International Journal of Plant & Soil Science

Volume 37, Issue 1, Page 76-80, 2025; Article no.IJPSS.129691
ISSN: 2320-7035

Development of Simplified Relationship between Rainfall Erosion Indices and Precipitation Indices for Soil Conservation in Hisar, Haryana, India

Sundeep Kumar Antil [a*], Ram Naresh [b++], Mukesh Kumar [b++], Kuldeep Singh [a] and Darshana Duhan [b++]

[a] DES, Agriculture Engineering, CCSHAU, KVK, Sonipat, India.
[b] Department of Soil and Water Engineering, COAE & TCCSHAU, Hisar, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ijpss/2025/v37i15253

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/129691

Original Research Article

Received: 06/11/2024
Accepted: 09/01/2025
Published: 10/01/2025

ABSTRACT

Soil erosion is the functional ability of rainfall to detach the soil particles and simultaneously the susceptibility of soil to resist against raindrop. In this study, an effort was made to develop a relationship between erosion indices and precipitation indices for the study area. The rainfall data of 16 years for the selected durations of 15-60 minute storms was analyzed to evaluate the erosion potential. A highly significant linear correlation was observed between erosion index (EI) and

---

[++] *Assistant Professor;*
**Corresponding author: E-mail: sundeepantil@gmail.com;*

Cite as: *Antil, Sundeep Kumar, Ram Naresh, Mukesh Kumar, Kuldeep Singh, and Darshana Duhan. 2025. "Development of Simplified Relationship Between Rainfall Erosion Indices and Precipitation Indices for Soil Conservation in Hisar, Haryana, India". International Journal of Plant & Soil Science 37 (1):76-80. https://doi.org/10.9734/ijpss/2025/v37i15253.*

precipitation index (PI) values computed for the durations of 15, 30, 45 and 60 minutes. The obtained correlation coefficient (r) was varied from 0.97 to 0.99. The precipitation index (PI_{30}) for 30 minutes duration also showed significant linear correlation with precipitation index PI_{15}, PI_{45} and PI_{60} minutes duration. The equations so developed could be used for the computation of erosion index (EI) values for Hisar region by substituting the corresponding values of precipitation index (PI) as independent variable and without going through the tedious process of computation of kinetic energy. The results could provide a quick idea on erosion potential for planning the general purpose soil and water conservation measures in the study area.

Keywords: Precipitation index; erosion index; runoff; rainfall intensity.

1. INTRODUCTION

Runoff is generally caused by excessive storms in which the intensity of rainfall plays a crucial role. Excessive rainfall generally causes soil erosion and is a complicated issue. An erosion model was designed to predict long term average soil loss in runoff from specific fields under specific cropping and management systems (Wischmeier and Smith, 1978). This equation was named the Universal Soil Loss Equation (U.S.L.E.). Over the years its practicality for widespread field use has been proven (ARS, USDA, 1961). The erosivity of rainfall in U.S.L.E. is defined as a factor (R). It defines the energy of the raindrops that break soil aggregates and then dislodge and transport the soil particles. The most reliable estimate of the rainfall erosion potential (EI_{30}) is the one-hundredth fraction of the product of the rainstorm's kinetic energy and the 30-minute intensity (I_{30}) (Wischmeier, 1959). The erosion index (EI_{30}) is popularly known as the rainfall factor (R) in the U.S.L.E when it is averaged annually. The erosion index (EI) is used to estimate soil loss to categorize rainstorms according to their potential and evaluate the erodibility of different soils. The precipitation index (PI) was introduced as a new rainfall parameter, and its high correlation with the erosion index (EI) was observed (Erasmus et al. 1970). The application of PI values needs to be critically examined at a number of locations despite the simplicity and prospect of wide applicability (Das and Rambabu, 1978). Recording types of raingauge data of usually more than 20 years are required for analyzing the EI values whereas in the absence of long term data, attempts could be made to compute EI values of lower frequencies of 2 years and 5 years (Gupta and Rambabu, 1967). The average annual erosion index and the relationship between the average annual rainfall and average annual erosion index have also been suggested to be useful for planning suitable soil and water conservation measures for different regions in the country (Ram Babu et al. 1978). In this study, an attempt was made to develop a relationship between the rainfall erosion index (EI), precipitation index (PI) and between the precipitation index (PI_{30}) and the precipitation Indices PI_{15}, PI_{45} and PI_{60} individually, to arrive at an easy estimation of the erosion index in the Hisar region in Haryana state.

