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Predicting Soil Erosion Rate Before and After Wildfires: The Case of Pineios dam drainage basin

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Introduction

One of the most significant outcomes of soil erosion in drainage basins is the extensive deposition of sediment within dam's water-reservoirs. This procedure could lead to an increased aggradation rate in the dam's water-reservoir which results in a reduced water storage capacity. World widely, soil erosion is calculated with the use of the Revised Universal Soil Loss Equation (RUSLE) adopted in a Geographical Information System (GIS) framework. In the current study, RUSLE and GIS were used for predicting soil erosion rate of Pineios dam drainage basin, before and after the wildfires of August 2007 occurred in the Ilia regional unit; thus examining the aggradation rate in the dam's water-reservoir. Factors that control RUSLE equation were imported in the GIS framework and applied on a Digital Elevation Model (DEM) map of Pineios River basin with 85m accuracy. Soil erosion rates were calculated before and after the wildfires by using as a dependent variable the cover management factor C, which is strongly influenced by large destructive fires.

Description of the study area

Pineios dam is located in the Ilia regional unit, Western Greece and its name comes from the homonymous river. It is one of the longest earth-filled dams in Greece. The Pineios River basin occupies an area of 1026 km^2, whereas the dam's drainage basin occupies an area of 673.41 km^2 (Figure 1). Surface water run-off from the dam's drainage basin is collected to a large water reservoir that occupies an area of 19.87 km^2. Pineios dam has a length of 2175 m, a height of 50 m, an absolute crest height of +101 m and is constructed with an impermeable clayey core. Its reservoir has been designed to collect 415*10^6 m^3 of surface water. The upper and lower height of water in the reservoir is +93 m and +65 m, respectively. The reservoir started to fill in with water after the completion of the dam's construction in 1967 (Depountis *et al.*, 2018).

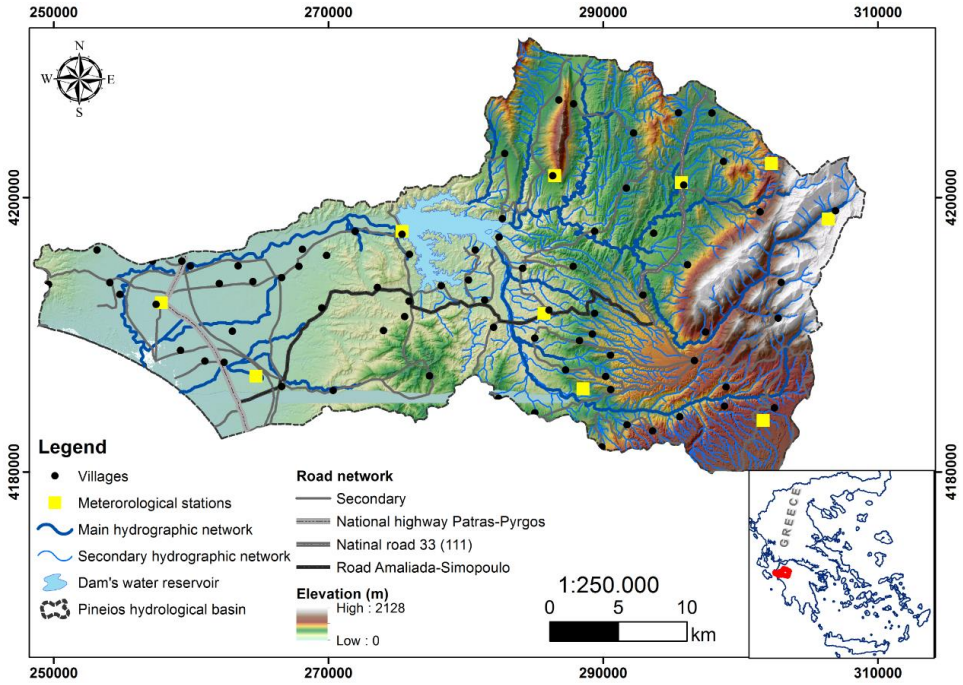

Figure 1. Digital Elevation Model (DEM) map of Pineios River basin.

