Journal of Information Systems Engineering and Management
2025, 10(4s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Application of Soil Erosion Estimation using NRCS-CN Method for Dillai Watershed in Karbi Anglong District, Assam

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ARTICLE INFO

Received: 12 Oct 2024

Revised: 05 Dec 2024

Accepted: 20 Dec 2024

ABSTRACT

Watershed degradation is thus a major environmental problem that impacts on agricultural yields and productivity, quality of water possessions, and stability of ecologies. The purpose of this research is to quantify the soil erosion rate in the Dillai watershed within the Karbi Anglong district of Assam using NRCS-CN technique. The NRCS-CN technique which is accepted as most effective and accurate choice is used to assess the runoff capability and the concomitant soil erosion.

Geographic Information System (GIS) as well as remote detecting data are used simultaneously for delimiting of the watershed, valuation of the LULC, types of soil and hydrogeological prospect of the region. These are then used to estimate the curve number for the diverse hydrological soil groups as well as land use and land cover combinations. Runoff and rate of soil destruction are estimated by using rainwater data along with CN values.

Information from the initial assessment indicates that areas within the watershed are differently exposed to soil erosion based on the topographical characteristics namely; slope, vegetation cover and rainfall intensity. The results give a useful estimation of spatial distribution of soil erosion risks and point out areas that are most important to conserve.

Thus, this investigation demonstrates how the NRCS-CN method can be applied for estimation of soil erosion on mountainous regions and provides scientific justification for the reasons in which appropriate soil and water conservation measures needs be applied. It is hoped that the findings will be useful in helping the relevant authorities, policy makers, environmentalist and local government in preventing further cases of soil erosion and in effectively managing the watersheds identified in the Dillai area.

Keywords: Soil erosion, NRCS-CN method, Dillai watershed, GIS, watershed management, Karbi Anglong district

INTRODUCTION:

Consequently, water resources require vigilant monitoring and management to ensure their long-term viability, since they are both essential and highly valuable to civilisation. Watersheds are strategic resource units because of the water and other resources they supply. In a 2017 study, Singh et al. The term "watershed" refers to a region where runoff from many sources eventually meets a shared drain. In a 2013 study, Sindhu et al. Water is becoming more scarce because of combined impacts of weather alteration and rising anthropoid activity. Singh et al. (2017) and Sample & Liu (2014) are cited. The prudent and efficient use of water resources necessitates the meticulous management of watersheds. For the purpose of evaluating and controlling water resources, surface hydrological indicators are a potentially useful scientific instrument. References: Ouyang et al. (2011) and Viji et al. (2015). Water resource assessment is very important because water affects people's capacity to make a living and the health of the economy in their area. Having a solid grasp of the hydrologic variability of a wetland or watershed is crucial for creating successful restoration or management plans. References: Ghobadi et al. (2012) and Viji et al. (2015).

There is an immediate need to assess water resources since water is a key component of sustainable living and the regional economy. If you want to manage or restore a watershed or wetland effectively, you need to know its hydrologic variability inside and out. References: Ghobadi et al. (2012) and Viji et al. (2015). This allows for the deliberate administration of water as well as further natural resource units known as watersheds.

When it comes to managing water resources, hydrological modelling is crucial. One of the biggest obstacles in this area is the investigation of rainfall-based external runoff. In 2015, Viji et al. When it comes to managing, developing, and planning for water resources, this analysis is crucial. In semi-arid environments in particular, the measurement of water amount using hydrological models is a complex and scientifically demanding undertaking. (The study conducted by Meshram in 2015). When water moves over land and into a canal, this is called overland flow. The process by which water seeps into a system, flows parallel adjacent to the soil's external, and then enters a conduit is called interflow. Base flow refers to the amount of water that seeps into streams from below. Following the satisfaction of all surface and subsurface losses, runoff is the water that flows via a canal from the catchment area. Run off refers to water that has evaporated and then percolates through rocks and then flows over the streambed. To better understand fluvial geomorphic processes and to manage and use water resources efficiently, it is clear that the study of river basin hydrology has been growing in significance over the last several decades. One popular approach to estimating the amount of external runoff that occurs in an ungauged basin after a rainfall occurrence is the SCS curve number prototypical. Data used in this prototypical for runoff curves was derived from the USDA Soil Conservation Service (SCS 1985), which took into account many aspects for instance soil type, land use/conduct, superficial disorder, as well as precursor dampness situations, among others. References include works by Al-Juaidi (2018), Amutha & Porchelvan (2009), Shah et al. (2017), Shi et al. (2009), and Viji et al. (2015).

