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Estimation of water erosion in Wadi Al-Maleh Basin by the Gavrilovich Model (EPM) and remote sensing and GIS

Dr. Asst. Ali Mohsin Kamil Jaafar

Babil Education Directorate, Iraq, Alimk0754@gmail.com

Abstract

Water erosion is one of the important processes in geomorphic studies, this process includes all water movements such as surface water, precipitation, and all forms of flow, like rivers, valleys and streams, contribute to shaping the features of the earth's surface, by the processes of water sculpture in various environments, the ability of water to sculpt depends on the influence of a group of factors, including the amount of water discharge, the speed of flow, and the nature of surface formations, this model was designed by Gavrilovich in the 1950s.

Keywords: *Erosion, sensing, GIS.*

INTRODUCTION

Research problem: What is the quality and quantity of soil lost from Wadi Al-Maleh basin as a result of water erosion?

Research hypothesis: There are quantities of soil in the Wadi Al-Maleh basin that are being lost as a result of water erosion. It must be identified.

Purpose of the study: The study aims to quantitatively and qualitatively estimate erosion, identification of bedrock and sedimentation areas in Wadi El Maleh Basin, by integrating indicators of the Gavrilovic erosion model, including rock structure, slope, state of vegetation cover, soil, precipitation, as well as temperature.

Materials and Methods:

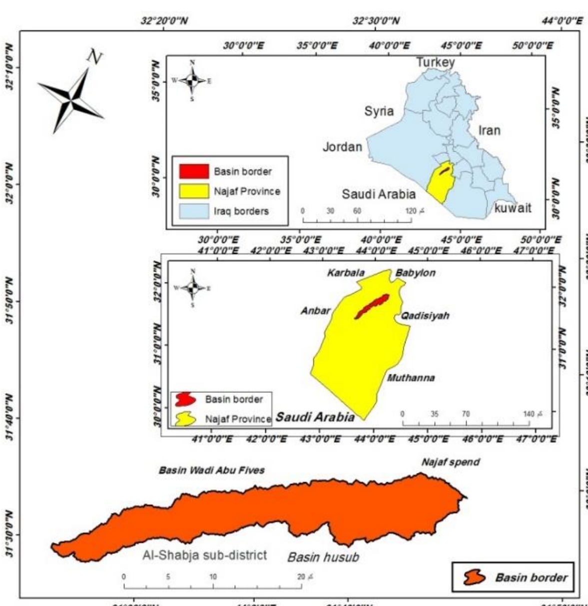
Research methodology:

The mathematical method was relied upon, to reach the amount of soil loss, by the relationship with the indicators used in erosion.

The limits of the study :

The area of the basin is (543 km2), administratively, it is within Shagbah district, and naturally within Najaf governorate, it is bordered from the south by Abu Talha and from the north by Al-Araj astronomically. It lies between longitudes (37 50 43 - 23 15 44) between two latitudes (17 0 3 31 - 17 58 31) (Map 1).

Map 1: The study area location



Results and Discussions:

 Qualitative assessment of water erosion through the EPM model.

The application of the (EPM) model was relied upon to extract water erosion, according to the following equations:

$$W=H*T*\pi*\sqrt{z^3}$$

whereas :

W = annual rate of erosion (m3/km2/year).

H = annual average precipitation.

T = heat coefficient.

z = potential erosion coefficient.

Extract the values (T, H) from the satellite data.

