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GEE-Based Geospatial Assessment of Soil Erosion Modelling in the Gundlakamma River Basin (Bapatla, Palnadu and Guntur Districts) Using the RUSLE Model

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Abstract
Soil erosion ranks amongst the major causes of land degradation affecting agricultural productivity, soil fertility, water availability, and ecological sustainability. This paper attempts to map soil erosion intensity in the Gundlakamma watershed, which includes Bapatla, Palnadu and Guntur (three districts) in Andhra Pradesh, by using the Revised Universal Soil Loss Equation (RUSLE) coupled with Google Earth Engine (GEE). They compiled multi-source geospatial datasets like GPM rainfall data, Cartosat DEM for elevation, Sentinel-2 satellite images from Earth observation satellite of the European Space Agency, NBSS&LUP soil map (soil information) to arrive at factors viz. rainfall erosivity (R), soil erosion susceptibility (K), length and steepness of slope (LS), management of surface cover (C), and land conservation factors (P). These parameters were combined in a raster-based spatial analysis to estimate overall annual soil erosion and pinpoint erosion-prone areas across a total area of 5959 sq km. It was found that the rainfall erosivity varied from 414.19 to 581.81 MJ mm ha^{-1} h^{-1} yr^{-1}, whereas the values of LS revealed the strong topographic control over soil erosion processes. As a result, the basin was further grouped into five levels: Mild (6.43%), Moderate (9.64%), Major (24.99%), Majorly Severe (38.11%) and Very Severe Erosion (20.82%). Nearly 83% of the basin is at high to very critical risk of erosion, which emphasises the potential for significant soil loss. The model performance was checked by Frequency Ratio (FR) validation. The highest FR was assigned to the class of very severe erosion (1.079), and the model overall achieved an FR of 1.400. The validation results support that the RUSLE-GEE method is highly reliable. The paper reveals locations of soil erosion hotspots, where immediate soil conservation is necessary, and the potential of online geospatial applications for the assessment of soil erosion at the watershed level and the formulation of strategies for land use planning.

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Keywords: Soil Erosion, RUSLE, Google Earth Engine, Frequency Ratio Validation, Watershed Management, Gundlakamma River Basin

1. Introduction

Soil erosion is a pervasive form of land degradation and a major environmental challenge that affects agricultural productivity, ecosystem stability, water resources, and sustainable land management worldwide (Wischmeier & Smith, 1978; Lal, 2001; Morgan, 2005; Pimentel, 2006; Boardman & Poesen, 2006) [31, 20, 7, 23]. Accelerated erosion removes nutrient-rich topsoil, reduces soil fertility, alters hydrological processes, and contributes to sedimentation in rivers, reservoirs, and irrigation infrastructure (Van der Knijff *et al*., 2000; Bhattacharyya *et al*., 2015; Borrelli *et al*., 2017; Panagos *et al*., 2018; Borrelli *et al*., 2021) [30, 5,9, 8, 21].

Climate change, land-use transformation, deforestation, agricultural intensification, and unsustainable cultivation practices have further intensified erosion risks across many regions of the world (de Vente *et al*., 2013; IPCC, 2023) [10]. India is particularly vulnerable to soil erosion because of its monsoon-dominated climate, diverse physiography, expanding agricultural activities, and increasing anthropogenic pressures (Bhattacharyya *et al*., 2015; Thomas *et al*., 2018) [5, 29]. Seasonal rainfall events generate significant runoff and sediment transport within river basins, causing substantial losses of productive soil and adversely affecting agricultural sustainability and watershed health (Adimassu *et al*., 2017; Fenta *et al*., 2020) [1, 14]. Consequently, accurate identification and spatial assessment of erosion-prone areas are essential for effective watershed management and land-resource conservation. The Gundlakamma region of Andhra Pradesh, including Bapatla, Palnadu, and Guntur districts, is an agriculturally important landscape characterised by intensive cultivation, irrigation networks, fertile alluvial soils, and rapidly changing land-use patterns.

Expansion of agricultural lands, urban growth, vegetation degradation, and recurring hydro-climatic extremes have increased susceptibility to land degradation and soil loss (Prasad *et al*., 2018; Ramachandra *et al*., 2018; Rao *et al*., 2020) [24, 25, 26]. Understanding the spatial variability of erosion processes in this region is therefore critical for sustainable agricultural planning and environmental management. Among the various approaches available for soil erosion estimation, the Revised Universal Soil Loss Equation (RUSLE) remains one of the most widely applied empirical models (Renard *et al*., 1997; Alewell *et al*., 2019) [27, 2]. RUSLE integrates rainfall erosivity (R), soil erodibility (K), topographic factors (LS), cover-management (C), and conservation practices (P) to estimate annual soil loss. Numerous studies have demonstrated its applicability for watershed-scale erosion assessment under diverse environmental conditions (Belayneh *et al*., 2021; Thomas *et al*., 2018; Fenta *et al*., 2020) [4, 29, 14].

