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ASSESSMENT OF SOIL EROSION AND SEDIMENT YIELD CHANGES USING EROSION POTENTIAL MODEL – CASE STUDY: REPUBLIC OF SRPSKA (BiH)

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Abstract: Soil erosion is one of the most significant forms of land degradation in the Republic of Srpska which is greatly influenced by land use. Since the period when mapping of erosion processes in Bosnia and Herzegovina (1980-1985) was performed, some significant changes have occurred in this area due to demographic changes. The main aim of this paper is to explain the demographic and land use changes due to war processes and the impact of these changes on intensity of soil erosion and sediment yield. The amount of eroded material on the territory of the Republic of Srpska has decreased in the last decades. For the purposes of quantifying the erosion intensity changes, overlapping of the territory has been done with the soil erosion maps from 1985 and recent state of erosion in 2011. The erosion potential model (EPM) was used for the calculation of gross annual erosion and sediment yield. With digitalization of the area affected by different categories of erosion of these two maps, it was made possible to determine those changes in the last 30 years. Specific annual gross erosion on the Republic of Srpska's territory was 298.21 m^3/km^2/year in 1985 while in 2011 it was 239.91 m^3/km^2/year. Therefore, due to changes in intensity of erosion processes the specific annual gross erosion in catchment areas was decreased by 58.30 m^3/km^2/ year. According to 1985 map of soil erosion, specific sediment yield in the Republic of Srpska was 182.03 m^3/km^2/year, while in 2011 was 146.44 m^3/km^2/year. These results are basis for all integral water management projects, soil protection, forest ecosystems and environmental protection, spatial planning, agriculture and other human activities.

Key words: erosion potential model, erosion mapping, intensity of soil erosion, demographic and land use changes.

1. INTRODUCTION

Soil erosion is a natural geomorphic process and recognized environmental problem of modern times (Lal, 1990; Chen et al., 2002; Dragicevic et al., 2010; Veerasingam et al., 2012; Tosic et al., 2012). Nowadays, there are many models for soil erosion and sediment yield prediction in use in the world. The emphasis has been put mainly on the development and study of three groups of models, physics-based, conceptual and empirical models. An important difference among the various models is a focus on either on-site or off-site effects of soil erosion (Clark, 1985; Birkinshaw & Bathrust, 2006; de Vente & Poesen, 2005; Tosic et al., 2011; Ştefănescu et al., 2011). Empirical models are generally the simplest of the three model types as they do not reval specific features of the erosion processes, but they can estimate erosion quite effectively. In general, they are focused more on the long-term gross erosion and sediment yield for large areas, than on evants for relatively small areas. They are not focused primarily on one or two erosion processes, but rather evaluate total potential sediment yield and sediment transport of the catchment (de Roo et al., 1996; Lane et al., 1997; van Rompaey & Govers, 2002; Renschler & Harbor, 2002; Merritt et al., 2003; Lenhart et al., 2005; Tosic, 2007). Empirical models are frequently used in preference to more complex models. They can be implemented in situations when data and parameter inputs are limited and for these reasons empirical models for soil erosion prediction and prediction of sediment yield are still widely in use in many countries (Verstraeten et al., 2003; Ananda & Herath, 2003; de Vente et al., 2006, 2008), including the Republic of Srpska/BiH (Tosic, 2008; Dragicevic et al., 2009).

Gavrilovic (1962, 1970, 1972) created and developed an empirical EPM (erosion potential model) model for the analytical determination of erosion coefficients, quantification of gross erosion and average annual sediment yield. This model is a result of experimental research on a station that was located in Serbia. Regarding examinations from experimental stations in Serbia, Bosnia and Herzegovina, Croatia, Slovenia and Montenegro, as well as from the work on the erosion mapping in former Yugoslavia, Lazarevic (1985) modified some parameters in Gavrilovic's data tables. This approach has been widely used in mapping erosion in former Yugoslavia during the last 40 years. Soil erosion map of Bosnia and Herzegovina was created using EPM model and finished in 1985. By using this model, 432 maps of soil erosion in scale 1:25000 were mapped. In addition, analysis of the state of soil erosion was conducted as well as annual gross erosion and sediment yield for all catchments in Bosnia and Herzegovina.

