MAY 2014 FLOODS IN SERBIA

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Abstract

In the middle of May 2014, a low-pressure area "Yvette" affected a large area of South-eastern and Central Europe. Some parts of the most affected countries, Serbia, Bosnia and Herzegovina and eastern Croatia, experienced a three-months amount of rain in just three days. Since the soil was already saturated due to intensive rainfalls in April and the beginning of May, the later event caused flash floods, erosion and landslides along small watercourses, but also disastrous flooding on right tributaries and the Sava River main course.

The flooding and landslides caused loss of human lives, and high amount of damages, especially to the housing, economic activities and infrastructure. While the damage assessment took place immediately after the flooding, the analysis of the flooding patterns in Serbia is still ongoing.

This paper gives description of the source of flooding, which was an intensive precipitation, of the current state of the analysis of the affected areas in the flooding events in the middle of May at the territory of the Republic of Serbia, and of the follow up activities triggered by this extreme situation.

Key Words: Floods, May 2014, Serbia

SOURCE OF FLOOD

A low pressure system, named Yvette, developed over the Adriatic Sea on May 13, as polar air from Central Europe penetrated into the Mediterranean basin. The cold polar air mass met with humid subtropical air, leading to very low pressure. Meteorologists often describe this weather phenomenon as a Genoa Cyclogenesis. In May 2014, the centre of the cyclone moved from a Genoese bay over the Apennines, southern Adriatic, south of Serbia, Bulgaria and Romania. The most common path that Genoese cyclones has is in the direction of the Black Sea, where they usually finally diminish (Nišavić et al, 2014). In this case, Yvette has departed from usual path and made an elliptic loop over the south-eastern part of the Pannonian Plain. The cyclone moved very slowly (Figure 1), generating extremely high precipitation rates over Southeast Europe and the Eastern Alpine Region.

