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BS Publications

Investigating the Effect of Forest Stand Volume on Soil Surface Erosion by Geographic Information System (GIS)

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ABSTRACT

One of the important problems in forest science is productive bed or forest soil protection, so investigate and research on different aspects of this topic is very important. This article tries to determine the relationship between surface erosion and tree cover, so after a primary study on basins, two nearby district with an area about 4580 hectare were selected and by land inventory it was appeared that these two areas except trees stand volume and climate have approximately similar geological, pedological, steep, dominant direction and altitudinal extension, age and stand composition characteristics. So this area is really suitable to achieve the mentioned goals. After selecting statistics community, the maps that are needed to use erosion model (PSIAC) were prepared and separated into 5.8*5.8 meters cells by use of ArcGIS\ArcMap software and 9 layers that were needed for each cell were prepared and its related measurements have been done and the erosion foe each cell was measured and classified into similar records and about 60 erosive sites for each district achieved. The mentioned information exported to "excel" and final measurements were done. Results showed that trees covering and surface erosion have a mathematical and inverse ratio.

KEY WORDS

Erosion, GIS, Stand Volume

INTRODUCTION

Today soil is not a lifeless, fix and limited to some centimeters for plant use that has some physical and chemical characteristics and will be distinguished by bedrock , but it is like a motive complex or dynamic structure [4] that we can name it a production bed in complex ecosystem , forest as a complex ecosystem is not an exception and if it has a change in the bed's characteristics it will have big changes in its ecosystems so we can say one of the most important characteristics of forest services is soil and organic matters protection the will conserve forest and its uses in a long term because if it received a little damage it may lose all the ecosystem and have an irreparable damages economically and environmentally. So, soil erosion control and at first knowing the amount of erosion is so important [6], and it so naturally to know the amount of erosion we should have a model that is compatible with local scale and in the big scale using of it is so simple, because stand volume is a factor that is used widely in forest program, this article to facilitate decision find the relationship between stand volume and soil erosion to estimate decrease and increase of the soil erosion for one meter of the extracted wood fast and easily.

MATTERS AND METHODS

To do this research and according to the plan goals we need to use Geographical, Pedological and silvicultural information and all of these analyzed in "GIS" because of their wide range.

Understudied sample selection

After primary studyings and presented maps study we decided to study to district 7,8 called Daryabon at north of Iran and west of Gilan province that is about 20 kilometers far from Hashtpar city and is on the north strip of Alborz mountain range we selected it because :

(a) The mentioned districts have mean slope about 60 to 80 percents.
(b) Both of them have high pedological and geological similarity
(c) The types of the species in both districts are similar.
(d) Accumulation in these two is different.
(e) Both of the areas are in mean height to high height range.

So, similarity all of the entire factor except plant cover accumulation helped us by compare them can find plant coverage share from soil erosion amount.

General characteristics of 7, 8 districts of Daryabon basin :

General situation and local situation of 7 district in Daryabon :

Daryabon 7th district is between 48ú 43'19" eastern iength, 37 ú40'48" northern width, 48ú48'6" eastern length and 37ú43'56" northern width and an area with about 2461 hectare area. Maximum height from sea in this district is 1918 and minimum is 450 meters. Maximum slope is extreme at big rock walls of Randehsar and minimum is zero on wide ridge and mean slope is between 30% to 60%.

General situation and local situation of 8 district in Daryabon :

Daryabon 8th district is between 48^{o} 47'13" eastern length, 37^{o} 41'10" northern width, 48^{o} 52'31" eastern length and 37^{o} 43'40" northern width and an area with about 2179 hectare area. Maximum height from sea in this district is 1248 and minimum is 200 meters. Maximum slope is extreme at big rock walls of Nav River and minimum is zero on wide ridge and mean slope is between 30% to 60%.

After selecting understudied samples applicable phase of this research is done like this:

Selecting erosive model :

In this process of research and to estimate the role of forest in losing soil we used PSIAC model.

