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Comparative performance of wepp and usle model for prediction of soil loss in karli river catchment

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Abstract
Soil erosion is a serious problem that seems from a combination of agricultural intensification, soil degradation and intense rainstorms. Erosion may also be exacerbated in the future in many parts of the world because of erotic climatic change results into more vigorous changes in hydrologic cycle. The different management theories, formulae, equations and models have been developed to predict the soil loss from the catchment.
In recent decades, models have been built (empirical, conceptual, or physically based) in order to represent and to quantify the processes of detachment, transport, and deposition of eroded soil, with the aim of implementing assessment tools for educational, planning and legislative purposes. Among the different models being used to predict the soil loss along with other important parameters the Water Erosion Prediction Project (WEPP) and Universal Soil Loss Equation (USLE) model are being widely used for the purpose therefore Comparative performance of Water Erosion Prediction Project (WEPP) and Universal Soil Loss Equation (USLE) model were used for prediction of soil loss from Karli river catchment.
The WEPP model computed soil loss for 7 channels and 18 hill slopes of Karli river catchment. The GeoWEPP model run for Karli river catchment with contributing total area to outlet was 3978.75 ha. The average annual soil loss from hill slopes and channels was found to be 42.89 t/ha/yr and 8.78 t/ha/yr respectively, totally to 51.67 t/ha/yr. The WEPP model also calculated the sediment yield of Karli river catchment that is 17.92 t/ha/yr. The Water Erosion Prediction Project (WEPP) model predicted the 9.01 t/ha/yr more soil loss than the Universal Soil Loss Equation (USLE) model. The Universal Soil Loss Equation (USLE) was used for estimation of soil loss from the watershed. The different parameters including soil loss and related were determined by using Remote Sensing data and Geographical Information System tools. The predicted soil loss by using USLE in the Karli river catchment was found to be 42.66 t/ha/yr and it is 9.01 t/ha/yr less than predicted by WEPP.

Keywords: WEPP, USLE, soil loss, sediment yield, Karli river

Introduction
Soil erosion is a serious problem that seems from a combination of agricultural intensification, soil degradation, and intense rainstorms. Erosion may also be exacerbated in the future in many parts of the world because of climatic change towards a more vigorous hydrologic cycle. Many planning and management theories and formulae have been developed in order to reduce soil loss from basins and as a result, sediment transport to hydrologic drainage networks. This latter phenomenon has a great deal of importance in optimizing policies for management of water resources, particularly when sediment is generated in such a way to seriously reduce the capacity of reservoirs. A Storage capacity of existing reservoirs is a valuable and non-renewable resource that must be protected from 'sediment danger' (DiSilvio, 1996) [1], and which can be restored only through costly periodic dredging. It is therefore desirable to predict distributions of soil loss, sediment yield, and sediment deposition upstream of a dam in order to plan structural works and other means for reducing the problem. Soil erosion resulting mainly from forest and agricultural land use, is associated mainly with environmental impacts as well as crop productivity loss in the latter (Lal, 1995; Pimentel *et al.*, 1995) [15] which makes the understanding of the erosion process important to guarantee food security (Daily *et al.*, 1998) and environmental safety (Matson *et al.*, 1997) [8].
The total estimated area of Maharashtra is 30.77 Mha. Among this total land area, 773.5 million tonnes (25.14 t/ha) of soil was lost due to soil erosion, were 94% of this erosion was mainly caused due to induction of water (Durbude, 2015) [2]. So it becomes essential to study the soil characteristics of various soil types, which are responsible for this phenomenon. The prevention of soil erosion, which means reducing the rate of soil loss to approximately that, which would occur under natural conditions,

relies on selecting appropriate strategies for soil conservation and this, in turn, requires a thorough understanding of the processes of erosion. The factors, which influence the rate of soil erosion, are rainfall, runoff, soil, slope, plant cover and the presence or absence of conservation measures (Morgan, 1986) [10].

