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PRELIMINARY ANALYSIS OF THE AFFORESTATION ROLE IN THE MAXIMUM RUNOFF IN VALEA RECE CATCHMENT

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Key-words: afforestation degree, runoff, flash flood, scenario

Abstract. The aim of this article is to demonstrate the afforestation role in maximum surface runoff. In this way, it was made a comparison of simulated flows in the current conditions of afforestation and the simulated flows in conditions of applying both afforestation and deforestation scenarios in Valea Rece catchment. Through HEC-HMS 4.1 hydrologic modeling software, using the method of unit hydrograph SCS Curve Number, were simulated flow of the river Valea Rece closing section of the basin, where precipitation amounts of 30,50,80,120 mm fallen in intervals of 1.3 to 6 hours on a soil with varying degrees of moisture: dry soil, average soil moisture and high humidity. This was done for the current degree of afforestation basin, for the results from a possible afforestation that would increase the afforestation degree to 80%, and for a possible deforestation that would lead to a degree of afforestation 15 %.

Introduction

The influence of afforestation on runoff is studied subject both in our country and abroad (Chongming and Chung, 1978; Cuza, Ursu and Lilia Țicu, 2012; Farley, Kathlee, Jobbágy and Jackson, 2005; Helmut and Moraes, 2000; Humann et al., 2011; Molchanov and Alekseevich, 1968; Teller, 1968; Shi and Wenhua, 2000; Zimmermann; Teller, 1968). Knowledge of the maximum runoff characteristics presents a major practical interest in hydrological forecasting activity and for taking measures against flooding from flash floods (Sorocovschi, 2009; Budui and Patriche, 2010; Sălăjan 2005). In this context, afforestation activities present a particular importance in order to reduce the negative effects of the torrential rainfall through their main components: the canopy of trees, the vegetation, litter, but also through specific forest soil, loose and powerful high-

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capacity drainage systems due root development (Miță and Mătreață, 2005). Besides climate, deforestations are favorable factors flash floods production due to the increasing of torrential flow, propagation speed and consequently, decreasing the concentration time of water on slopes. The maximum runoff attenuation represents also the main positive effects of the forest, because once with decreasing of maximum flood flow, it is reduced the flood magnitude.

Study area

Valea Rece river basin is located in the central north east of the country in the central group of the Eastern Carpathians (Fig. 1). This river is a left tributary of Trotuş, characterized by a small area around 122 km². It is also characterized by an average gradient of 28% (Fig. 2), the hydrological soil group A (fig. 3) and a low level of afforestation about 38% (Fig. 4), which are contributing factors to flash floods occurred.