Advances in the fields of remote sensing and geographic information systems have led to much improvement in the estimation of RUSLE parameters by combining satellite data with digital terrain datasets (Batjes, 2016; Didan, 2015; Drusch *et al*., 2012; Farr *et al*., 2007; Funk *et al*., 2015) [12, 11, 3, 13, 15]. The spatial coverage and consistency of data from satellites like Landsat, Sentinel-2, MODIS, and SRTM have greatly improved. Through land cover, vegetation indices, topography, and rainfall variability parameters measured, these data enable accurate mapping and identification of soil erosion risk zones. Cloud-computing geospatial platforms have become instrumental in environmental monitoring and the implementation of large-scale spatial models on a global level (Bhandari *et al*., 2018; Gorelick *et al*., 2017) [6, 16]. The biggest advantage of the Google Earth Engine platform (GEE) is allowing researchers to access petabyte-scale geospatial data along with very strong computational resources. These powerful capabilities allow users to analyse extensive amounts of remotely sensed data and generate information efficiently and accurately (Kumar & Mutanga, 2018; Tamiminia *et al*., 2020) [18, 28].

The platform has found numerous applications in the fields of land-use monitoring, drought assessment, hydrological modelling, flood mapping, and soil erosion studies. It has also served as a convenient tool for integrating RUSLE with GEE to obtain rapid, reproducible, and scalable evaluation of soil erosion while at the same time reducing the disadvantages that desktop GIS software brings with it. The combination of RUSLE and GEE was tested and confirmed as a reliable method for identifying erosion hotspots, and its use was successfully replicated at the watershed scale, as illustrated by Patel and Singh in 2024 [22], Kumar and Mutanga in 2018 and Tamiminia and colleagues in 2020[28]. With the growing availability of satellite datasets, it is now possible to derive various RUSLE parameters within one computational environment using freely available data such as CHIRPS (precipitation), SRTM (DEM), MODIS (vegetation), and ESA WorldCover (land cover) (Funk *et al*., 2015; Drusch *et al*., 2012; Didan, 2015) [15, 12, 11]. Such integration brings the added benefits of having consistent and reliable outputs while, at the same time, it supports well-informed decisions.

This investigation explores the use of the RUSLE approach within the GEE platform for predicting soil erosion risk throughout the Gundlakamma River basin while focusing on Bapatla, Palnadu, and Guntur districts. Besides estimating the amount of soil loss, we try to spot places with a high erosion risk, look into how factors like topography, climate, soil types and land use affect soil erosion, and create detailed soil erosion risk maps. The results are anticipated to help with the planning of watershed management, the management and protection of soil and water resources, the development of sustainable agriculture, as well as the management of land resources at the ground level, which is resilient to climate change. It also brings forward a study which contributes a lot to the expanding field of research that shows how cloud-based geospatial technologies can be used to assess environmental situations, particularly in a region that is suffering from a lack of data or resources (IPCC, 2023; Alewell *et al*., 2019; de Vente *et al*., 2013; Borrelli *et al*., 2021) [2, 10].

2. Study Area

The Gundlakamma River Basin, as it flows through the neighbouring districts of Bapatla, Palnadu, and Guntur in the state of Andhra Pradesh, is an interesting and essential geographical feature. This area, located in the rain-shadow zone of the Eastern Ghats, has a unique mix of an intricate river system, varying terrain, and a climate that can be considered harsh as well as very productive. According to geographic extent, the basin stretches latitudinally from about 15°50'N to 16°15'N and longitudinally from 79°45'E to 80°45'E.

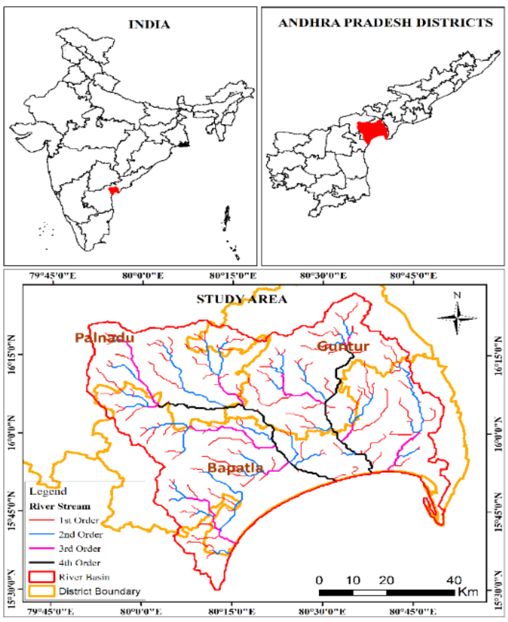

Fig 1: Location Map of Study Area

From the west and north part of Palnadu, the basin covers the rugged and old hill formations (Nallamalais) of the Eastern

Ghats. Moving on, it passes through the wide, rich alluvial plains that descend slowly towards the Bay of Bengal in Bapatla, Palnadu and Guntur. Gundlakamma River rises from the Nallamala Hills near Ardhaveedu and, after flowing in a north-easterly direction, gets diverted toward the Coromandel Coast. It is the main hydrological component of the basin. Other rivers, like Naguleru and Chandravanka, meet the main river through tributary relations. It is through the river's influence that people's lives are controlled and the region changes gradually. In certain areas, like the western region, the land is rocky with hills of various sizes formed mainly of ancient crustal rocks such as granite, gneiss, etc while in the eastern region, the river plain becomes flat and is very near to the level of the sea and is termed as the tract of the estuary. The deposition of silt from the delta has been the chief cause of the formation of these low-lying coastal plains over thousands of years. The black soil in the plain region, as against the shallow and red sandy loam soils of the higher areas, results in deep, dark, nourishing soils in these regions. This variation in geology and topography significantly influences patterns of drainage, types of soils and ultimately the agricultural potential of the region.