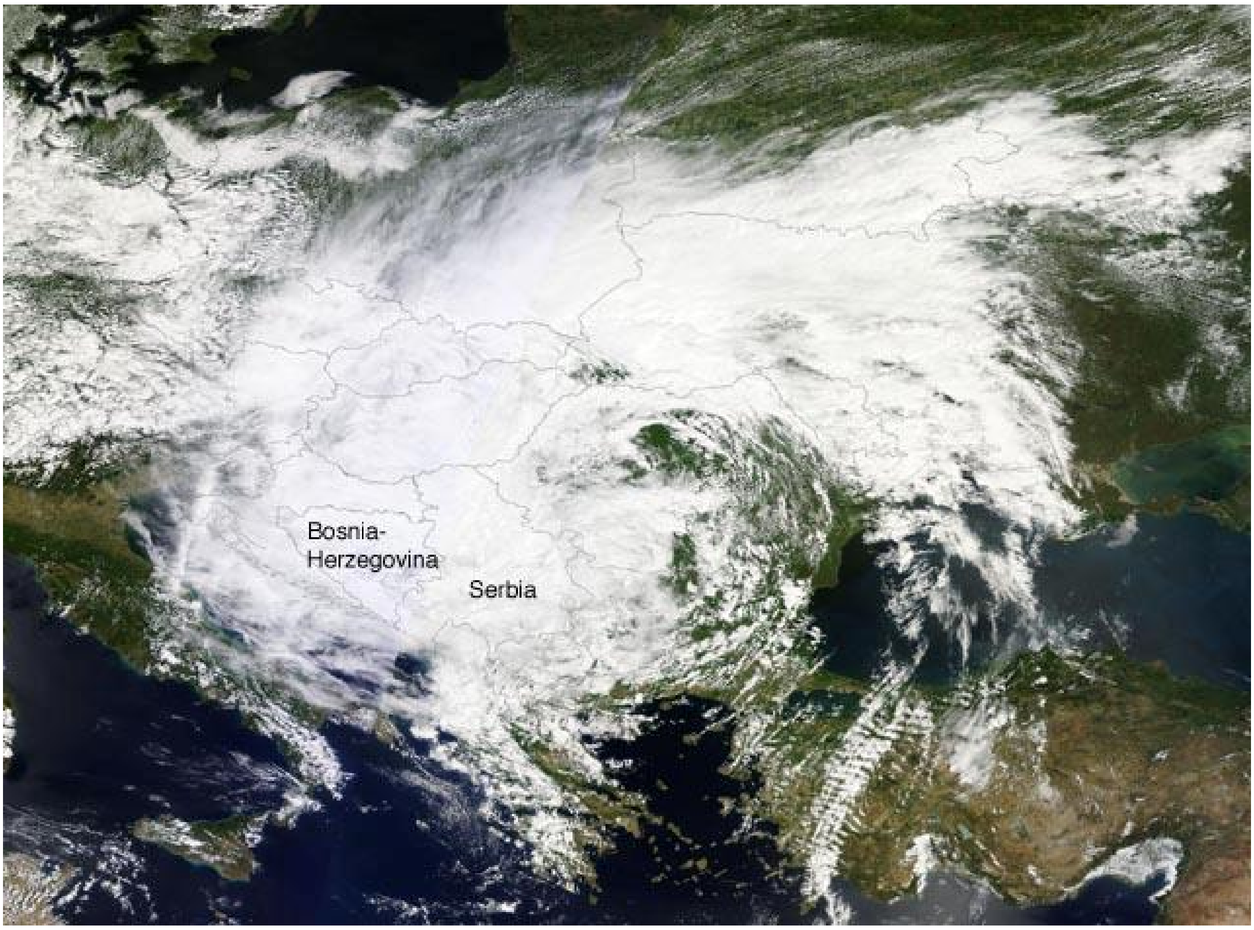

Figure 1. Cyclone Yvette on May 15, 2015 (source: NASA)

The highest amount of rain was recorded in period 14-16 May 2014. Western and central parts of Serbia were the most affected, with three-day precipitation exceeding the average values for the month of May. Parts of the Drina and the Kolubara river basins were affected by rainfall which exceeded 1000-year three-day rains (Figure 2). The situation was additionally aggravated due to extreme soil moisture (Figure 3), which was a consequence of rains in April and beginning of May.