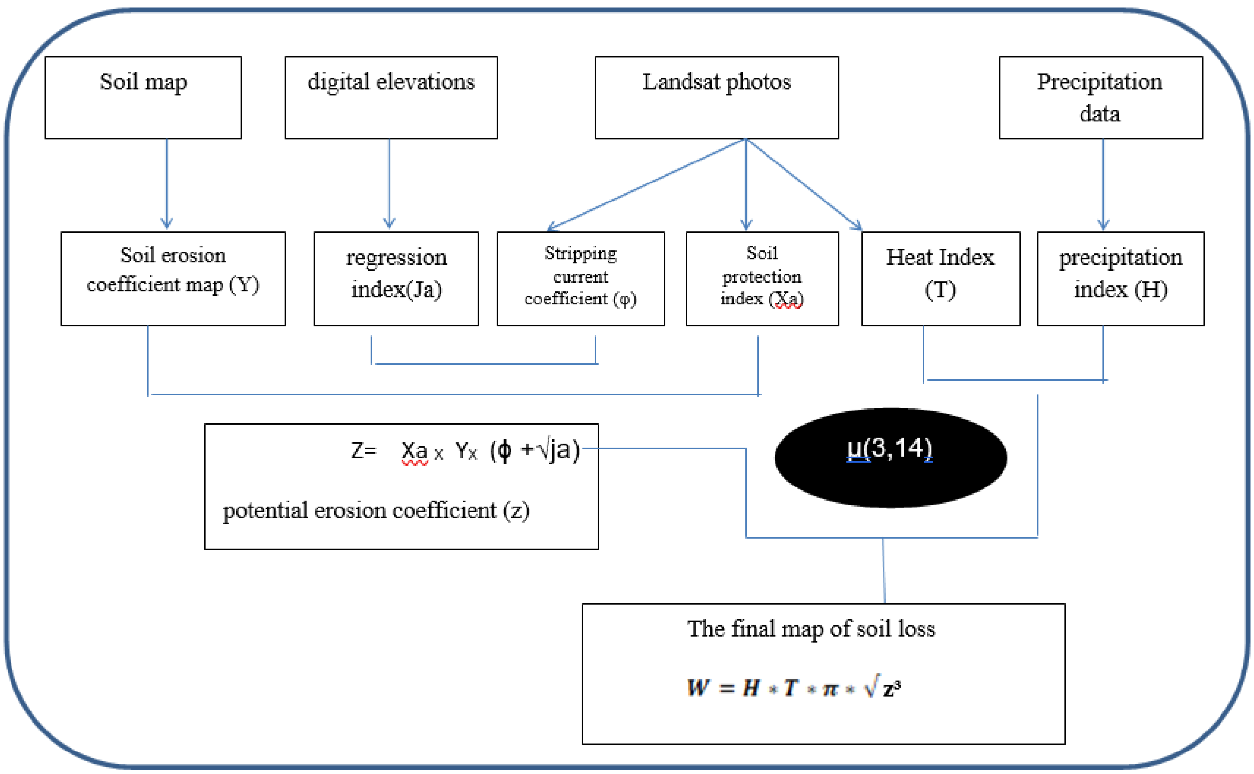
Z = potential erosion coefficient

 Methodology for applying the potential water erosion model by the (EPM) model:

1. The annual average rainfall:

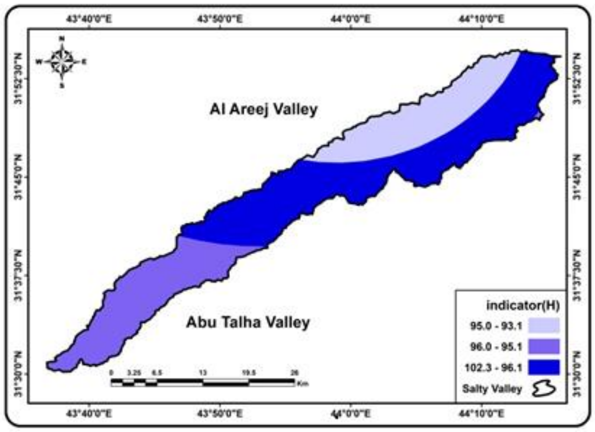
2. Heat coefficient index:

Figure (1): A diagram of the sequence of stages of applying the model (EPM).

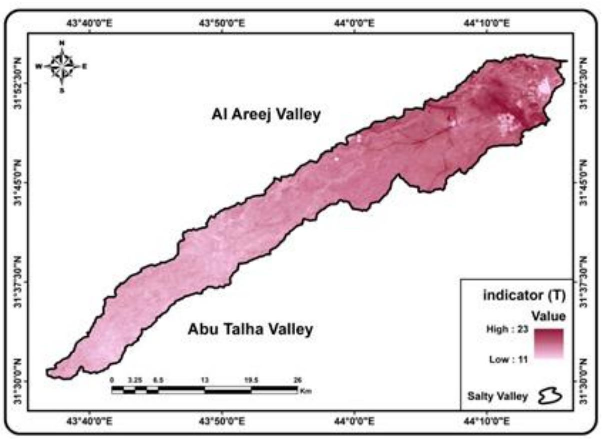


Source: Jamal Shawan, Ali Faleh, Abdel Hamid Siddiqui and Haitham Masrar, “Employment of remote sensing and GIS in the quantitative assessment of water erosion in the Wadi Amzaz Basin (the middle countryside) through the Javrilovic model”, Journal of the Geography of Morocco, Issue (1-2). , Volume (28), 2013, p. 76.