Scheduled rainfall, land use/cover, soil, angle, hydrology, and precursor dampness circumstances are just a few examples of the non-spatial and spatial information that may be integrated by means of stable NRCS-CN model (Gitika & Ranjan, 2014). According to soil technique, there are four Hydrologic Groups. Soils in Group A take a high moisture rate of infiltration, whereas soils in Group D take a low rate of infiltration. There has been a lot of usage of NRCS-CN since it is dependable, modest, easy to use, as well as produces visible results (Katara et al., 2013). The NRCS-CN prototypical is the utmost reliable and broadly acknowledged approach among hydrologists. ("Bondelid et al., 1982; Verma et al., 2020; Voda Alutercu et al., 2019; Williams & LaSeur, 1976"). Their rising popularity in natural resource management, planning, and development is a direct result of their seamless integration with GIS and RS technologies. As a tool for decision support, GIS allows for the integration of different data sources and post-spatial analysis. In a 2002 study, Jasrotia et al. The focal aim of this research was to use the NRCS - CN technique in the Dillai River watershed to simulate runoff via the use of GIS as well remote identifying.

STUDY AREA:

The research region is situated in Dillai River Watershed and includes the Karbi-Anglong Autonomous Hill districts of Assam. Its location in north-eastern India, in the state of Assam, is convenient. The examined area comprises 10,434 sq. km, with 10,397 sq. km being rural and just 37 sq. km being urban. This represents about 13.53% of the overall geographical area of the state, which is 78,438 sq. km. The geographical range of the research area is from $25^{o}50^{/}44.80^{//}$ N $26^{o}\,6^{/}51.75^{//}$N latitudes and it extends from $93^{o}40^{/}25.24^{//}$ to $93^{o}27^{/}25.50^{//}$ E longitudes.

METHODOLOGY

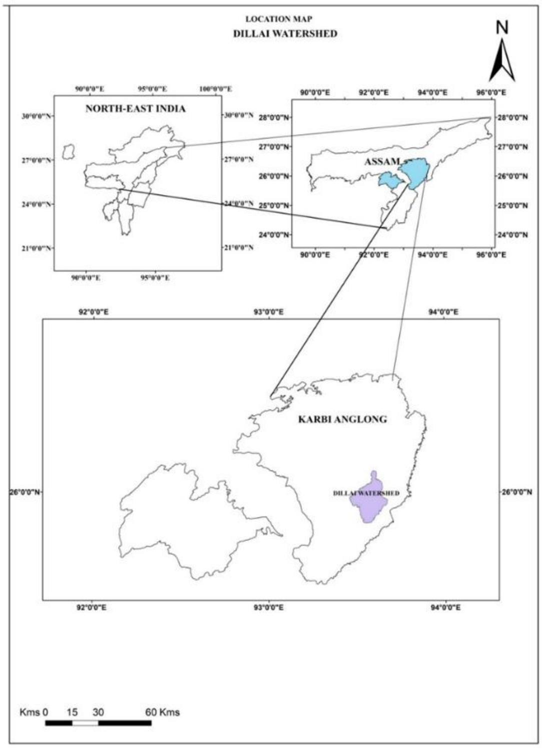
Research into fluviogeomorphic processes and the subsequent runoff production is directly tied to the land degradation caused by surface and groundwater flow and other forms of water movement. It is conceivable to evaluation external water runoff using any number of hydrological models. The models in these categories, however, tend to be laborious and expensive. The NRCS-CN process (1972) and the Green & Ampt Infiltration technique (Infil) from 1911 are the two ways that surface runoff may be estimated in the Soil and Water Assessment Tool (SWAT). This investigation estimates surface runoff by means of NRCS Curve Number technique. The primary factors that need to be considered in order to calculate yearly runoff remain precipitation, soil, geology, angle, land use/protection, as well as earlier dampness conditions. Delineated from SOI at a toposheet scale of 1:50,000, this map shows the boundaries of the Dillai River watershed. Because runoff is spatially variable, the amount of runoff generated by any given area of the Earth's surface will vary according to its unique geohydrological setting. Advances in geospatial technology in the last few years have made it possible to reasonably estimate runoff volumes. The purpose of this work was to investigate geospatial technologies for runoff estimation via a improved type of the NRCS curve number equation. In order to make the runoff parameters work in the GIS and Remote Sensing domain, a modification is performed. Although conventional data collection techniques and equipment are time-consuming, costly, and labour-intensive, remote sensing data may monitor a variety of hydrological variables in space and time.

In the NRSC runoff equivalence, the proportion of concrete holding to watershed loading and the proportion of effective rainfall to concrete runoff are both expressed mathematically as equal.

$$FS=\frac{Q}{(P-I)} \quad (1)$$

Where, F= Definite Holding (in mm); S = Watershed Loading or Holding (in mm); Q = Real Direct Runoff (in mm); P = Entire Rainfall (in mm); I = Initial Construct (in mm).

The overall holding of tempest is made up of initial construct (I) as well real holding (F). Therefore, water balance equivalence may be used to describe conservation of mass equivalence:



$$F=(P-I)-Q \quad (2)$$

Equivalence 2 produces when F is substituted in equivalence 1 above.

$$(P-I)-\frac{Q}{S} = \frac{Q}{(P-I)} \quad (3)$$

Q, the entire storm runoff, is determined as well represents the runoff.

equivalence-

$$Q = \frac{(P-I)^2}{(P-I)} + s \quad (4)$$

To avoid having to estimate both values, we were able to derive the link between I and S needed by the above equivalence by analysing rainfall runoff data for several slight watersheds. At first, the function I was thought to be based on the original Abstraction's maximum holding, S. An experimental connection amongst I and S was used to represent this, and it was described as-

$$I = 0.2S \quad (5)$$

To get link between rainfall and runoff, we may plug equation 5 into equation 4 instead of initial abstraction.