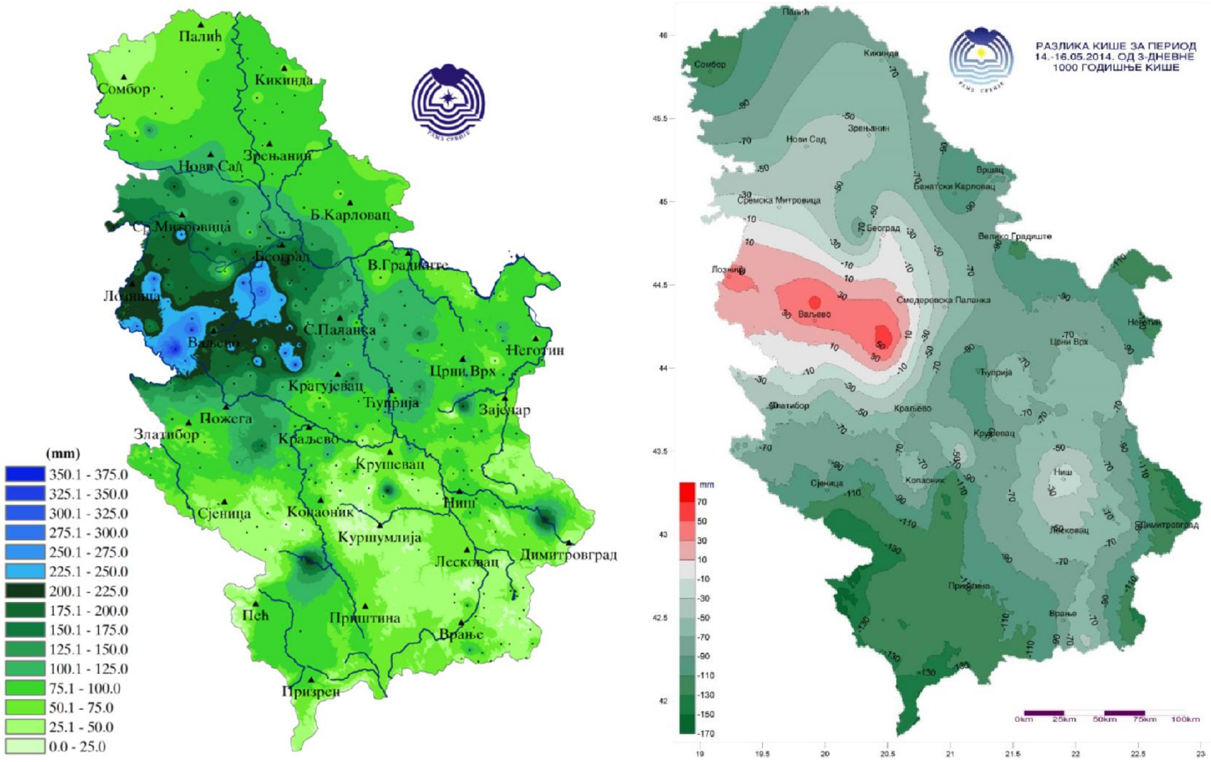

Figure 2. Spatial distribution of the three-day rainfall (left) and deviation of the three-day rainfall sum from the statistical 1000-year three-day rainfall, May 14-16, 2014 (source: Republic Hydrometeorological Service of Serbia)

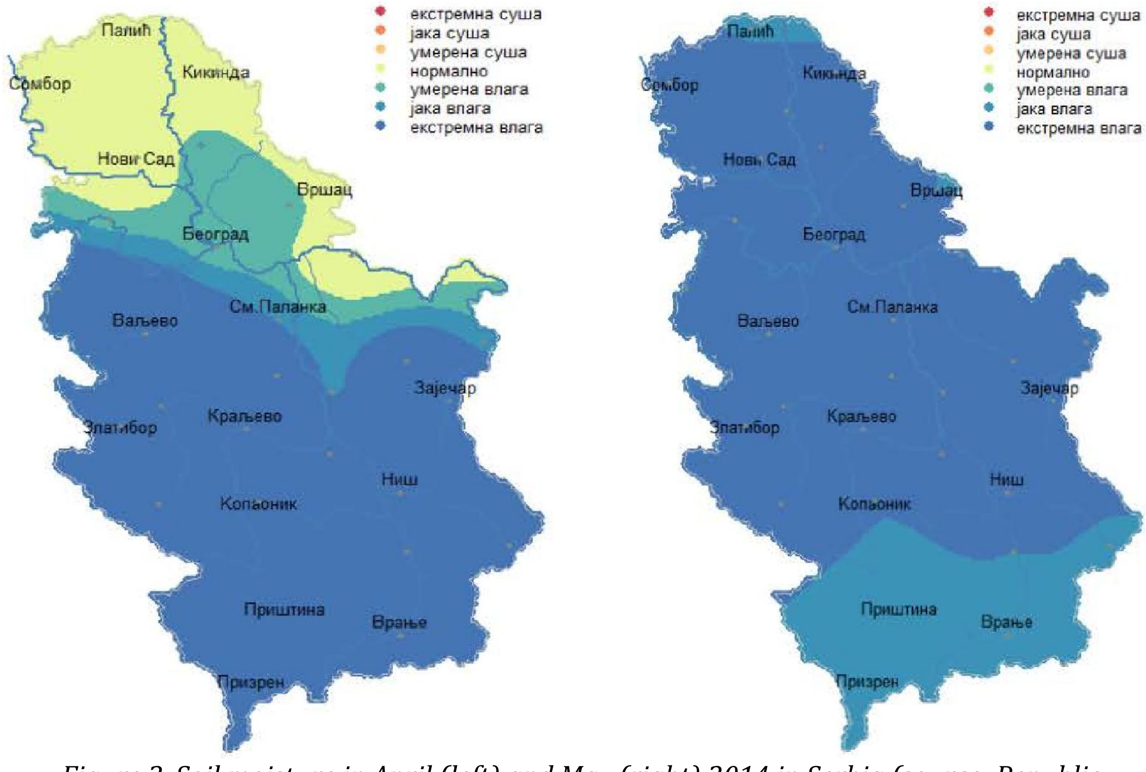

Figure 3. Soil moisture in April (left) and May (right) 2014 in Serbia (source: Republic Hydrometeorological Service of Serbia)

Serbia's river network is dense, with thousands of small torrential streams in the hilly and mountainous parts of the country, numerous rivers of various sizes, and several major lowland rivers.