Map (2) The annual average rainfall in the Al-Maleh Basin



Map (3) The temperature coefficient in the Al-Maleh Basin



3. Index of potential erosion coefficient Z

The Z index is an indicator of potential erosion in aquatic basins, the most important elements of the Gavrilovich model, as they enter into the calculation of a set of variables, it has the benefit in tracking the change in erosion levels over time to test the levels of change in practices and changes in activities and land uses. Potential erosion levels have been classified according to the value of the Z coefficient into five levels (Table 1). The Z value is calculated through the following equation:

$$Z= Y^* \ Xa^*(\varphi +\sqrt{ja})$$

whereas

Y = soil erosion coefficient.

Xa = erosion protection coefficient.

φ = coefficient of erosion development and drainage network.

ja = slope of the surface in percent.

For the numbers of the model indicators, Figure (1), we relied on four main sources of data

A. Soil map (calculation of y coefficient).

B. Precipitation data (according to the H coefficient).

C. The digital heights of the earth (Ja coefficient calculation).

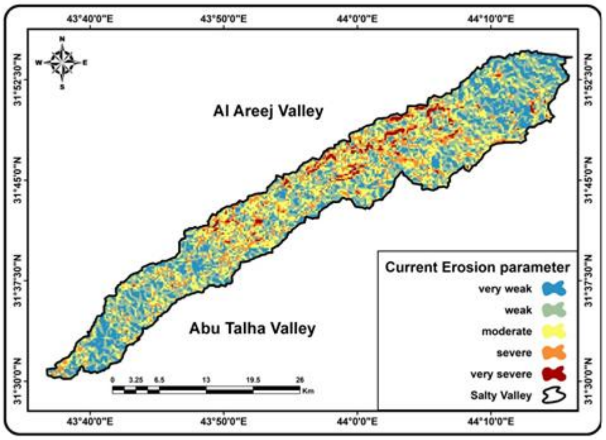
D. Lancet satellite image (calculation of coefficients, φ, Xa, (H, T).

According to the results of map (4), the rate of potential erosion in more than 60% of the basin is weak to moderate erosion, and this is related to the low slope of the fragile rocks and the lack of vegetation cover in Al-Malih basin.

Table (1) Potential erosion levels according to the value of the Z coefficient.

average value	Z	level of potential erosion
1.25	**1.01- (> 1.51)**	very severe
0.85	**0.81 -1.0**	severe
0.55	**0.41-0.80**	medium
0.30	**0.20-0.40**	light
0.10	**0.01-0.19**	very light

Map (4) Potential erosion levels according to the value of the Z coefficient in Al-Malih Basin



3-1 Soil erosion index (y):

To determine this indicator, 50,000 topographical maps and accompanying laboratory analyzes were relied upon, especially those related to texture, organic matter and structure in order to calculate the erosion susceptibility coefficient of soils according to Fischmeyer.

y=(0.00021*(12-oM)^1.14+3.25(s-2)+2.5(p-3))I100)*1.58

whereas

y = soil erosion susceptibility coefficient.

om = percentage of organic matter.

n = tissue.

S = structure code.

P = permeability symbol.

By the results of the possible equation, map (5) the different soils were classified according to the degree of their resistance according to Table (2).) and between soft sandy deposits and soils that have no resistance, as the percentage of the area occupied by them reached (32.6)%, (Table 3).

Table (2) Coefficient of susceptibility of soil or rock to erosion.

average value	Y	soil erosion coefficient
0.2	**0.1 – 0.3**	severe resistance
0.4	**0.3 – 0.5**	moderate resistance
0.55	**0.5 -0.6**	Poorly resistant soil
0.7	**0.6–0.8**	debris aggregates, coarse sediments, and clayey soils
0.95	**0.9–1.0**	fine sandy sediments and soils that have no resistance