Q=$\frac{(P-0.2S)^2}{(P=0.8S)}$ P≥ $0.2S$ (6)

The holding constraint is denoted as S. If we alter the soils, land uses, and slopes over time, and we also modify the soil water content over space, then we have a mathematically defined retention parameter.

S=25.4 $(\frac{1000}{CN-10})$ (7)

The time period's curve number is CN. This dimensionless runoff index is calculated using the following variables: antecedent moisture condition (AMC), hydrologic conditions, land use, as well hydrologic behavior. Variables ranging from 1 to 100 make up the CN value. Surface runoff is proportional to the value of CN. Soil texture (average soil percentages for sand, silt, and clay) and remotely sensed pictures were used to generate CN values in this research. Here is the equation that is used to compute CN:

CN={In$\left[\left(\frac{Sa}{C}\right)+\left(\frac{Sa}{Si)}\right)+\left(\frac{Si}{Sa}\right)+\left(\frac{Si}{C}\right)+\left(\frac{C}{Sa}\right)+\left(\frac{C}{Si}\right)+3\right]\times\ [CI\times 0.4]$} (8)

Where, Sa= % of Sand, C= % of Clay, Si= % of Silt, and CI= Composite remote sensing image.

To get the CN standards for the typical Antecedent Moisture Condition (AMC), one uses this equation. Traditional techniques for calculating CN values have relied on the established correlations between certain types of hydrological soil as well various land use with cover classifications, with a 5% assumed angle.

As a result of heterogeneous character of land usage as well land protection, this procedure is exclusive and laborious, and in larger watersheds, accuracy of the work may be compromised due to changes in spatial and temporal contexts of up to 20 meters and one fortnight, respectively. Therefore, even when using the conventional NRSC CN standards, the equivalence should be able to compute CN standards in the GIS display place. In almost 85% of the situations, the computed CN standards show a high degree of similarity when compared to those obtained using the conventional technique of computation. This equation's greatest strength is in its adaptability to many geographical and temporal contexts.

To determine CN for AMC II, one uses the given equation. The AMC measures the amount of moisture in the watershed and the amount of soil storage that is available preceding to a hurricane. In terms of AMC, that three distinct levels: dry (AMC I), normal (AMC II), as well moist (AMC III). The AMC III system for solving mathematical problems using the Curve Numbers (CN) -

$CN_1=CN_2-\frac{(100-CN_2)}{[100-CN_2+\exp(2.533-0.0636\times(100-CN_2))]}$ (9)

$CN_3=CN_2\ \text{x}\ \exp[0.00673\ \times(100-CN_2)]$ (10)

An equivalence also limits the computation of CN values to an angle of 5%. A mathematical technique for slant adjustment of these CN values to slopes other than base slope is provided by Williams, as described in the section, and it is necessary to correlate the current CN value with the slope parameter of that region in order for it to be trustworthy with other slope values. (CN recalculated using the CN2S slope for AMC II)

$CN_{2S}=\left[\left(\frac{CN_3-CN_2}{3}\right)\times\ (1-2\exp(-13.86\ \times Slope))+\ CN_2\right]$ (11)

Here advantage of CN_{1S} as well CN_{3S} stream equivalence 9 and 10

through lone alteration that CN_2 with CN_{2S}.

OUTCOMES AND ARGUMENT

The entire volume of runoff was computed by means of the Arc GIS Spatial Analysis tool, and various necessary GIS layers were produced for each of the SWAT sequence equations. The final runoff estimate was prepared in raster grid format.

This research estimates the depth of surface runoff by means of the NRCS Curve Number technique and a database of satellite remote sensing data. Highly recommended: Changes in slope, land use, and soil type (and, more briefly, soil water content) all have an impact on the runoff's geographic variability. Runoff is spatially variable, meaning that various parts of the Earth's surface produce varied amounts of runoff depending on their geohydrological settings.

Surface runoff is quite spatially and temporally variable. According to the data in figure 1, the research area's annual surface runoff ranges from 130.05 mm to 1117.67 mm CN standards. The surface holding dimensions was determined by means of equivalences 7, 8, 9, 10, and 11. The correlation between surface retention capacity and CN levels is negative. In contrast to surface retention, which tells us how much water can be held by a surface given a certain quantity of precipitation, CN shows the likelihood of runoff.