Torrential streams are generally not trained or there are only local structural flood defences in place. Although flash floods affect smaller areas of land than floods on large rivers, they pose a considerable danger and sometimes lead to human casualties. This is a consequence of their rapid onset (which limits the warning and response time), high flow velocity, and transport of river sediment and debris.

Due to the high intensity of rainfall that affected large areas and because the ground was already saturated by previous rainfall events, in May 2014 the floods on nearly all rivers in western and central Serbia were torrential in nature.

The heavy rainfalls triggered almost immediate reaction of the smaller river basins. The first to swell were small torrential rivers in western Serbia, which registered extremely high flow velocities and large-scale sediment transport. The most notable example was the flood in Krupanj, which was flooded by several small torrential streams in a very short time; the trained sections of the channels were ruined and covered with enormous amounts of sediment, while many landslides were activated.

Medium-size rivers in western and central Serbia had exceptionally high flows that overtopped or breached flood defences in many places. The catchment area of the Kolubara River, suffered the greatest damage on settlements, infrastructure and farmland. Medium-size watercourses in the Velika Morava River basin, as well as the Mlava River, were also affected.

As for the large rivers, a dangerous situation occurred on the Sava. Due to a concentration of extreme flood waves on the right tributaries of the Sava in Bosnia and Herzegovina (especially the Bosnia River that measured the highest discharge on record), the stages at Sremska Mitrovica and Šabac rapidly reached record levels, some 70 cm higher than the previous 1974 and 1981 extremes. Only a short time was available to organize and implement flood defense measures, where needed, to prevent flooding of the riparian lands and a number of cities. However, there were two extenuating circumstances in that difficult situation. The embankments along the right bank of the Sava in Bosnia, and along the left bank in Croatia, were breached immediately upstream of the border with Serbia. Inundation of the floodplain lowered the peak of floodwave and consequently the water levels of the Sava in Serbia. Also, the upper part of the Drina River basin and the catchment area of the Lim were not hit by extreme rainfall, and therefore did not contribute dramatically on the Sava peak flow (Babić Mladenović and Kolarov, 2014).

AFFECTED AREAS

Floods of May 2014 proved the proper identification of the Areas with Potential Significant Flood Risk (APSFR), as the result of the Preliminary Flood Risk Assessment, which was completed in 2012 for the territory of the Republic of Serbia. 99 APSFRs were identified along 95 rivers. Figure 4 shows those APSFRs which were affected by the May 2014 floods. Floods occurred along other rivers, which were not identified as APSFRs in 2012, as well. The significance of the damage caused by floods along these rivers shall be further analysed and in the following planning cycle the list of APSFRs may be amended.

Figure 4. Areas with Potential Significant Flood Risk (source: IJC, 2011), and those affected by the May 2014 floods

SOME EXAMPLES

The Jaroslav Černi Institute has been working on the analysis of the efficiency of flood defence structures and measures implemented during the events, identification of mechanisms and flood extents, where available, for the entire territory of Serbia. Besides, more detailed expert opinions are prepared for the most affected areas, as the Mačva region, the Jadar River, and the towns of Valjevo, Svilajnac and Paraćin. Hydraulic reconstruction of floodwaves is conducted to give more answers to the amounts of water that, obviously, exceeded the flood protection system.

Paraćin is a good example of a town where a small river, the Crnica, caused considerable damage. The expert opinion was prepared by the Jaroslav Cerni Institute in March 2015, and it included hydrological and hydraulic computations, as well as proposal of future actions. The conclusion was that, although the river was trained within the town (design flood is 180 m^3/s), the channel was overtopped because it did not have sufficient capacity to convey flood waters, especially near bridges. Hydraulic reconstruction revealed that peak of May 2014 flood was 260 m^3/s. The upgrade of flood protection system is planned for near future, and it will encompass elevation of banks along the river and use of flood retention ponds upstream of the city.

