European Journal of Humanities and Educational Advancements (EJHEA)
Available Online at: https://www.scholarzest.com
Vol. 4 No.12, December 2023
ISSN: 2660-5589

USING THE GAVRILOVIC MODEL TO ESTIMATE SOIL EROSION IN THE AL-ZIYADI BASIN USING GEOGRAPHIC INFORMATION SYSTEMS (GIS)

Latif J Farhan
College of Basic Education, University of Maysan, Maysan, Iraq
Corresponding author: *ltyfjbar86@gmail.com*
https://orcid.org/0009-0001-2188-9246

Article history:

Received: October 17th 2023
Accepted: November 14th 2023
Published: December 20th 2023

Abstract:

The Wadi al-Ziyadi basin is part of the Hamrin Hills region extending as a strip surrounding the alluvial plain from the east, parallel to the Zagros Mountain range, Mount Qalaat Waizan in Iranian territory. The area of this basin is about 62.58 km^2. The climate of this region is characterized by a dry and semi-arid climate, while the upper sources are the basin extends in Iranian lands that receive rainfall exceeding (290) mm annually within the humid climate that supplies the basin with water. The slope is more than 87 degrees. The aim of this research was to estimate the extent of soil erosion towards the mouth of the valley, and systems were used. Geographic information (GIS) in order to apply the equations of the EPM model. The results extracted from the application of this model show that the most important factors affecting the intensity of erosion depend on terrain indicators as well as climatic factors (rain and temperature), while the Z factor for potential erosion reached about (0.2- 1.6), and the extent of erosion in the valley amounted to about (95.5-31,900) of the total basin area, and this confirms that most of the basin area is exposed to severe erosion according to the EPM model.

Keywords: water erosion, EPM model, geographic information systems

INTRODUCTION

When the intensity of rainfall exceeds the rate of percolation, excess surface water accumulates on the soil, and the surface depressions are filled with surface runoff in sheets. Flow can occur at the Earth's surface. In this time, due to technological development and the great pressure on natural resources, especially the investment of agricultural soils, which led to erosion being considered one of the problems facing decision makers and planning development in fertile lands (Battany and Grismer, 2000).

Soil erosion in water basins occur as a result of several factors that require further studies on these factors. Climate and topography are also among the most important factors that have a direct effect on the extent of erosion of water basins. The terrain characteristics, such as the length of the slope, the slope and the direction of the slope, as well as the influence of rain and heat can create special conditions that help erode soils in different regions of the world (Panagopoulos and Ferreira, 2010; Al-Saadi, 2023). Furthermore, soil erosion leads to water pollution by carrying nutrients and pesticides into rivers and groundwater resources. There are many factors that increase water erosion such as rainfall, soil type, slope, vegetation type, and the presence or absence of conservation measures.

The main result of soil erosion is reduced productivity due to loss of nutrients, physical degradation, reduced soil thickness, and in some cases, complete loss of soil. The importance of estimating the probability of this erosion was to implement preventive measures against these losses (Chadli, 2016; Hassan and Al-Asadi, 2023a). During the past two decades, there have been many methods that have been used to estimate the extent of erosion in water basins. These methods are also tools for estimating sediments in water basins. Recently, many researchers have been used geographic information systems and remote sensing with the aim of quantitatively estimating the extent of erosion and sedimentation (Hassan and Al-Asadi, 2023b; Yildirim and Erkal, 2013).

Soil loss modeling is a very complex process due to the spatial variation of control factors and big data involved (Bhattarai and Dutta, 2007), but this process becomes more feasible by integrating information and data generated from the use of spatial models using GIS and RS techniques. Thus, estimating the rate of soil loss and classifying its spatial density, allowing for soil conservation and management measures (Yildirim and Erkal, 2013). Some researchers have also developed some special criteria for using the appropriate coefficient to estimate the extent of erosion including accuracy in the results of the indicator or factor, easy for apply, the elements used in the indicator must be logical and scientifically acceptable, the factor must be sensitive in the event of changing elements (Oreibi, 2022).

The problem of the study

The problem of the study revolves around the following question:

1-What is the possibility of estimating the extent of erosion in the Wadi Al-Ziyadi basin?