Due to worldwide use of Universal Soil Loss Equation (USLE) which predicts the long-term average annual rate of erosion on a field slope based on rainfall pattern, soil type, topography, crop system, and management practices. But this empirical model having some certain limitations which were overcome in Physical process based WEPP model, which computed the soil erosion for hillslope area at finer scale with less time required. So it needs to study the comparative performance between the USLE and WEPP Model. In Maharashtra state the Konkan region was bestowed by world recognized unique biodiversity but highly vulnerable to erosion. The total geographical area of Konkan was 30763.39 ha which was having average annual soil loss of 38.90 t/ha/yr (Natural Resources Atlas of Konkan, 2018) [13]. So this kind of study was very essential for the Konkan region.

Remote Sensing (RS) and Geographic Information Systems (GIS) techniques make it possible to measure these hydrologic parameters on spatial scales. The RS and GIS techniques have become valuable tools, especially when assessing erosion at larger scales due to the amount of data needed and the greater area coverage (Parveen and Kumar, 2012). With the advance of RS, it becomes possible to measure hydrologic parameters on spatial scales while GIS integrates the spatial and analytical functionality for spatially distributed data. With above study entitled was undertaken with the objectives to predict soil loss by using WEPP model and USLE model also compare performance of WEPP and USLE models.

Materials and methods

Study area: The present research work was conducted at Karli river catchment, Taluka- Kudal, District – Sindhudurg, Maharashtra. The Study area is located between the longitude 73.92^0 to 74.01^0 E and latitudes 16.04^0 to 16.10^0 N on the western coast of India in the southern part of Maharashtra state as shown in (Fig 1). The total length of the Karli River is 56 km^2. The total geographical area of study location is 4247.12 ha. It is on the eastern side of the Western Ghats forming the narrow strip of land of about 40 km between the Sahyadri on the east and the Arabian Sea on the west. It is highly hilly and undulating, being cut up by many east-west trending ridges, some of which reach right to the coast.

The area under investigation receives average annual rainfall of about 3,287 mm. geologically; the area is endowed with a variety of lithological types ranging in age from Achaean to Recent. Lithotypes like gneisses, quartzite, and schist are exposed while Cretaceous basaltic flows of Deccan Volcanic are present at higher elevations.

Maharashtra | Sindhudurg District | Location map of the study area

The following data were used to compute soil loss by using WEPP model for the Karli river catchment.

1. Daily rainfall data from 1990 to 2013 (24 years) of Dukanwadi station was used to prepare climate input file for WEPP model (www.mahahp.gov.in).
2. Harmonised World Soil Database (HWSD) was used as soil input file for WEPP model (http://www.fao.org).
3. The slope input file for WEPP Model was created from the Digital Elevation Model (DEM) from Bhuvan website portal (http://bhuvan.nrsc.gov.in).
4. Satellite images used for preparation of management input file for WEPP model were downloaded from LANDSAT data (http://ftp.glcf.umd.edu).

Data Requirement for Universal Soil Loss Equation (USLE) and WEPP Model

The following data were used to compute soil loss by using USLE model for the Karli river catchment.

1. Daily rainfall data of Dukanwadi station has been used from (1990-2013) 24 years data to compute annual rainfall erosivity (R factor) (www.mahahp.gov.in).
2. The different soil parameters such as sand, silt, clay and organic carbon of Kudal Taluka was collected from, Estimation of Erodibility at Selected Locations in Konkan Region to compute soil erodibility (K factor) for USLE model (Thawakar, 2014) [17].
3. The slope length map for USLE Model was created from the Digital Elevation Model (DEM) from Bhuvan website portal (http://bhuvan.nrsc.gov.in).
4. Landsat Satellite images used for preparation of Land Use/Land Cover (LULC) map for USLE model were downloaded from LANDSAT data portal (http://ftp.glcf.umd.edu).
5. Crop cover data of Kudal Taluka was collected from the Taluka Agriculture Office, Kudal, Dist-Sindhudurg, (Maharashtra) to obtain the crop cover management (C factor).