Figure 5: Scenes from the 2014 flood in Paraćin

The catchment area of the Kolubara River suffered the greatest damage in May 2014. The Kolubara basin experienced multiple devastating floods over the past twenty years (in the near past in 2001, 2006 and 2010 in the catchment area of the Kolubara, and especially in 1999, 2006 and 2009 in the catchment area of its major tributary - the Tamnava River). Even though, the most recent flood in 2014 was exceptional in terms of both human casualties and the extent of damage.

In general, the geomorphological and hydrological characteristics of the Kolubara River catchment area are such that it is especially prone to the formation of enormous flood waves. At present only a few small river reservoirs and retention basins exist in this river basin; the only significant reservoir (Rovni) is currently under construction. The capacities of the existing reservoirs and retention basins for flood wave attenuation are relatively modest.

The central part of the Kolubara River basin hosts the Kolubara Coal Mining Complex, comprised of open-pit mines and associated infrastructure. The importance of the mining operations with regard to flood risk management in the Kolubara basin is twofold. Namely, they are of major significance to Serbia's stable electric power supply, meaning that a high level of flood protection is necessary; on the other hand, they affect the flood regime downstream. In this context, the City of Obrenovac is especially sensitive, as it is located at the downstream part of the river basin, on low-lying ground and in highly complex hydrographic conditions (confluence of the Kolubara and Sava rivers).

In May 2014, numerous tributaries of the Kolubara had extremely high flows and the flood caused damage to settlements, infrastructure and farmland. At the Kolubara River, the flood defenses within the City of Valjevo sustained considerable damage (with minor overtopping in the city center), the bridges were either damaged or destroyed, and the open pit coal mine "Tamnava – West Field" was flooded with some 200 million m^3 of water.

The entire City of Obrenovac, was flooded because the dikes were breached some ten kilometers upstream from the city. In parts of the flooded area, the flood waters were several meters deep. When the Sava levee failed at two locations, the water from the flooded area gravitated to the Sava as much as possible due to a highly unfavorable configuration of the terrain on which the city is located. Namely, some residential areas are situated on very low-lying land – abandoned branches of the Sava and the Kolubara, from which flood water had to be pumped.

Figure 6: Scenes from the 2014 flood in the Kolubara river basin (left: flooded "Tamnava – West Field", right: flood in Obrenovac)

This flood in Kolubara river basin was extraordinary in terms of both peak and volume. Given all disastrous consequences, a new flood risk management strategy needs to be promptly developed. As the first step towards it, a comprehensive and broad-based study on flood issues should be done. It should assess the flood risk and flood protection measures from hydrological, economic, social and technical perspectives, providing groundwork for the development of an appropriate strategy for the future that will identify needed structural and non-structural measures, which will maximize flood protection effectiveness at a reasonable cost.

FLOOD DAMAGE ASSESSMENT

The Government of the Republic of Serbia has conducted a post-disaster needs assessment to estimate damages and losses, as well as the financial requirements to undertake recovery and reconstruction. The World Bank methodology was used.

The assessment revealed that the total effects of the disaster in the 24 affected municipalities amounts to EUR 1,525 million, of which EUR 885 million (57% of the total effects) represent the value of destroyed physical assets, and EUR 640 million (43% of the total) refer to losses in production. When considering the additional affected municipalities, the total value of disaster effects was estimated to EUR 1.7 billion (GRS, 2014). Figure 7 presents damage assessment per municipality, using data of the Government, municipalities and other.