PSIAC model :

In this model we study on the effect and role of 9 important and effective factors in soil erosion and sediment production in watershed included in geology, soil, climate, run off, topography, earth coverage, land use, superficial erosion and river erosion and according to the intensity and weakness of each factor we give the a value and by have a look on the sums of the achieved values for different factors, the amount of setting of the watershed will be estimated by this formula:

$$Qs = 38.77e^{0.0353R} \quad (1)$$

Qs : yearly setting a basis of m^3/km^2

R : degree of setting means sun of different factors values in PSIAC model

The above relation with correlation degree r = 0.9964 and according to statistical test in level 0.1% is meaningful.

Information processing by use of geographical information system (GIS) :
After studying presented data to select erosion assigning method to facilitate geographical information system (GIS) and needed 9 maps in PSIAC that is 9 informational levels of this method is prepared and after fitness geographic coordinate with map coordinate and needed digits charged into 5.8 *5.8 cells and after making needed maps by use of distinction table of PSIAC model and according to the done process on each factor value of the different parts of the map investigated and put in separated layers and overlapped to each other and sum value of each pixel estimated separately and put in a new layer in the next step each pixel's value put in special erosion model of PSIAC formula and the erosion of each pixel achieved into m^3/km^2 unit. After pixel's classification into similar units the amount of each unit conserved in a data bank and the site erosion achieved into m^3/hectare.

Results :
After selecting understudied samples and doing some tests and needed processes the related results accumulated to analysis.

The results of study on the effect of forest sites on erosion :
In this step because of using PSIAC model factors of this model are studied and these results achieved.

Superficial geology :
According to the need of research study concentrated on land type and four unites distinguished according to the land type.

First type lands :
These lands compose low to mean heights in 8^{th} district and geologically depend on low – mean Cretaceous period sediments and their lime amount is more than volcanic sediments, stability of these types of lands is so weak and ancient marks of landslide is observed in it. In dry sites these types of lands are called (bad land). These lands are sensitive to soil erosion especially in sites that lost their plant coverage.

Second type lands :
These lands compose mean to nearly high heights of districts 7 and 8. Mostly are composed of corrugations units related to high Cretaceous period. Rocks have good inflexibility and their permeability is low.

Third type lands :
These lands compose high heights of 7^{th} and 8^{th} districts of Daryabon with dome – shaped peaks, mean slope and more depth soil than the other types of lands. Around valleys slope will be more and the rocks observed but, above the ridge and peaks, surface is smooth and soils are deep and according to the morphological conditions, these types of lands are more suitable than the other mechanically.

Fourth type lands :
These lands included in rocky and steep walls around the main river (Nav river), it is clear that these sites are so sensitive to soil erosion and earth landslide according to the above objects, the value of geology factor achieved according to this table 1 :

Table 1 : Value table for geology factor.

Row	Land type	Value in PSIAC model
1	First type	8
2	Second type	6
3	Forth type	5
4	Third type	3

Soil :

Soil report of 7th and 8th districts of Daryabon is prepared by use of pedology map in scale 1/25000 and topography map their accordance and preparing soil lands units and studying the profile of roads marines and flood ways are observed and sampling of them and studying their laboratory results. According to the above studies these sites divide to four general series:

First type soils :

This unit included in low to nearly high mountains that includes volcanic tufa and erosion Basalt with sand – rock which has near high slope to high slopes class. Generally have rocks and forest coverage with trees like Beech, Horn beam, Maple tree, Alder and other species. Depth of humus is 1-3 cm soil is a superficial to low – depth with maximum depth about 40 – 45 cm, profile type AC to A (B) C. the B zone characteristics is between A and C zones. In all the profile surface has no reaction to HCL 10%, PH is acidic and it's amount is about 5.3 – 5.8, rooting is mean, root influence depth is about 40-45 cm in bedrocks, water penetration in soil is good, soil texture is average loamy with less than 20% clay , soil structure is tiny-sand to big sand. Soil type is uncompleted Ranker to new brown one.

