Peer review status:

This is a non-peer-reviewed preprint submitted to EarthArXiv

Estimate rainfall-runoff using Google Earth Engine in the Minab River Basin

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Abstract

The Soil Conservation Service Curve Number (SCS-CN) method is a widely accepted and reliable approach for estimating rainfall-runoff relationships within a watershed. This technique is instrumental in hydrological studies, particularly for sustainable water resource management, flood control, and soil conservation. The integration of the SCS-CN method with Google Earth Engine (GEE), a cloud-based geospatial analysis platform, enhances runoff estimation by leveraging high-performance computing and extensive satellite datasets. This study applies the SCS-CN method within the GEE framework to estimate surface runoff in the Minab basin for the period 2022–2023. The research highlights the effectiveness of combining remote sensing and hydrological modeling to improve watershed management and decision-making processes.

Key Words; rainfall-runoff , Google Earth Engine, Minab River Basin

Introduction

The Soil Conservation Service and Curve Number (SCS-CN) method is the most dependable statistical technique for estimating rainfall-runoff of a specific watershed among the several rainfall-runoff modeling methods. Through surface runoff estimation, the SCS-CN approach assists in identifying a watershed's hydrological characteristics and aids in the creation of appropriate plans for the management of water resources by watershed planners (Schulze et al. 1992). Due to its significant advantages for watershed development, notably in soil permeability, land use development, and antecedent soil water conservation, the SCS-CN technique has gained widespread acceptance among researchers worldwide (Bansode and Patil 2014).Many scholars, including Amutha and Porchelvan (2009), Sindhu et al. (2013), Gitika and Ranjan (2014), Satheeshkumar et al. (2017), Pal and Chakrabortty (2019), Zahabnazouri, 2020, Zahabnazouri et al, 2021; Psomiadis et al (2020) and others, have developed approaches based on the SCS-CN method to estimate the watershed-based surface rainfall–runoff. Without requiring complex data, the SCS-CN approach produces satisfactory outcomes (Chatterjee et al. 2001). The SCS-CN approach is one tool for information integration for establishing flash flood hazard zones (Abuzied and Mansour , 2019).
One of the important hydrologic parameters in water resource studies is rainfall–runoff, particularly for modeling rainfall–runoff within a watershed (Ningarahu et al. 2016). This study estimated rainfall-runoff to preserve water resources and practice sustainable watershed management in a Minab basin utilizing the SCS-CN method with GEE techniques. GEE is a web-based cloud-based platform that facilitates planetary-scale geospatial analysis to address numerous high-impact social and natural issues (Gorelick et al, 2017).

Study are

The Minab basin is located in Hormozgan province and it is one of the most watery rivers in southern Iran. Among the forms of erosion, surface erosion is significantly present in the most parts of the basin. The occurrence of floods is one of the important natural processes that play a major role in shaping the Minab River (in the absence of a base discharge due to the construction of Minab Dam to the Strait of Hormuz) in establishing balance in its behavioral patterns. At the same time, in order to use this river as much as possible, it is inevitable for humans to interfere in the natural behavior of the water flow, especially to control and deal with the adverse consequences resulting from the floods of this river. Improving and correcting the course of the river is one of the common measures that are taken to guide the flow and reduce the destructive effects of floods. This method can be considered as a part of the comprehensive flood control measures, which in terms of its effect on the natural behavior of the flow and morphological characteristics, awareness of the river's actions and reactions and recognition of the mutual effects and prediction of the consequences of the improvement measures are necessary. All these cases can have an effect on the entire territory of the river and make the process of dividing its different parts a problem. The rocks in the studied area are mostly composed of sandstone, siltstone, mudstone, conglomerate, gray marl with interlayers of sandstone, gypsum marl, and calcareous marl with thin intervals of sand. The aforementioned outcrops are mostly composed of sandstone, limestone and conglomerate, and they are resistant and stable and are seen as blades (Hosseinzadeh et al ,2015)
The increase in density on the extent of the destruction of the bed and the bank of the Minab River has an increasing rate and accelerates the amount and extent of erosion (Shweidi , 2019), the bedrock consists of layers of sandstone, conglomerate, interspersed between layers of marl and marl shale, and these layers do not have the same resistance and stability, and as a result, they have different erosibility (NohaGar, 2018), Soil erosion and subsequent redeposition are regarded as one of the primary mechanisms of soil deterioration. (Shirzadi et al, 2023)