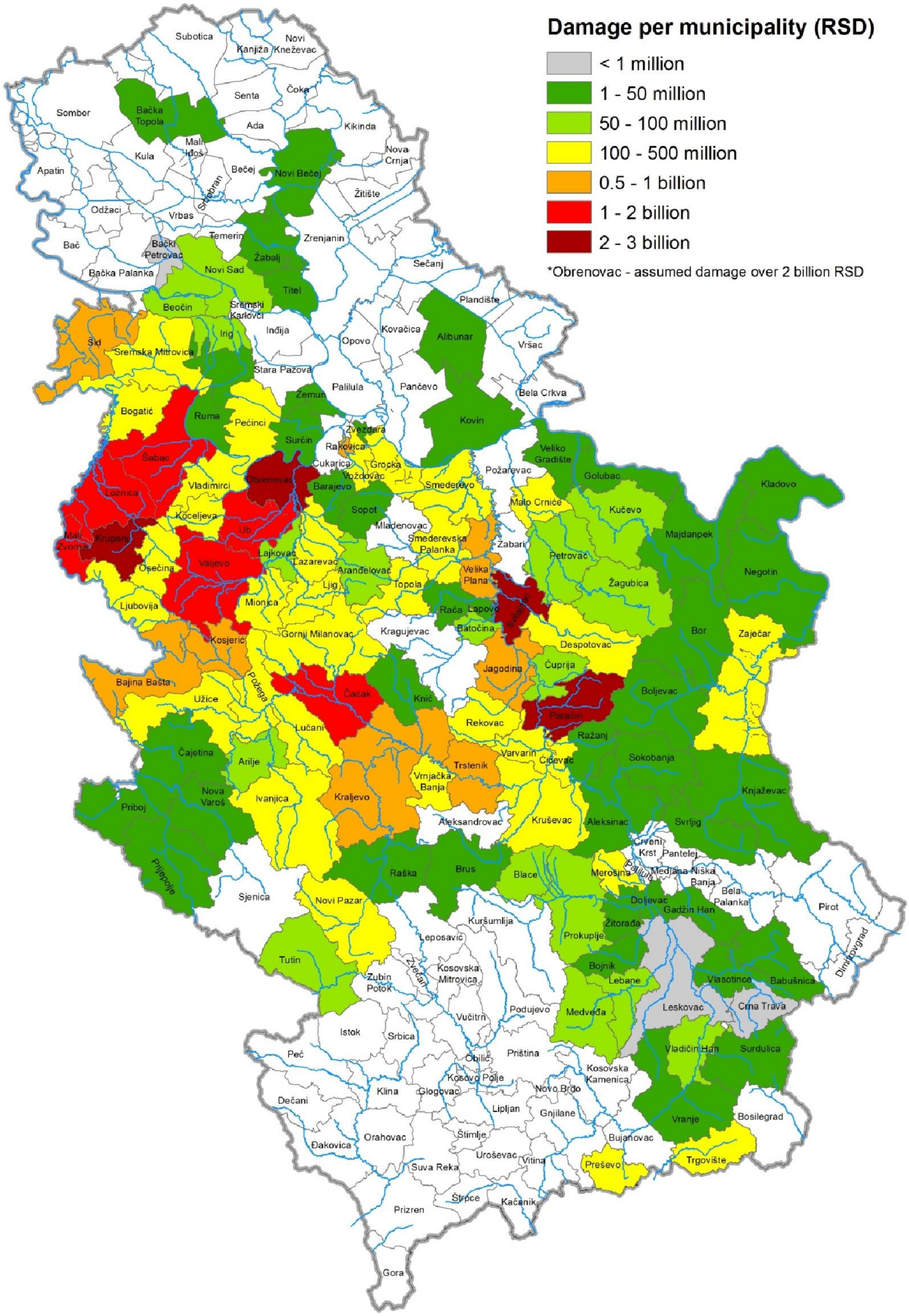

Figure 7. Damage caused by floods in May 2014 per municipality

FUTURE ACTIONS

Flood risk management is a cyclic process, comprised of three stages: response to a flood event, recovery, and preparedness for the next event. After the disastrous 2014 flood and following necessary repairs of flood defences, there will be an opportunity to define an appropriate set of preventative measures for each river basin, and to implement such measures in the coming years.

Serbia intends to enact its national Flood Risk Management Plan by the year 2017, which shall include measures to achieve sustainable flood management. The water sector is primarily responsible for planning and implementing preventative measures, including river training and construction of river flood and inland flood protection systems, as well as erosion control and flash-flood protection. Flood protection solutions need to be based on contemporary global approaches and the condition of existing systems, while the implementation timeframe will depend on the economic strength of society.

