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J. Geogr. Inst. Cvijic. 65(2) (131–143)

Review paper

UDC: 911.2:551.311.2(497.11)
DOI: 10.2298/IJGI1502131P

CHALLENGES OF TORRENTIAL FLOOD RISK MANAGEMENT IN SERBIA

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Received 11 June 2015; reviewed 10 July 2015; accepted 13 August 2015

Abstract: Torrential floods are the natural hydrological hazards manifesting as a consequence of extreme rainfall episodes which have a quick response from the watersheds of small areas, steep slopes and intensive soil erosion. Taking in consideration the nature of torrential flood (sudden and destructive occurrence) and the fact they are the most frequent natural hazards in Serbia, torrential flood risk management is a real challenge. Instead of partial solutions for flood protection, integrated torrential flood risk management is more meaningful and effective. The key steps should be an improvement of the legal framework on national level and an expansion of technical and biological torrent control works in river basins. Consequences for society can be significantly reduced if there is an efficient forecast and timely warning, rescue and evacuation and if affected population is educated about flood risks and measures which can be undertaken in case of emergency situation. In this paper, all aspects of torrential flood risk management are analyzed.

Key words: torrential flood, frequency, impact, risk management

Introduction

Torrential floods belong to the natural hydrological hazards manifesting as sudden occurrence of maximal water discharges with high rate of sediment in torrential flood wave, frequently coinciding with landslide movements and mud flows (Norbiato, Borga, Esposti, Gaume, & Anquetin 2008; Gaume et al., 2009; Marchi, Borga, Preciso, & Gaume, 2010; Kostadinov, Borisavljević, & Mlađan, 2014a; Foulds, Griffiths, Macklin, & Brewer, 2014; Tiranti, Cremonini, Marco, Gaeta, & Barbero, 2014; Garambois, Larnier, Roux, Labat, & Dartus, 2014; Liste, Grifoll, & Monbaliu, 2014; Petrović, 2015). This phenomenon is a consequence of extreme rainfall episodes which have a quick response from the watersheds of small areas, steep slopes and intensive soil erosion. Research of frequency of torrential flood occurrence in Serbia have pointed out there are two maxima within a year – primary in June and May, and secondary in March and February (Ristić, Radić, & Vasiljević, 2009; Petrović, 2014). The rate between

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average and maximum discharge during a torrential flood wave may be more than 1:1000.

Natural conditions and processes in the watershed are usually modified by urbanization in lower parts and agriculture or deforestation in higher parts of the watershed. By increase of urban surfaces, permeable surfaces are decreased while irrational forest exploitation and inadequate soil cultivation disturb the natural soil structure making the favourable conditions for intensification of soil erosion, sudden surface runoff on slopes and maximal discharges in river bed.

Torrential floods are the most frequent natural hazards in Serbia (Dragićević et al., 2013) with severe consequences in social, economical, cultural and ecological sphere so that the torrential flood risk management needs full attention by the authorities. Some torrential flood events in the course of recent history were fatal for human lives and local economies. Such were torrential flood events in 1915, 1929, 1938, 1939, 1951, 1969, 1983, 1988, 1999 and 2010 in Central Serbia, according to the Inventory of torrential floods in Serbia (Petrović, Kostadinov, & Dragićević 2014). Practically, the torrential flood with extreme water discharges and catastrophic consequences for society and environment, with low probability of occurrence, are taken as historical flood events. Having in mind the quantity and intensity of rainfall events, maximal water discharges, death tolls and extents of material damages in Krupanj, Obrenovac and Tekija, the torrential flood in May and September 2014 were announced at four corners of the world and are already recorded as historical flood events in Serbia.

Ecological impact of torrential flood refers to water reservoir siltation by erosion sediment driven by flood wave, so that useful volume of reservoir for catching the torrential flood wave is reduced and water quality is deteriorated. Soil degradation, mechanical and chemical water degradation are the main negative ecological effects of almost synchronized processes of soil erosion and runoff genesis (Kostadinov et al., 2014b).