Results and Discussion

Water Erosion Prediction Project (WEPP)

After launching GeoWEPP initially input DEM is mainly required. Soil and land use/land cover files are also required as input for start processing. If one of file from land use/ land cover and soil file are not available then the default file has been used.

Water Erosion Prediction Project (WEPP) model Run
GeoWEPP delineated the Karli River catchment in 7 channels and 18 hills. Each channel and hill was assign the Land Use/Land Cover (LULC) as management input file and soil data as soil input file separately to run each hill slopes and channel successfully. WEPP model calculated the average annual soil loss and average annual sediment yield for each channel and hill slopes separately. The WEPP watershed simulation for representative each hill slopes and each channels.

From Table 1 it was recoded that the soil loss and sediment yield from 7 channels was observed to be 8.78 t/ha/yr and 0.12 t/ha/yr respectively. From Table 1, it was seen that, the average annual soil loss was minimum in channel 7 that is 0.02 t/ha/yr and maximum in channel 4 that is 6.68 t/ha/yr. the average annual sediment yield was minimum in channel 7 that is 0.0006 t/ha/yr and maximum in channel 1 that is 0.09 t/ha/yr.

Table 1: WEPP watershed simulation for 7 channels

S. No.	Channels Name	Channels soil loss (t/ha/yr)	Channels sediment yield (t/ha/yr)
1.	Channel 1	1.52	0.09
2.	Channel 2	0.13	0.005
3.	Channel 3	0.13	0.005
4.	Channel 4	6.68	0.002
5.	Channel 5	0.18	0.005
6.	Channel 6	0.10	0.003
7.	Channel 7	0.02	0.0006
	Total	8.78	0.12

Similarly, The WEPP watershed simulation delineated the Karli river catchment in 18 sub-catchments/hills. From Table 1, it was seen that, the maximum average annual soil loss and sediment yield was in hill slope 7 that is 24.98 t/ha/yr and 6.10 respectively and the minimum average annual soil loss and sediment yield was in hill slope 4 that is 0.04 t/ha/yr and 0.02 t/ha/yr respectively.

Table 2: WEPP watershed simulation for different hill slopes/ sub-catchments

S. No.	Hill slopes	Hill slopes Soil Loss (t/ha/yr)	Hill slopes Sediment yield (t/ha/yr)
1.	Hill 1	0.28	0.12
2.	Hill 2	0.91	0.26
3.	Hill 3	0.44	0.25
4.	Hill 4	0.04	0.02
5.	Hill 5	0.19	0.08
6.	Hill 6	2.19	0.70
7.	Hill 7	24.98	6.10
8.	Hill 8	1.91	0.92
9.	Hill 9	0.006	0.003
10.	Hill 10	0.28	0.20
11.	Hill 11	1.56	1.20
12.	Hill 12	2.25	0.78
13.	Hill 13	0.31	0.24
14.	Hill 14	0.09	0.07
15.	Hill 15	1.15	0.31
16.	Hill 16	3.94	2.08
17.	Hill 17	1.27	0.50
18.	Hill 18	1.11	3.96
	Total	42.89	17.80

The GeoWEPP model run for Karli river catchment with contributing total area to outlet was 3978.75 ha. The Average Annual total hill slopes and channels soil loss was 42.89 t/ha/yr and 8.78 t/ha/yr respectively. Average Annual total channel soil loss and sediment discharge from outlet was 34949.80 t/yr and 18472.4 t/yr respectively for watershed. The WEPP model also calculate the sediment yield of Karli river catchment was 17.92 t/ha/yr. WEPP model computed average annual soil loss from Karli river Catchment was 51.67 t/ha/yr with having the sediment delivery ratio of 0.270.

