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Prioritization of Sub-Watershed Based on Soil Loss Estimation Using RUSLE Model:
A Case Study of Digaru Watershed, Assam, India

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ABSTRACT

Soil erosion is one of the most crucial land degradation problems and is considered the most critical environmental hazard worldwide. The present study uses remote sensing data integrated with the geographical information system (GIS) technique and the revised universal soil loss equation (RUSLE) model for assessing the annual average soil loss of the Digaru watershed of India for 1999 and 2020. The estimated mean gross yearly soil loss from the entire watershed was 102716 t yr-1 in 1999 and 178931.6 t yr-1 in 2020. The overall average soil loss rate increased significantly between 1999 and 2020, rising from 4.73 t—ha-1yr-1 to 8.43 t—ha-1yr-1. The sub-watersheds are prioritized as high (≥ 40 t ha−1yr−1), moderate (20–40 t ha−1yr−1), and low (<20 t ha−1yr−1) based on the spatial distribution of soil erosion. Seven sub-watersheds have been grouped under low priority, followed by seven under moderate priority and one under high priority. This study demands instant attention for soil and water conservation efforts in highly eroded watershed areas.

KEYWORDS

Digaru Watershed, GIS, Land Degradation, RUSLE, Soil Erosion, Sub-Watershed Prioritization

INTRODUCTION

One of the most serious environmental challenges facing the world today is land degradation, which is threatening many areas across the globe at an alarming rate (Devatha et al., 2015; Olorunfemi et al., 2020). Land degradation happens when natural and anthropogenic processes reduce the land's capacity to sustain crops, livestock, and organisms (Bhan, 2013). Approximately 6 billion hectares of land have been impacted by various forms of land degradation worldwide, including soil erosion, sealing, pollution, salinization, and acidification (Mohammed et al., 2020; Wessels et al., 2007; Kertesz, 2009; Inbar & Zgaier, 2016; Ganasri & Ramesh, 2016, Djoukbala et al., 2018). Soil

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erosion is accelerated by uncontrolled deforestation, poor land use and land management practices, over-grazing, incorrect tillage, and unscientific agricultural practices adopted in the upland areas of watersheds (Arekhi et al., 2012). The most common effects of land degradation are a raised risk of flooding, eutrophication, turbidity, lowered topsoil nutrients, decreased agricultural output, decreased vegetation growth, excessive sedimentation, and other effects (Hlaing et al., 2008; Pradeep et al., 2015; Eniyew et al., 2021, Kebede et al., 2021).

Therefore, throughout the past three decades, watershed-level research has become the subject of both societal concern and hydrological exploration (Wang et al., 2016). Despite being a global problem, soil erosion is more prominent in the tropics and sub-tropics. In India, the sustainability of the human population is seriously threatened by soil erosion, which also jeopardizes the productivity of all other natural ecosystems, including wetlands, grazing, and agriculture. In addition, soil erosion induces aquatic imbalances, harm to drainage systems, declining water bodies and reservoir water quality, and environmental and infrastructural problems (Kumar & Sahu, 2020). The projected overall land degradation in India is estimated at 147 million hectares, of which around 94 million hectares have been degraded by acidity and the rest by flooding, wind erosion, salt, or a combination of these processes (Bhattacharyya et al., 2015).

The north-eastern region of India is endowed with distinct physical characteristics including mountainous topography and torrential downpours with broad spatial fluctuations. Thus, this region is vulnerable to significant soil erosion due to unsustainable and improper land-use practices along the steep hill slopes (Choudhury et al., 2022). To implement successful management techniques, it is necessary to conduct a quantitative and detailed assessment using a scientific database to determine the intensity and severity of soil erosion issues. This will further aid in identifying the probable sites for soil erosion. By implementing necessary strategies and measures, improved planning for soil conservation and agricultural activities could be accomplished (Tiwari et al., 2018). Soil loss estimation at the watershed level and its management through sub-watershed prioritization have been found to be authentic and satisfactory (Naqvi et al., 2012). Various empirical models have been developed to estimate soil loss, followed by watershed prioritization.

The most popular empirical model is the Universal Soil Loss Equation (USLE), developed by Wischmeier and Smith in 1965 and refined in 1978 (Wischmeier & Smith, 1978). Furthermore, numerous scholars have employed the new model, the Revised Universal Soil Loss Equation (RUSLE) developed by Renard et al. (1997), in subsequent studies to investigate soil loss estimation. When Geographical Information System (GIS) is combined with remote sensing, the RUSLE can effectively show the regional variance of long-term average soil loss on both a large and small scale (López-Vicente & Navas, 2009; Onori et al., 2006). In the RUSLE model, six important factors are considered: rainfall erosivity (R), soil erodibility factor (K), slope length (L), slope steepness factor (S), cover management factor (C) and conservation practice (P) factor. The model is widely utilized because of its ease of use and simple input parameter calculation compared to other models.

There are several studies conducted globally on soil loss estimation employing USLE and RUSLE models at international level. Hao et al. (2017) conducted a study on the karst basin of Guizhou Province, China to quantify the distribution of soil erosion using the RUSLE model. Their findings emphasised that the average annual soil loss rate of the simulation was 30.24 Mg ha–1 yr–1. Compared with the previous observation result, the RUSLE model performed effectively with the selected sub-models for all the factors. Al-Mamari et al. (2023), focusing on Oman, realized that the RUSLE method has shown potential for predicting soil loss in wadi systems using a GIS environment and satellite remote sensing data. They have estimated a total soil loss of 196,599 ton/ha yr− 1. Mohammed et al. (2020) studied the spatial distribution of soil erosion in the southern part of Syria using a RUSLE-integrating geoinformatics approach, concluding that the integration of GIS and remote sensing technology played a key role in estimating the soil erosion risk in a simple, easy, and scientific way. Further, they have quantified that the potential soil erosion ranged from 1.26 to 350.5 tons' ha− 1 yr− 1, where 5% of the study area showed extreme erosion risk.