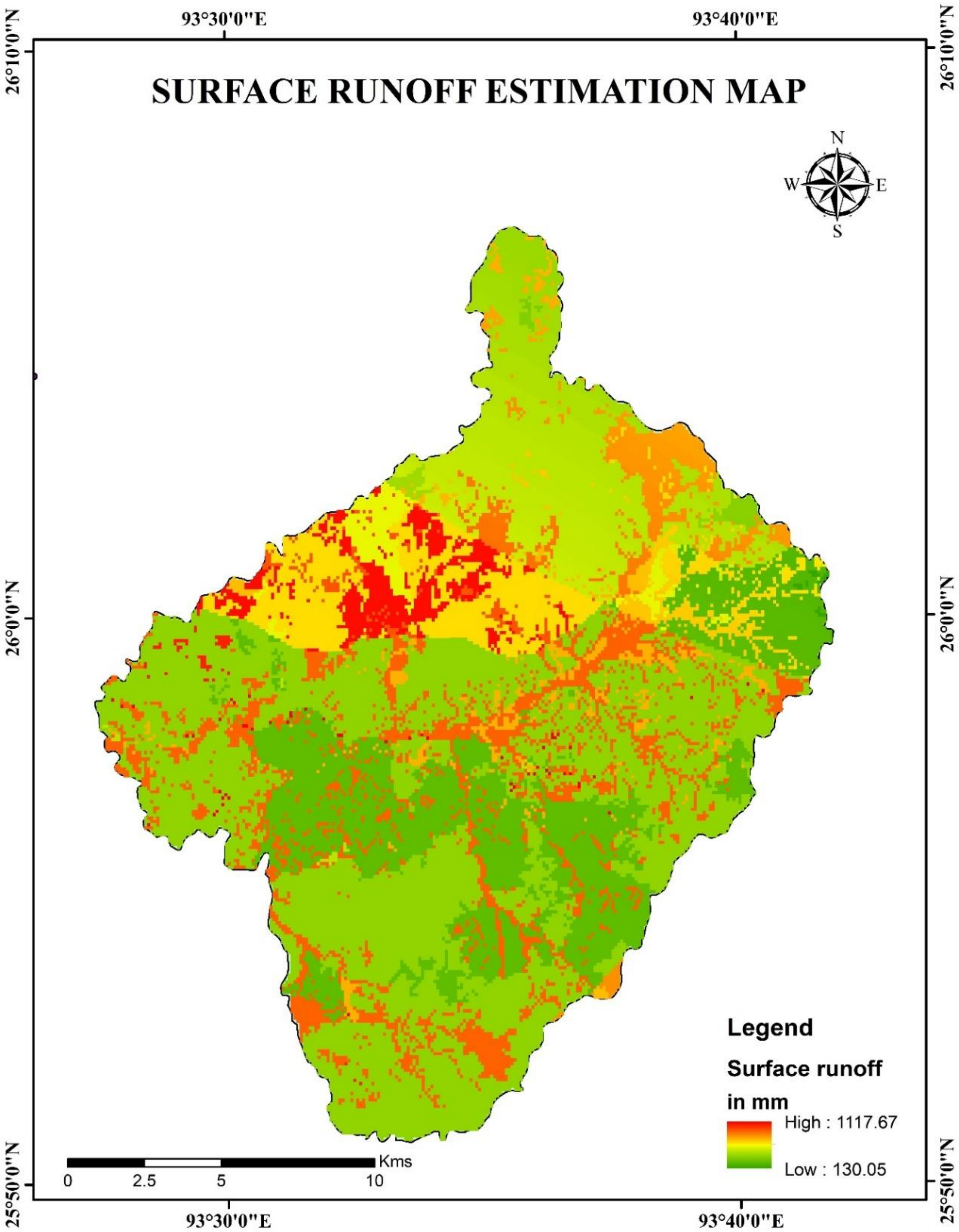


Fig. 1: Runoff approximation map via NRCS – CN technique

A common tool in the fight for environmentally responsible management is the land use as well land cover (LULC) matrix. The statement is from Durasamy et al. (2020). Figure 2 demonstrations that eight dissimilar varieties of land use and land protection in Dillai River basin. Land that is barren, cropland, jhum fallow, mixed scrub, settled, lush, sparsely vegetated, and water body are all present. Severe forest alteration has resulted from land removal for agriculture and construction.