3. Methodology and Data

Soil erosion in the area was calculated using the Revised Universal Soil Loss Equation (RUSLE), which is a very popular empirical model used around the world for estimating long-term yearly average soil erosion that is caused by sheet and rill erosion (Renard *et al.*, 1997) [27]. The model is expressed as:

$$A = R \times K \times LS \times C \times P$$

Where A is the estimated average annual soil loss (t/ha/yr), R is the rainfall-runoff erosivity factor, K is the soil erodibility factor, LS is the slope length-steepness factor, C is the cover-management factor, and P is the support practice factor. Using a GIS environment, each factor was derived as a separate raster layer, and afterwards, all were combined with raster (map) algebra to get the soil loss map. Based on the Revised Universal Soil Loss Equation (RUSLE).

Table 1: Data Sets Used for Analysis

Factor	Data Required	Data Sources
R - Factor	Long-Term Rainfall Data	GPM Satellite Rainfall
K - Factor	Soil Texture	NBSS&LUP
LS - Factor	Slope and Flow Accumulation	Cartosat DEM,
C - Factor	LULC, NDVI	Sentinel-2 Classified LULC and NDVI
P - Factor	Land Management	Agriculture Area (P=1 If None)

Each component or factor has been prepared as a single raster layer using GIS software separately and joined to produce the overall soil loss layer by performing raster (map) algebra operations. Besides, using RUSLE together with a GIS system, five factors have been taken to get an estimate of soil loss in this area. In the calculation of the rainfall erosivity factor (R), satellite GPM products providing long-term rainfall information have been used to derive the factor with the formula $R = 0.0483 \times P^{1.61}$, where P is the mean annual rainfall in millimetres. For the soil erodibility factor (K), soil texture data from the National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) have been used with Williams' (1995) [32] EPIC formulation.

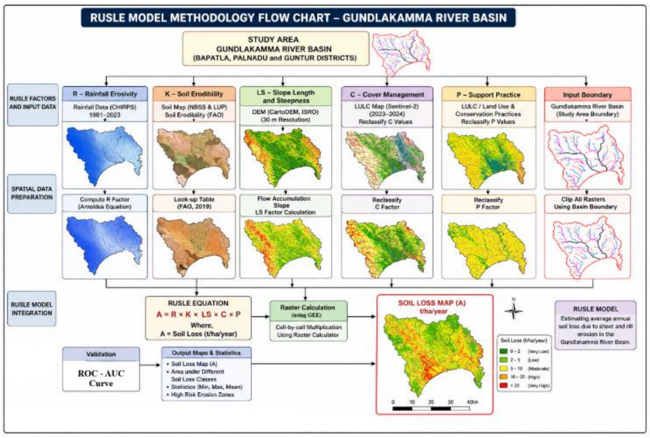

Fig 2: Methodological Flow Chart

The slope length-steepness factor (LS) was determined by computing slope gradient and flow accumulation from the Cartosat Digital Elevation Model, followed by implementation of the $LS = (\lambda/22.13)^m \times (0.065 + 0.045S + 0.0065S^2)$ equation, where λ is slope length, S is the slope steepness, and m is the exponent depending on slope. To generate the cover-management factor (C), Sentinel-2 satellite imagery data were classified to determine the land use/land cover (LULC) classes with the help of the NDVI index. Then, for each determined class, according to previous literature and common values (C) is attributed. The last parameter, i.e., "support practice factor" (P), was defined based on types of conservation measures practised and the corresponding slopes in agricultural lands. In regions where conservation measures are not explicitly adopted or mentioned, P = 1 is the default value. All the maps created have been resampled to the same raster cell size and multiplied by means of map algebra, leading to the soil loss map for an average year. Further, to perform spatial analysis, the soil loss map was classified, and the resulting categories were interpreted as soil erosion severity zones of the landscape.

3. Result and Discussion

3.1. RUSLE Parameter Estimation

3.1.1. R factor (Rainfall Erosivity Factor)

R-factor measures the erosive capacity of rain, and it is the climatic element of soil erosion. In the Gundlakamma River Basin, rainfall erosivity is in the range of 414.19 to 581.81 MJ mm ha^{-1} h^{-1} yr^{-1}, implying moderate to high potential for erosion by raindrops. These very high R factor values have been observed in the north and north-east parts of the basin, implying the occurrence of heavy rainfall events capable of producing a lot of runoff and erosion of soils. The south and coastal areas have shown lower values for erosion due to the rainfall. This spatial distribution pattern shows that rainfall intensity increases from the south coastal region to the northern uplands. As rain is the main trigger that starts the erosion process, areas that have higher rainfall erosivity will also have a much higher potential of being degraded by the soil in such circumstances as steep slopes and erodible soils combine. Overall, rainfall is therefore one of the major factors shaping the basin's erosion dynamics.