Torrential Flood as Emergency Situation

Unlike the floods of great rivers, the occurrence of torrential floods is sudden and time for reaction is exceptionally short. One of characteristics of this phenomenon is usually short duration and a real local havoc afterwards. Certainly, the hardest consequence is a loss of human lives. In the Inventory of torrential floods in Serbia (Petrović et. al., 2014), over 133 casualties as a consequence of torrential floods are recorded, while data about injured individuals are rare. After torrential flood event and especially in case of poor

emergency situation management, waterborne diseases are frequent. Besides physical, there are consequences of psychological character such as trauma and diseases caused by trauma. In the emergency situation caused by torrential floods, the measures for evacuation of infirm and immobile individuals from hospitals should be specially developed.

When torrential flood event gets the scale of emergency situation, the Sector of Emergency Management of the Ministry of Interior of the Republic of Serbia with over 3 000 operatives is responsible for protection and rescue of citizens. A great support in emergency situation is given by the operatives from the ranks of the Army of Serbia and Serbian Mountain Rescue Service. The emergency situation, triggered by torrential flood event, can be described by the following examples from newspapers, describing the historical torrential flood events, which are the part of the Inventory of torrential flood events in Serbia. Some of the examples are:

20th May 1915, "Politika" wrote: "Torrential floods in the watersheds of the Crni Timok, Beli Timok and Veliki Timok are the consequence of downpour in the night between May 19 and 20. At first, the Zlotska and Brestovačka rivers have made a real havoc. The first one flooded half of Zlot and Sumrakovac villages, the second one spilled in Brestovačka Banja and Metovnica. The railway Zaječar - Paraćin was destroyed at many locations and train station in Bogovinska banja is whole in the water. The Beli Timok flooded several countries and took away the train bridge by Vratarnica. Never Timok has taken so many casualties as now – in Mokranje 10 casualties, in Brestovačka banja 6, in Metovnica 5, several in Zlot and Rečka."

27th October 1939, "Vreme": The ferocious torrents from the Suva Planina Mountain took 17 lives in Bela Palanka and destroyed all the bridges. Disaster lasted around two hours. Twenty houses were razed to the ground, 142 tended to decline, while 264 terribly damaged, over 500 head of cattle disappeared in the torrents.

23rd July 1956, "Politika": The material damage in Vršac county is over 2 billion Dinars and there are casualties. Only in Vršac 125 houses are ruined and 107 are damaged. The Army and Police are in the action of evacuation and recover of flooded areas.

24th November 1979, "Politika": Flood calamity left severe material damages in even 25 municipalities. In Novi Pazar, damages are the greatest with even 3 casualties. In Priboj death toll numbers 2 human lives. Due to damages, the

teaching in 21 schools is stopped and over 213 bridges of different importance are taken away by torrents, 34,000 ha of arable land are covered by water.

26th June 1988, Kostadinov, 1989: Torrential floods in the Vlasina river basin are the consequence of intensive rainfall episode - one third of annual rainfall is poured down in only 4 hours. 500 homes flooded, 80 km of roads and 32 bridges ruined, 3 casualties are the results of this flood event. There were floods of torrents in this river basin with return period of 800 years (Ravna reka).

Figure 1. Floods in Despotovac, June 1969; Industry zone in Kragujevac under water, July 1999 (Archive of Inventory of torrential flood events in Serbia, "Politika")

11th July 1999, "Politika": Great floods in Šumadija Region. The torrential flood of the Topčiderska River and its tributaries flooded international train, homes and took 10 lives. In Smederevska Palanka 1000 homes are flooded, in Topola 2 500 homes and 10,000 ha of crops, in Gornji Milanovac 1000 homes, in Aranđelovac several hundreds of homes. Flood of the Lugomir river has 1 casualty, the Lepenica river 2, the Kalenićka river 1. The torrents ruined several bridges.