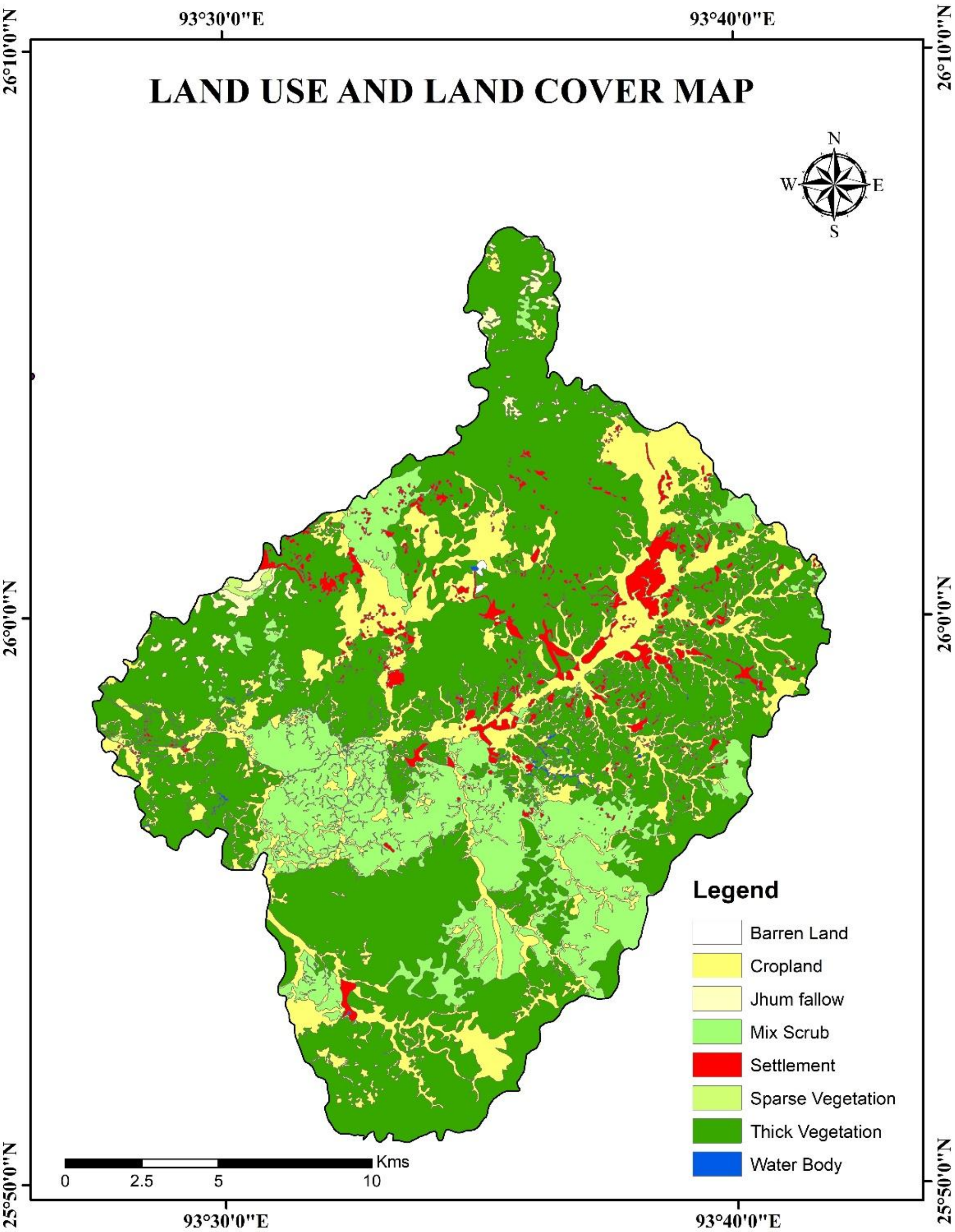


Fig. 2: Land Use Land Cover atlas of the research part

See Figure 3 for an estimate of the Dillai River watershed's slope, which ranges from 0^{o} to 47^{o}. The five types of slopes are as follows: 0^{o}–4^{o}, mild (4–8), moderate (8^{o}–13^{o}), high (13^{o}–21^{o}), and extremely steep (>21^{o}) according to the slope angle.