2-Do the values of the annual erosion rate vary based on the indicators of the Gavrilovic model?

Study hypothesis

It is possible to estimate the extent of erosion using the Gavrilovic equation.The values of the erosion rate vary according to the classifications of the Gavrilovic erosion model indicators in the Al-Ziyadi basin.

Objective of the study

1- Estimating the types of water erosion in the Al-Ziyadi Basin.

2-Identifying the risks of water erosion in the basin and the possibility of treating and managing the erosion problem.

3- Drawing a map of the spatial variation and variation of erosion in parts of the basin.

Location of the study area

The study area is located in the northeastern part of Wasit Governorate, with the area of the basin reaching (62.58) km^2. It is bordered to the east and northeast by the Iranian hills, especially the Waizan Qalaat mountain, to the south by the lands of Al-Hatira, and to the west by Jassan district, while its astronomical location is confined between two latitude circles (32 53 – 33 2) to the north and between longitudes (46 6 – 46 14). The region is also characterized by its dry climate and the flow is usually seasonal (figure 1).

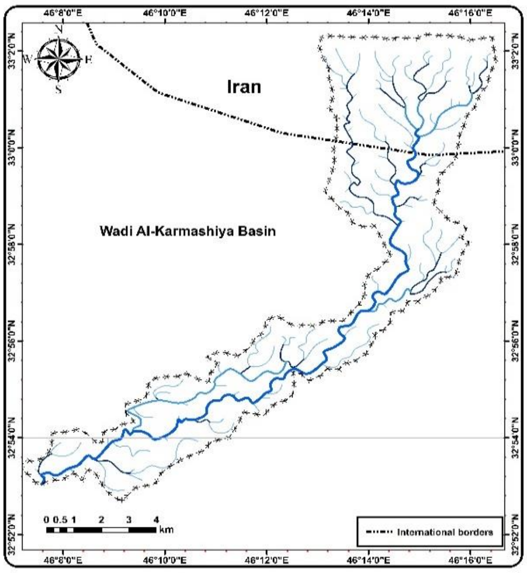
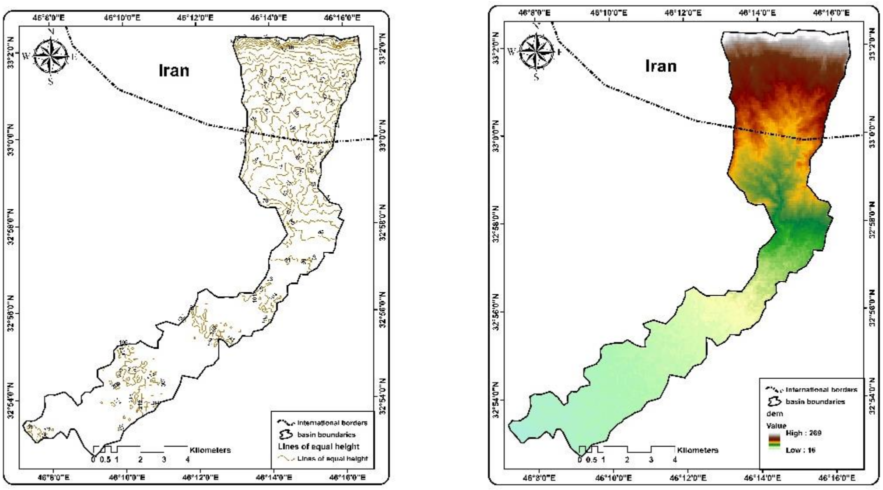


Figure (1) Study area location, Based on the output of GIS 10.5

Natural characteristics of the Al-Ziyadi Basin

Figure (2) shows that the surface levels of the Al-Ziyadi Basin are varied, as the area was divided into four levels of elevation based on the digital elevation model. The values ranged between (5-245 m) above sea level. It can be inferred by referring to the isoheight map, which shows the convergence of isolines in the upper regions of the basin, which indicates the elevation of this region, which is located within the range of the Qalaat Waizan Mountain in Iranian lands. The height increases as we head south, reaching the plain areas of Iraqi lands, which formed a fertile floodplain invested in agriculture. In addition, the slope map shows that the region is characterized by a slope with a north-south direction, which generates surface runoff during rainfall, which causes rapid soil erosion in the Al-Ziyadi Basin.