2. MATERIALS AND METHODS

The study was carried out in the Hisar district of Haryana, India. Hisar has a latitude of 29^0 10’ North and a longitude of 75^0 45’ East and is located in the western zone of Haryana. The normal annual rainfall received at Hisar is 400 mm, approximately 80% of which received during the monsoon period. The erosive rain storm data were collected from the India Meteorological Department, New Delhi for the Hisar region, for a selected duration of 15 - 60 minutes of storm rainfall, for a period of 16 years from 1982-1999. The recorded rain gauge data for the years 1986 and 1987 were not available. Autographic rainguagery charts were analyzed for the magnitude and intensity of rainfall. The erosion index values for all storms separated by more than six hours were considered different storms, the slopes of the rainfall lines with corresponding time intervals on the autographic rainguagery charts were separated and tabulated, the and rainfall intensities for 15, 30, 45 and 60 minutes were determined. Rainfall intensities of 25 mm/hr were taken as practical threshold levels for separating erosive and non-erosive rain (Ellision, 1944).

The product of amount of the rainfall and its intensity for the selected time interval was derived for each storm and termed as the precipitation index (Erasmus et al. 1970). The precipitation index (PI) was analyzed by multiplying the 6-h storm rainfall by the maximum per hour rainfall intensity for the selected durations of 15, 30, 45 and 60 minutes, which were designated PI_{15} PI_{30} PI_{45} and PI_{60} respectively.

The erosion index (EI_x) for each erosive storm was computed. (Wischmeier, 1959), (Wischmeier and Mannering, 1969). The kinetic energy for these durations was computed in metric units via the method described below.

$$KE = 210.3 + \log I \quad (1)$$

where,

KE= Kinetic energy in metric tons/ha cm and
I = Rainfall intensity, cm/hr

$$EIx = K.E. \times Ix / 100 \quad (2)$$

where,

EI_x =Erosion index for duration x (minutes)
KE = Kinetic energy of the storm (metric tons/ha)
I_x = Maximum per hour rainfall intensity (cm/hr) for duration x (minute)

The erosion indices (Eis) for all selected durations i.e. 15, 30, 45 and 60 minutes were calculated and the relationship between the corresponding values of the precipitation indices were obtained.

3. RESULTS AND DISCUSSION

A linear relationship was found between the erosion index (EI) values and corresponding precipitation index (PI) values for all selected durations of 15, 30, 45, and 60 minutes. The corresponding equations are shown in Table 1. The erosion index (EI) and precipitation index (PI) (the value of R varied from 0.97 to 0.99) were significantly correlated. Rainfall intensities of the aforementioned durations are frequently encountered within storms and can be easily computed on the time axis of self-recording -type rating charts. The equations developed in this study (Table 1) can be utilized for the computation of erosion index values for the required duration for the Hisar region by substituting the corresponding values of the precipitation index as independent variables without going through the tedious process of computing kinetic energy.

As suggested, the one-hundredth fraction of the product of the kinetic energy of the storm and the 30minute duration intensity (I_{30}) was the most reliable single estimate of the rainfall erosion potential (EI_{30}) to be utilized as a numerical substitute for the rainfall factor in the U.S.L.E. (Wischmeier,1959). Therefore, to compute the rainfall erosion potential (EI_{30}), the relationships of precipitation index for 30 minutes (PI_{30}) with precipitation indices (PI_{15}, PI_{45} and PI_{60}) were evaluated individually. A highly significant linear correlation was observed in each case (Table 2).

The erosivity index varies with rainfall, and various techniques and methods have been used by many researchers for calculating the erosivity index (Pandit and Isaac, 2015). A similar attempt was made, and the precipitation index values were correlated with the corresponding erosion index values for the 345 storms in Kota which were highly significant (Parkash, et al. 1985). Similar rainfall duration viz., 15, 30, 45 and 60 minutes were used to analyze the rainfall intensity duration return period equation for this study area and obtained the value of constants required for rainfall intensity durations and frequency relationship. (Antil, et al., 2010).

Table 1. Correlation between the erosion index (EI) and precipitation index (PI)

Sr. No.	Duration (Minutes)	Equation	Correlation Coefficient (r)
1.	15	EI_{15}= 2.78 PI_{15} – 0.66	0.97
2.	30	EI_{30}= 2.83 PI_{30} – 2.34	0.98
3.	45	EI_{45}= 2.73 PI_{45} – 3.29	0.97
4.	60	EI_{60}= 2.88 PI_{60} – 4.72	0.99

Table 2. Precipitation index (PI_{30}) and precipitation indices (PI_{15}, PI_{45} and PI_{60})

Sr. No.	Duration (Minutes)	Equation	Correlation Coefficient (r)
1.	15	PI_{30}= 0.91 PI_{15} – 1.63	0.97
2.	45	PI_{30}= 1.10 PI_{45} +0.42	0.97
3.	60	PI_{30}= 1.12 PI_{60} +4.25	0.97