Concept of Torrential Flood Risk Management

Torrential flood risk management in narrow sense considers the management of emergency situation triggered by torrential flood, but in broader sense it considers application of measures before and after torrential flood event in order to decrease its impact. In the torrential flood risk management there is a need for integrated approach implying the prevention, response and recovery. The special focus should be on prevention in order to give an adequate response and shorten recovery period. Since torrential floods cannot be hindered, the great attention should be given to the response and recovery measures with the aim of faster overcoming the existing situation. The model of organized and integrated natural risk management with its phases and belonging measures can be found in

Switzerland (Figure 2), where the focus is on two main aims: to reduce the vulnerability and to reduce the damage.

Uncertainty in risk management is present due to risk variability in long-term sense as well as uncertainty in rainfall extreme and flooding forecast in short-term sense (Schumann, 2011). Due to risk changing, there is a need to improve and update the existing torrential flood risk management by revision of risk assessment and improvement of watershed monitoring.

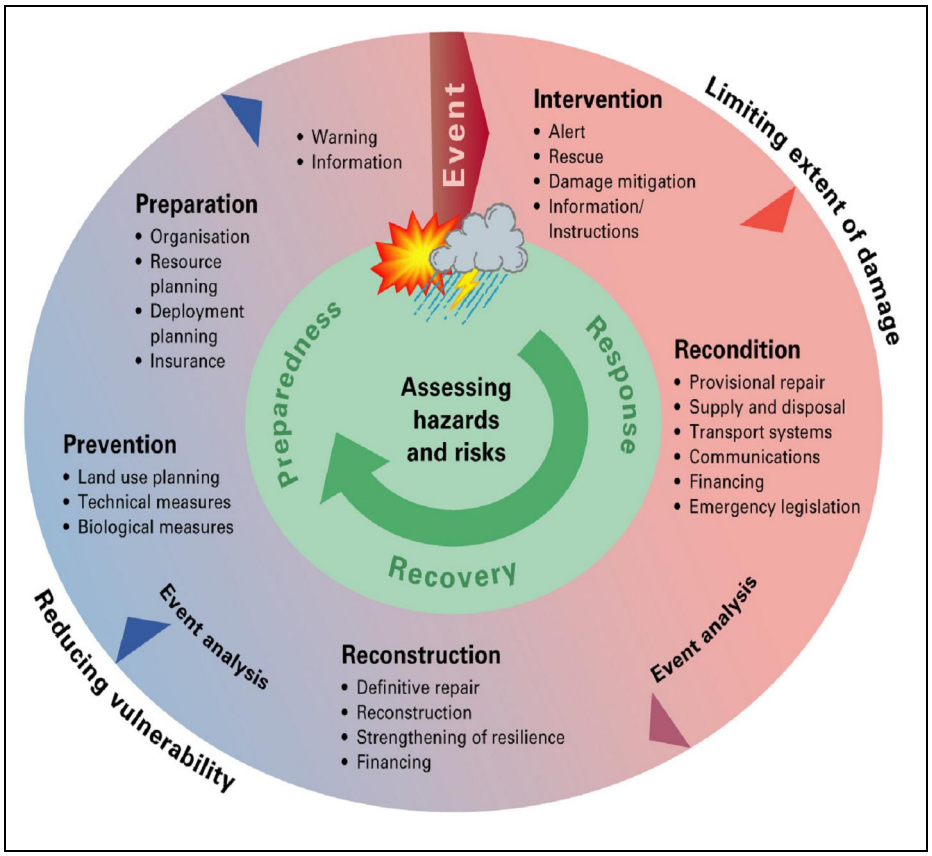

Figure 2. Cycle of integrated natural risk management in Switzerland (Source: Hess & Schmid, 2012)

The torrential flood risk management in Serbia should be based on properly established:

– legal and institutional system

– system of torrential flood control.