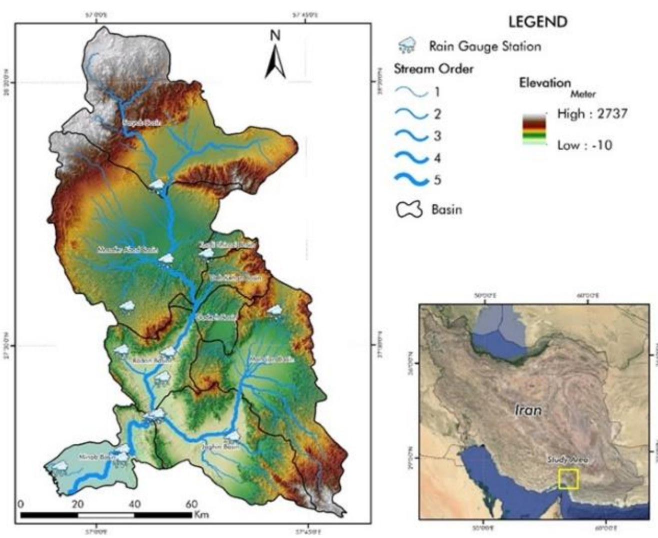

Figure 1. Study area

Material and methods

The development of Google Earth Engine (GEE), a cloud-based platform for processing and analyzing geographic information, is crucial to resolving issues with remote sensing research. GEE has been widely used in regional and international geoscience research because it enables users to access mature satellite remote sensing datasets and apply high-performance computing resources without requiring the download of large amounts of remote sensing image data or complex image processing (Senay et al., 2022, Zahabnazouri et al, 2024). One of the most important tasks in hydrological research is the estimation of runoff, especially in applied water resources research for various purposes such as flood control and soil and water conservation. However, it can be difficult to accurately determine surface runoff in watersheds that are poorly surveyed or not surveyed at all. Various hydrological models are available for estimating runoff. For estimating runoff from precipitation, hydrologists and other water resource professionals consider the SCS-CN (Soil Conservation Service-Curve Number) method now known as the NRCS-CN (Natural Resource Conservation Service-Curve Number) method to be one of the most popular, reliable and attractive approaches (Voda et al. 2019, Verma et al. 2020).This study aims to estimate surface runoff by utilizing the SCS curve number approach in conjunction with the GEE platform. We utilize the GEE assets dataset for runoff calculations. In this research runoff calculated for Minab basin in 2022-2023,

Results and Discussion

Based on the lowest soil penetration rate, the SCS developed a unique system for classifying soil into four hydrologic soil groups: A, B, C, and D (USDA-SCS 1974). Since the SCS-CN method requires a soil type map, several methods are provided for its creation. The texture of the soil is a basic parameter to study the soil-water relationship and the hydraulic characteristics of the soils (Al-Ghobari et al , 2020) . The soil texture map of the study area shown in figure 2, and Hydrological groups map shown in figure 3. The distribution of rain shows a maximum rise of 177 in the year 2022 (figure4). Rain also coincidentally causes an increase in runoff.