4. CONCLUSION

A highly correlated linear correlation between the erosion index and the precipitation index for durations of 15, 30, 45 and 60 minutes was observed. The precipitation index for the 30-minute duration (PI_{30}) also has a significant linear correlation with the precipitation indices for the 15-, 45-, and 60-minute durations. The developed equation may be utilized for computing the erosion index for the Hisar region in Haryana. The equations developed in this study can be utilized for the computation of erosion index values for the Hisar region by substituting the corresponding values of precipitation indices as independent variables without the tedious process of computing of kinetic energy. The representation of the erosion index by the EI_{30} is the most common rainfall erosivity estimation method. Many researchers, in the absence of rainfall intensity data, have developed various methods using rainfall depth data. The potential soil loss for Hisar district was estimated through geospatial techniques and reported as 1.37 million tons year^{-1} (Kumar et al., 2022). Highest correlation was observed between erosion index and surface runoff volume and which directly influenced the amount of soil erosion (Yulianti, et al., 2019). Currently, artificial neural techniques and machine learning models are gaining popularity (Suhara et al., 2023). The conventional neural network models has identified the soil erosion with higher accuracy as compared with traditional methods of soil erosion estimation (Liu et al., 2023). Integration of the geospatial technologies with soil erosion models have been widely used around the world to predict the potential soil erosion of the respective region. (Antil et al., 2022). Land-use land-cover changes are also prime factors which influenced the soil erosion with great extent. The inclusion of other environmental co-variates which contributes in land cover land use changes certainly improve results of the study (Khush Lata et al., 2024). Absence of long-term rainfall intensity data for the study area is main constraint for such intensities based studies. However the remote sensing based gridded rainfall data and modern computer based algorithms could be used for future studies and more accurate results with higher accuracy could be achieved.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Agricultural Research Service, U.S. Department of Agriculture (1961). A Universal Soil Loss Equation for predicting erosion losses. ARS, 22-66, 11.

Antil, S. K., Sidhpuria, M.S., Kumar, M., Kumar, S. & Bhardwaj, N. (2022). Review on land use, land cover analysis and soil loss estimation through RUSLE and geospatial technologies. Journal of Plant Development Sciences, 14(7), 615-619.

Antil, S.K., Jhorar, R.K. & Sidhpuria, M. S. (2010). Rainfall intensity-duration-return period eqatuion for Hisar district in Haryana. Annals of Biology, 26 (2), 173-175.

Das, D. G. & Rambabu (1978). Computation and estimation of rainfall energy and erosion indices in metric units. Indian Forester, 105 (3), 212-222.

Ellison, W. D. (1944). Studies of raindrop erosion. Journal of Agricultural Engineering, 25, 131-136.

Erasmus, O.O., Madanlal., Raghunath, B. & Mathur, P. S. (1970). Evaluation of erosion potential from rainfall data. Indian Forester, 96 (11), 818-825.

Gupta, S. K. & Rambabu (1967). Rainfall erosion index of Dehradun. Indian Forester, 93 (10), 734-738.

Khush Lata, Antil, S. K., Parwasi, R. & Kumar, A. (2024) Land use land cover change assessment in Fatehabad district, Haryana: A GIS and remote sensing based case study. Forage Research. 50 (2), 220-227.

Kumar, S., Singh, D., Kumar, A., Kumar, M., Giri, K., Devi, K. & Singh, S. (2022). Estimation of soil erosion in Indo-Gangetic region using Revised Universal Soil Loss Equation (RUSLE) model and geospatial technology. Modeling Earth Systems and Environment, 9, 1-23.

Liu, C., Li, H., Xu, J., Gao, W., Shen, X., & Miao, S. (2023). Applying convolutional neural network to predict soil erosion: A case study of coastal areas. International

Journal of Environmental Research and Public Health. 20 (3), 2513.

Pandit, D.V & R. K. Isaac, R.K. (2015). A Scenario of Rainfall Erosivity Index Research. International Journal of Engineering Research, 4(12), 668-672.

Parkash, C., Verma, B. & Roa, D.H. (1985). Precipitation index - A parameter for computing erosion index. Journal of Agricultural Engineering (India) ISAE, 21(4), 85-88.

Rambabu, Tejwani, K. G., Agarwal, M. C. & Subash Chandra (1978). Rainfall erosion potential and iso-erodent map of India. Central Soil and Water Conservation Research and Training Institute. Bulletin No. (2), 42.

Suhara, K.K.S., Varughese, A., Sunny, A.C. & Anjitha Krishna, P R (2023). Erosivity factor of the Revised Universal Soil Loss Equation (RUSLE)-A systematized review. Current World Environment,18(2), 433-445.

Wischmeier, W. H. & Mannering, J. V. (1969). Relation of soil properties to its erodibility. Soil Science Society of America Proceedings, 33, 131-137.

Wischmeier, W. H. & Smith, D. D. (1978). Predicting rainfall erosion losses. A Guide to Conservation Planning, The U.S.D.A. Agricultural Handbook, 537(58).

Wischmeier, W. H. (1959). A rainfall erosion index for a Universal Soil Loss Equation. Soil Science Society of America Proceedings. 23, 246-249.

Yulianti, E., Limantara, L. M., Suhartanto, E. & Dermawan, V. (2019). Model of rainfall erosion index for predicting the potential erosion rate by using a rainfall simulator. IOP Conference Series: Earth & Environmental Science. 437, 012045.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/129691