Since the period when mapping of erosion processes in Bosnia and Herzegovina was carried out, some significant changes have occurred in this area due to the anthropogenic influence. The civil war left serious consequences and made important impact on decrease in population and households, population migration, land use structure, but also on gross erosion and sediment yield (Gavrilovic, 1972; Lazarevic, 1985-a; Tosic, 2008; Dragicevic et al., 2009). Soil erosion map of the Republic of Srpska was created using EPM model. By using this model, 274 maps of soil erosion in 1:25000 scale were mapped and erosion database of 29147 polygons and 524646 attributes were created.

The aim of this article is the analysis of changes in the soil erosion intensity and changes in amount of gross soil erosion and sediment yield for the whole territory of the Republic of Srpska and for main nine catchments based on soil erosion maps from 1985 and 2011. The results of this analysis are important because they will illustrate in what degree anthropogenic factor manifested through human activities and partly caused by the war events is determination factor for changes in the soil erosion intensity, erosion rate and sediment yield in the last 30 year. In addition, these results are basis for all integral water management projects, protection of soil, forest ecosystems and environmental protection, spatial planning, agriculture and other human activities.

2. THE STUDY AREA

The Republic of Srpska is a political and territorial subject (Entity) of the state of Bosnia and Herzegovina. The study area is located in Southeastern Europe within a location of 42°33'19" and 45°16' 34" N and 16°11'06" and 19°37'44" E; its area is 25.053 km^2 (Fig. 1). The whole area of the Republic of Srpska is a part of the large morphologic clusters: Panonic region, Mountain-valley region and Adriatic region. The climate in the north of the Republic of Srpska (Panonic region) has the characteristics of moderate-continental climate with an average annual temperature above 10°C and rainfall of 700-1500 mm, mountainous depression area has the features of mountainous and specific local climate (parish climate) with average annual temperature <10°C and rainfall varying between 700-1000 mm, while the southern part of Republic of Srpska has been under firm influence of modified Adriatic climate with an average annual temperature of 11-14°C and rainfall of 1400-1900 mm (Tosic et al., 2011).

The dominant soils in the Panonic region are Planosols-pseudogley, Fluvisols, Gleysols-dystric, eutric and mollic ones. Mountainous area and hilly terrain are characterized by the presence of Luvisols-chromic luvisols, Cambisols-eutric cambisols, Rendzinas and Vertisols, while mountain-valley region has been characterized by the dominance of Rendzinas and Regosols. The region of the Outer Dinarides, called Adriatic region, has been characterized by several different types of land of which the most dominant are Rendzinas, Regosols, Rankers, Cambisols-chromic cambisols, Fluvisols in the river valleys, as well as Gleysols-eutric and mollic ones in the karst field (Burlica & Vukorep, 1980).

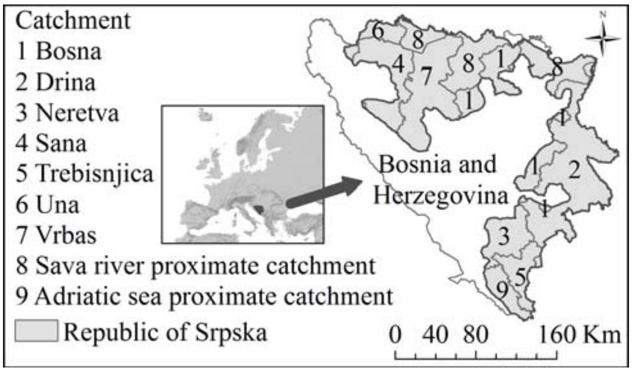

Figure 1. Location of study area: Republic of Srpska - Bosnia and Herzegovina

After 1992/1995 civil war no census was carried out, so we can only use estimations that Institute of Statistics or other relevant institution provide. Having 1991 census in mind on the present Republic of Srpska territory, there were 463954 households in which 1623842 citizens lived, or 37% of Bosnia and Herzegovina's population. In 2010 Institute of Statistics of the Republic of Srpska estimated that 1433038 citizens lived in the Republic of Srpska in 410173 households that gave average of 55.5 people/km^2. This data shows quantity of demographic destruction and problems after changes in population density-one of the most important quantitative and qualitative indicators of spatial-demographic relations-took place. The mentioned population density of 59.5 people/km^2 does not emphasize real essence of the problem. Some town areas and larger settlements near river valleys have large population density while hilly, mountainous areas and inter-entity borderlands are mostly rarely populated or even without population. Consequently, these demographic changes have influence not only on socio-economic features of the Republic of Srpska, but also on land use changes and characteristics of erosion intensity on the Republic's territory.