Map (5) Soil erosion coefficient (y) in the Al-Maleh Basin

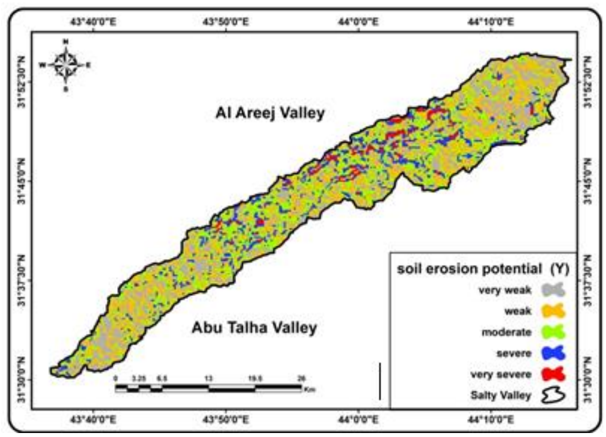


Table (3) Soil erosion coefficient (y) in the Al-Maleh Basin

Percentage %	area km^2	soil erosion potential (Y)
25.9	141	very weak
32.6	177	weak
26.1	142	moderate
12 .2	66	severe
2.9	16	very severe
100	543	total

3-2 Soil protection index (xa):

Vegetation plays a role in reducing erosion, by protecting the vegetation cover of the soil from the direct effects of precipitation, by reducing the severity of its uprooting of soil particles and raising the permeability ratio, the vegetation cover index is related to forests, cultivated shrubs, grasses and their density, in the plowed or cultivated lands, the coefficient of land uses according to the cultivated varieties, the cultivation cycle, and plant residues after harvest differs according to seasons. The NDVI index was extracted, and then the value of the soil protection index (xa) was calculated according to the following equation:

xa=(xaNDVI-0.61)*(-1.25):

So that :

Xa = soil protection index.

NDVI xa=vegetation coefficient adjusted to suit the soil protection index criteria.

When applying the above equation, we notice that the value of (xa) amounted to (0.6), with an average value of (0.7), and when compared to Table (4), which corresponds to degraded farms and pastures and bare rocks, as the value of (xa) is very weak in most of the basin, as it occupied an area of (190) km, or 35%.

Table (4) descriptive factors for determining soil protection treatment Xa.

average value	Xa	Soil protection index) **Xa(**
0.125	0.05 –0.2	Mixed, dense, medium-density and tall forests
0.3	0.2 –0.4	Coniferous forests and vegetal bunches scattered on the sides of water channels
0.5	0.4–0.6	Degraded pastures and forests or rainforests
0.7	0.6–0.8	Degraded farms and pastures
0.9	0.8–1.0	Coastline

Map (6) Soil Protection Index Xa in the Maleh Basin

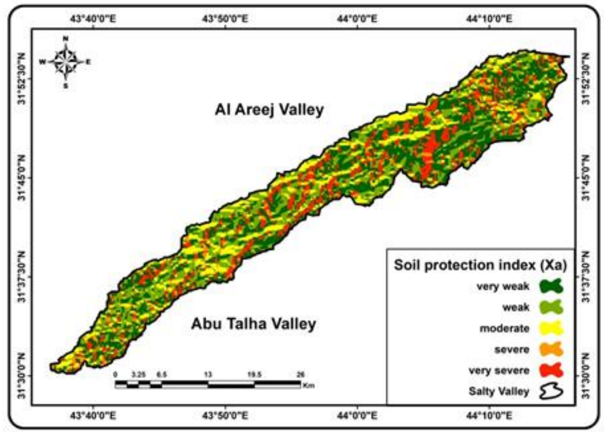


Table (5) Soil Protection Index Xa in the Salt Basin

Percentage %	area km^2	Soil protection index **(Xa)**
35	190	very weak
26.9	146	weak
15.5	84	moderate
5.7	31	severe
17	92	very severe
100	543	total

3-3 Stripping current index φ:

The values of the current erosion index differ according to the size of the water basins, and the current erosion index was extracted from the equation formulated by ((Mellivsky 2008) to calculate this index based on (LANDSA) images, which depend on the square root of the third range (Tm3) divided with the maximum value of radiation ((Qmax), as in the following equations:

$$\varphi=\sqrt{((TM3)\div Qmax)}$$

The results of this equation translate the spatial distribution of the erosion bands (Map 7) according to the radiation ratios, as the radiation ratios steadily increase with the increase in the intensity of erosion. By observing the map, we notice that most of the basin have weak φ values, as it reached (34.4%) (Table 6).

