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# Estimation of Surface Runoff Depth for Kohima and Dimapur Districts of Nagaland, India

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**Abstract:** The surface runoff was assessed for Kohima and Dimapur districts of Nagaland from rainfall events for 18 years (from 2003 to 2020) using USDA Soil Conservation Service-Curve Number (SCS-CN) method. This study generated the hydrologic soil group (HSG) and land use land cover (LULC) maps using the GIS tools. The weighted curve number (CN) values were determined based on the Antecedent Moisture Condition (AMC-2), integrating the HSG and LULC classes. The highest runoff and rainfall were found in July, with 206.1 mm and 307.6 mm values, respectively. This indicates that maximum runoff is generated during the kharif (June to September), resulting from higher rainfall. The study shows that, without reliable hydrological data, the SCS-CN model can be utilized to estimate surface runoff depth.

**Key words:** Surface Runoff, SCS-CN**,** hydrologic soil group

## 1.Introduction

Water is one of the most essential natural resources for agriculture, so it must be utilized wisely. Runoff and rainfall are the two vital elements of the hydrologic cycle. Water resource applications heavily rely on runoff, and its occurrence and volume are influenced by the features of rainfall, such as its intensity, length, and dispersion. In addition to these aspects of rainfall, several catchment-specific elements, such as soil type, vegetation cover, slope, and catchment type, directly affect the frequency and amount of runoff. Also, maintaining agricultural production in a way that is both economically and environmentally sustainable depends critically on our ability to harvest rainfall runoff effectively. However, a deeper comprehension of the hydrological processes is necessary for the widespread application of runoff collecting without adversely affecting downstream hydrological systems (Sharma & Singh, 2012).

Conventional runoff estimation techniques are expensive, time-consuming, and difficult to use, and they are challenging to use in hilly and inaccessible terrains. In investigations of rainfall runoff, remote sensing technologies can significantly supplement traditional approaches (Murmu & Biswas, 2012). Collecting data on the various facets of land use and soil cover is essential, which are crucial factors in assessing watershed runoff. Because it offers a framework for gathering, storing, processing, manipulating, and displaying spatial and non-spatial data for specific purposes, the Geographic Information System (GIS) is an effective strategy (Sharma & Singh, 2012). As a result, using GIS technology as a tool for spatial data management and analysis offers an efficient method for conducting hydrologic and hydraulic investigations. The Soil Conservation Service Curve Number (SCS CN) approach is frequently used to forecast the direct runoff volume from a particular rainfall event. The National Resources Conservation Service (NRCS), part of the United States Department of Agriculture, created this technique in its initial form in 1969. Land use, soil, and antecedent soil moisture condition determine the CN for a drainage basin. It is a commonly used hydrological model for estimating runoff and provides a quantitative description of the properties of a watershed's land use, land cover, and soil complex (SCS, 1972). An empirical connection for estimating initial abstraction and runoff as a function of soil type and land use is included in this SCS-CN. The CN index also represents the watershed's potential for runoff. Because the SCS-CN approach is well-known, easy to use, and highly recognized, many researchers have utilized it to forecast runoff potential (Mishra et al., 2006; Panigrahi et al., 2010; Somashekar et al., 2011; Nagarajan et al., 2013; Muthu & Shanti, 2015). In this study, the surface runoff potential for the Kohima and Dimapur districts of Nagaland was estimated using the widely adopted SCS-CN method.

## 2. Materials and Methods

This study is conducted in Nagaland, a region of Northeast India, with a particular emphasis on the districts of Kohima and Dimapur (Fig. 1). The location of Nagaland lies between latitudes 25°6'N and 27°4'N and longitudes 93°20'E and 95°15'E. It shares its borders with the Indian states of Assam, Manipur, and Arunachal Pradesh, as well as the country of Myanmar.

There are four distinct seasons in this humid subtropical area: summer, monsoon, autumn, and winter. Between 2000 and 2500 mm of rainfall annually, most falling between June and September during the monsoon season. Nagaland has a hilly and mountainous topography ranging from 200 to 3826 m above mean sea level (MSL).

Kohima, the capital city of Nagaland, is located in the southwestern part of the state. It is bordered by rocky hills and steep valleys and has an average elevation of 1500 m above MSL. Dimapur, the largest and most populous city in Nagaland, is located in the western part of the state. It lies at a relatively lower elevation, with an average elevation of 260 m above MSL. The average elevation is 260 m above MSL, making it relatively lower.

Different kinds of land usage can be found in the Kohima and Dimapur districts. The primary land use types are urban areas, woods, agricultural land, and aquatic bodies. The land use type for both districts is shown in table 1 & 2. A mixture of deciduous and evergreen forests, plantations, and cultivated crops make up the vegetative cover. The region has various soil types, including lateritic soils, clay loams, and sandy loams.

The features of the rainfall, such as intensity, duration, and distribution, impact the hydrological behaviour in the research area. These rain-related variables significantly affect the frequency and amount of runoff. Runoff is produced and moved by various catchment-specific characteristics, including soil type, vegetation cover, slope, and catchment type.