Legal and Institutional Framework

Contemporary legislation in water field, beside water use and water protection, regulates the topic of adverse impact of water. The Water Law in Serbia (2010) does not encourage the intensified preventive measures in the torrential flood control. The reason is that financing of torrential watershed control is accredited to the local municipalities which are, however, not capable neither in financial nor in personnel sense. They are requested to create and adopt the Plan of erosion areas proclamation and Operative plan for torrential flood control, but majority of them have not accomplished this mission (Kostadinov & Borisavljević, 2012).

In the Law of emergency management in Serbia (2012), torrential floods are defined as one of triggers for emergency situations. By this act, planning, programming and financing of protection and rescue system in emergency situation are arranged. Product of this law is the National Strategy for Protection and Rescue in Emergency Situations. According to this law, each municipality is obliged to create and adopt two documents: Vulnerability assessment of natural and other disasters and Plan of for protection and rescue in emergency situations. However, likewise for implementation of the Water law, majority of them have not accomplished this mission.

Torrential flood risk management in Serbia is obliged to follow the guidelines of the European Union Flood Directive (2007/60/EC). In the implementation process of the Flood Directive, there are three phases:

1. Preliminary risk assessment (implying the historical information acquisition and data analysis),

2. Flood hazard and risk mapping (implying definition of scenarios for low, medium and high probability of flood occurrence as well as information on number of inhabitants and economic activities potentially affected),

3. Flood risk management plan based on previous two phases (focusing on measures for reduction of potential adverse consequence of flooding). However, all three parts should be reviewed and updated when necessary.

The great contribution to the implementation of the first phase in terms of torrential flood risk management is building the Inventory of torrential floods in Serbia (Petrović et al., 2014). The Inventory should cover the period 1915-2013

in which 848 torrential flood events with over 133 casualties are recorded. On the Inventory level, frequency of torrential flood occurrence within a year shows primary peak in warmer part of year - June and May and secondary peak in colder part of year - March and February; within a period of 99 years a linear increase is perceived. Due to its importance, the Inventory should be integrated in a future unique multi-user database on natural hazards in Serbia. Moreover, it should become a part of the European databases of natural hazards (such as EMDAT and ESWD) considering the obligation to building the infrastructure of spatial data (INSPIRE Directive, Theme - Natural hazard zones).

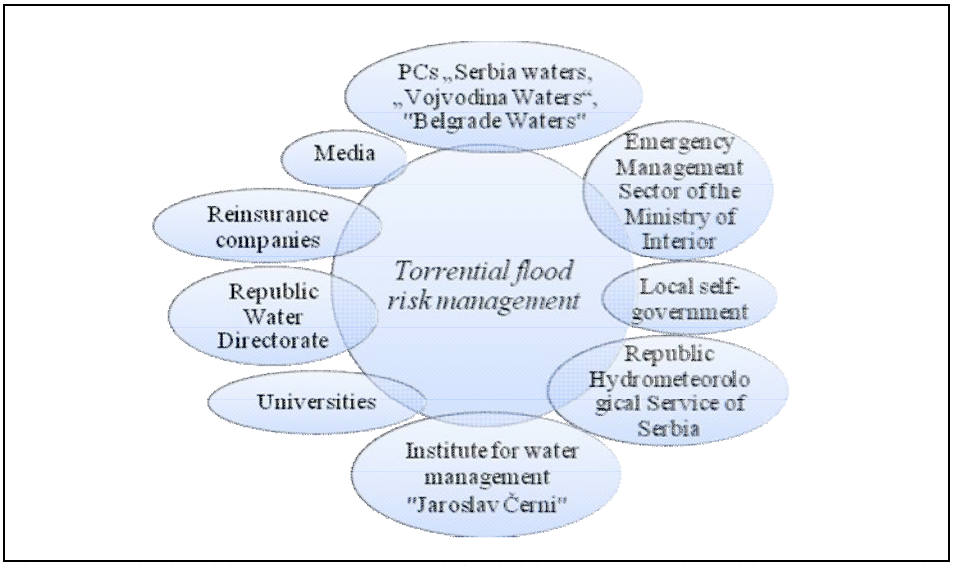

Figure 3. Institutional framework in torrential flood risk management in Serbia (Source: Made by author, 2015)