Second type soils :

This unit is in low heights to nearly high ones included in silt-lime and tiny sandy and conglomerate in slope class is in approximately high slope to high with rock, sometime with rocky wall and stone and sand. Its forest coverage is Horn beam, Beech and Maple tree with other forest species. depth of humus is 1-4cm, it's on uncompleted soil with low depth and maximum depth about 40cm in some cases it's area is about 20cm with profile type AC to A(B)C that B zone characteristics are between A and C. all the profile area on the soil has no reaction to HCL 10%, PH is acidic to neutral and is about 6.5-6.7, lime is washed very good and doesn't have Calcique zone, percent of the neutral matters is low and it is about 0.3-5 and on bedrocks mixed with plant soil it has so week activity rooting is so weak and root influence depth is about 40-45cm with low distribution, in lower depth it is with wind fallen in thick trees, water permeability in soil is good to average, soil texture is light (sand loam) at surface and at the lower depth it is a little heavy (clay loam), sand structure is tiny sandy to big sandy and it's type is uncompleted washed Randzine.

Third type soils :

This unit is at lower heights to higher ones included in erosion volcanic tufa and Basalt with sandstone it has a low slope class to mean without any rock or with a little of it, with gravel and forest coverage like beech, Horn bean, Maple tree, Alder and other species, depth of humus is about 2-3cm it is a completed soil with approximate deep depth and maximum depth is 80-85cm with profile type ABC, B zone depth is about 40-45 cm which shows soil evolution. In all the area of profile these aren't any reaction to HCL 10%, soil PH is acidic and it's amount in understudied profile is about 6.1-6.5, it's lime less and in Calcique zone percent of the active lime is near zero, good rooting , depth of root permeability is about 60-65cm with suitable distribution in lower depth, water permeability in soil is good to middle soil texture is average (loam) to a little heavy (clay loam) with percent about 24-30% clay and has a little changes in different zones. Soil type is forest brown soil with acidic PH.

Fourth type soils :

This unit is in relatively high heights with more slopes that it's characteristics are rock and lack of forest coverage, here soil has a little plant coverage and somewhere it is completely without any coverage specially in valleys walls that is covered with grass and bushes humus is very low and often its like losses of grass and bushes but it is full of humus in zone A. this unit has uncompleted superficial soil to low depth one, maximum depth is 40cm with AC profile type in all the area of the profile there aren't any reaction to HCL 10%, PH is acidic and it is about 5-5.3, rooting is to some extent weak, soil texture is loamy with less than 25 percents clay, soil structure is tiny gravel to big. Soil type is uncompleted ranker.

After studying pedology results below table achieved for soil factor value in PSIAC model :

Table 2 : Value table for pedology factor

Row	Soil type	Value in PSIAC
1	Forth type	7
2	Third type	6
3	First type	5
4	Second type	2

Climate :

In basin of Asalem Nav where these two districts are in it, there are 3 stations due to climate investigations (hydro climatology) which are Kharjegil station in height 130 meters, Khalian station in 780 meter height, Nav station in height 1000 meters and a temporary station in Nareband police station in height about 1000 meters from sea with more than 10 rain gouge that are in Gavkhos, Ganzno, Vanehkhoni, Komehdasht and etc. that give every suitable information from this basin and according to the statistics of Kharjegil, Khalian and Nav station that are in 130 to 1000 meters heights, the hottest days of year are 30,35 and 34 degrees and the coldest ones are-6.5,-10,-13 degrees for each station in higher mounts these marks are different but as decrease temperature. In this basin different rains, like rain, snow, and hail have been reported, and in forest sites that have suitable plant coverage there are sub plant coverage rain or sub tree rains also according to the achieved statistics from different stations and as a sample Nav station mean of maximum temperature at the hottest month is +20.5 and mean of minimum temperature at the coldest month is -3.1 and mean of rain is 619.2 mm. (most of its rain is snow) , and mean time of sunshine is 234.25 minutes-day . This site climate by use of Emberger classification relates to heights climate. So climate value in model PSIAC is 7.