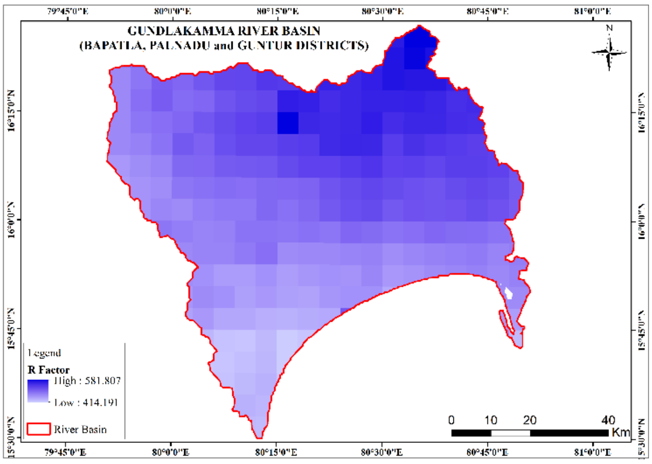

Fig 3: Rainfall Erosivity Factor

The equation used for the calculation is as follows:

$$R = \sum_{1}^{12} 1.735\ X\ 10^{\left(1.5\ log10\left(\frac{Pi}{P}\right) - 0.08188\right)} \qquad (1)$$

Where R is a rainfall erosivity factor (MJ mm ha−1 h−1 per year); Pi is monthly rainfall (mm); P is annual rainfall (mm).

3.1.2. K Factor (Soil Erodibility Factor)

K factor is a parameter which quantifies the potential of the soil to erode depending on its physical characteristics such as texture, structure, porosity and the presence of organic matter. The figure presents the K values as ranging from 0 to 0.05, which is relatively low to moderate for soil erosion in the area. Most locations have a minor erodibility; this suggests that cohesive characteristics of the soil, combined with their resistance to physical disintegration by rains and floods, make most soils stable ground. It is mainly in the coastal plains, the northern areas, and a few central parts where high K areas can be seen, since those are places where soils with high silt percentage and fine sand could be dominant and thus more prone to erosion. The map showing the soil erosion factors is very useful as it reminds us that the soil's qualities by themselves can't lead to severe erosion, but along with the rain's erosivity and adverse land shape (slopes and their steepness), they can significantly alter the erosion rate. Thus, it is advisable to make thorough planning of the land use and implementation of various soil protection measures in those regions which have high K values, in order not to allow further degradation of the environment. This is the formula which is to be applied:

$$K = 27.66\ m^{1.14} X\ 10^{-8} X\ (12 - a) + 0.0043\ X\ (b - 2) + 0.0033\ X\ (c - 3) \qquad (2)$$

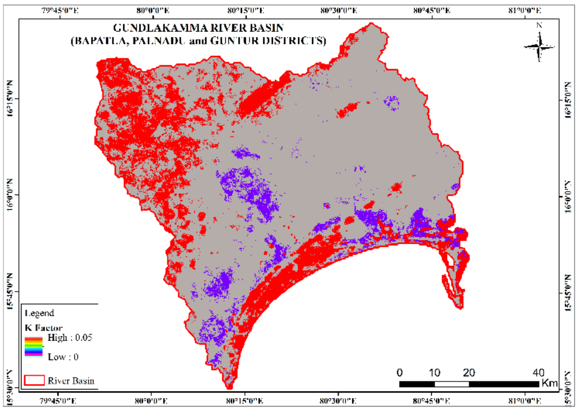

Fig 4: Soil Erodibility Factor

3.1.3. LS Factor (Slope Length and Steepness Factor)

LS factor represents the effect of topography on erosion by integrating slope length and slope gradient as a single factor. In the basin, LS values vary drastically between very low (1.69) and very high (11, 857.7) figures. Low LS values dominate the majority of the basin, which means the terrain is mostly flat or gently sloping and has low erosion risk. Besides these low-erosion areas with little or no erosion potential, steep and long hills have a very high LS where the land erodes rapidly, detaches particles of soil, transports them, and eventually deposits sediment down the valley. The map clearly shows that topography is one of the main erosion drivers in this area by highlighting high-LS zones as places of major erosion where the main soil loss efforts in watershed management and soil conservation are expected to be targeted. This is the formula which is to be applied:

$$LS = \left[\frac{\mathrm{Qa}M}{22.13}\right]^{y} \times (0.065 + 0.045 \times S_g + 0.0065 \times S_g^2 \quad (3)$$

Where LS = Topographical factor; Qa = Flow Accumulation grid; Sg = Grid slope in percentage; M = Grid size (x × y); y = dimensionless exponent that assumes the value of 0.2–0.5.