3. RESEARCH METHODOLOGY

Erosion is a very complex process and it depends of numerous factors. Differentation of those factors is a very difficult and compound task (Walling & Webb, 1996; Kinnel, 2003; Van Oost et al., 2005; Tosic, 2008). Although all of these factors interact with human activity to a certain extent, land use is the most 'changeable' and a very important factor of soil erosion processes (Ananda & Herath, 2003; Szilassi et al., 2010; Xu et al., 2011). In this research we used Gavrilovic's EPM for the calculation of gross annual erosion and sediment yield. This model was originally developed for application in torrential catchments of former Yugoslavia. Bazoffi (1985) applied the EPM model in four catchments in central Italy, Beyer Portner (1998) applied this model to five catchments of the Swiss Alps, and for large watershed in Greece the EPM model was applied by Emmanouloudis et al., (2003) but to assess gross erosion without application of the sediment delivery ratio and estimate sediment yield. The EPM model was applied on several catchments in Iran during investigation of land use changes impact on soil erosion processes (Karim et al., 2009, 2009a).

Erosion in EPM model is calculated from a soil protection factor, erodibility factor, and a factor describing the type and severity of erosion (Gavrilovic, 1972; Lazarevic, 1985). The EPM model uses a scoring approach for three descriptive variables: soil protection coefficient, soil erodibility coefficient and erosion and stream network developed coefficient (Table 1).

The quantitative values of the erosion coefficient (Z) have been used to separate erosion intensity to classes or categories. Based on EPM methodology, mapping procedure requires investigations and computations to determine and present on a map the surfaces with same quantitative erosion category. The basic EPM value of the quantitative erosion intensity is the erosion coefficient (Z).

Table 1. Descriptive factors used in the EPM model (Gavrilovic, 1972; Lazarevic, 1985).

Soil protection coefficient	**X**
Mixed and dense forest	0.05-0.20
Thin forest with grove	0.05-0.20
Coniferous forest with little grove, scarce bushes, bushy prairie	0.20-0.40
Damaged forest and bushes, pasture	0.40-0.60
Damaged pasture and cultivated land	0.60-0.80
Areas without vegetal cover	0.80-1.00
Soil erodibility coefficient	**Y**
Hard rock, erosion resistant	0.1-0.3
Rock with moderate erosion resistance	0.3-0.5
Weak rock, schistose, stabilised	0.5-0.6
Sediments, moraines, clay and other rock with little resistance	0.6-0.8
Fine sediments and soils without erosion resistance	0.8-1.0
Erosion and stream network development coefficient	**ϕ**
Little erosion on watershed	0.1-0.2
Erosion in waterways on 20–50% of the catchment area	0.3-0.5
Erosion in rivers, gullies and alluvial deposits, karstic erosion	0.6-0.7
50–80% of catchment area affected by surface erosion and landslides	0.8-0.9
Whole watershed affected by erosion	1.0

Table 2. EPM erosion qualitative categorization and range of erosion coefficents (Z) (Gavrilovic, 1972; Lazarevic, 1985).

Erosion category	Qualitative name of erosion category	Range of erosion coefficient (Z)
I	Excessive erosion	1.00 - 1.50 > 1.50
II	Intensive erosion	0.71 - 1.00
III	Medium erosion	0.41 - 0.70
IV	Slight erosion	0.21 - 0.40
V	Very slight erosion	0.01 - 0.20

The soil erosion coefficient (Z) for erosion polygon can be estimated using corresponding tables (Table 2) or calculated from equation:

$$Z = Y \cdot X \cdot (\varphi + \sqrt{I}) \qquad (1)$$

In which, Y is the soil erodibility coefficient, X is soil protection coefficient, ϕ is erosion and stream network developed coefficient, and I is average slope steepness of the catchments in angle. The main value of the EPM erosion coefficient (Z) for catchment's area is the basic value for all calculations. The EPM erosion coefficient (Z_{mean}) for entire catchment or part of it (smaller sub-catchment within larger one) is calculated using following equation:

$$Z_{mean} = \frac{Z_1 \cdot f_1 + Z_2 \cdot f_2 + ... + Z_n \cdot f_n}{F} \quad (2)$$