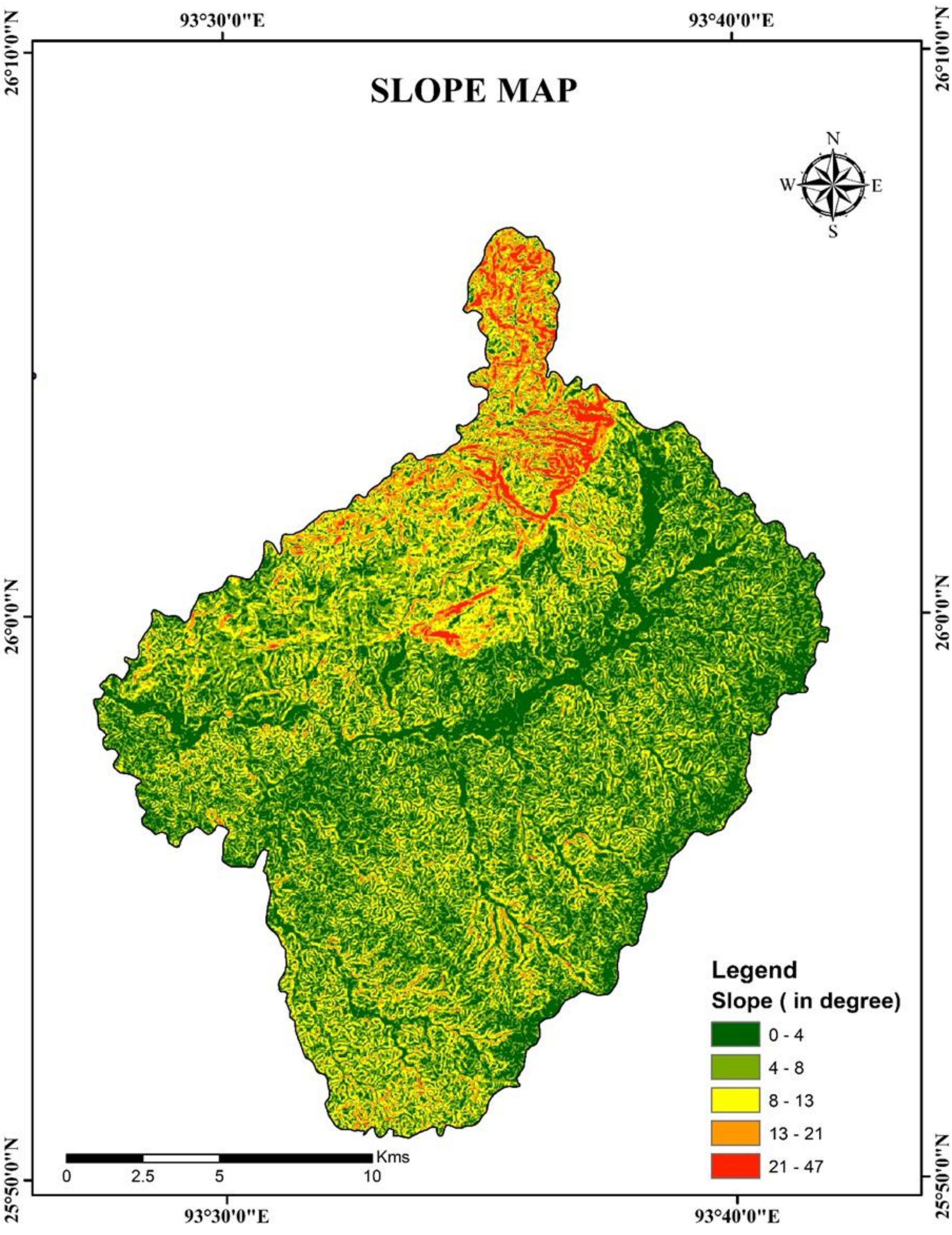


Fig. 3: Angle map of the research part

Second, soil has a part in variability of surface runoff. The hydrological groups of soils were determined by using the NRCS - CN soil categorisation system. There are four distinct types of soils recognised by hydrologic classification: One of the four letters from Table 1 (A, B, C, or D). (The 2016 study by Tailor and Shrimali). Figure 4 shows that the northern portion of the research part is enclosed by clay loam soil in foothill topography. This soil type is ideal for recharging since the lithology is porous and most surface water infiltrates and flows as subsurface runoff.turned off. The impermeable nature of coarse loam soil means that recharging is unlikely; instead, the majority of precipitation falls as surface runoff, with an estimated 539.56 mm and an average of 670.54 mm each year.