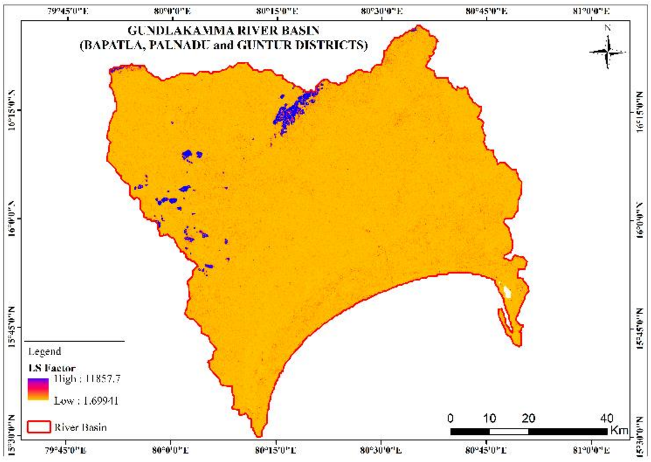

Fig 5: Slope Length and Steepness Factor

3.1.4. C Factor (Cover and Management Factor)

C Factor is the soil conservation factor, which gives us an idea of how much the type of vegetation, the system of cultivation and the method of using the land will affect the amount of soil erosion that is going to take place. As C factors are not available for most Indian crops, we used the C factors obtained by Karaburun (2010) [33], which were the best available at that time, to reflect the influence of farming and management practices on erosion rates on agricultural lands. In the Gundlakamma River Basin, C-factor values range from 0.00076 to 1.83. This significant diversity reflects quite different land-cover conditions at the landscape level. The fact that a large portion of the basin has low C-factors (the green regions in the maps) means extensive vegetation cover and land where crops are growing well, which can reduce the damage from raindrops, increase the capacity of the land, and prevent detachment and transport of soil particles.

Higher C-factor values are localised on barren and thinly vegetated areas together with built-up land cover and exposed soils, which is the case especially in the area around the coast and the water bodies. These types of areas, which, due to minimal ground cover, are very easily eroded. The map generally shows how the presence of vegetation cover plays an important role as a physical barrier to soil erosion. This way, not only does it help preserve the physical integrity of the soil surface, but it also reduces the quantity of sediment produced and transported within nearly all parts of the basin. The equation below is used for calculating the parameter.

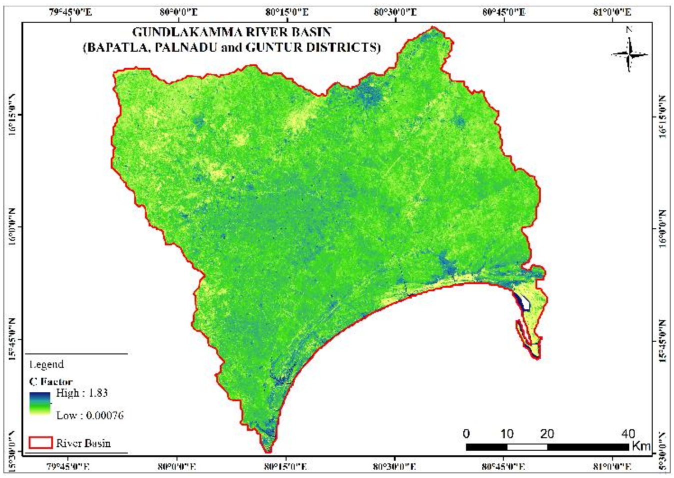

Fig 6: Cover and Management Factor

3.1.5. P Factor (Support Practice Factor)

The P factor assesses the effectiveness of soil conservation measures and land management practices in reducing erosion. The conservation practice factor (P) represents the ratio of soil loss by a support practice to that of straight-row farming up and down the slope and is used to account for the positive impacts of those support practices. Values range from 0.5 to 1.0, where lower values indicate the presence of erosion-control measures such as contour farming, strip cropping, terracing, and conservation agriculture, while higher values represent areas lacking such interventions. Most of the Gundlakamma River Basin is characterised by lower P-factor values, suggesting that agricultural practices and land management strategies contribute significantly to controlling runoff and soil loss. Higher values are observed along certain coastal stretches, drainage corridors, and localised agricultural zones where conservation measures are limited or absent. The spatial pattern indicates that existing support practices help reduce erosion risk over large portions of the basin; however, vulnerable areas with high P-factor values remain susceptible to accelerated soil loss and should be targeted for improved conservation efforts.

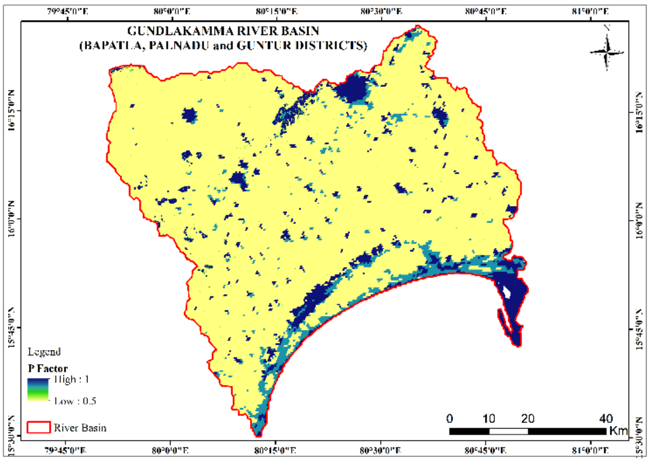

Fig 7: Support Practice Factor

3.2. RUSLE Annual Soil Erosion Class

The yearly soil erosion map, derived from the RUSLE model, is a comprehensive picture showing soil loss potential over the Gundlakamma River Basin. Five levels of erosion risk, Very Low, Low, Moderate, High, and Very High, are determined for the basin based on annual soil loss rates. Most of the basin is covered with Very Low and Low classes of erosion that indicate fairly stable land surfaces and protection from land use and natural conditions against erosion. On slopes and in drainage systems where there is less natural vegetation, these Moderate erosion zones form due to more runoff concentration.

