MODELLING FLASH FLOODS IN SMALL FORESTED MOUNTAIN WATERSHEDS USING GEOGRAPHICALLY REFERENCED DATA

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I. INTRODUCTION

Severe storms which appear in mountainous areas in Romania produce highly unpredictable flash floods. Many mathematical models, rather expeditious than analytic, are used in predicting this kind of phenomena (Drobot, 2007).

II. RESEARCH LOCATION AND METHODOLOGY

This study used a highly analytic method for modelling flash floods produced in Valea Băii experimental watershed (fig, 1).

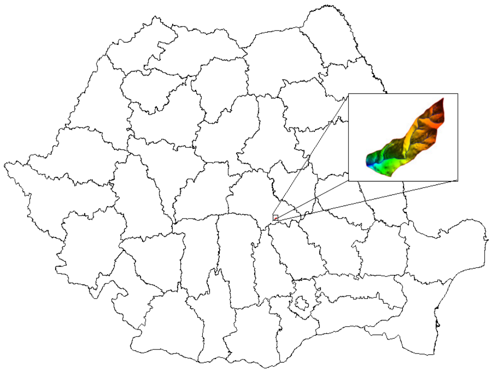

FIG. 1: Valea Băii experimental watershed location

For calculating the flood hydrograph we choose for the use of sensors-logger, which record the pressure of the water column above it (Clinciu, 2001). The sensor was placed in the lake formed upstream a hybrid crested spillway placed on the main course of the river (fig. 2).

FIG. 2: View from the front, back and top of the hybrid spillway installed on the main course of Valea Băii watershed (Photo: Niță, 2009)

For modelling the flood hydrograph the method is based on mathematical quantification of soil potential accumulation of water and uses geographically referenced data on: soil texture, soil porosity, soil humidity, antecedent rains, soil cover and watershed morphometry. Many modelling methods, despite of soil importance in producing the surface and subsurface flow, do not use too many data for characterizing this influence. Therefore the prognosis quality is enhanced in the presented study with the geospatial data on soil.

The method itself (called MPA – Potential Accumulation Method) predicts the flash floods phenomena by creating a synthetic hydrograph (Gaspar, 1997). The flood wave simulation is based on following cell raster characteristics: slope, soil cover, rainfall intensity, overland flow distance, and the discharge is calculated based on rainfall intensity and derived runoff coefficients.

The input data for the application of MPA in isochronous mode are:

- Raster: digital elevation model, satellite images, orthophotoplan;
- Vector: watershed, the river network, forest compartments (or categories of land in the watershed).

The calculation involved the following steps:

- Determination of the four factors which quantify the land use effect, average slope effect, the effect of rainfall intensity and the effect of traffic in the watershed;
- Determination of effective porosity using data on the soil;
- Determination of calculation soil depth;
- Determination of maximum retention capacity and effective retention;
- Derivation of potential accumulation of water in the soil;
- Estimate the initial retention and infiltration losses;
- Estimate the actual drained layer;
- Creating flood hydrograph and calculating peak discharge.

MPA implementation problem in reconstructing the flood hydrograph is to establish a relationship for determining the flow depending on the drainage time, on watershed characteristics and on the characteristics of rainfall data. Therefore we used flow coefficient determined by the MPA in a rational equation formula type to convert the value of drained layer in the discharge water value.

$$Q = \frac{1}{6} \cdot K \cdot S_t \cdot i_t \text{ m3/s}$$

where:

K is the average drainage surface factor contributing to calculation section and is based on a correction coefficient

C_o which takes into consideration all the caracteristics described above.

$$C_o = e^{-\frac{N}{10 \cdot h_e^{\frac{0,3}{h_e} + 0,15\left(\frac{N}{h_e}\right)^{0,2} + 0,25\left(\frac{h_e}{N}\right)^{0,2}}}}$$

S_t - active watershed area (ha) contributing to the drain at a time;

i_t - the intensity of rain at a specific time.

For preparing the data input and modelling the flood flood hydrograph was used the open source program SAGA GIS. For validating an alternative software, the licensed ArcMap was used.

Both programs offered functions and procedures for applying the algorithms necesarry for determining especially the data input used in model run.

Using the method of potential accumulation and determining, based on isochronous surfaces, the active surface, we could derive the flood hydrograph for the flood from 14 July 2010.

As input were used variable intensities (calculated in a step of 10 minutes) of the rainfall event that generated the flood and mean drainage coefficient at cell level which contributes at that time with flow in calculation section (Beven, 2011).

III. RESULTS AND CONCLUSIONS

Modelled hydrograph (fig. 3) using as input data the drained layer evaluated with the potential accumulation the method and the isochronous surfaces, is close in form to the hydrograph measured in the field (difference 10 minutes between peaks of hydrographs and an overestimation of peak discharge by 6%).

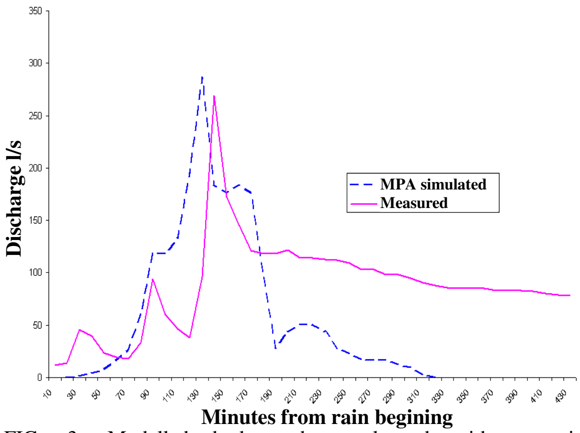

FIG. 3: Modelled hydrograph overlapped with potential accumulation method applied under isochronous regime with the measured hydrograph

Differences appeared between the last sections of the hydrographs; in case of the measured one it goes down more slowly than the modelled one. We explain these differences that in the modelling process of isochronous theory, since rain is stopped the active watershed area is reduced with isochronous areas from closest to farthest.

Even though the peak discharge is predicted with high accuracy (both temporal and quantitative) there are fluctuations in the real hydrograph which could not be modelled by the method. This is explained in the lack of the method of introducing more sensitive parameters in morphometric characterisation of the watershed.

The MPA method can be used successfully in predicting peak discharge and modelling the flood hydrograph in small torrential forested watersheds, placed in mountainous areas.

The capacity for accepting geographically referenced data as input, offers the opportunity in applying the method in near real-time forecasting systems.

Estimating in short time the probable peak discharge produced by a certain rain ensures the decision makers a better assessment of danger.

IV. ACKNOWLEDGMENTS

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