Torrential flood risk management calls for interdisciplinary knowledge and experience and consequently, the communication of organizations of different profiles. In adaptive torrential flood risk management, there is a need for coordination of research and operative institutions (Figure 3). Framework for cooperation in decision making process make: Republic Hydrometeorological Service (Department of meteorological observation system, Department of hydrological observation system and analysis, Department of hydrometeorological early warning system), Sector for emergency management of the Ministry of Interior (and local emergency management offices), Republic Water Directorate (Department for activities in protection from harmful effects of waters), Public companies "Serbia Waters", "Vojvodina Waters" and "Belgrade Waters" (Department for activities in protection from harmful effects

of waters) and local self-government (implementation of aforementioned laws). Their work in prevention, response and recovery needs to be supported by the expertise of the Universities and Institute for water management "Jaroslav Černi". For example, the expertise of the Faculty of Forestry, the University of Belgrade is a strong support to development of the prevention measures in torrential flood risk management. The formal (e. g. through geography teaching in primary and secondary education) and informal education contributes to the realistic risk perception, strengthening the resilience of population and building a prevention culture (Kovačević Majkić, Milošević, Panić, & Miljanović, 2014). In raising public awareness on torrential flood risk, the national and local media (television, radio, newspapers) have the great role. In developed countries of the European Union, reinsurance companies (such as Munich Re and Swiss Re) are an important link in the torrential flood risk management, providing the financial support to the insured when it comes to damage caused by torrential flood event. In developing countries, when it comes to natural hazard, the state budget is expected to cover material damages of affected citizens. In Serbia, torrential floods mostly affect the poor and undeveloped counties, whose citizens are not aware of insurance benefit or not able to afford the natural hazard insurance for their property. Therefore, the legal entities (industries, commercial companies and banks) are the most frequent clients in the insurance of natural hazards.

The Research of Torrential Flood Phenomenon

In most cases, torrential watersheds have small area, so they are hydrologically unstudied or not sufficiently studied. This means that the discharge or water level monitoring is shorter than 15 years or there were no measurements at all. While the statistic methods of stochastic hydrology are used for studying monitored watersheds, parameteric hydrology methods based on the principle of transformation of effective rain to computational discharge are used for non-monitored torrential watersheds. The complex and combined procedure of computation of maximal discharge probabilities in torrential hydrology consists of synthetic unit hydrograph for computation of maximal unit discharge and SCS method for definition of effective rainfall from total rainfall quantity (Ristić et al., 2009). Additionally, there is a method of reconstruction of torrential flood event on the basis of hydraulic traces and dendrogeomorphic methods.

In torrential flood phenomenon research, field work is of great importance for observation of needed parameter data (morphometry, physical geographical characteristics: geology, soil properties, land use, vegetation, state of erosion and especially identification of indirect and direct factors of torrential flood occurrence). The field work in combination with map and hydrometeorological

data analysis (precipitation, discharge and water level) gives the base for complete study of watershed in which these hydrological hazards occur. In recent decades, the application of software packages (such as SHETRAN, HEC-HMS using GIS) for flood simulation is widespread and a valuable tool in decision making process and emergency proclamation. By hydrological modelling it is possible to:

1. Simulate the answer of watershed when planning the land use changes in watershed,

2. Forecast and announce torrential flood timely in case there are reliable forecast rainfall data, and

3. Define risk zones.

Results of torrential flood research, initiating measures for vulnerability and damage reduction, have scientific and practical importance for the torrential food risk management. Together with this, the results have importance for the local sustainable development.