The equation for temperature coefficient T, where T_0 is average yearly temperature (°C) is as follows:

$$T = \sqrt{\frac{T_0}{10} + 0.1} \quad (3)$$

According to Gavrilovic (1972), the analytical equation for calculation of the average annual gross erosion W (m^3/year):

$$W_{year} = T \cdot H_{year} \cdot \pi \cdot \sqrt{Z^3 \cdot F} \quad (4)$$

Where W_{year} is the average annual gross erosion (m^3/year), T is the temperature coefficient, H_{year} is the average yearly precipitation (mm), F is the catchment area (km^2), and Z is the erosion coefficient.

After the total annual soil erosion rates are calculated, we can start with calculation of sediment delivery ratio (R_u), which is needed for actual sediment yield calculation. The sediment delivery ratio is calculated using morphometric characteristics of the watershed such as the perimetar, length of the catchment and average elevation (Ferro et al., 1998; Lu et al., 2005; de Vente et al., 2007). Gavrilovic (1972) has suggested the following equation for determination of the sediment delivery ratio:

$$R_u = \frac{\left(\sqrt{O \cdot D}\right)}{0.2 \cdot (L + 10)} \quad (5)$$

Where O is perimeter of watershed (km), D is average elevation of the watershed (km) and L is length of the catchment (km).

Finally, the anual catchment sediment yield (G) was calculated as:

$$G_{year} = W_{year} \cdot R_u \ (\mathrm{m}^3 / year) \quad (6)$$

The approaches for using EPM model in combination with GIS techniques represent a great potential for soil erosion prediction and sediment yield calculations at the river basin or regional scale (Desmet & Govers, 1995; Baban & Yusuf, 2001; Bhuyan et al., 2001; de Vente & Poesen, 2005; Tosic, 2007). In this study, GIS was successfully integrated with EPM model aiming to determine surfaces with same quantitative erosion category, but also to define the soil erosion coefficient (Z) for each erosion polygon, and erosion coefficient (Z) for all catchments or for their sub-catchments. The data on lithological structure of the study area were obtained from a digital geological map in the 1:100000 scale and relevant data about soils from a digital pedological map in the scale of 1:50000 while the data on topography were obtained from the 20 meter resolution digital elevation model. Integrating GIS with the EPM model resulted with Map of soil erosion of the Republic of Srpska in scale 1:25000, also regarding 274 Map sheets of soil erosion in scale 1:25000. Usage of GIS environmental enabled creation of geodatabase containing 29147 erosion polygons and 524646 attributes. Each erosion polygon in database is accompanied by18 attributes about status of soil erosion for years 1985 and 2011.

4. RESULTS AND DISCUSSIONS

According to 1985 erosion map of the Republic of Srpska (Fig. 2) 21851.04 km^2 of the total Republic's territory was under different intensity of erosion, while 3277.19 km^2 were manifested as accumulations. According to categories of erosion 1.22 % of the territory was affected by excessive erosion, 1.79 % by intensive erosion, 11.05% by medium erosion, 9.15% by slight erosion, and 76.77% by very slight erosion.

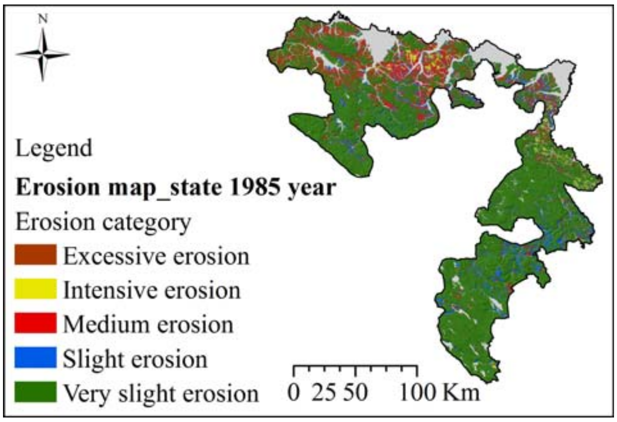

Figure 2. Soil erosion map of the Republic of Srpska – state 1985 year.

