category of the most important renewable natural resources on earth. But due to their indiscriminate use, they can be seriously endangered. Hence it is essential to manage natural resources sustainably to preserve them for the future. For soil prevention, Morphometric analyses only drainage pattern. However, Land Use/Land Cover (LULC) and soil characteristics should also be considered. Thus, it is necessary to combine all methods of prioritization to provide reliable results. As the Ganga watershed in India is currently under environmental distress, therefore in the present study, Morphometric, land use/land cover and Universal Soil Loss Equation (USLE) analysis are done in this watershed using ArcGIS and ArcSWAT. To identify the erosion prone areas for effective planning and management of groundwater resources the study area was divided into seventeen sub-watersheds for the analysis. The mainstream of the basin is of eighth order, and drainage patterns of sub-basins are mostly of sub dendritic to dendritic. Various linear, areal and relief parameters of each sub-watersheds have been determined, and sub-watersheds are prioritized by ranking them according to erodibility characteristic. The results reveal that according to Morphometric analysis out of seventeen sub-watersheds, Rajpura Region, Narahi Region and Mughal Sarai Region Sub-watersheds are subjected to more soil erosion, and Sarai Meer Region, Balia Region and Ghazipur Region Sub-watersheds are subjected to least soil erosion. Whereas according to LULC and USLE analysis Narahi Region, Pipra Region, Gahmar Region Sub-watersheds and Rajpura Region and Mughal Sarai Region Sub-watersheds are likely to be subjected to more soil erosion respectively. Sarai Meer Region, Lalganj Region, Pindra Region Sub-watersheds and Sarai Meer Region, Lalganj Region,Magharia Region Sub-watersheds are subjected to least soil erosion according to LULC and USLE analysis respectively. Integrating all the three methods, we found that Chandauli Region, Narahi Region and Mirzapur Region Sub-watersheds are suffering from severe soil erosion problem and Sarai Meer Region, Lalganj Region and Ghazipur Region Sub-watersheds have least soil erosion. These results can be further used for soil erosion and sediment yield modeling projects.

1. Introduction

Interest in developing a different algorithm for prioritizing watershed and identifying the critical soil erosion prone areas has increased from last few years. The researchers knowing the hazardous effects of soil erosion on water quality and agricultural production are trying to develop certain measures for mitigating these effects. The real challenge for planning and management of natural resources at a micro-level is due to high precision data requirements. Therefore micro-level hydrological unit (sub-watersheds) are chosen circumspectly for improved planning and management (Aher et al., 2014). The watershed management practices cannot be carried out for the full watershed. It should get started from the most sensitive sub-watershed. Welde (2016) has divided the watershed into 47 sub-watershed and then with the help of SWAT 2009 identified and prioritize the most sensitive watershed. Comin et al. (2014) have prioritized watershed for water quality improvement in an agricultural watershed.

Soil erosion assessment has gained attention because it can be used as a base for developing effective soil and water conservation

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plans (Ahmad and Hagos, 2016). Estimation of soil erosion and identification of critical soil erosion prone area for implementation of sediment filtration basins and other Best Management Practices (BMPs) is central to the success of soil conservation program (Ganasri and Ramesh, 2015). Sediment filtration basins are the structural BMPs to mitigate non-point source pollution of urban areas (Jeong et al., 2013). The hydraulics engineers give high priority to the study of geotechnics of soil erosion as the soil erosion is the main cause of bridge scouring. Various methodologies have been applied for the soil erosion assessment (Guo and Yu, 2017). SWAT model is a very helpful tool for identifying and prioritizing soil erosion prone areas (Ghafari et al., 2017). Raja et al. (2015) used Sediment Yield Index (SYI) method for prioritizing the watershed to know the extent of soil loss. There are many factors which are affecting soil erosion directly or indirectly. Soil erosion is changed by the impact of Land use and soil management (Vanwalleghem et al., 2017). Land management is certainly the key factor to minimize a wide range of damaging effects of soil erosion. To implement BMPs, we need to determine soil loss tolerance and identify and prioritize vulnerable and high-risk zones (Ghafari et al., 2017).