Average Annual Soil Loss using Water Erosion Prediction Project Model
The WEPP model computed soil loss for 7 major channels and 18 sub-catchments/hills of Karli river catchment. The average annual soil loss from 7 major channels and 18 sub-catchments/hills was 8.78 t/ha/yr were and 42.89 t/ha/yr respectively. The average annual soil loss from study area was 51.67 t/ha/yr and average annual sediment yield was 17.92 t/ha/yr. The average annual soil loss map has been prepared and is shown in Fig 1.

Average Annual Soil Loss using USLE
All the layers viz. R, K, LS, C and P were generated in GIS and were overlaid to obtain the product, which gave annual soil loss of the Karli river catchment. Average annual soil loss from study area was 42.66 t/ha/yr. Area under slight erosion class was found to be 88.91 ha, moderate erosion class was 692.22 ha, moderately severe erosion class was 436.17 ha, severe erosion class was 1076.82 ha, very severe erosion class was 1010.25 ha and under extremely severe erosion class the area was 942.75 ha. Highest per cent of area before recommendation of soil and water conservation measures was found under the severe soil erosion class of (25.35 %),

followed by very severe (23.78 %), extremely severe (22.19 %), moderately severe (11.21 %), moderate (16.29 %) and slight (2.09 %).

It showed that more than 71 per cent of area comes under severe to extremely severe erosion class which was cause of concern. Average annual soil loss from study area was 42.66 t/ha/yr as shown in Table 3 and in (Fig. 2). These prove the need of soil and water conservation measures in the watershed for the sustainable management of natural resources.

Table 3: Soil erosion under different classes before conservation measures for Karli river catchment

Soil erosion class	Soil loss (t/ha/yr)	Area (ha)	Per cent area
Slight	0-5	88.91	2.09
Moderate	5-10	692.22	16.29
Moderately severe	10-20	436.17	11.21
Severe	20-40	1076.82	25.35
Very severe	40-80	1010.25	23.78
Extremely severe	>80	942.75	22.19

Comparative Performance of WEPP and USLE model

The Comparative Performance of Water Erosion Prediction Project (WEPP) and Universal Soil Loss Equation (USLE) model were based on the soil loss, sediment yield, different input file, Data required and pre processing of data, Time Consumption and mode of operation, and various outcomes.

According to soil loss

1. The predicted soil loss by using Water Erosion Prediction Project (WEPP) model was 51.67 t/ha/yr.
2. The predicted soil loss by using Universal Soil Loss Equation (USLE) model was 42.66 t/ha/yr.
3. The Water Erosion Prediction Project (WEPP) model predicted 9.01 t/ha/yr more soil loss than the Universal Soil Loss Equation (USLE) model.

According to sediment yield

1. The predicted sediment yield by using Water Erosion Prediction Project (WEPP) model was 17.92 t/ha/yr.
2. The predicted sediment yield by Water Resources Department, Hydrology Project observed data was 8.12 t/ha/yr.
3. The Water Erosion Prediction Project (WEPP) model predicted 9.80 t/ha/yr more sediment yield than the government observed data.

According to different Input files

1. The Water Erosion Prediction Project (WEPP) model required only four input file such as Slope, Climate, Soil and Management input file.
2. The Universal Soil Loss Equation (USLE) model required five input file such as Rainfall erosivity, Soil erodibility, Slope length, Crop management, and Conservation practice factors are overlaid with each other.
3. The Water Erosion Prediction Project (WEPP) model required less input file than the Universal Soil Loss Equation (USLE) model.

According to data required and pre-processing of data

1. The Water Erosion Prediction Project (WEPP) model required Digital Elevation Model (DEM), Rainfall data, detailed Soil Data and pre-processed Land Use/Land Cover (LULC) data.
2. The Universal Soil Loss Equation (USLE) model required pre-processed Digital Elevation Model (DEM), pre-processed Rainfall erosivity factor, pre-processed Soil erodibility factor, and pre-processed Land Use/Land Cover (LULC) factor with all crop data of study area.
3. The Water Erosion Prediction Project (WEPP) model required less data with only LU/LC pre-processed file but in the Universal Soil Loss Equation (USLE) model required crop data and all files are should be pre-processed.