The level of flood protection that these structures should ensure depends on technical, economic, environmental, social and other criteria, conditions and constraints. It is defined for each system or flood cell (protected floodplain), based on the population residing there and the extent of potential damage. The level of flood protection provided by structures is equal to the respective design flood return period. However, climate change and anthropogenic impacts are modifying the conditions for the formation of high flows and the characteristics of floods, such that design river discharges no longer fall into an unchangeable category. In order to ensure an appropriate level of flood protection, additional measures and works are needed, such as mobile flood protection systems for the cities and reconstruction of existing structures.

Permanent structures designed for a flood return period of up to 100 years are recommended for protection of cities with more than 20,000 inhabitants, and of major industrial zones, but along with additional protection (mobile flood barriers) from floods with a return period of 500 or 1000 years (for large cities such as Belgrade).

Flood protection also needs to be provided for smaller settlements and top-quality farmland, but the level of protection can be lower. Other types of farmland should be protected only from smaller flood waves, and large areas of land should be left in their natural state, to be able to accommodate a part of the flood waters.

Retention ponds need to be formed on less valuable land (forests and farmland) along transboundary rivers (the Sava and the Danube), to reduce flood wave peaks originating in upstream countries.

Flood protection along smaller rivers needs to be significantly upgraded in the coming years, given the potential deterioration of high-flow regimes due to climate change. In that context, active flood protection measures need to be promoted as much as possible, including reservoirs and retention ponds, to attenuate flood waves. Apart from such measures, timely warning and evacuation of people and assets will remain an important flood protection activity.

Inappropriate use of water land (high flow channel or "real" flood-prone area) and potentially flooded areas (protected by dikes), is a major cause of damage in our region. This requires flood hazard and flood risk maps to be produced, water land designated and entered into land registries and spatial plans, and oversight of its use provided. In order to protect human lives and property, regulations should be put in place to prohibit any new construction in floodways. Also, through special conditions and permits, any further flood risk increase in areas potentially threatened by floods (protected floodplains) should be restricted.

Infrastructure, especially bridges, sustained enormous damage from the 2014 flood. In the coming years, new bridges should be designed and constructed so that they do not act as obstacles to high flows, while undersized bridges should be reconstructed.

Construction of dikes and other structures is not sufficient for effective protection of people and property. In accordance with the sustainable development concept in flood protection, future flood protection in Serbia can only be achieved through an adequate combination of structural and non-structural measures.

Non-structural flood protection measures should gradually be introduced in Serbia: (a) Initial phase encompasses compilation and preparation of background information and groundwork (e.g. risk maps, plans, regulations); (b) Phase of the implementation of non-structural flood protection measures (installation of alarm systems, training of response services and the population, etc.); and (c) Phase of application of non-structural measures that include ongoing evaluation, elaboration and improvement.

Integrated basin-wide flood protection is the underlying postulate, since only an integrated approach will ensure technically feasible, economically and environmentally viable, and sustainable flood protection solutions (Babić Mladenović and Kolarov, 2014).

CONCLUSIONS

Each large flood in the past pointed out weak points and had initiated reconstruction of flood protection system. Affecting a large area, the flood of May 2014 showed the need for improvement of system for protection from erosion and torrents, river floods and, excess groundwater and precipitation. Further on, it emphasised the need for cooperation of different sectors involved in flood defence, as well as the need for international cooperation with neighbouring countries.

Flood protection system, considering all types of floods, has lacked maintenance and investments in a long past period. The flood of May 2014 showed that damage can exceed such costs. Even worse, many human lives were lost and they call for urgent attention to the entire system of flood defence.

In the national Flood Risk Management Plan, which due is end of 2017, Serbia will present all measures related to planning and implementing preventative measures, including river training and construction of river flood and inland flood protection systems, as well as erosion and torrent control.

Further cooperation with other sectors involved in flood protection will be better defined after launching the National Disaster Risk Management Program. Its goal is to build an adequate long-term system of natural disaster risk management in the country, and it will entail the cooperation of different institutions working together towards minimizing risks and a more efficient response to natural disasters.

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