To determine soil erosion, the model should be capable enough to satisfy the requirements of universal acceptability (Pandey et al., 2016). The most widely used method for estimating soil erosion is Universal Soil Loss Equation (USLE) (Mancino et al., 2016). Singh and Panda (2017) used USLE to assess the soil erosion potential to identify the soil erosion prone areas in Kapgari watershed of India. USLE and USLE-M model for predicting maximum annual values of event soil loss, according to him USLE based models are attractive from the practical point of view as the input data are easy to obtain (Bagarello et al., 2017). Ganasri and Ramesh (2015) has integrated revised USLE model with GIS to estimate soil Loss.Morphometric characterization is important to recognize the hydrological behavior of the basin for carrying out management strategies (Aher et al., 2014). Prioritization only by Morphometric analysis is not reliable enough as it does not consider land use land cover and soil characteristics, therefore, in this study along with Morphometric analysis we used USLE, and Land use Land cover based prioritization to identify the critical soil erosion prone areas.In this study, we have first time considered the morphometric, LULC and USLE model together to estimate the soil edibility of the study area. The main objectives of this work:

1. To analyze the morphometric parameters of the study area.
2. To estimate the soil loss using USLE with the help of rainfall data, DEM and Land Use/Land Cover map.
3. To find out the erosion prone area by prioritizing the sub-watershed

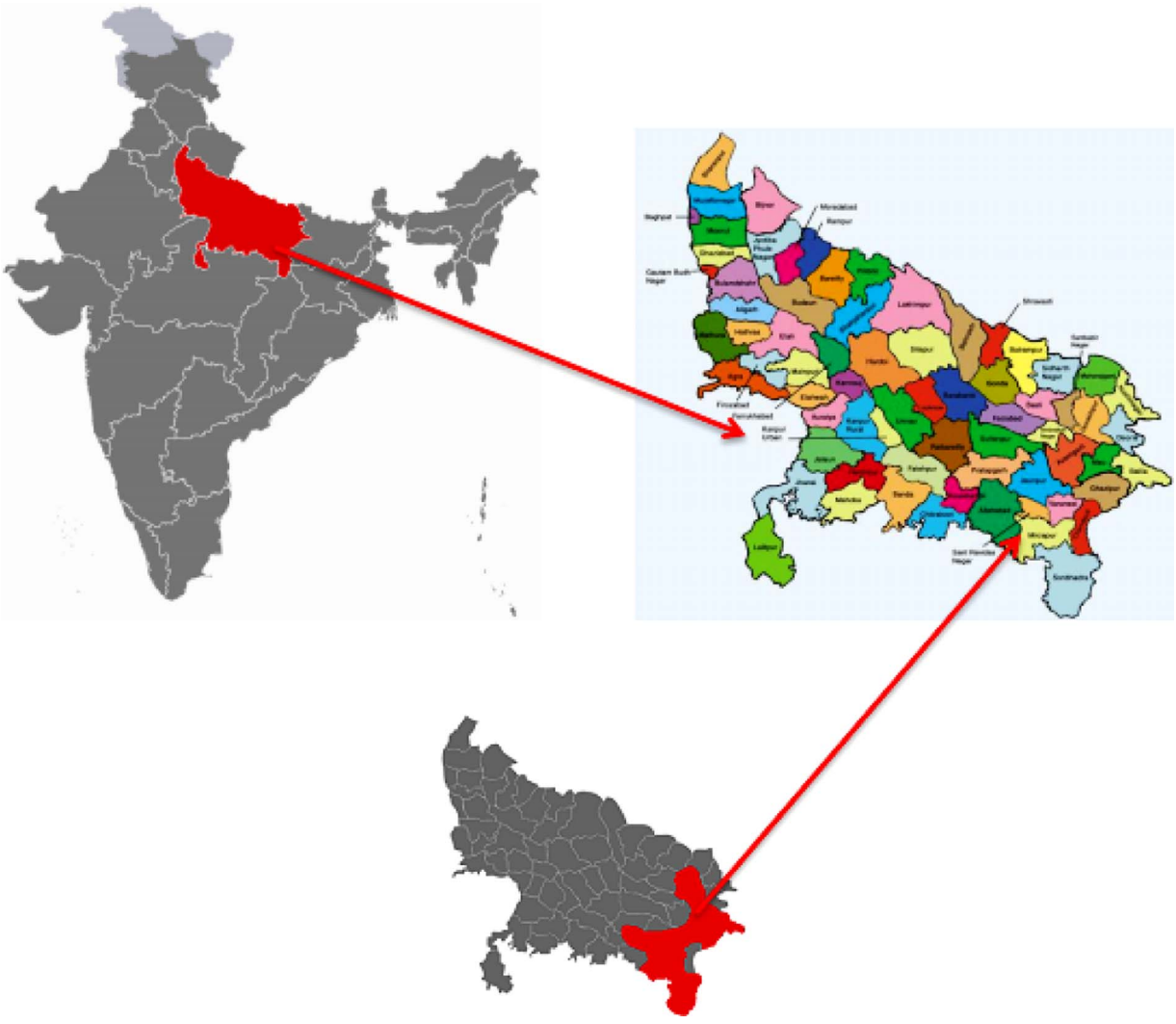

Fig. 1. Study Area.