According to time consumption and mode of operation

1. The Water Erosion Prediction Project (WEPP) model required less data and less input, less time to run the model and ease to understand and operate.
2. The Universal Soil Loss Equation (USLE) model was very time consuming model, it take the more time to collect and pre processing the data but not ease to operate.

According to various outcomes

1. The Water Erosion Prediction Project (WEPP) model mainly calculates the soil loss, Sediment yield, Runoff, and Sediment delivery ratio.
2. The Universal Soil Loss Equation (USLE) model only computes the soil loss.
3. The Water Erosion Prediction Project (WEPP) model has more number of outcomes than the Universal Soil Loss Equation (USLE) model.

According to the observed data, the average annual sediment yield was 8.12 t/ha/yr whereas the predicted sediment yield from the WEPP model was 17.92 t/ha/yr. which is 54.68 % more predicted than the observed data. The sedimentation also 15.71 % and 34.68% of predicted soil loss by WEPP and for the observed sediment yield and predicted sediment yield respectively. The similar statement is made and that is the sediment yield is 30 to 60% of soil erosion loss (Fernandez *et al*., 2003; Vemu *et al*., 2012; Richarde *et al*., 2014) [3, 18, 16].

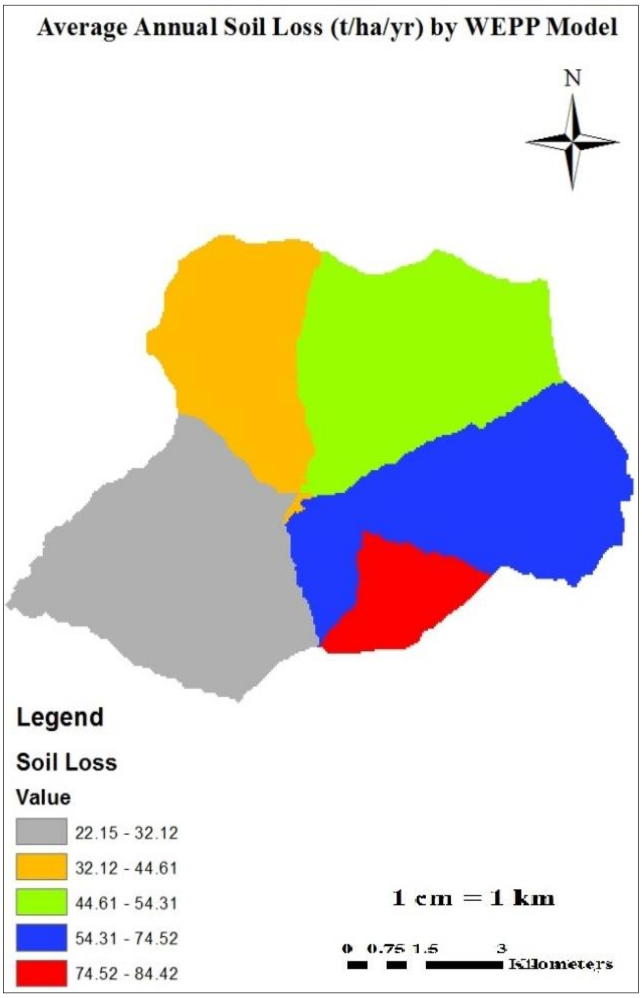

Fig 1: Average annual Soil Loss map of Karli River Catchment by Water Erosion Prediction Project Model