The RUSLE equation

Revised Universal Soil Loss Equation (Renard *et al.*, 1997) is based on the Universal Soil Loss Equation, USLE (Wischmeier and Smith, 1978), with soil erosion rates calculated by the following formula: **SE = R*K*L*S*C*P. SE** is the computed average soil loss per unit area expressed in tones/ha/year, **R** is the rainfall-runoff erosivity factor expressed in MJ.mm.ha^{-1}.h^{-1}.year, **K** is the soil erodibility factor expressed in t.h.MJ^{-1}.mm^{-1}, **L** is the slope length factor, **S** is the slope steepness factor, **C** is the cover management factor and **P** is the erosion control practice factor. In the current research R factor was calculated by using rainfall data from the seven (7) meteorological stations located in the dam's drainage basin, K factor was calculated by applying the appropriate erodibility factors in each of the geological formations prevailing in the area of interest, L and S factors were calculated by using a Digital Elevation Model (DEM) map with

85m accuracy (Figure 1). P factor was set to 0,5 taking into consideration that a high percentage of the study area is devoted to agricultural land such as olive groves, complex cultivation patterns, non-irrigated arable land, land principally occupied by agriculture, with significant areas of natural vegetation, which means that erosion control techniques are implemented indirectly, mainly with terraces (Koulouri, 2004). Finally the dependent variable C which stands for the cover management factor was set to different values before and after the wildfires of 2007 by modifying appropriately land uses from the Corine data base.

Soil erosion rate before and after the wildfires

By applying the RUSLE equation in the GIS framework, with the assumption that LS factor's equation equals to LS = (FlowAccumulation*CellSize/22.13)$^{0.6}$(Sin(Slope*0.01745)/0.09)$^{1.3}$*1.3 (Mitasova and Mitas, 2001) and C factor has been increased by an average value of 35.29 % due to wildfires, the following soil erosion rate maps are produced before (a) and after (b) the wildfires. In detail, the raster files that represent the six factors of RUSLE were multiplied in order to create a new raster image. Therefore, a composite predictive soil erosion rate map was created, with the soil loss given in t/ha. Soil erosion rate before the wildfires calculated as SE(a)=80 t/ha/year, whereas after the wildfires SE(b)=104 t/ha/year; thus, an increase of 30% in soil loss occurred due to the wildfires.

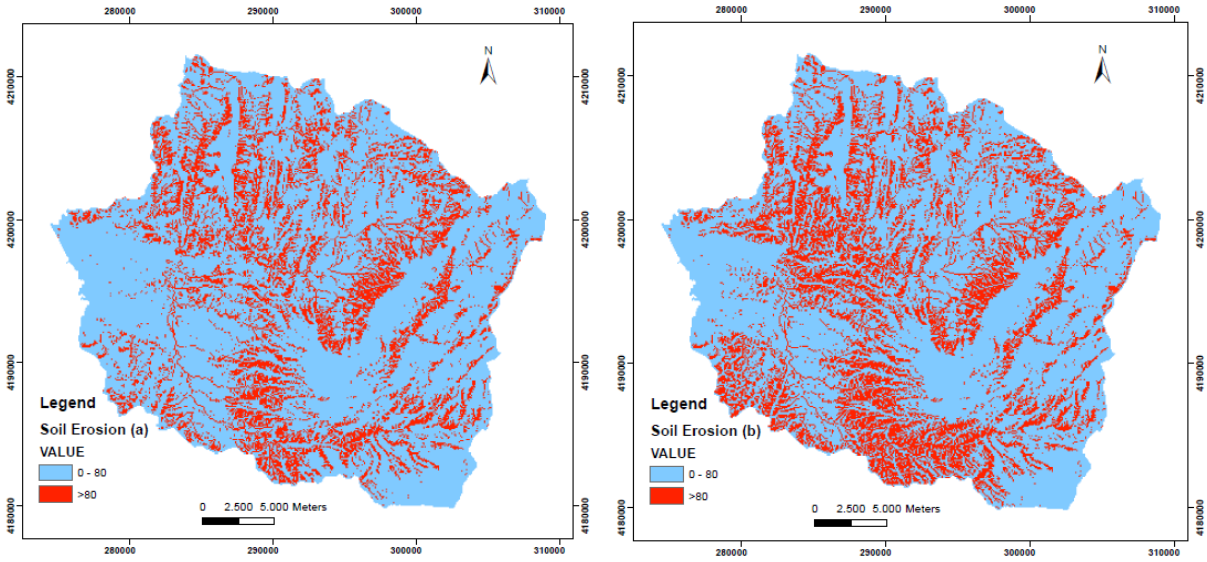

Figure 2. Soil Erosion (SE) rate map of the basin of Pineios dam before (a) and after (b) the wildfires of 2007.

Conclusion

With the use of RUSLE equation and GIS framework, soil erosion rate of Pineios dam drainage basin was calculated as SE(a)=80 t/ha/year and SE(b)=104 t/ha/year, before and after the wildfires of 2007, respectively, by using a DEM with 85m accuracy. This reflects to an increase in soil erosion of 30% and the controlling factor for this increase is basically the cover management factor C. A significant amount of this soil loss volume has been deposited for the last 50 years in the water reservoir of Pineios dam. This volume has to be verified with measurements in the thickness of the reservoirs deposited material in order to validate the accuracy of the results obtained with the use of RUSLE equation.

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