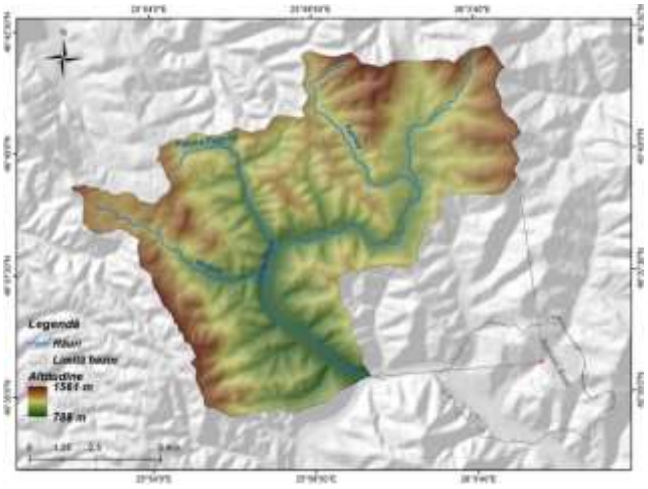

Fig. 1 Valea Rece basin location in Romania

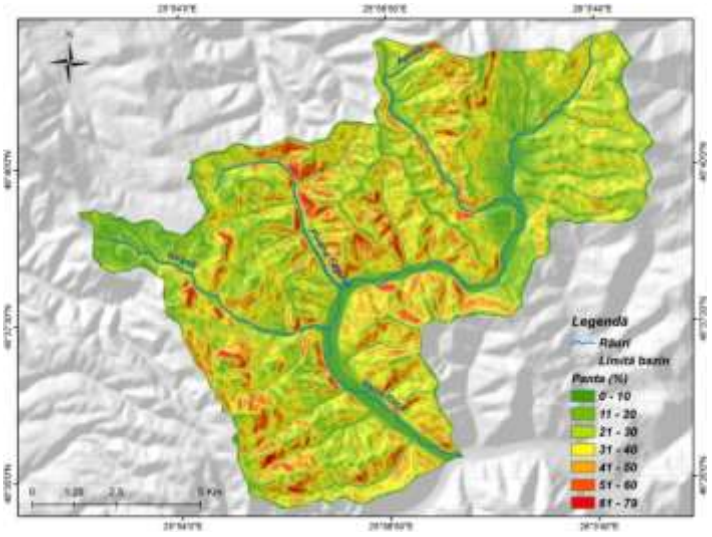

Fig. 2 Slopes map in the Valea Rece basin

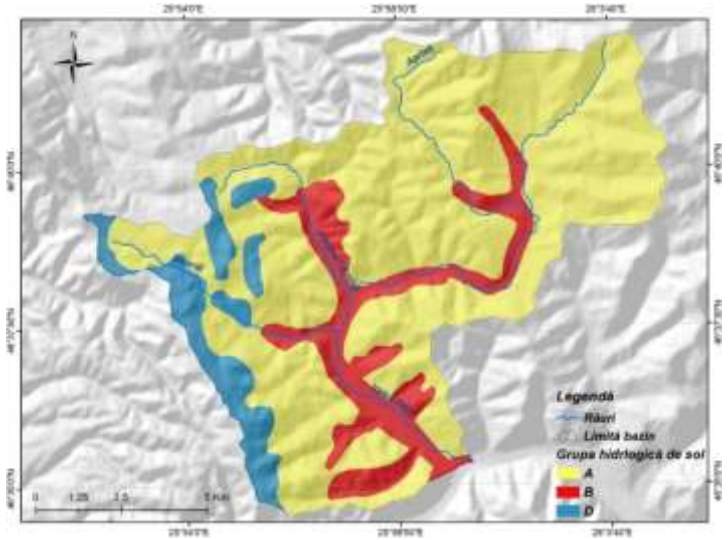

Fig. 3 Hydrological soil group in Valea Rece (adaptation of Chendeș, 2011)

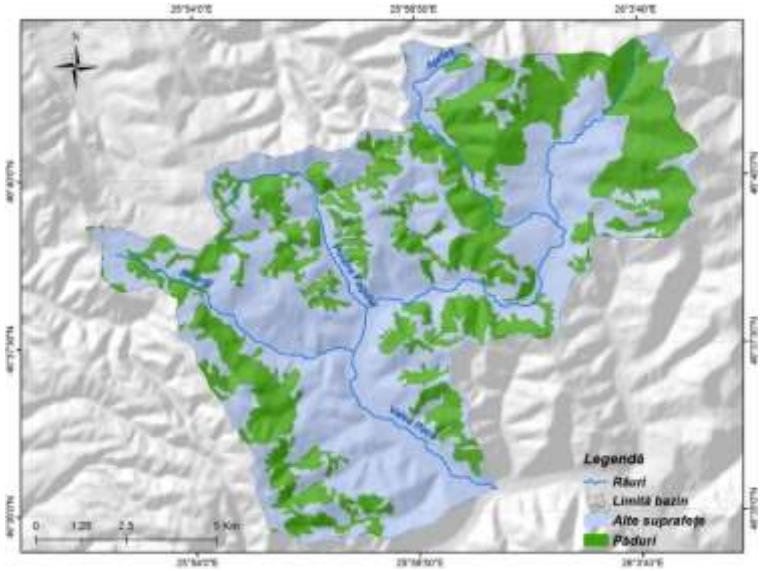

Fig. 4 Afforestation surfaces map in Valea Rece basin

Date and methods

The date used in this study refers to:

- Digital Elevation Model – from which was derived the slope;
- Land Use (Corine Land Cover 2006)
- Hydrological soil group (soil map from România 2002)
- Quantities of the different rainfall scenarios (30,50,80,120 mm)
- Historical flow data for model calibration HEC – HMS 4.1

In order to obtain the results both GIS techniques and hydrological modeling were applied. Through GIS was calculated the average number of curve (junction of land use and hydrologic soil group) and further the basin Lag Time, methods studied in numerous papers (Costache 2014; Garen, David C., and Moore, 2005; Hawkins, Richard H., and all, 2009). Through hydrological modeling HEC-HMS 4.1 software, using the method of unit hydrograph SCS Curve Number (Fig. 5) were simulated flow of the Valea Rece closing section of the basin by entering data basin (name, area CN, Lag Time) amounts of rainfall step for 10 minutes (fig. 6) and the period for which the simulation will be achieved.