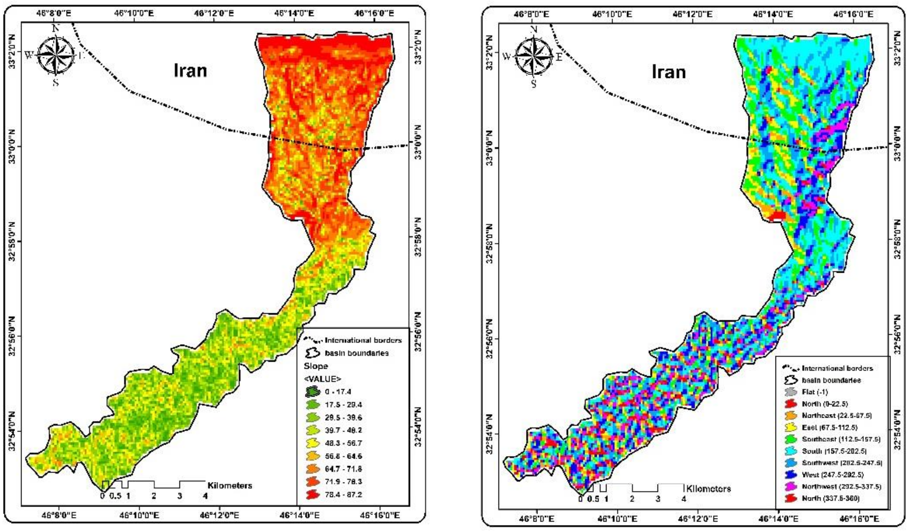


Figure (2) topographic characteristics in the Al-Ziyadi basin, Based on the output of GIS 10.5

Precipitation index H:

It is known that the rate of rainfall increases causes the increasing of volume of surface runoff, which affects the effects of the increase in runoff on the erosion process. This indicator was extracted from the data recorded for the study stations in Iranian and Iraqi territories, and after entering the data into the GIS environment, the IDW model, which is widely used in similar studies, was applied to estimate erosion. The results in Table (1) and figure (3) showed that the calculations divided the basin into five levels, with rainfall values limited to between 165-250 mm annually. It became clear that the first level had an area of about 25.96 km^2, at a rate of 41.47%, and the second level had an area of about 18.70 km^2, at a rate of 29.88%. The area of the third level also decreased by 6.32 km^2, at a rate of 10.09%, as is the case for the fourth level, about 5.69 km^2, at a rate of (9.09%), and the fifth level 5.90 km^2, at a rate of 9.44%.

Table (1) rainfall levels at Al-Ziyadi basin

Rain	percentage	area
165 - 178	41.47827	25.96071
179 - 192	29.8831	18.70344
193 - 210	10.09824	6.320356
211 - 229	9.099857	5.695481
230 - 250	9.440535	5.908707

Source: Based on mathematical the output of GIS 10.5

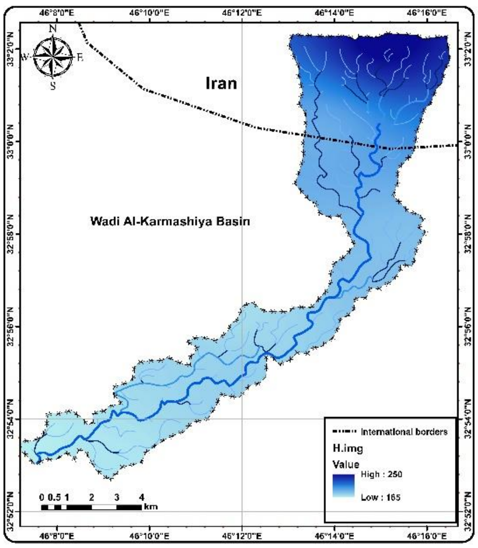


Figure (3) rainfall indicator at Al-Ziyadi basin

Heat index:

The temperature index is one of the most important indicators used in the EPM model due to its effect on rock fragmentation. Table (2) shows that the calculated temperature was divided into 5 levels and the values decreased between 29.9-43.4 °C.