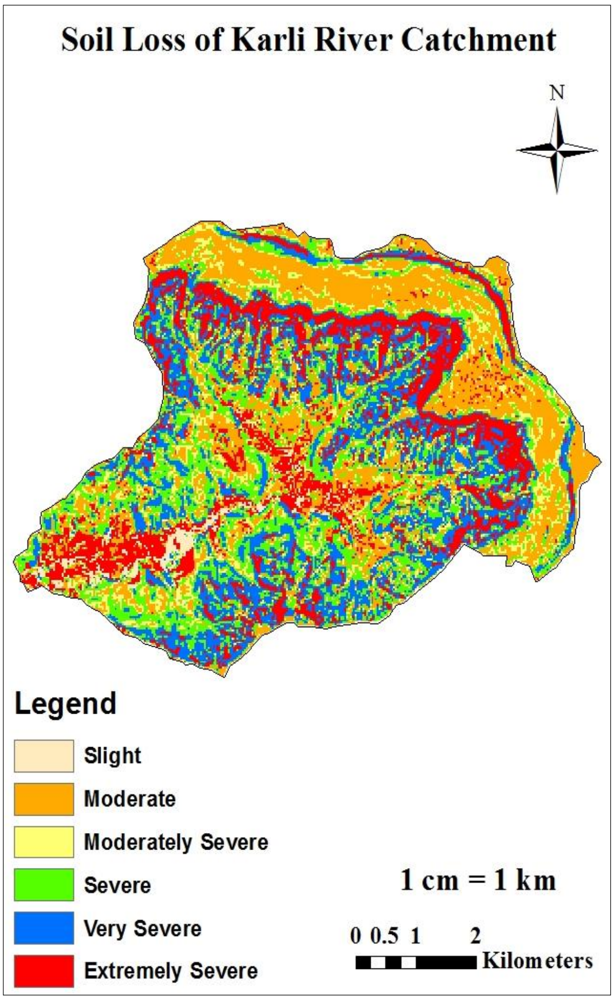

Fig 2: Soil Loss map of Karli River Catchment by USLE

Summary and Conclusions

Soil erosion is a complex phenomenon as it is governed by various natural processes, and it, in turn, results in decreasing in soil fertility and reduction in crop yield. In recent decades, models have been built (empirical, conceptual, or physically based) in order to represent and to quantify the processes of detachment, transport, and deposition of eroded soil, with the aim of implementing assessment tools for educational, planning and legislative purposes.

The average annual soil loss and soil erosion rates (t/ha/yr) were estimated for Karli river catchment by GeoWEPP model. Soil, climate, management and slope files were generated in GeoWEPP and were used as input in the WEPP model, which gave average annual soil loss and soil erosion rates of the study area. The WEPP model computed soil loss for 7 channels and 18 hill slopes of Karli river catchment. The GeoWEPP model run for Karli river catchment with contributing total area to outlet was 3978.75 ha. The Average Annual total hill slopes and channels soil loss was 42.89 t/ha/yr and 8.78 t/ha/yr respectively. The WEPP model also calculate the sediment yield of Karli river catchment was 17.92 t/ha/yr. The Water Erosion Prediction Project (WEPP) model predicted the 9.01 t/ha/yr more soil loss than the Universal Soil Loss Equation (USLE) model. It also overestimates the sediment yield than the government data by 9.80 t/ha/yr.

Universal Soil Loss Equation (USLE) was used for estimation of soil loss from the watershed. The parameters of these models were determined by using Remote Sensing data and Geographical Information System tools. R factor values were calculated using relationship between the daily rainfall and erosivity index of Wakawali region by developing regression equation. The average annual erosivity obtained for Dukanwadi station was 6635.65 MJ-mm/ha-hr-yr. Soil erodibility factor values were estimated using sand (%), silt (%), clay (%), organic matter content (%), structural code and permeability code of each village. Weighted soil erodibility factor for Karli river catchment was ranging between 0.040 to 0.041 t-ha-hr/ha-MJ-mm.

