Scientific Bulletin of Politehnica University of Timişoara

Transactions on HYDROTECHNICS

Volume 63(77), Issue 2, 2018

THE EFFECT OF DEFORESTATION ON LIQUID FLOW IN SMALL HYDROGRAPHICAL BASINS

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Abstract: Forests are essential to life on Earth and provide fundamental services by: producing oxygen; carbon capture; water purification and retention; protection against floods, erosion and landslides; supporting and protecting biodiversity; production of wood, fiber, biomass; participation in the definition of cultural identities and spiritual values; providing recreational facilities etc. Massive deforestation without control endangers the possibility to provide these fundamental services for life. This paper presents the effects of deforestation on environment, especially the effect of deforestation on liquid flow in small hydrographical basins. The water discharges in output section of hydrographical basin are calculated with advanced hydroinformatic tool MIKE11, Rainfall-Runoff module.

Keywords: forest, deforestation, liquid flow, modelling.

1. INTRODUCTION

Forests are essential to life on Earth and provide fundamental services by: producing oxygen; carbon capture; water purification and retention; protection against floods, erosion and landslides; supporting and protecting biodiversity; production of wood, fiber, biomass; participation in the definition of cultural identities and spiritual values; providing recreational facilities etc. Massive deforestation without control endangers the possibility to provide these fundamental services for life. [1]

Around 78% of the remaining pristine forests existing in Europe are in Romania. Romania's forests are concentrated in principally in the mountain area. Deforestations are a large-scale phenomenon in Romania, especially in mountain counties, and the local and central authorities have the responsibility to control, monitor and manage the human interventions on forestry. [2]

Between 2000 and 2011, in Romania, the process of massive deforestation has dramatically accelerated. Approximately 400 000 ha of forest has been illegally cut in Romania in the last 25 years, causing an estimated damage of 5 billion euros. [3]

At national level, the area covered by forest fell dramatically in the twentieth century, reaching today at 28.95 %. Now we are well below the EU average of 32.4 % - well below the calculated 45 % optimum capacity. [1]

At present the national forestry fund has an area of 6 900 962 ha, half of which is public property of the state under the administration of the National Forestry Registry - Romsilva RA, and the other half is private property of the state, administrative-territorial units, communes and persons physical. About 415 000 hectares of forest belong to small owners with areas under 100 ha and are not managed and therefore exposed to illegal deforestation (Figure 1). [1]

Figure 1. Deforestation in Romania mountain areas [4,5,6]

The Greenpeace study reveals that almost half of deforested surfaces between 2000 and 2011, meaning 48.95 %, are located within the protected natural areas. Protected areas in Romania are represented, mainly, by 29 national and natural parks, by the Natura 2000 sites, which are, up to now, 383 sites of communitary importance and 148 special protection avifaunistic areas. In the protected areas are applied the Law no.49/2011 regarding the regime of natural protected areas, conservation of natural habitats, wild flora and fauna. [2]

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The phenomenon of deforestation is all the more serious as it occurs in virgin forests; these are among the most valuable. Romania has 218 000 hectares of virgin forests, compared to other countries in Europe, where only smaller areas of virgin forests are left. [2]

The Greenpeace study shows that the total deforested and degraded area between 2000 and 2011 has been of 280 108 hectares – approximately 28 000 hectares per year. The most affected counties are Harghita, Suceava, Maramures, Arges, and Cluj (Figure 2). [2]

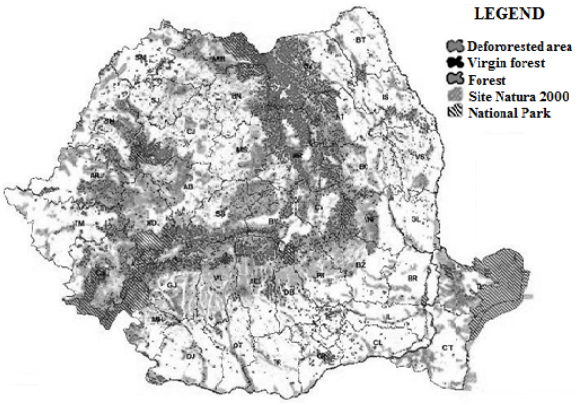


Figure 2. Deforested areas in Romania 2000-2011 (GREENPEACE)