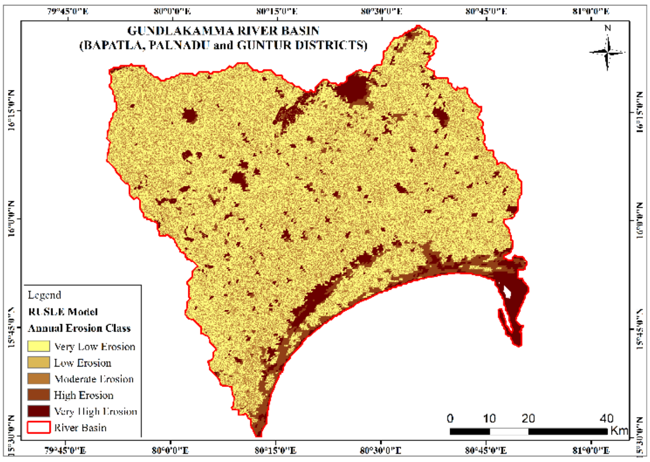

Fig 7: Annual Soil Erosion by RUSLE Model

High and Very High erosion classes along the steep riverbanks, river channels, and coastal areas where the combined effects of heavy rains, very high LS values, and lack of vegetation cover increase the susceptibility to erosion. These erosion-prone areas are the priority zones for the implementation of watershed conservation and practices of sustainable land management.

3.3. RUSLE Soil Erosion Risk Map

The final RUSLE soil erosion risk map, produced using Excel's spatial integration of rainfall erosivity (R), soil erodibility (K), topography (LS), vegetation cover (C), and conservation practices (P), provides a detailed, quantitative assessment of erosion levels over the entire 5, 959 sq.km Gundlakamma River Basin. According to the results given by

Excel, Slight erosion is only present on an area of 383.25 sq. km (6.43%) and Moderate erosion is found in 574.72 sq.km (9.64%). However, it is clear that when we join not only High and Very High, but also the Very Severe category (which is >40 t/ha/yr and is located on 1, 240.89 sq. km; 20.82%) altogether, they represent 83.92% of the basin, which in itself is quite large. This is an indicator of the basin's overall situation: that high to severe levels of erosion stress are the normal state, while the Very High category is not only the biggest among them but is by itself bigger than the total of the Moderate categories.

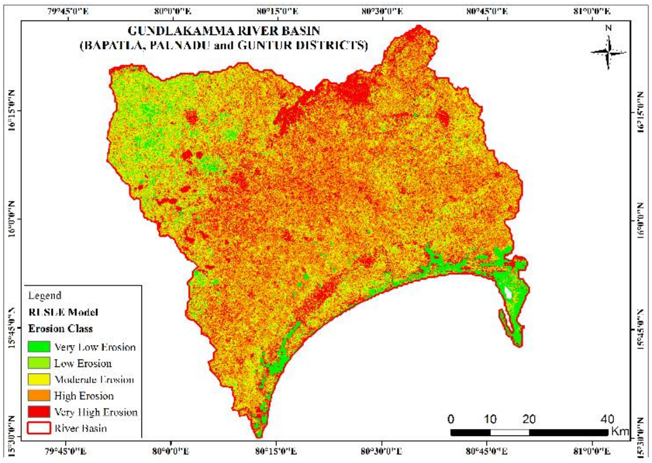

Fig 8: Soil Erosion by RUSLE Model

Table 2: Severity Level of Soil Erosion Model

Sl. No.	Severity Level	Class Range	Area (in Sq. km)	Area (in %)
1	Slight	< 5	383.25	6.43
2	Moderate	5-10	574.72	9.64
3	High	10-20	1488.96	24.99
4	Very High	20-40	2271.18	38.11
5	Severe	> 40	1240.89	20.82
Total			5959	100

In terms of distribution, the combined area of Very High to Severe (58.93%) consists mainly of steep, localised hotspot areas of drainage channels that have topography and heavy downpour, which are the major reasons for soil removal. Compared to the other two, which are Slight to Moderate, the share of risk is very small, and their distribution area is mainly in flat areas that are very densely covered by vegetation and have proper land use management measures, which result in a very low loss of soil. The areas that will be affected by measures have to be identified and prioritised as the first steps in order to prevent soil erosion, especially as over 80% of the water catchment area has severe erosion problems according to these Excel results. As such, they highlight not only the urgent need for implementing targeted measures to conserve soil and water but also the importance of measures such as contour bunds, reforesting and planting, vegetation barriers, small dams, integrated watershed programmes which would effectively decrease sediment load and protect the diminishing agricultural output, and at the same time provide for the long-term environmental sustainability of a water catchment area like the Gundlakamma River Basin.