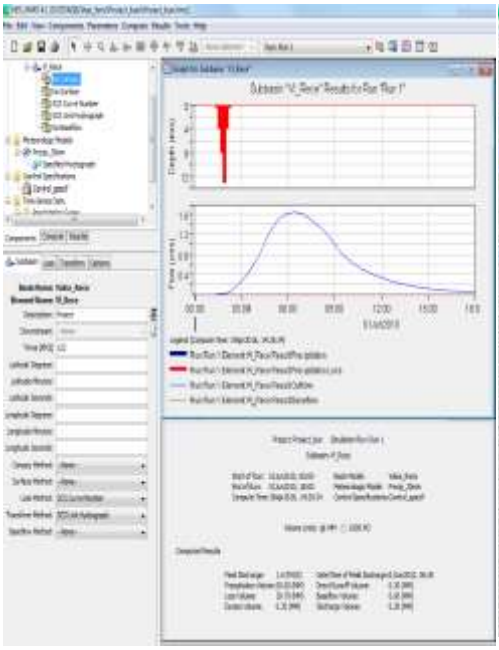

Fig. 5 Hec – Hms sheet work
(SCS -Curve Number)

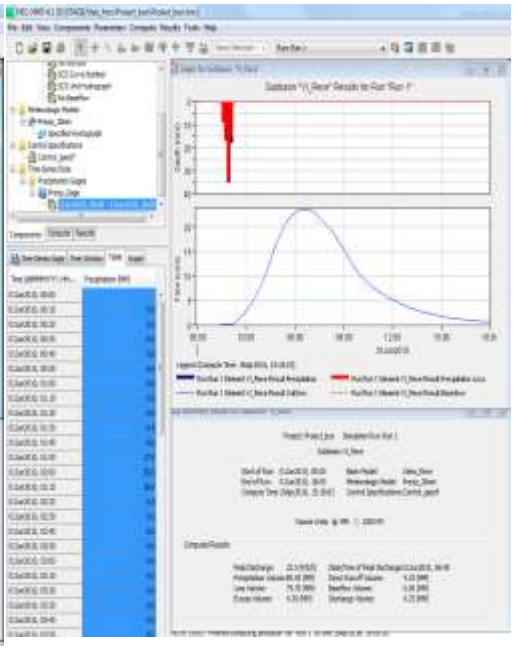

Fig.6 Hec – Hms sheet work
(rainfall amounts)

Results

After the hydrological simulation were obtained the following results:

In the case of 30 mm/h rainfall, under current afforestation degree, hydrological simulations results (fig. 5) shows the following: if a dry soil, where CN = 33 and Lag Time = 320, the peak flow is 2,8 m³/s; if an average soil moisture with CN = 51 and Lag Time= 274, maximum flow rate is 3.3 m³/s and if a soil with high humidity CN = 70 Lag time = 122, maximum flow rate can reach 14 m³/s. In the case of 50 mm/h under the same conditions, the maximum flow in case of a dry ground is 4.7 m³/s in the case of an average soil moisture is 5.5 m³/s in the case of a soil moisture increased 80 m³/s. Regarding a rain of 80 mm/h, maximum flow values start to increase reaching for a soil with high humidity to 257 m³/s. For a rain of 120 mm/h, the flow registered under the dry soil is about 14 m³/s, in the wet antecedent average may reach 100 m³/s, and high humidity can exceed up to 550 m³/s.

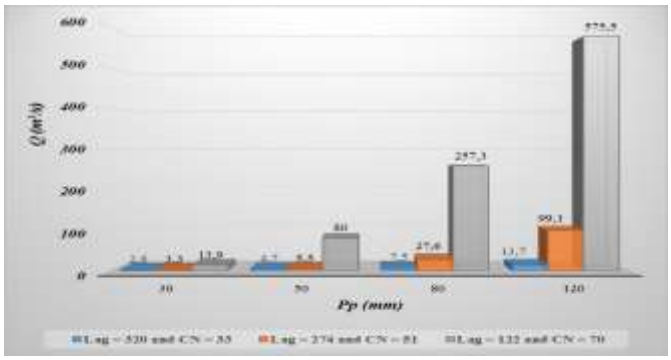

Fig. 5 Simulated flows in current conditions of afforestation for different amounts rainfall fallen in 1hour

In the figures with numbers 6 and 7 are plotted flows simulated in the current afforestation for different amounts of precipitation (30, 60, 80, 120mm) fallen in a period of 3 h (Fig. 6) and 6h (Fig. 7) on soils with different degrees of humidity. It can be seen that the maximum flow value decreases with increasing time interval.