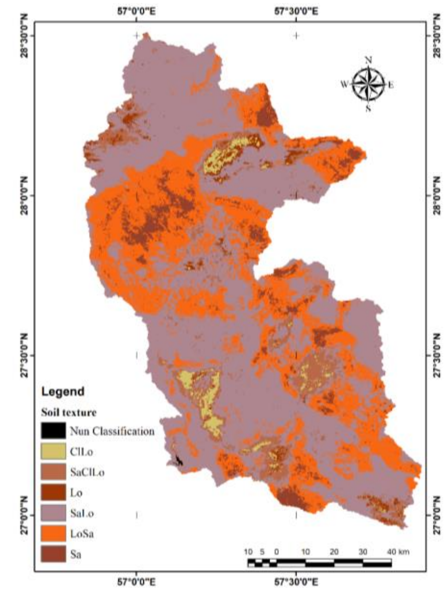

Figure2. Soil Texture

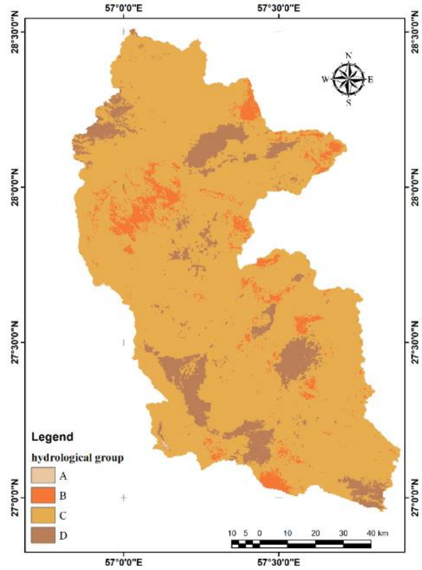

Figure3. Hydrological groups of the study area

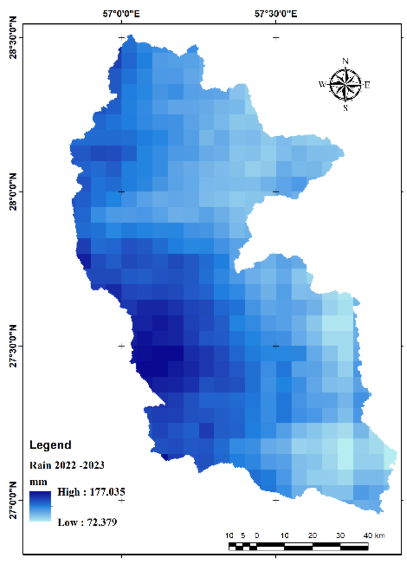

Figure4 . Rain Distribution

Curve number (CN)

Curve Number (CN) is an empirical parameter used in hydrology to predict the runoff potential of a storm event for a specific land area for use in runoff prediction models. (United States Department of Agriculture ,1986). The CN parameter is a dimensionless number that ranges from roughly 30 for permeable soils with substantial infiltration rates to 100 for water bodies and completely impermeable soils. When the CN values are almost or equal to zero, we have a surface that resembles the ideal "sponge." The precipitation is absorbed and retained in full or almost full amounts. We are dealing with impermeable soils or surfaces where precipitation is converted completely, or almost completely, into runoff when CN values are equal to or near 100. You can observe how the cumulative rainfall changes into net rain around the CN number in the following figure. The CN value of this watershed ranges between 0 and 91 (figure5). The outcome of runoff depth and runoff volume (Tiwari et al, 2018; Sujud et al, 2022)

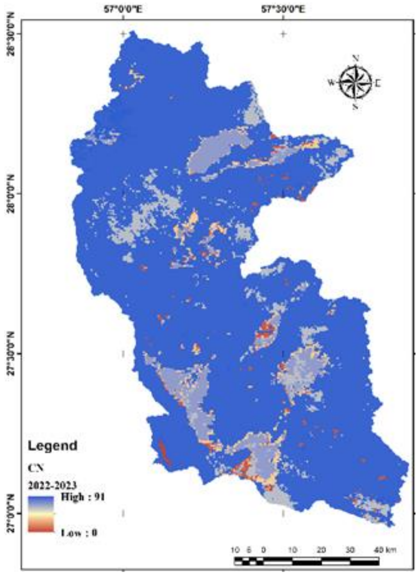

Figure5. CN map

Runoff

One of the most important hydrological elements required for the management of water resources is typically runoff. One of the biggest hydrological issues is determining the discharge quantitatively from ungauged dry basins. Consequently, additional study must be done to improve runoff prediction (Sayl et al. 2019). In the GEE platform, we generated runoff using a number of satellite sensors (figure6).

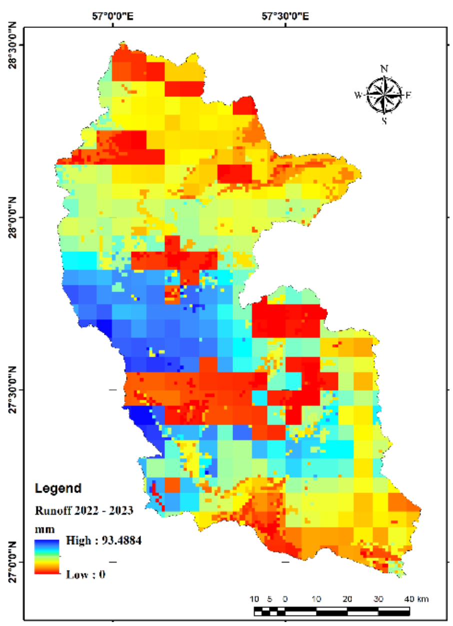

Figure6. Runoff map

As shown in the runoff map, it is noticeable that the peak of runoff is 93 in 2022, which indicates the runoff increased significantly in this region.

Conclusion

Because GEE can handle vast amounts of data via cloud computing, it has evolved into an effective tool for managing water resources and doing hydrological research. RUN-OFF is the most important hydrological component, and various models for water resource planning have been developed, ranging from conceptual to empirical to physically based. Runoff is extremely high in this location, as demonstrated by runoff charts that suggest a peak of 93 in 2022.

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