It is clear from map (4) that most of the areas that recorded high temperatures are rocky lands in the upper sources of the basin, in addition to plain areas and barren lands devoid of vegetation.

Table (2) Heat index values in the Al-Ziadi basin

Temperature	percentage	area
29.9 - 34.3	6.443125	4.032667
34.4 - 36.6	13.38807	8.379417
36.7 - 38.4	21.88736	13.69901
38.5 - 39.9	30.82232	19.29129
40 - 43.4	27.45913	17.18631

Source: Based on mathematical the output of GIS 10.5

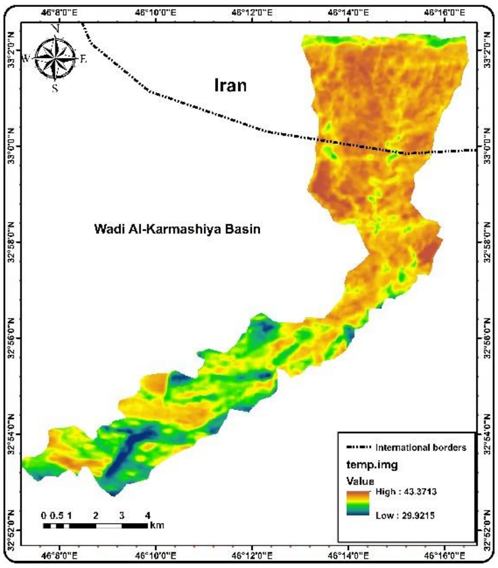


Figure (4) heat index in the Al-Ziyadi basin, based on mathematical equations and GIS10.5

Soil erodibility coefficient (Y)

The coefficient (Y) is defined as the effect of soil characteristics on the volume of soil eroded during the period of rainfall, and its susceptibility to water erosion was proven by analyzing the geological characteristics, soil, and land uses. The values of the soil susceptibility index in the al-Ziyadi basin ranged between 0.09 as the lowest value and 0.85 as the highest value. The central and southern region of the basin is characterized by a slight slope and has fragile soil, is more affected by erosion. However, the upper source areas, those located in Iranian lands with a solid rock composition, are the areas least affected by erosion, depending on the hardness of their formation.

It is also clear from Table (3) figure (5) that the lands characterized by rough rock sizes have an area of 31.31 km^2 and a percentage of 50.03%, while the second category reached 3.02 km^2 and a percentage of 4.82%, and the third category was 4.82%. Its area is 24.84 km^2, with a percentage of 39.69%. In the last category, it represents the mouth of the basin; its area was 3.40 km^2, with a percentage of 5.44%.

Table (3): Area and percentage of soil erodibility index in Al-Ziyadi basin

Factor Y	percentage	area
0.09	50.03508	31.3163
0.0901 - 0.248	4.828114	3.021853
0.249 - 0.65	39.69003	24.84147
0.651 - 0.85	5.446776	3.409066

Source: Based on mathematical the output of GIS 10.5

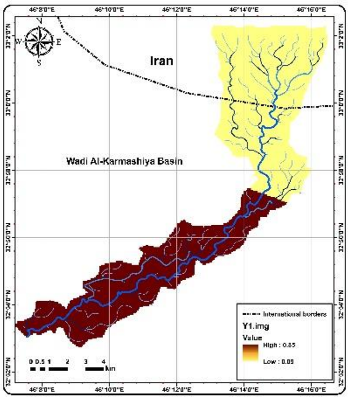


Figure (5) soil erosion susceptibility factor (Y) in the Al-Ziyadi basin, based on mathematical equations and GIS10.5

Soil Protection Factor (Xa):

EPM model is the density level of vegetation cover, which can contribute to the stability and stability of the soil, as well as determining the speed of surface runoff to reduce its erosion. It is clear from Table (4) and figure (6) that the first category has an area of 1.73 km^2, at a rate of 2.77%, while the second category occupies an area of 6.15 km^2 at a rate of 9.83%, however the third category occupies an area was 14.86 km^2 at a rate of 23.75%. The fourth category occupied an area was 25.30 km^2 and a percentage of 40.42%, while the last category had an area of 14.52 km^2 and a percentage of 23.20%.