Effective water resource management, particularly for agricultural reasons, depends on having a thorough understanding of the runoff characteristics in Nagaland, notably in the districts of Kohima and Dimapur. It is possible to improve water resource planning and management techniques by researching the area's hydrological behaviour and considering the interactions between rainfall, terrain features, and runoff generation.

The SCS curve number method (U.S. Soil Conservation Service, 1986) has been used in this study to estimate the surface runoff. The watershed coefficient is called the curve number (CN), which represents the runoff potential of the land cover soil complex. This model involves the relationship between land use, hydrologic soil group, and curve number. The SCS model computes direct runoff using the following relationships (Subramanya, 1994).

$$Q = \frac{(P-0.2)^2}{(P+0.8S)} \qquad (1)$$

Where,

$Q$ is the surface runoff in mm

$P$ is the rainfall in mm

$S$ is the initial abstraction and is given as:

$$S = \frac{25400}{CN} - 254 \qquad (2)$$

$CN$represents the curve number and is a fraction of the hydrologic soil group, land slope, and vegetation cover.

Using the above equations 1& 2, surface runoff was computed using the daily rainfall data of the Kohima and Dimapur districts for 18 years (2003 to 2020). The monthly surface runoff yield was determined for above 18 years from the daily rainfall events.

## 3. Results and Discussion

***Rainfall and runoff yield***

The daily rainfall data for 18 years (2003 to 2020) was analyzed, and then monthly rainfall was obtained (Fig 2). Accordingly, using the daily rainfall events, the resulting monthly surface runoff yield was estimated from the SCS-CN method and is presented in Fig 3. It reveals that the highest rainfall and surface runoff was found in the month of July (307.57 mm and 206.10 mm), followed by the month of August (279.94 mm and 175.93 mm) and September (259.74 mm and 168.20 mm). It has been noted that most of the yearly precipitation falls during the kharif season (June to September), which also produces the highest runoff, most of which is lost as wastewater. Given that more rainfall is only experienced in these four months compared to the rest of the year, it suggests that there is plenty of runoff accessible in the months of June, July, August, and September.

The results of the present study show that the SCS-CN method can be used to calculate surface runoff potential effectively. The knowledge of the estimated surface runoff potential will be very helpful for understanding rainfall-runoff relationships, water budgeting, and applications/planning of water harvesting structures. Additionally, efficient land use planning and watershed management can be implemented to create a proper crop plan for the study area and improve the region's agricultural sustainability.

## 4. Conclusion

The results of the present study shows that the SCS-CN method can be used to calculate surface run off potential effectively. The knowledge of estimated surface run off potential will be very helpful for understanding rainfall run off relationships, water budgeting, and application/planning of water harvesting structures. Additionally, efficient land use planning and watershed management can be implemented to create a proper crop plan for the study area and improve the regions agricultural sustainability.

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Fig. 1 Location of Study Area