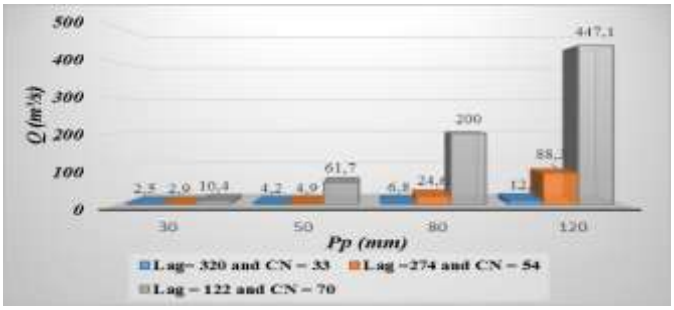

Fig. 6 Simulated flows in current conditions of afforestation for different amounts rainfall fallen in 3hour

For an afforestation scenario of approximately 80% of the total basin area, the maximum flow value changes significantly. Thus, in case of the same rain of 30 mm/h, in dry soil conditions, CN = 31 and Lag Time = 348, peak flow drops to 2.6 m³/s; on average soil moisture CN = 47, Lag Time = 303, maximum flow rate is 2.9 m³/s, and high humidity conditions, where CN = 66 and Lag Time = 136, maximum flow rate not exceeding 8 m³/s. If the amount of rainfall will increase (Figure 8 present scenarios for different amounts of rainfall), and the time interval remains the same, the values of maximum flow rate also increase, leading in case of 120 mm/h rainfall amounts, at a value of maximum flow for dry soil of 10.7

m³/s antecedent soil moisture exceeds average 66 m³/s, and if a soil with high humidity increased about 450 m³/s.

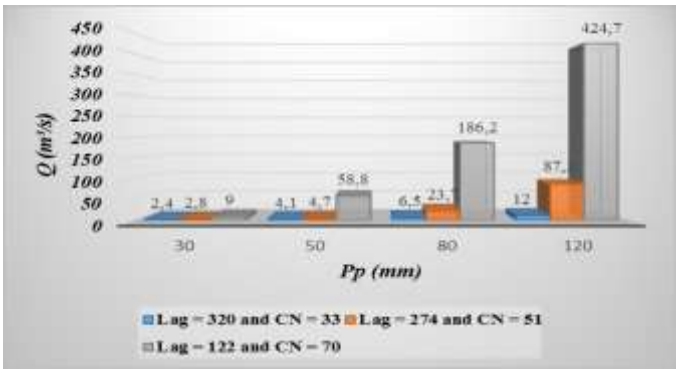

Fig. 7 Simulated flows in current conditions of afforestation for different amounts rainfall fallen in 6hour

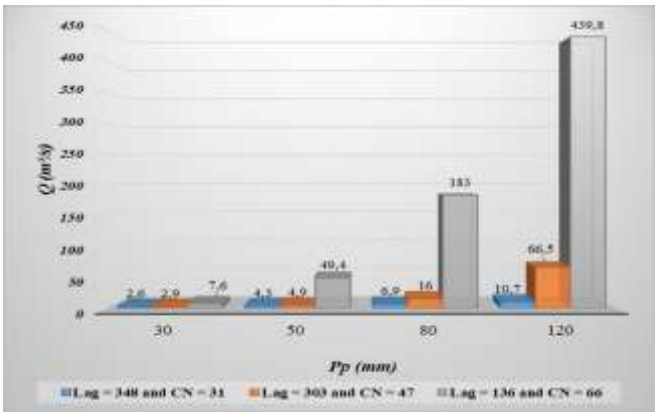

Fig. 8 Simulated flows in conditions of afforestation degree of 80% for different amounts rainfall fallen in 1hour

Figures 9 and 10 illustrate graphs which are simulated flow under the same conditions for afforestation (80%) for different amounts of precipitation (30, 50, 80, 120mm) fallen in time of 3h (Figure 9) and 6h (Figure 10). There is a significant decrease in maximum flow value, which for a 120mm rain fell within 6h on a soil with high humidity (CN = 66, Lag Time = 136) reached 329.8 m³/s of flow simulated current conditions of afforestation, for the same rain fallen at the same time, he got to the maximum rate of 424.7 m³/s.