Table (4) Area and percentage of parts of the Soil Protection Index Al-Ziadi Basin

Xa	percentage	area
0.28 - 0.494	2.775102	1.7369
0.495 - 0.552	9.837951	6.157445
0.553 - 0.592	23.75803	14.86984
0.593 - 0.626	40.42734	25.30294
0.627 - 0.759	23.20158	14.52156

Source: Based on mathematical the output of GIS 10.5

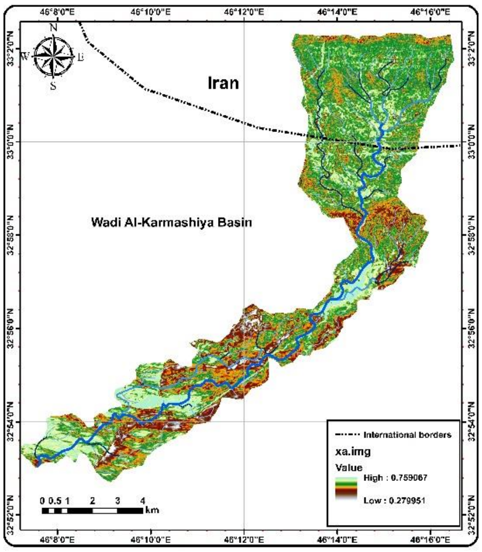


Figure (6) Soil Protection Index (Xa) in the Al-Ziyadi Basin, based on mathematical equations and GIS10.5

Graduation index (Ja):

Slope plays a fundamental role in the process of water erosion, depending on its severity. The greater the degree of slope of the land, the greater the speed of water flow, which facilitates soil erosion and erosion. The first category had an area in the basin of 32.19 km^2, at a rate of 51.43%, followed by the second category, with an area of 17.01 km^2, at a rate of 27.19%, while the third category had an area of about 9.88 km^2, with a rate of 15.79%, followed by the fourth category, with an area of 2.59 km^2, with a rate of 4.14%. Finally, the area of the fifth category reached was 0.90 km^2, with a rate of 1.43% of total area of the basin (Figure 7 and Table 5).

Table (5): Area and percentage of parts of the regression index of the Al-Ziyadi Basin

Ja	percentage	area
0 - 1.99	51.43215	32.19071
2 - 4.17	27.192	17.01911
4.18 - 7.3	15.79737	9.887369
7.31 - 13	4.140088	2.591227
13.1 - 24.2	1.438399	0.900275

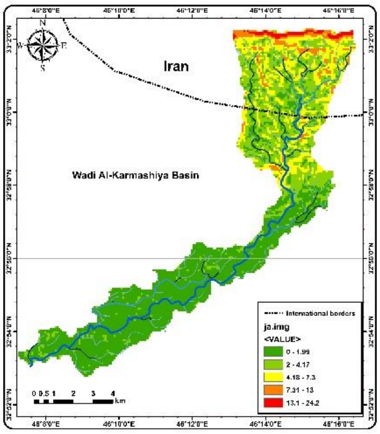


Figure (7) regression index in the Al-Ziyadi basin, based on mathematical equations and GIS10.5

Erosion development index:

There is a variation in the values of the erosion development index depending on the size of the water basins. The results of Table (6) and figure (8) showed that the erosion development in the first category was about 5.97 km^2, at a rate of 9.54%. The total area of erosion in the second category amounted to about 14.90 km^2, at a rate of 23.81%, and the total area in the third category decreased by about 20.86 km^2, at a rate of 33.32%, and in the fourth category, about 15.05 km^2, at a rate of 24.04%. The fifth category is about 5.79 km^2, at a rate of 9.26%.