The most important causes of deforestation are:
- to produce fuel (half of illegally removed trees from forests are used as fuel);
- to extension land for housing and urbanization;
- to commercial interest: production of paper, furniture and homes;
- to produce food (oil from palm trees);
- to create available land for zootechnical farms. [7]

Effects of deforestation:
- Contributing factors to global climate change. The most important problem caused by deforestation is the impact on the global carbon cycle, with strong influence on greenhouse effect. Carbon dioxide (CO_2) is the most important greenhouse gas. About 300 billion tons of carbon, 40 times the annual greenhouse gas emissions from fossil fuels, is stored in trees, according to Greenpeace. According to the 2010 Global Forest Resources Assessment, deforestation releases nearly a billion tons of carbon into the atmosphere per year. Deforestation is the second largest anthropogenic (human-caused) source of carbon dioxide to the atmosphere (after fossil fuel combustion), ranging between 6 percent and 17 percent, according to a study published in 2009 in Nature. Another gas that favors greenhouse effect is water vapor. Deforestation has a great impact on the exchange of water vapor and carbon dioxide between the terrestrial land surface and the atmosphere. [7]
- Negative effects on ecosystems. Forests are complex ecosystems that affect almost every species on the planet. When they are degraded, deforested, they trigger a series of devastating events at local, regional and global level. [7]
- Loss of species. 70 % of the world's plants and animals live in forests and are losing or degrading their habitats through deforestation, according to National Geographic. Loss of habitat can lead to species extinction. It also has negative consequences for medicinal research and local populations that rely on the animals and plants in the forests for hunting and medicine. [7]
- Negative influence on water cycle, hydrology and hydrogeology, massive deforestation can caused devastating flash floods. Trees are important to the water cycle. They absorb rainfall and produce water vapor that is released into the atmosphere. Trees also lessen the pollution in water, by stopping polluted runoff. [7]
- Soil erosion. Tree roots anchor the soil. Without trees, the soil is free to wash or blow away, which can lead to vegetation growth problems. Massive deforestation can caused extreme soil erosion and landslide problems. [7]
- Degradation of life quality. Soil erosion contributes to silt lakes, reservoirs, streams and other water sources. This decrease local water quality for population and contribute to poor health in populations in the affected area. [7]
- The disturbance of native people. Many native tribes live in the rainforests of the world, and deforestation in this area is the destruction of these peoples' homes and way of life. [7]

2. MIKE11 HYDROINFORMATIC TOOL

Advanced hydroinformatic tools, MIKE11 by DHI, are useful for to study the effects of deforestation on catchment hydrology, in specially to estimate maximum discharges in water courses in output section of hydrographical basin. MIKE11 is an advanced hydroinformatic tools, professional engineering software package for simulation of one-dimensional flows in estuaries, rivers, irrigation systems, channels and other water bodies. It was developed by DHI Water • Environment • Health, Denmark. MIKE 11 has the following modules: Hydrodynamic Module (HD), Rainfall-Runoff (RR) Module, Sediment Transport (ST) Module, Water Quality (WQ) Module.

Different types of Rainfall-Runoff models are available: NAM - a lumped, conceptual rainfall-runoff model, simulating the overland-, inter- flow, and base-flow components as a function of the moisture contents in four storages; UHM - the Unit Hydrograph Module includes different loss models (constant, proportional) and the SCS method for estimating storm runoff; SMAP - a monthly soil moisture accounting model; Urban - two different model runoff computation concepts are available in the Rainfall Runoff module for fast urban runoff: time/area method and non-linear reservoir (kinematic

wave) method; FEH - Flood Estimation Handbook, a method for flood estimation in the UK; DRiFt (Discharge River Forecast) - a semi-distributed event model based on a geomorphologic approach; Combined - the runoff from a number of catchments, constituting parts of a larger catchment, can be combined into a single runoff series. [8]

For the study of deforestation effect on maximum water discharges in small hydrographical basins we use the RR module, UHM methods (Figure 3).