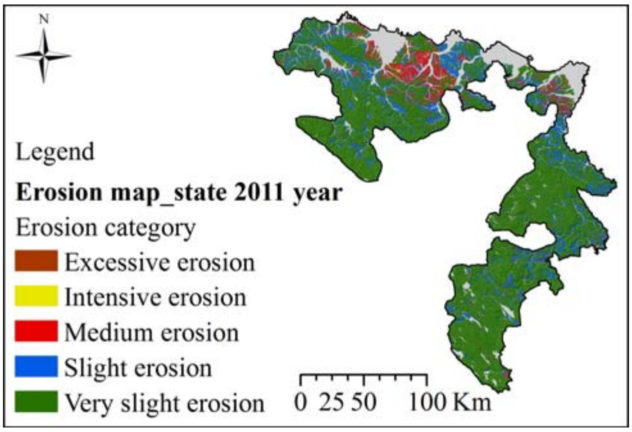

Figure 3. Soil erosion map of the Republic of Srpska – state 2011 year.

Presented spatial distribution of erosion intensity is reflection of dominant way of land use, number of population and households and role of primary erosion factors in development and intensifying erosion processes. Hence, according to 1985 Map of erosion it is possible to conclude that erosion intensity was increasing from main Dinaride's mountains towards north and decreasing towards south. Considering primary erosion factors, intensity of erosion processes was analogous to the way land was used and emphasized role of geologic-pedological factors in development and intensifying erosion processes. According to 2011 Map of erosion (Fig. 3), 86.95 % of the Republic of Srpska territory was under erosion of different intensity, while on 13.05 % of the territory accumulation was dominant process. According to categories of erosion 0.87 % of the territory was affected by excessive erosion, 0.03 % by intensive erosion, 5.22 % by medium erosion, 17.08 % by slight erosion, and 76.77% by with very slight erosion. Data gathered during mapping intensity of soil erosion and presented on Map of erosion in 2011 characterize decreasing tendency for I, II and III category of soil erosion and increasing of IV category of erosion processes intensity (Table 3).

Table 3. State of erosion by category on the territory of the Republic of Srpska.

Erosion category	State_1985 (km^2)	State_2011 (km^2)	Difference (km^2)
I	266.6855	191.8959	74.7897
II	392.6659	7.2720	385.3940
III	2414.7515	1141.6169	1273.1346
IV	2000.7271	3733.5673	-1732.8403
V	16776.2112	16776.6892	-0.4779

Main reason for those changes is due to land use changes, decreasing number of population and households, migrations and consequences of the civil war in Bosnia and Herzegovina. Therefore, according to Statistical yearbook of the Republic of Srpska from 1985 and 2011 population number is decreased by 190804 citizens and households by 53781. However, if we compare land usage on the Republic of Srpska territory according to 1985 and 2011 data, it is noticeable that on 1678.52 km^2 of the Republic's territory in 2011 there was no agricultural production. This fact influenced spatial distribution of soil erosion intensity. Agricultural production is still present in Northern parts of the Republic of Srpska but it is drastically decreased so areas that once had II and III category of erosion intensity now has IV and V category. In mountainous and hilly areas intensity of erosion was decreased due to migrations (many households are empty because this area was line between sides in conflict) but also due to depopulation that was going on long before civil war started. For this reason, great areas under I category of erosion changed character of erosion processes intensity due to land use changes, depopulation and migration, increased grassland, shrub and woodland areas with characteristic vegetation. According to 2011 erosion map of the Republic of Srpska, slightest erosion was present in Higher and Lower Herzegovina. This area was built by calcareous and dolomite rocks and karst relief is dominating (on 6354.79 km^2 of the Republic's territory). Previous civilizations destroyed soil layer that was basis for life by uncontrolled usage and exploitation of natural potentials of this area. This is why this part of the Republic of Srpska is least populated, poorest and has very low intensity of erosion. Therefore, erosion processes are active mainly on calcareous and dolomite foundation with thin layer of soil.

General tendency of erosion processes development during the last 30 years (1985-2011) is characterized by decreasing erosion processes intensity almost throughout the Republic of Srpska territory. Settling of erosion processes intensity began in the late 1980s as a result of socio-economic changes and increasingly continued by results of warfare in Bosnia and Herzegovina. Having in mind soil protection of areas that were influenced by I, II and III category of erosion this is very positive. However, in context of economical and overall social development of the Republic of Srpska this is devastating because it symbolizes decrease in population and household number, migration, decrease of arable areas, very slow technological and economy growth and all other characteristics that should not be significant for societies in 21st century.