Table (6): Areas and rates of erosion development in the Wadi Al-Ziyadi basin

Phi	percentage	area
0.377 - 0.441	9.543187	5.972955
0.442 - 0.467	23.81267	14.90404
0.468 - 0.488	33.32998	20.8608
0.489 - 0.514	24.04849	15.05163
0.515 - 0.584	9.265676	5.799265

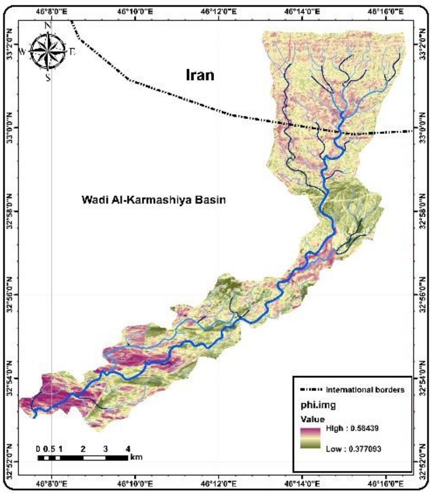


Figure (8): Erosion development index in the Al-Ziyadi basin, based on mathematical equations and GIS10.5

Potential water erosion index (Z):

The indicator is one of the important indicators used to estimate potential erosion in the basin, as it is extracted by applying the following equation:

It $Z = Y \times Xa \times (\varphi + \sqrt{Ja}$ became clear from Table (7) and figure (9) that the values of Z were represented by five categories. The first level had an area of 33.68 km^2 and a percentage of 53.81%, followed by the second category with an area of 7.42 km^2 and a percentage of 11.86%. The third category had an area of 11.02 km^2 with 17.62%, the fourth category amounted to about 7.96 km^2 or 12.71%, and the fifth level reached 2.50 km^2 or 3.99%.

Table (7): Area and percentage of potential water erosion in the Al-Ziyadi basin

Z	percentage	area
0.025222491 - 0.2	53.81425	33.68164
0.2 - 0.4	11.86377	7.425377
0.4 - 0.8	17.60714	11.02008
0.8 - 1.1	12.71836	7.960256
1.2 - 1.6	3.996481	2.501345

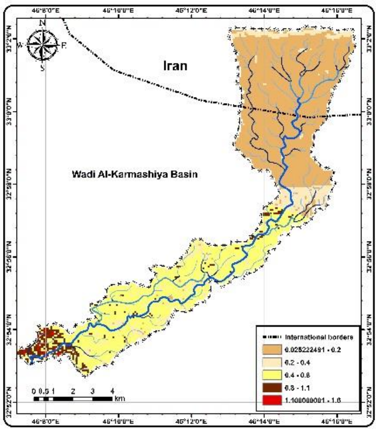


Figure (9) potential erosion in the Al-Ziyadi basin, based on mathematical equations and GIS10.5

Quantitative estimation of water erosion EPM:

This indicator was used for the first time in Yugoslavia to study soils exposed to erosion for a period of about 40 years (Gavrilovic, 1988). Also, when this model was applied, it became clear that due to the nature of the rock formation, as well as the different texture of the soil and the nature of the rocks' susceptibility to erosion, the variation in the region's exposure to erosion was reflected. (Ayalew & Yamagishi, 2005). The erosion values were extracted according to this model through the following equation:

$W = \pi \times T \times H \times \sqrt{Z^3}$

W=Annual erosion rate (m3/km2/year)

π = constant value 3.1415

T = average annual temperature

H = average annual rainfall mm

Z=potential erosion rate

It is clear from Table (8) and figure (10) that the first level reached 34.87 km^2 at a rate of 55.72%, while the second level amounted to about 10.30 km^2 at a rate of 16.46%, the third level reached 10.22 km^2 at a rate of 16.33%, and the fourth level was represented by severe erosion, the area amounting to 5.39 km^2, with a rate of 8.62%, and the last level, which was represented by very severe erosion 1.78 km^2, at a rate of 2.84%.

Table (8): Quantitative level of erosion in the Al-Ziyadi basin

Quantitative level	percentage	area
95.5 – 3.460	55.72519	34.87767
3.470 – 7.450	16.4631	10.30404
7.460 – 11.400	16.33588	10.22441
11.500 – 16.700	8.625954	5.398872
16.800 – 31.900	2.849873	1.783698