The salient conclusions drawn from the present study are as follows:

1. Estimated soil loss and sediment yield from Karli river catchment using Water Erosion Prediction Project (WEPP) model was 51.67 t/ha/yr and 17.92 t/ha/yr respectively.
2. Estimated soil loss from Karli river catchment using Universal Soil Loss Equation (USLE) model was 42.66 t/ha/yr.
3. According to comparative performance Water Erosion Prediction Project (WEPP) model overestimates 9.01 t/ha/yr soil loss value and 9.80 t/ha/yr sediment yield value than the Universal Soil Loss Equation (USLE) model and Government data respectively.
4. WEPP model was suitable model for Karli river catchment due to its less input files, less time consumption, ease to operate and understand, and less data requirement with minimum pre-processed data.

References

1. DiSilvio G. Interrimento e riabilitazione degli invasi artificiali. *L'acqua*. 1996; 6:49-54.
2. Durbude D. Hydrological impact assessment of SWC measures in Ralegon Siddhi model watershed. Indian Journal of Soil Conservation. 2015; 43 (3):197-203.
3. Fernandez C, Wu JQ, McCool DK, Stockle CO. Estimating water erosion and sediment yield with GIS, RUSLE, and SEDD. Journal of Soil and Water Conservation. 2003; 58(3):128-136.
4. Flanagan DC, Gilley JE, Franti TG. Water Erosion Prediction Project (WEPP): development history, model capabilities, and future enhancements. American Society of Agricultural and Biological Engineers. 2007; 50(5):1603-1612.
5. http://bhuvan.nrsc.gov.in.
6. http://ftp.glcf.umd.edu.
7. http://www.fao.org.
8. Matson PA, Parton WJ, Power AG, Swift MJ. Agricultural intensification and ecosystem properties. Science. 1997; 277(5325):504-509.
9. Morgan RPC. Soil Erosion and Conservation. Silsoe College, Cranfield University. 1994; 62(1):15-24.
10. Morgan RPC. Soil erosion and conservation. Longman Group Limited, National Soil Resources Institute, Cranfield University. 1986; 55(3):70-80.
11. Morgan RPC, Nearing MA. Handbook of Erosion Modeling. Blackwell Publishing Limited, 2011, 1-5.
12. Narayana VVD, Babu R. Estimation of soil erosion in India. Journal of Irrigation and Drainage Engineering. 1983; 109(4):419-433.
13. Natural Resources Atlas of Konkan, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, 2018. (www.dbskkv.org)
14. Reddy MS. Theme paper on Water: Vision 2050 Indian Water Resources Society, Roorkee, 1999, 51-53.
15. Pimentel D, Harvey C, Resosudarmo P, Sinclair K, Kurz D, McNair M *et al*. Environmental and economic costs of soil erosion and conservation benefits. Science. 1995; 267(5217):1117-1123.
16. Richarde MS, Celso AGS, Alexandro MS. Predicting Soil Erosion and Sediment Yield in the Tapacura Catchment, Brazil. Journal of Urban and Environmental Engineering. 2014; 8(1):75-82.
17. Thawakar SM. Estimation of Erodibility at Selected Locations in Konkan Region. Published M. Tech. Thesis submitted to Department of Soil and Water Conservation Engineering, Dr. B. S. K. K. V. Dapoli, 2014.
18. Vemu S, Udaya BP. Sediment Yield Estimation and Prioritization of Watershed Using RS and GIS. International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 2012.
19. Williams JR. Sediment routing for agricultural watersheds. Water Resource. 1975; 11:965-975.
20. Wischmeier WH, Johnson CB, Cross BV. Soil credibility Nomograph for farmland and construction sites. Journal of Soil and Water Conservation. 1971; 26:189-193.
21. Wischmeier WH, Smith DD. Predicting rainfall erosion losses from cropland east of the Rocky Mountains. Handbook No. 282. Washington, DC, USDA, 1965.
22. Wischmeier WH, Smith DD. Predicting rainfall erosion losses- A guide to conservation planning. Agricultural Handbook No. 537, USDA, 1978.
23. www.soinakshe.uk.gov.in.