3.4. Validation by the FR probability model

Table 3: Frequency Ratio Probability

Sl. No.	Severity Level	Area (in Sq. Km)	FR Ratio
1	Slight	1706.55	0.020
2	Moderate	445.78	0.116
3	High	1942.83	0.069
4	Very High	1760.42	0.116
5	Severe	103.42	1.079
Total		5959.00	1.400

Validation of the Frequency Ratio (FR) demonstrates a high Positive correlation of actual erosion spots with the severe erosion class, which had a maximum of FR 1.079. This means the severe erosion areas are likely to be the places where actual soil loss will happen; the model can identify these areas quite reliably. Compared to these, the Slight (FR = 0.020), High (FR = 0.069), Moderate (FR = 0.116), and Very High (FR = 0.116) classes have less than 1 FR value, which means, comparatively, a relatively smaller number of ground-verified erosion spots were found in these classes. The overall sum of the FR equalling 1.400 shows that the RUSLE model has adequate predictive ability for erosion-prone sites in the basin.

Spatially severe and very high erosion zones are concentrated in localised patches connected with steeper slopes, drainage channels and exposed land surfaces. Conversely, low erosion areas are basically confined to the coastal plains and flat terrain. Such evidence points out the significance of prioritised soil and water conservation work in the severely eroded hotspots in order to minimise sediment loss and promote the long-term management of the watershed in the Gundlakamma River Basin.

4. Conclusion

This research effectively combined an up-to-date RUSLE with the Google platform to perform a soil erosion vulnerability study using data from multiple satellite systems in Andhra Pradesh's Gundlakamma district of the basin. It found that factors affecting rainfall, landscape features, types of cover plants, conditions of soil, and human measures of soil conservation all have an effect on the distribution of loss of soil through erosion at different points of the river basin.

From the results of RUSLE factors, the level of changes within the watershed regarding the degree of rainfall and the form of the slope was identified. Soil loss was very high, with the erosion map revealing that about 16.07% of the basin experienced erosion that was slight or moderate, while about 83.92% was subjected to high to severe erosion. Severe erosion areas were mainly found in regions with steep slope features, open soil surfaces, and limited vegetational cover along water streams. Hence, the major contribution to soil degradation appears from land and landscape features.

Frequency Ratio method gave more evidence about correct model outputs, with the Severe category having the highest FR (1.079) and a total FR of 1.400, which means fairly acceptable results that can be used for picking out erosion-prone spots. The results show the immediate demand for introducing measures for soil and water conservation like contour bunding, terracing, vegetative barriers, afforestation, check dams and integrated watershed management in these highly susceptible places. The research illustrates that the use of RUSLE together with cloud-based geo-technological interfaces makes it possible for soil loss to be identified and quantified in a time-efficient, affordable, and extendable way. These soil erosion risk maps would work as good decision-support tools not only for the sustainability of the land-use plans in the Gundulamma river basin and the area around it with low rainfall, but also for the development of climate-resilient watershed restoration, agricultural, and resource management strategies.

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References

1. Adimassu Z, Mekonnen K, Yirga C, Kessler A. Effect of soil conservation practices on soil loss reduction. Land Degrad Dev. 2017;28(2):843-855. doi:10.1002/ldr.2676.
2. Alewell C, Borrelli P, Meusburger K, Panagos P. Using the USLE: chances, challenges, and limitations of soil erosion modelling. Int Soil Water Conserv Res. 2019;7(3):203-225. doi:10.1016/j.iswcr.2019.05.004.
3. Batjes NH. Harmonized soil property values for broad-scale modelling (WISE30sec) with estimates of global soil carbon stocks. Geoderma. 2016;269:61-68. doi:10.1016/j.geoderma.2015.12.020.
4. Belayneh M, Yirgu T, Tsegaye D. Soil erosion assessment using RUSLE and GIS in a highland watershed of Ethiopia. Environ Earth Sci. 2021;80(5):1-18. doi:10.1007/s12665-021-09454-8.
5. Bhattacharyya T, Pal DK, Chandran P, Ray SK, Mandal C, Telpande B. Soil information for agricultural land use planning in India. Curr Sci. 2015;109(9):1544-1556.
6. Bhandari S, Phinn S, Gill T, Smart J. Cloud computing approaches for environmental monitoring using geospatial datasets. Remote Sens Appl Soc Environ. 2018;11:95-108. doi:10.1016/j.rsase.2018.06.002.
7. Boardman J, Poesen J, editors. Soil erosion in Europe. Chichester: John Wiley & Sons; 2006.
8. Borrelli P, Alewell C, Alvarez P, Anache JAA, Baartman JEM, Ballabio C, *et al*. Soil erosion modelling: a global review and statistical analysis. Sci Total Environ. 2021;780:146494. doi:10.1016/j.scitotenv.2021.146494.
9. Borrelli P, Robinson DA, Fleischer LR, Lugato E, Ballabio C, Alewell C, *et al*. An assessment of the global impact of 21st-century land use change on soil erosion. Nat Commun. 2017;8:2013. doi:10.1038/s41467-017-02142-7.
10. de Vente J, Poesen J, Verstraeten G, Vanmaercke M, Van Rompaey A, Arabkhedri M, *et al*. Predicting soil erosion and sediment yield at regional scales: where do we stand? Earth Sci Rev. 2013;127:16-29. doi:10.1016/j.earscirev.2013.08.014.
11. Didan K. MOD13Q1 MODIS/Terra vegetation indices 16-day L3 global 250 m SIN grid V006 user guide. Tucson: NASA EOSDIS Land Processes DAAC; 2015.
12. Drusch M, Del Bello U, Carlier S, Colin O, Fernandez V, Gascon F, *et al*. Sentinel-2: ESA's optical high-resolution mission for GMES operational services. Remote Sens Environ. 2012;120:25-36. doi:10.1016/j.rse.2011.11.026.
13. Farr TG, Rosen PA, Caro E, Crippen R, Duren R, Hensley S, *et al*. The Shuttle Radar Topography Mission. Rev Geophys. 2007;45(2):RG2004. doi:10.1029/2005RG000183.
14. Fenta AA, Tsunekawa A, Haregeweyn N, Poesen J, Tsubo M, Borrelli P, *et al*. Land susceptibility to water and wind erosion risks in East Africa. Sci Total Environ. 2020;703:135016. doi:10.1016/j.scitotenv.2019.135016.
15. Funk C, Peterson P, Landsfeld M, Pedreros D, Verdin J, Shukla S, *et al*. The climate hazards infrared precipitation with stations (CHIRPS): a new environmental record for monitoring extremes. Sci Data. 2015;2:150066. doi:10.1038/sdata.2015.66.
16. Gorelick N, Hancher M, Dixon M, Ilyushchenko S, Thau D, Moore R. Google Earth Engine: planetary-scale geospatial analysis for everyone. Remote Sens Environ. 2017;202:18-27. doi:10.1016/j.rse.2017.06.031.