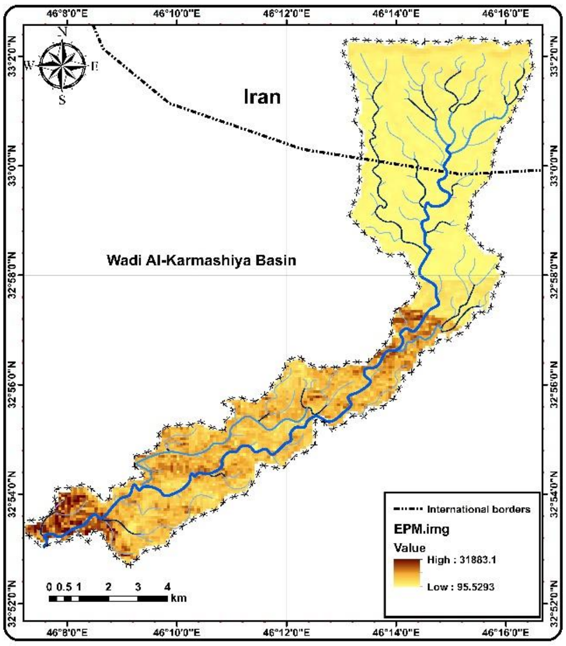


Figure (10) Quantitative estimation of erosion in the Al-Ziyadi basin, based on mathematical equations and GIS10.5

CONCLUSIONS

The study concludes that the most important factors affecting erosion were the terrain features, especially the slope and its direction. The study showed a decrease in the area of vegetation covers, which contributed to the process of soil erosion. The EPM model was able to show that a large percentage of the basin is subject to erosion between the level of slight erosion and very severe erosion.

REFERENCES

1. *Al-Saadi, M. W. H. H. (2023). Analysis and modeling of drought effects based on drought indicators in the eastern region of Missan.* Journal of Sustainable Studies, 5*(2).*
2. *Ayalew, L., & Yamagishi, H. (2005). The application of GIS-based logistic regression for landslide susceptibility mapping in the Kakuda-Yahiko Mountains, Central Japan.* Geomorphology, 65*(1–2), 15–31.*
3. *Battany, M. C., & Grismer, M. E. (2000). Rainfall runoff and erosion in Napa Valley vineyards: Effects of slope, cover and surface roughness.* Hydrological Processes, 14*(7), 1289–1304. https://doi.org/10.1002/(SICI)1099-1085(200005)14:7<1289::AID-HYP43>3.0.CO;2-R*
4. *Bhattarai, R., & Dutta, D. (2007). Estimation of soil erosion and sediment yield using GIS at catchment scale.* Water Resources Management, 21*, 1635–1647.*
5. *Chadli, K. (2016). Estimation of soil loss using RUSLE model for Sebou watershed (Morocco).* Modeling Earth Systems and Environment, 2*, 1–10.*
6. *Gavrilovic, Z. (1988). Use of an Empirical Method(Erosion Potential Method) for Calculating Sediment Production and Transportation in Unstudied or Torrential Streams.* International Conference on River Regime. Hydraulics Research Limited, Wallingford, Oxon UK. 1988. p 411-422, 5 Fig, 4 Tab, 8 Ref.
7. *Hassan, M. W., & Al-Asadi, K. A. W. H. (2023a). Analysis of large-scale correlations on temperatures over Iraq.* Arab Gulf Journal of Scientific Research, 41*(1), 2–17. https://doi.org/10.1108/AGJSR-05-2022-0046*
8. *Hassan, M. W., & Al-Asadi, K. A. W. H. (2023b). Synchronous Impact of the North Atlantic Oscillation (NAO) and Southern Oscillation Index (SOI(Poles on Temperature and Rain Over Iraq.* Israa University Journal for Applied Science, 7*, 290–302. https://doi.org/10.52865/EXZS7896*
9. *Oreibi, A. P. P. H. J. (2022). Estimation of the magnitude of soil and sediment erosion in the Yaraa Valley Basin using the.* Thi Qar Arts Journal, 2*(38), 236–250.*
10. *Panagopoulos, T., & Ferreira, V. (2010). Erosion risk map of a Foupana river watershed in Algarve, Portugal.* WSEAS Transactions on Environment and Development, 6*(9), 635–644.*
11. *Yildirim, U., & Erkal, T. (2013). Assessment of soil erosion in the Ihsaniye watershed area, Afyonkarahisar, Turkey.* Scientific Research and Essays, 8*(10), 388–397.*