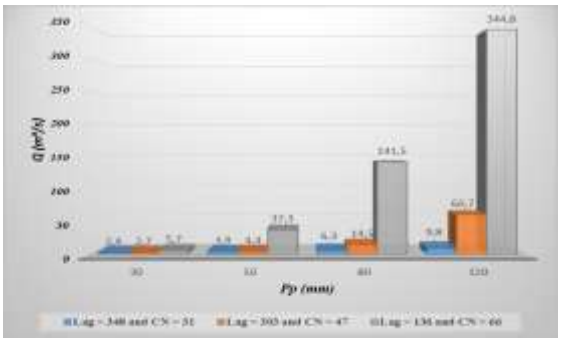

Fig. 9 Simulated flows in conditions of afforestation degree
of 80% for different amounts rainfall fallen in 3hour

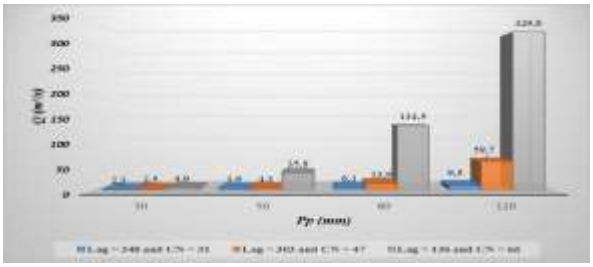

Fig. 10 Simulated flows in conditions of deforestation degree of 15%
for different amounts rainfall fallen in 6hour

For a scenario of deforestation, maximum flow value for a surface covered with forest covering just 15%, increase significantly, which can reach in case of a rain of 30 mm/h on a dry soil to 3.1 m³/s (where CN = 37, Lag Time = 289), in case of the average soil moisture (CN = 54.5, Lag Time = 182), the maximum flow rate reach to 5 m³/s, and in case of increased soil moisture (CN = 73 Lag Time = 113) the maximum value of flow can reach 23 m³/s.

With the increasing amount of rainfall fallen in the same time and under the same conditions, increase the value of maximum flow, so for a rain of 120 mm/h, the flow registered under the dry soil is about 25 m³/s, in conditions of average soil moisture reaches 185 m³/s, and in high humidity soil conditions, the maximum flow value can reach 700m³/s. As the time interval increases, decreases the value of peak flow, due to the time of the concentration of water in basin is increasing, in figures 12 and 13 is plotted flow values simulated on the same conditions, but in different time intervals of 3 hours (fig. 12) and 6h (fig. 13).

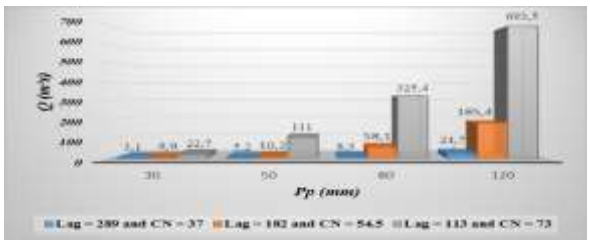

Fig. 11 Simulated flows in conditions of deforestation degree of 15% for different amounts rainfall fallen in 1hour

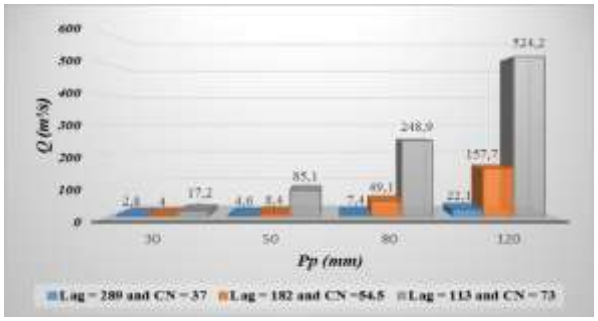

Fig. 12 Simulated flows in conditions of deforestation degree of 15% for different amounts rainfall fallen in 3hour

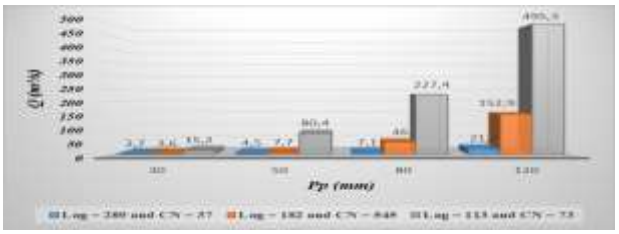

Fig. 13 Simulated flows in conditions of deforestation degree of 15% for different amounts rainfall fallen in 6hour

Conclusion

After applying the method, they notice the same amount of precipitation fallen on the soil with the same moisture, the value of the maximum flow increase significantly in case of deforestation, from 575 m³/s in current afforestation, 693 m³/s under deforestation of up to 15%. In the case of afforestation of 80% they notice a decrease for value of the maximum flow rate up to 439 m³/s.

Obtained results highlight the role of afforestation areas have on runoff reduction. Once reduced the maximum runoff, the flood waves attenuated and implicitly producing floods.

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