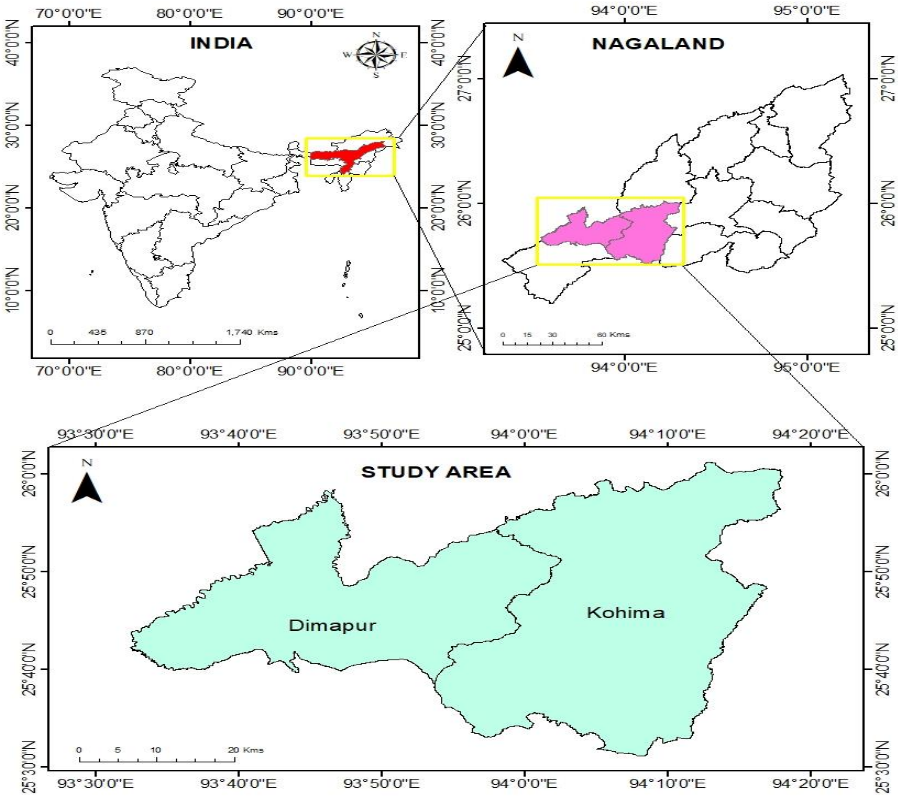


**Table 1:** Land Use/Land Cover Classification of the Dimapur

| Sl. No. | Classes | Area ($Km^2$) | Percentage |
|---|---|---|---|
| **1** | Forest areas | 525.04 | 61.02 |
| **2** | Agriculture | 192.07 | 22.32 |
| **3** | Builtup areas | 135.23 | 15.72 |
| **4** | Wasterbodies | 1.16 | 0.14 |
| **5** | Wasteland | 6.93 | 0.81 |

**Table 2:** Land Use/Land Cover Classification of the Kohima

| Sl. No. | Classes | Area ($Km^2$) | Percentage |
|---|---|---|---|
| **1** | Forest areas | 1145.19 | 90.24 |
| **2** | Agriculture | 73.38 | 5.78 |
| **3** | Builtup areas | 48.27 | 3.81 |
| **4** | Wasterbodies | 0.51 | 0.04 |
| **5** | Wasteland | 1.63 | 0.31 |

**Fig 2:** Mean monthly precipitation

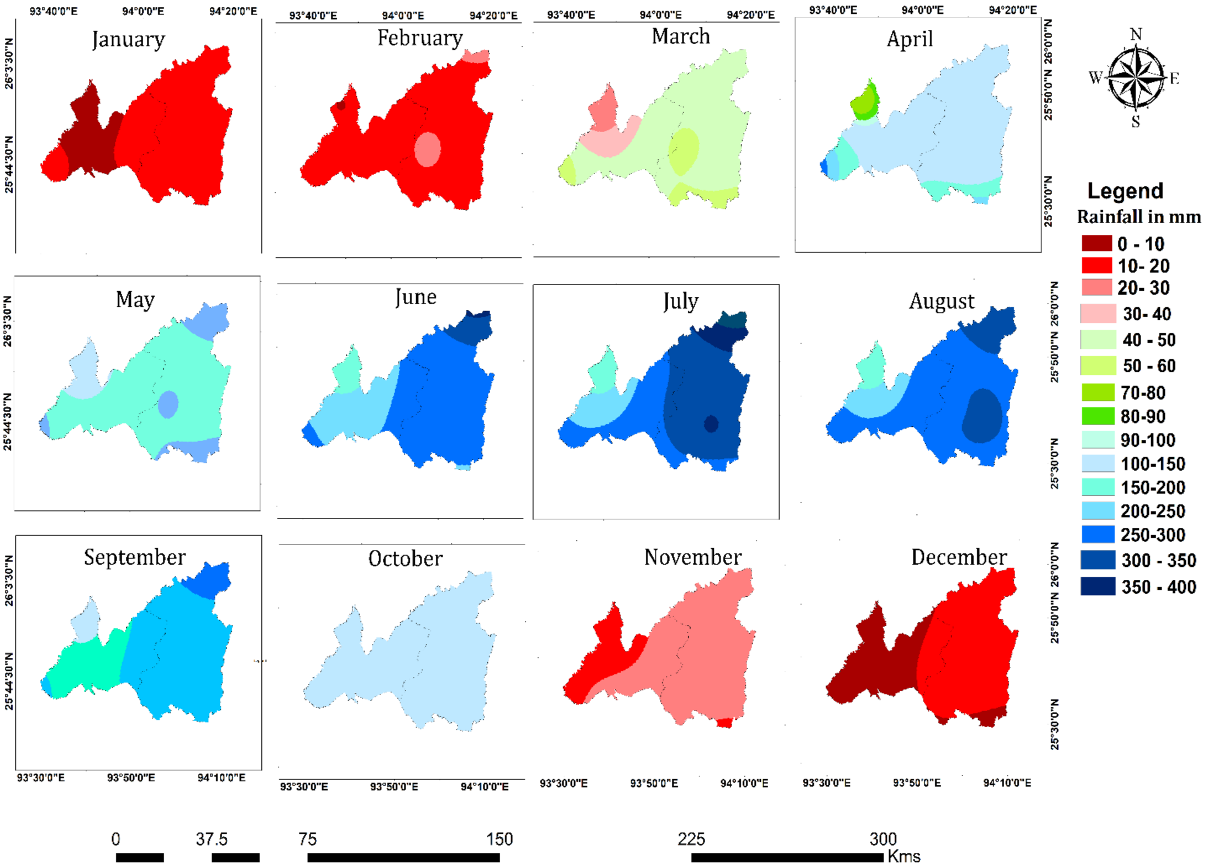


**Fig 3:** Surface runoff depth