Alongside the status of erosion processes intensity in the Republic of Srpska, mapping of these processes gives us opportunity to see status of catchments as well (Table 4). Greatest changes are evident in catchments where agricultural production decreased and where demographic destruction was most noticeable (migration and largest number of killed during conflict). Small changes are present in catchment areas where slight and very slight erosion was already present, areas with low population density and areas where land was barely cultivated.

Therefore, greatest changes are detected in Drina, Bosna, Sana, Vrbas and Sava river catchments which correspondents the areas with most intense warfare actions during 1992-1995 conflict. Mapping intensity of soil erosion after thirty years, and especially after the war and socio-economic changes, identified and highlighted influence of anthropogenic factor on the character and tendency of changes of soil erosion on the territory of the Republic of Srpska as well as in the catchment areas.

Changes in erosion processes intensity reflect an annual soil erosion rates. Nevertheless, to determine changes in annual soil rates it was necessary to define average erosion coefficients (equation 4) for each catchment. Changes in average erosion coefficient (Z) value are results of all previously illustrated processes (Table 5).

Table 4. Erosion by category in the catchments.

Erosion Category	State_1985 (km^2)	State_2011 (km^2)	Difference (km^2)
Bosna			
I	45.3541	29.9761	-15.3780
II	47.0509	0.0000	-47.0509
III	308.9787	84.1621	-224.8165
IV	251.2011	538.4465	287.2454
V	1977.4648	1977.4648	0.0000
Drina			
I	91.1684	62.8396	-28.3289
II	200.9827	0.1005	-200.8821
III	295.1665	118.6429	-176.5235
IV	751.9243	1157.6588	405.7345
V	4683.9756	4683.9756	0.0000
Neretva			
I	23.7305	18.9974	-4.7331
II	1.7291	0.0311	-1.6980
III	25.2644	8.6704	-16.5940
IV	158.1910	181.2161	23.0251
V	1506.8412	1506.8412	0.0000
Sana			
I	19.8688	10.1659	-9.7029
II	6.3139	0.0000	-6.3139
III	381.9019	45.1673	-336.7346
IV	108.6614	461.4128	352.7514
V	1797.4204	1797.4204	0.0000
Trebisnjica			
I	8.5565	7.9183	-0.6382
II	11.3095	0.2076	-11.1019
III	11.9334	10.2219	-1.7115
IV	64.8715	78.3231	13.4516
V	1097.9411	1097.9411	0.0000
Una			
I	0.3995	0.1972	-0.2023
II	3.6427	0.0000	-3.6427
III	193.4212	30.3048	-163.1164
IV	31.6433	198.6047	166.9614
V	533.2391	533.2391	0.0000
Vrbas			
I	22.9275	8.0472	-14.8803
II	24.4969	5.9116	-18.5854
III	438.6990	203.3101	-235.3889
IV	266.4163	535.2709	268.8545
V	2691.1635	2691.1635	0.0000
Sava proximate catchment			
I	47.5712	47.4684	-0.1028
II	96.9000	1.0212	-95.8788
III	757.1825	640.3141	-116.8684
IV	347.7607	560.1327	212.3720
V	1564.5216	1564.9996	0.4779
Adriatic sea proximate catchment			
I	7.1090	6.2858	-0.8232
II	0.2404	0.0000	-0.2404
III	2.2038	0.8232	-1.3807
IV	20.0575	22.5017	2.4442
V	923.6440	923.6440	0.0000

Table 5. Erosion coefficient (Z) for catchments.

Catchment	Z mean 1985	Z mean 2011
Bosna	0.24	0.20
Drina	0.53	0.45
Neretva	0.10	0.10
Sana	0.19	0.15
Trebisnjica	0.06	0.06
Una	0.07	0.06
Vrbas	0.27	0.23
Sava River proximate catchment	0.30	0.27
Adriatic sea proximate catchment	0.04	0.04

Table 6. Specific annual gross erosion per unit area (km^2) by catchments on the territory of the Republic of Srpska.