Map (7) Current erosion index φ in Al-Malih Basin

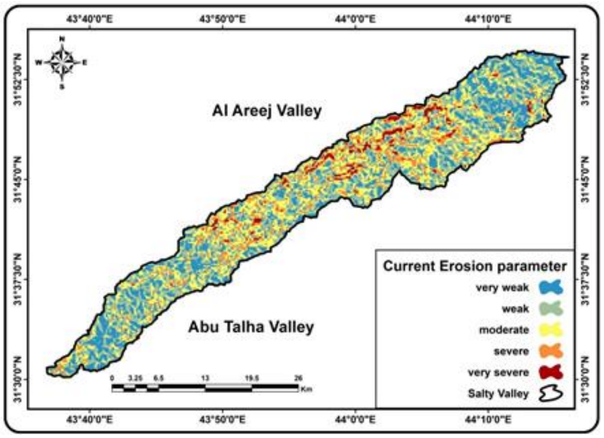


Table (6) Current erosion index, φ, in Al-Malih Basin

Percentage %	area km^2	Current Erosion Index
24.3	132	very weak
34.4	187	weak
26.1	142	moderate
12.1	66	severe
3	16	very severe
100	543	total

3-4 Regression Index (Ja)

Many factors conspired to make the slope somewhat divergent, and the Al-Malih basin is among the few declines, as the rate of decline reached (4.22)% in the Al-Maleh basin.

- Erosion volume estimated by Epm model:

Milevsky and his colleagues see that the rates of weak erosion are less than (500) m3/km2/year, the high erosion rates are higher than (800) m3 /km2/year, according to the application of the Gavrilovic model quantization erosion. Six classes of water erosion have been identified according to the volume of lost soil, as shown in Table (7).

By observing map (8) and comparing its results with table (7), we notice that the rate of erosion in most of the basin is very weak or unclear, as it occupied an area of (273) km2 at a rate of (50.3%), while medium erosion occupied an area of (113) km2 at a rate of (20.9%) as in Table (8).

Table (7) Levels of erosion according to the size of the uprooted soil

erosion intensity	Volume of uprooted soil (m^3/ km^2/year)	Class
absence or unclear	**< 50**	**1**
weak erosion	**50–500**	**2**
medium erosion	**500–1500**	**3**
generalized erosion	**1500–5000**	**4**
strong erosion	**5000 –20000**	**5**
catastrophic erosion	**>20000**	**6**

Map (8) Levels of erosion according to the size of the uprooted soil in the Al-Maleh Basin

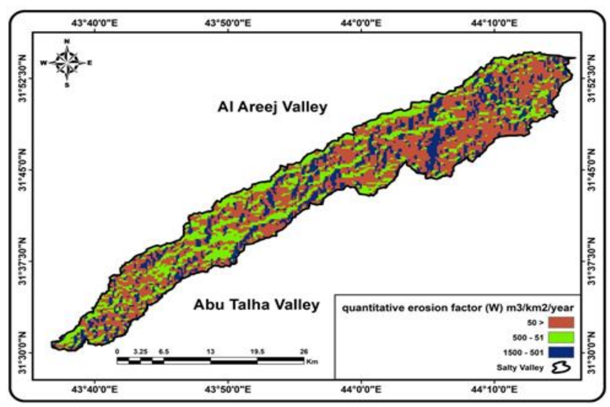


Table (8) Levels of erosion according to the size of the uprooted soil

Percentage %	. km^2	quantitative erosion factor (W) m^3/km^2/year.
50.3	273	50>
29	157	50-500
20.9	113	501-1500
100	543	total

Conclusions:

1. The amount of rain in the basin is very low and is a contributing factor to the weak soil erosion, as it reached a quantity of up to (90 mm) per year, and this helps to weak soil erosion.

2. The potential erosion coefficient z indicates weak potential erosion in the basin, and this is due to the lack of rainfall, poor rock formation and soil fragility, as well as the lack of vegetation cover.

3. Weak soil erosion coefficient This is due to the fact that the rocks of the region are between medium resistance debris rubble, coarse sediments, and clay soils, and weak resistance, soft sandy sediments, and soils that have no resistance.

4. We note that the average volume of erosion in most of the basin is very weak or unclear if it ranges between less than 500, whose area reached (273) km2, which occupied more than half of the area of the basin, while medium erosion occupied (501-1500) An area of (113) km 2 is more than 20% of the area of the Salt Basin.

5. The results of applying the water erosion model on the basin revealed that more than 60% of the area of the basin does not suffer from severe or strong erosion, and this corresponds to the natural elements of the basin such as lack of rain, lack of slope, and others.

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- From the researcher's work, based on the erosion equation w, map (8).