Torrential Flood Forecast and Warning

Taking in account the sudden occurrence of torrential flood wave, timely forecast is more demanded than in case of floods of the great rivers in Serbia (the Danube, the Sava, the Tisza). The practice show that number of casualties and injured (and in some cases the extent of material damages) is reduced owing to improvement of torrential flood forecast and warning (French, Ing, Von Allmen, & Wood, 1983). There are two types of forecast in case of torrential floods:

– Spatial, long-term and
– Temporal, short-term forecast.

Besides hydrological modelling, meteorological models play a great role in torrential flood forecast and warning in developed countries. Usage of meteorological radar and satellite (such as METEOSAT -7, -8, -9, -10) in last decades for rainfall detection supports this aspect of torrential flood risk management. Torrential flood risk knowledge and development of hydrological and meteorological models are of essential importance for defining the triggers of torrential flood occurrence, the critical rainfall and discharge thresholds, and finally for the purpose of adequate forecast and warning.

On web portal of the RHMS, the section "Warnings and announcements" is given for the public use. On web portal of Sector of Emergency Management, guidelines for handling with emergency situation and map with natural hazard information are published. However, the improvement and more interactive communication with possibly affected population seem to be imperative.

What can be really done? Torrential Flood Control

The torrential flood phenomenon cannot be fully controlled. However, the adverse effects can be significantly decreased. Contemporary frequency of torrential flood occurrence, as a consequence of climate extremes, requires permanent improvement and upgrading the prevention and protection from adverse effect of floods (Kostadinov et al., 2014a).

Recent practice in Serbia in the part of water management – protection from adverse impact of water, was based on principle "fight against floods" by investing in water reservoirs and dam building, river regulations in order to insure the safety of people in hazardous zones. Contemporary trend, called "live with floods", is integrated in concept of sustainable development, considering the actual state of flood protection, economical strength and respect of ecological principles.

In torrential flood risk reduction essential role plays realization of two groups of control works in watersheds: technical (longitudinal and transversal works in torrential riverbeds) and biological works (forestation, grassing, razing of orchards, shelterbelts, wickers and terraces on slopes) (Kostadinov & Borisavljević, 2012). Although there is a practice of torrent control lasting more than 100 years with phases of different dynamics, the efficacy of accomplished works ($1{,}5 \times 10^6$ m^3 technical and 1 210 km^2 biological) are reduced since they have not been kept preserved. The extent of new works in recent decades is poor and at the same time the torrential flood frequency is intensified.

In the context of recent fatal flood events in Serbia, torrent researchers call for establishing two main conditions. The first one is adequate state directive on soil erosion and torrent control. The second one is stabile sources of financing of torrent control works (Kostadinov & Petrović, 2013; Kostadinov, Košanin, Petrović, & Milčanović, 2013).

Conclusion

Instead of partial solutions for flood protection, integrated torrential flood risk management is more meaningful and effective. In the concept of the integrated

watershed management, through coordinated activities in agriculture, forestry, water management, transport and industry, and identification of the specific pressures, the aim is to protect the watershed ecosystem (Borisavljević, 2009; Borisavljević & Kostadinov, 2012). In the case of torrential watersheds, torrential hydrological and sediment transport regime and their off-site and on-site effects, soil erosion, landslides, and mudflow are to be defined as special pressures. The coordinated activities in this direction are to

– Improve the legal framework and
– Provide the expansion of technical and biological torrent control works in hydrological network and on watershed slopes,

in order to ensure the safety for local population and their property, environment protection and local sustainable development. When the torrential flood event occurs, consequences for society can be significantly reduced if:

– There is an efficient forecast and timely warning, good coordination of the Sector for Emergency Management in rescue and evacuation and
– Affected population is educated about flood risks and measures which can be undertaken in case of emergency situation.

The fatal torrential floods in April, May and September 2014 with catastrophic material damages and death tolls should be an alert for significant improvements in torrential flood risk management in Serbia (Petrović, Dragićević, Radić, & Milanović, 2015).

Acknowledgements
This paper is a part of the project 47007 III, grant of Ministry of Education, Science and Technological Development of the Republic of Serbia.

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