17. Intergovernmental Panel on Climate Change. Climate change 2023: synthesis report. Geneva: IPCC; 2023.
18. Kumar L, Mutanga O. Google Earth Engine applications since inception: usage, trends, and potential. Remote Sens. 2018;10(10):1509. doi:10.3390/rs10101509.
19. Lal R. Soil degradation by erosion. Land Degrad Dev. 2001;12(6):519-539. doi:10.1002/ldr.472.
20. Morgan RPC. Soil erosion and conservation. 3rd ed. Oxford: Blackwell Publishing; 2005.
21. Panagos P, Ballabio C, Borrelli P, Meusburger K, Klik A, Rousseva S, *et al*. Rainfall erosivity in Europe. Sci Total Environ. 2018;511:801-814.
22. Patel SK, Singh PK. Application of Google Earth Engine for soil erosion mapping in a critical river basin. J Environ Manage. 2024;351:119789.
23. Pimentel D. Soil erosion: a food and environmental threat. Environ Dev Sustain. 2006;8(1):119-137. doi:10.1007/s10668-005-1262-8.
24. Prasad NR, Garg V, Thakur PK. Role of SAR data in water body mapping and reservoir sedimentation assessment. ISPRS Ann Photogramm Remote Sens Spat Inf Sci. 2018;IV-5:151-158. doi:10.5194/isprs-annals-IV-5-151-2018.
25. Ramachandra TV, Vinay S, Subash Chandran MD. Quantification of annual sediment deposits for sustainable sand management in the Aghanashini River estuary. J Environ Manage. 2018;206:1263-1273. doi:10.1016/j.jenvman.2017.07.060.
26. Rao KN, Saito Y, Naga Kumar KCV, Kubo S, Pandey S, Li Z, *et al*. Holocene evolution and Anthropocene destruction of the Krishna Delta on the east coast of India: delta lobe shifts, human impacts, and sea-level history. Mar Geol. 2020;427:106229. doi:10.1016/j.margeo.2020.106229.
27. Renard KG, Foster GR, Weesies GA, McCool DK, Yoder DC. Predicting soil erosion by water: a guide to conservation planning with the revised universal soil loss equation (RUSLE). Agriculture Handbook No. 703. Washington (DC): US Department of Agriculture; 1997.
28. Tamiminia H, Salehi B, Mahdianpari M, Quackenbush L, Adeli S, Brisco B. Google Earth Engine for geo-big data applications: a meta-analysis and systematic review. ISPRS J Photogramm Remote Sens. 2020;164:152-170. doi:10.1016/j.isprsjprs.2020.04.001.
29. Thomas J, Joseph S, Thrivikramji KP. Soil erosion assessment in tropical river basins using RUSLE. Environ Earth Sci. 2018;77:1-16.
30. Van der Knijff JM, Jones RJA, Montanarella L. Soil erosion risk assessment in Europe. Ispra: European Soil Bureau; 2000.
31. Wischmeier WH, Smith DD. Predicting rainfall erosion losses: a guide to conservation planning. Agriculture Handbook No. 537. Washington (DC): US Department of Agriculture; 1978.
32. Williams JR. The EPIC model. In: Singh VP, editor. Computer models of watershed hydrology. Highlands Ranch (CO): Water Resources Publications; 1995. p. 909-1000.
33. Karaburun A. Estimation of C factor for soil erosion modelling using NDVI in Buyukcekmece watershed. Ozean J Appl Sci. 2010;3(1):77-85.

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