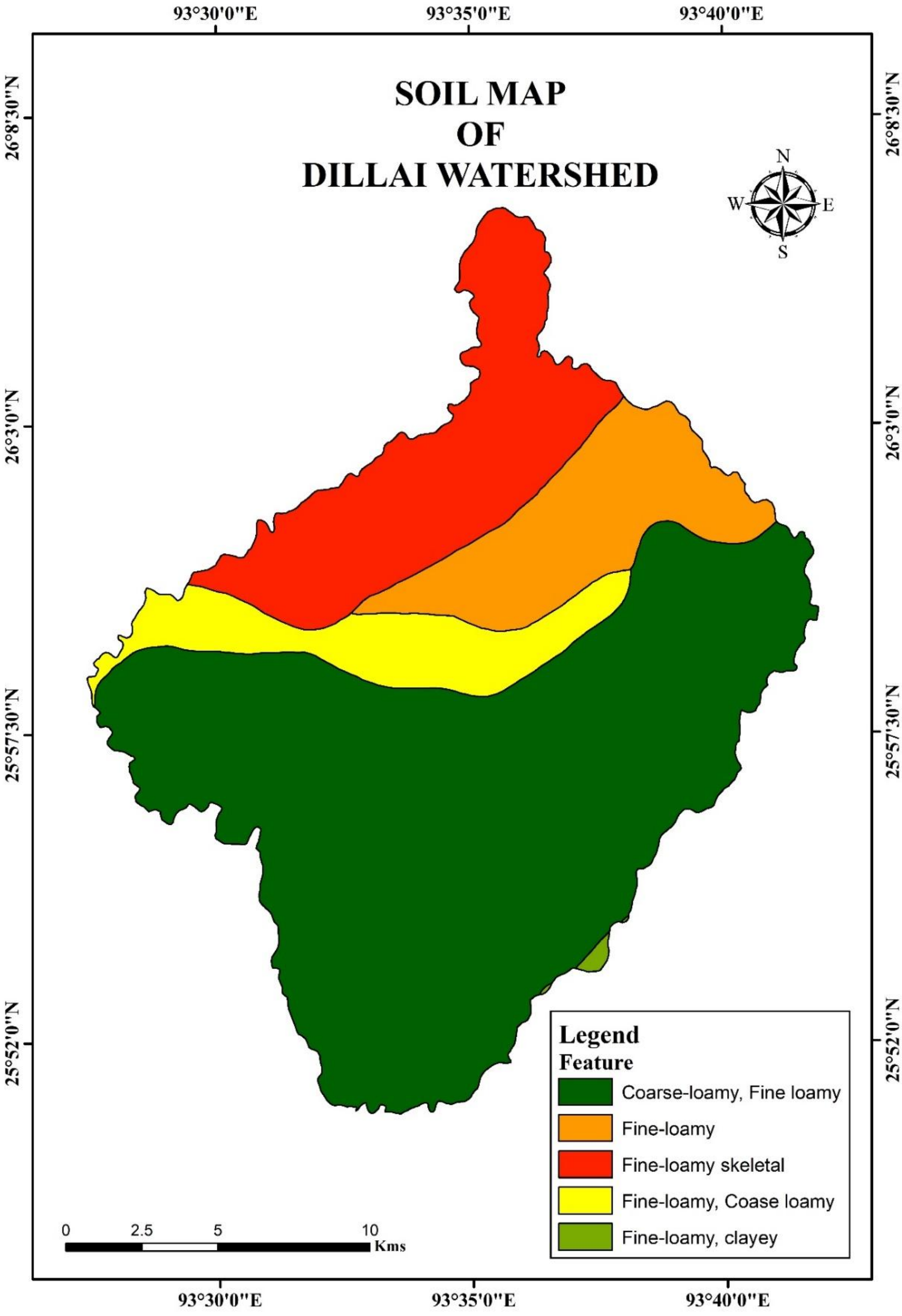


Fig. 4: Soil map of the research part

Table 1: Hydrologic soil cluster for diverse soil surfaces (Source USDA-SCS).

HSG	Soil surface	Category of Soil	Runoff Probable	Comments
A	Sand, Loamy sand, or Sandy loam	Bordering on deep sand and gravel soils in some instances and more so, well drained sands and gravels with a deep profile.	Low	It has been considered that rate of water transmission is high.
B	Silt loam or loam	Medium going up to deep, well exhausted and with discreetly fine to rough surfaces.	Moderate	Reasonable rate of water conduction
C	Sandy clay loam	sandy loam, clay loams, shallow, and moderately fine to fine intermissions.	Moderately high	Reasonable rate of water conduction
D	Clay loam, silty Clay loam, Sandy clay, Silty clay, or Clay	Expanding clay soils, heavy slate or clay shale, highly plastic clay soils, and soils with constant high water bench	High	There is usually low rate of water transmission that is prevalent in the society.

CONCLUSION

By means of NRCS-CN technique to evaluation soil erosion in Dillai watershed of Karbi Anglong district, Assam has offered a wealth of knowledge about this area's hydrological propensity for erosion. In the course of the research, GIS and remote sensing were combined to map LU/LC, Soil type, and hydrological condition in order to determine CN and estimate runoff.

This made it easier to identify regions with high possibility of experiencing high degrees of soil erosion, due to factors such as steep slopes, sparse vegetation and highly://rainfall intensity. These results support the importance of specific S & W conservation efforts in the identified critical areas of the watersheds in direction to minimize further soil erosion as well as to progress future sustainability of watersheds.

This research validates the utility of the NRCS-CN technique particularly on steep slopes and confirms its suitability in aiding in the management of watersheds. Of particular use to regional policymakers/planners & environmental administrators, conservation management objectives noted in this paper offer a pragmatic approach to allocate resources to conserve processes & species in the Dillai watershed and comparable areas.

Future work could be done in direction of using long term rainfall changeability and climatic conditions to enhance the models of soil erosion and investigate social and economical effects of erosion prevention on population.

REFERENCES

[1] Al-Juaidi, A. (2018). A simplified GIS-based SCS-CN method for the assessment of land-use change on runoff. *Arabian Journal of Geosciences*, *11*. https://doi.org/10.1007/s12517-018-3621-4

[2] Amutha, R., & Porchelvan, P. (2009). *Estimation of surface runoff in Malattar sub-watershed using SCS-CN method | Journal of the Indian Society of Remote Sensing*. *37*, 291–304.