Catchment	W year spec. ($m^3/km^2/year$)		
	1985 year	2011 year	Difference
Bosna	303.64	226.65	76.99
Drina	326.31	260.86	65.45
Neretva	260.69	241.84	18.85
Sana	289.05	201.13	87.92
Trebisnjica	236.18	216.11	20.07
Una	329.69	228.07	101.62
Vrbas	263.01	210.08	52.93
Sava River proximate catchment	365.15	310.26	54.90
Adriatic sea proximate catchment	177.62	174.26	3.36
Total in the Republic of Srpska	298.21	239.91	58.30

Table 7. Specific sediment yield per unit area (km^2) by catchments on the territory of the Republic of Srpska.

Catchment	G year spec. ($m^3/km^2/year$)		
	1985 year	2011 year	Difference
Bosna	185.35	138.35	47.00
Drina	199.18	159.23	39.95
Neretva	159.13	147.62	11.50
Sana	176.44	122.77	53.67
Trebisnjica	144.17	131.92	12.25
Una	201.25	139.22	62.03
Vrbas	160.54	128.24	32.31
Sava River proximate catchment	222.89	189.38	33.51
Adriatic sea proximate catchment	108.42	106.37	2.05
Total in the Republic of Srpska	182.03	146.44	35.59

These values only in quantitative context pointing to explained changes that will clearly be visible during annual gross erosion and sediment yield calculation. According to 1985 map of soil erosion, specific sediment yield in the Republic of Srpska was 182.03 $m^3/km^2/year$, while in 2011 was 146.44 $m^3/km^2/year$. Specific sediment yield rates per unit area in 1985 varied between 108.42 and 222.89 $m^3/km^2/year$, while in 2011 specific sediment yield rates per unit area varied between 106.37 and 189.38 $m^3/km^2/year$ (Table 7). Specific annual gross erosion on the Republic of Srpska's territory was 298.21 $m^3/km^2/year$ in 1985 while in 2011 it was 239.91 $m^3/km^2/year$. Therefore, due to changes in intensity of erosion processes the specific annual gross erosion in catchment areas was decreased by 58.30 m^3/km^2/year. Specific erosion rates in 1985 per unit area varied between 177.62 and 365.15 m^3/km^2/year, while in 2011 these rates varied between 174.26 and 310.26 m^3/km^2/year (Table 6).

Decrease in specific sediment yield for 35.59 m^3/km^2/year is very concerning because of high sediment exploitation intensity in areas of minor and major Bosna, Vrbas, Sana, Una and Sava river bed. Pressured by highway construction (Sarajevo-Samac, Banja Luka-Gradiska, Banja Luka-Doboj, Banja Luka-Kupres) sediment exploitation is getting more severe. Degradation of areas near mentioned rivers influence flood occurrences that endanger parts of catchments especially having in mind their geographical location.

5. CONCLUSION

Soil erosion is a natural process which has been greatly influenced by human activities (Dragicevic and Milevski, 2010; Du et al., 2011). Demographic and land use changes due to war processes in the Republic of Srpska had significant impact on changes in the intensity of soil erosion, gross erosion and sediment yield on the territory and catchments of the Republic of Srpska/Bosnia and Herzegovina. The results of this research present decrease in specific gross erosion for 58.30 m^3/km^2/ year and sediment yield for 35.59 m^3/km^2/year and that clearly represents considerable influence of land use and demographic changes on soil erosion and sediment yield.

Erosion map produced by EPM model has been used for catchment management plans in Bosnia and Herzegovina over the last 30 years. However, in the future it will be the main resource in both catchment management and environmental studies. This is significant especially for the non-gauged catchments and large number of areas in Bosnia and Herzegovina that are deficient in measured data on water discharge and sediment transport. Nevertheless, these data are necessary for the designs of all types of construction dealing with water, as well as for design of all kinds of erosion control and torrent management works.

Erosion models can be an important tool to support management decisions when used carefully and properly. Therefore, besides model accuracy, it is important to realize what the information that is provided by a model is. Application of any model for decision-making requires awareness of: data availability required for the model, accuracy of the prediction and type of information provided by the model. This is why the EPM is still widely in use in former Yugoslavia countries, but in some other countries as well. Hence, besides using EPM model, it is advisable to further check this model, but in future time apply new models for soil erosion and sediment yield estimation on territory of the Republic of Srpska.

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