Runoff :

As the reports say hydrometric station of Khalian is in 760 meters height, Kharjegil is 130 meters high and Nav is in 1000 meters heights and after visiting there at rain time runoff value in PSIAC is according to Table 3.

Table 3 : Value table for runoff factor.

Row	Amount of runoff	Value in PSIAC
1	High runoff	2
2	Low runoff	1

Topography :

This factor usually is estimated by slope so by use of topography map with 1:25000 scale, slope map of the site is prepared and classified into 6 follow classes and value of each class is showed in PSIAC model according to Table (4):

Table 4 : Value table for topography factor.

Row	Slope	Value in PSIAC
1	>30	20
2	20-30	15
3	12-20	9
4	8-12	6
5	5-8	3
6	0-5	0

Land coverage:
According to the achieved statistics from forest and forest description by forest walking coverage map is prepared and its value follows Table 5 :

Table 5 : Value table for land coverage factor.

Row	Coverage	Value in PSIAC
1	High compacted coverage	-10
2	Mean coverage	-6
3	Low coverage	-3
4	Have bush coverage	0
5	Have grass coverage scattered	5

Land use method:
Use in this site is generally forestry use even in sites that are empty in time of this study have reforestation program, so for this entire site forest use is considered and value is zero.

Superficial erosion:
This site has been studied by aquiferous studies in it and inspecting it as a superficial erosion map and the value of each portion of it followed table 6:

Table 6 : Value table of erosion factor

Row	Erosion amount	Value
1	Have more than 50 percents extreme erosion	25
2	35 percents of extreme erosion	15
3	Average	8
4	Very low	2

River erosion:
According to the special form of the site and its value in PSIAC is considered for site 5.

Estimating soil erosion and sediment production:
According to the achieved information the site erosion estimated according to erosion map that it's made by GIS layers of PSIAC model factors in area unit and with other factors put in table 7.

Table 7 : Amount of erosion with other factors of the site

	8^{th} district	7^{th} district
Seri area in hectare	2144.2933	2436.53
Number of trees in hectare	171.67	121.8
Volume in hectare	251.51	217.86
Erosions in hectare in year	1.69	2.19

And in general by a comparison between factors of table 7 we can conclude table (8).

Table 8 : Comparison between differences in two sites

Volume difference in hectare in two series	3365
Erosions in hectare in two series	0.5
Share of 1 cubic meter word in erosion	0.015

DISCUSSION AND CONCLUSION

We should consider that these two district have special characteristics because although they are near to each other because of their special social economical condition their stand volume is different, this made erosion analyzing so easy by have a consider in table (7) we find out although the number of trees in 7^{th} district is less than 8^{th} district about 29 percents, but volume in hectare of 7^{th} district is about 13 percents less than 8^{th} district. This clearly shows that presented forest is older in 7^{th} district and its young trees than 8^{th} district is less that shows problems related to reproduction and it shows the problems that are related to social – economical problems in this site. Although this shows that erosion amount is more agree sociable with number in hectare than volume in hectare. But because this method to evaluate erosion is so applicable in harvesting it looks that comparison between erosion and volume in hectare is more applicable than number in hectare, so table (1) completely shows this relationship, it shows that each 33.65 cubic meter wood can decrease about 0.5 cubic meter erosion in soil. So according to table (8) we can say that one m^3 wood can prevent of 0.015 erosion in soil and this means that if 1 m^3 wood extracted from an area about 1 m^2 with 1.5 cm diameter, during a year there will be empty of soil, according to the above mentioned discussion and by yearly considering the site we can use the above conclusion as a factor to distinguish the amount of fast erosion in local scale.

SOURCE

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