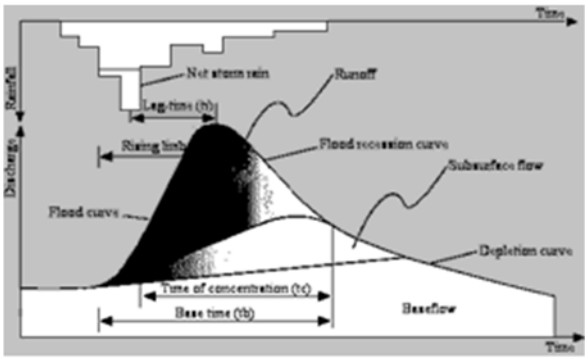


Figure 3. UHM method - terminology

The UHM methods of Rainfall-Runoff module of MIKE 11, simulates the runoff from single storm events by the use of the unit hydrograph techniques and constitutes an alternative to the NAM model for flood simulation in areas where no streamflow records are available or where unit hydrograph techniques have already been well established. Unit hydrograph is a hypothetical unit response of the watershed to a unit input of rainfall. [8]

3. CASE STUDY

In order to study the effect of deforestation on liquid flow in small hydrographical basin we chose the Sub-basin of Topla River, with a length of 2.3 km, a surface of 171 ha, average slope of water course 2.43%; the location and the forms of small hydrographical basins shown in figure 4.

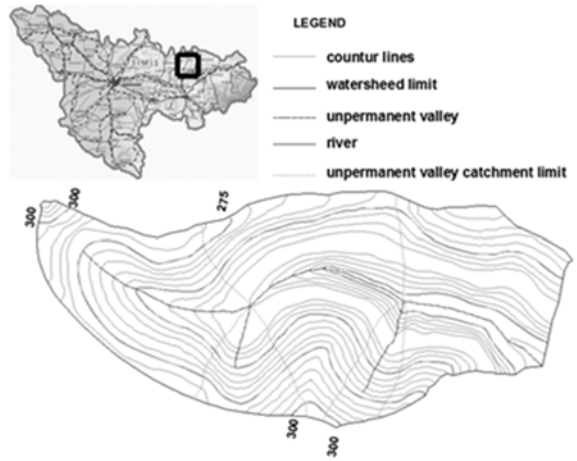
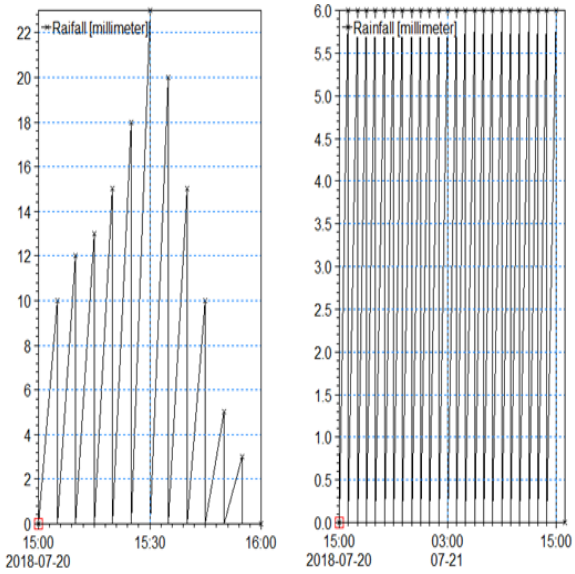


Figure 4. The location of studied area

For the study we considered the following hypotheses:

- the constant intensity of the rain on the entire surface of the hillslope;
- the same soil type for the entire hillslope - Typic Hapludalfs (with more subtypes), of a middle and heavy texture (reduced permeability), being part of the hydrological group C;
- soil use is the same all over the hillslope surface: forest, respectively after deforestation, degraded pasture;
- there are no hydrotechnical arrangements;
- base flow 0.2 mc/s;
- initial abstraction depth 20 mm for forest, 1 mm for degraded pasture.

The modeling of the liquid flow in the studied hydrographic basin, using the MIKE11, RR module, was done in two hypotheses of precipitation production: a 1 hour heavy rain (Figure 5a) and 24 hours of constant rainfall (Figure 5b), in the summer time (July). The total amount of precipitation in both scenarios was 144 mm.



a. b.