[3] Bondelid, T. R., McCuen, R. H., & Jackson, T. J. (1982). Sensitivity of SCS Models to Curve Number Variation. *JAWRA Journal of the American Water Resources Association*, *18*(1), 111–116. https://doi.org/10.1111/j.1752-1688.1982.tb04536.x

[4] Duraisamy, K., Balasubramanian, A., T, S., & Krishnaraj, S. (2020). Rainfall-surface runoff estimation for the Lower Bhavani basin in south India using SCS-CN model and geospatial techniques. *Environmental Earth Sciences*, *79*, 335. https://doi.org/10.1007/s12665-020-09079-z

[5] Ghobadi, Y., Pradhan, B., Kabiri, K., Pirasteh, S., Shafri, H. Z. M., & Sayyad, G. A. (2012). Use of multi-temporal remote sensing data and GIS for wetland change monitoring and degradation. *2012 IEEE Colloquium on Humanities, Science and Engineering (CHUSER)*, 103–108. https://doi.org/10.1109/CHUSER.2012.6504290

[6] Gitika, T., & Ranjan, S. (2014). Estimation of surface runoff using NRCS curve number procedure in Buriganga Watershed, Assam, India-a geospatial approach. *International Research Journal of Earth Sciences*, *2*(5), 1–7.

[7] Jasrotia, A., Dhiman, S., & Aggarwal, S. (2002). Rainfall-runoff and soil erosion modeling using Remote Sensing and GIS technique—A case study of tons watershed. *Journal of the Indian Society of Remote Sensing*, *30*, 167–180. https://doi.org/10.1007/BF02990649

[8] Katara, P., Machiwal, D., Mittal, H. K., Dashora, Y., & Bhagat, A. (2013). *Estimation of runoff for Ahar river catchment in Udaipur district using integrated remote sensing and geographical information system*.

[9] Meshram, S. (2015). Estimation of Surface Runoff Using Remote Sensing and Geographical Information System. *International Journal of U- and e-Service, Science and Technology*, *8*, 113–122. https://doi.org/10.14257/ijunesst.2015.8.4.12

[10] Ouyang, N., Lu, S., Wu, B., Zhu, J. J., & Wang, H. (2011). Wetland Restoration Suitability Evaluation at the Watershed Scale- A Case Study in Upstream of the Yongdinghe River. *Procedia Environmental Sciences*, *10*, 1926–1932. https://doi.org/10.1016/j.proenv.2011.09.302

[11] Sample, D. J., & Liu, J. (2014). Optimizing rainwater harvesting systems for the dual purposes of water supply and runoff capture. *Journal of Cleaner Production*, *75*, 174–194. https://doi.org/10.1016/j.jclepro.2014.03.075

[12] Shah, M., Fazil, S. M., Ali, S. R., P, Y., ey, Faisal, S., & Mehraj, I. (2017). Modeling of Runoff using Curve Expert for Dachigam-Telbal Catchment of Kashmir Valley, India. *International Journal of Current Microbiology and Applied Sciences*, *6*(11), 3822–3826. https://doi.org/10.20546/ijcmas.2017.611.449

[13] Shi, Z.-H., Chen, L.-D., Fang, N.-F., Qin, D.-F., & Cai, C.-F. (2009). Research on the SCS-CN initial abstraction ratio using rainfall-runoff event analysis in the Three Gorges Area, China. *CATENA*, *77*(1), 1–7. https://doi.org/10.1016/j.catena.2008.11.006

[14] Sindhu, D., Shivakumar, B. L., & Ravikumar, A. S. (2013). ESTIMATION OF SURFACE RUNOFF IN NALLUR AMANIKERE WATERSHED USING SCS-CN METHOD. *International Journal of Research in Engineering and Technology*, *02*, 404–409. https://doi.org/10.15623/ijret.2013.0213076

[15] Singh, L. K., Jha, M. K., & Chowdary, V. M. (2017). Multi-criteria analysis and GIS modeling for identifying prospective water harvesting and artificial recharge sites for sustainable water supply. *Journal of Cleaner Production*, *142*, 1436–1456. https://doi.org/10.1016/j.jclepro.2016.11.163

[16] Tailor, D., & Shrimali, N. J. (2016). *Surface runoff estimation by SCS curve number method using GIS for Rupen-Khan watershed, Mehsana district, Gujarat*. *36*(4), 1–5.

[17] Verma, S., Singh, P. K., Mishra, S. K., Singh, V. P., Singh, V., & Singh, A. (2020). Activation soil moisture accounting (ASMA) for runoff estimation using soil conservation service curve number (SCS-CN) method. *Journal of Hydrology*, *589*, 125114. https://doi.org/10.1016/j.jhydrol.2020.125114

[18] Viji, R., Prasanna, P. R., & Ilangovan, R. (2015). Modified SCS-CN and Green-Ampt Methods in Surface Runoff Modelling for the Kundahpallam Watershed, Nilgiris, Western Ghats, India. *Aquatic Procedia*, *4*, 677–684. https://doi.org/10.1016/j.aqpro.2015.02.087

[19] Voda Alutercu, M., Şarpe, C., & Voda, A. (2019). Romanian River Basins Lag Time Analysis. The SCS-CN Versus RNS Comparative Approach Developed for Small Watersheds. *Water Resources Management*, *33*. https://doi.org/10.1007/s11269-018-2100-8

[20] Williams, J. R., & LaSeur, W. V. (1976). Water Yield Model Using SCS Curve Numbers. *Journal of the Hydraulics Division*, *102*(9), 1241–1253. https://doi.org/10.1061/JYCEAJ.0004609