Figure 5. Rainfall

4. RESULTS AND DISCUSSION

The results of simulation with MIKE11, RR module, in the two hypotheses of precipitation production are shown in Figure 6, Figure 7 and in Table 1.

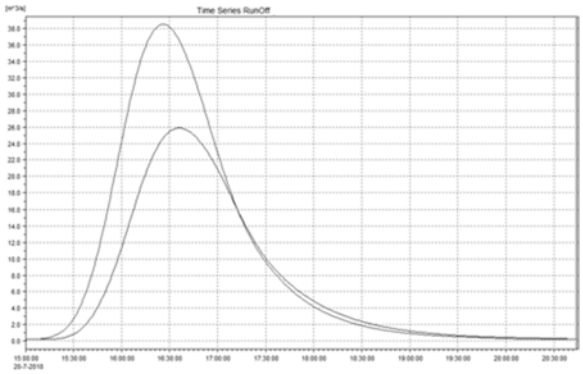


Figure 6. Time series runoff for 1 hour of heavy rain duration

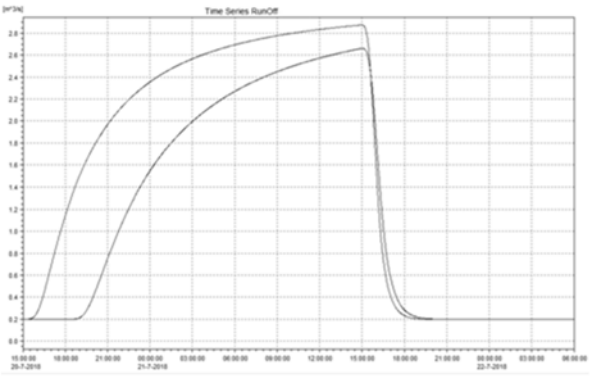


Figure 7. Time series runoff for 24 hours of rain duration

Table 1. RR module-hypotheses of precipitation

	1 hour rain		24 hours rain	
	before deforestation	after deforestation	before deforestation	after deforestation
Maximum discharge (m^3/s)	26	39	2.65	2.90
Flood wave duration (h)	5.00	5.25	25.00	28.00

It can be seen that the maximum discharge increases by about 50% and the peaks of the hydrographs are offset with 20 minutes, in the case of a 1 hour heavy rain. In case of 24 hours rain, the maximum discharge increase with only about 9.4% and peaks of the hydrographs are produced approximately simultaneously. The discharges are about ten - fifteen times higher in case of 1 hour heavy rain towards 24 hours rain.

Regarding the duration of the flood wave, in the case of 1 hour heavy rain, the duration is five times higher than rain duration; in the case of 24 hours rain, the duration of flood wave is higher with just a few hours.

These differences are observed due to the following:

- the forest significantly reduces the intensity of rain entering the ground, thus reducing the kinetic force of the rain drops, which is higher in case of heavy rain;
- the retention phenomenon of forest action. Of the amount of precipitation falling on the canopy, part is retained in leaves, branches and on stems of trees. The total quantity retained in this way depends, in principally, on: the intensity of the rain, the presence and the characteristics of the wind, the character of the foliage, the roughness of the bark, the composition of the tree and its age.
- the runoff depend on the characteristics of the soil; the development of roots systems, the presence of dead or recently rooted roots, percentage of vegetation coverage, the characteristics of micro and macrorelief, slopes, initial humidity are factors that determine the amount of rainwater infiltrated into the soil.

5. CONCLUSIONS

The forms under which the forest exercises its positive influence over the water regime and hydrological cycle on a given territory are multiple: protects the soil from erosion and landslides; through retention phenomenon reduce the maximum discharges of flood waves; reduce the risk of flash flood occurrence; water purification and retention etc.

Due to the important role of the forests, the authorities in the field must keep track of the exploitation of the forests according to a well-defined plan, prevent abusive deforestation and ensure that the deforested surfaces are replanted with saplings.

ACKNOWLEDGMENT

This paper can be possible thanks to project: Development of knowledge centers for life-long learning by involving of specialists and decision makers in flood risk management using advanced hydroinformatic tools, AGREEMENT no LLP-LdV-ToI-2011-RO-002/2011-1-RO1-LEO05-5329. This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

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