Local Communities and Challenges of Torrential Floods

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Manual for local communities and civil society organisations

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Contents

Foreword I

Cataclysm in Serbia!
Floods cause massive destruction - where to flee? Krupanj is destroyed by a huge torrential flow. Torrent in Tekija destroys everything before it. Floods in 2014 affected 1,6 million people in Serbia, 32,000 people were evacuated from their homes, 5,000 required temporary shelter in camps, health facilities, schools and agricultural land was heavily affected. Total damages and losses were estimated as 1,525 billion Euros. On 15 May the Government declared a state of emergency for its entire territory.

Do we still want to read this type of news and reports? Flooding is generally accepted as a natural phenomenon that cannot be completely controlled. Are we going to settle with fate or bartender ways to deal with the disaster?
NO! We can do something to minimize flood hazard and risk. We can do something to face torrential hazards.
So, what we can do? We need systemic, not sporadic decisions.
In a context of rapid urbanization and climate changes, the occurrence of intense hydrological events will increase. Since the last decade of the 20th century, hazards caused by hydrological phenomenon in the Balkans have become increasingly serious, resulting in negative impact to the population, economy, natural and cultural heritage.
The Manual: "Local communities and challenges of torrential floods", is comprised of the following chapters including: Introduction to Challenges of Torrential Floods; Erosion and Erosive Areas; Historical overview of erosion and torrent control; Torrents; Floods; Flood Risk; Obligations and Possibilities for Local Self-governments and the Role of Civil Society Organizations in Flood Issues.
The Manual is a unique document that highlights the strategic importance of the role of local authorities in creating "flood resilient communities". A section of the Manual is dedicated to engaging the civil society in raising awareness of local communities in disaster risk reduction and the importance of their co-operation and partnership with elected officials, to create a "culture of preparedness". The Manual is intended to be a straight-forward resource which allows the user to enforce plans and policies, with minimum effort, for most torrential floods risk management schemes.
I'd like to congratulate the authors for developing the Manual. I hope its content will be an inspiration for the readers and will prompt their engagement in torrential risk management – especially at local level and contribute to mitigating torrential and erosion risks. This Manual could also be used beyond the borders of Serbia, considering that the entire Balkan region is faced with a common problem – torrential floods.

Good luck!

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II

Dear reader, the fact that you have taken this publication into your hands and intend to view its content fills me with great pleasure and expectation. It is written for each one of us, in other words - for the good of the people. In my humble opinion, you are holding (or browsing an e-version), an honest and open call to all of us to cooperate and make progress in the field of protection against floods, torrents and erosion in Serbia, and beyond. I also hope it will be accepted as a source of further inspiration and ideas on the demanding path of establishing our sustainable coexistence in a given natural environment.

Of course, it is difficult not to mention the disastrous floods in May 2014, the consequences of which, Serbia will have to cope with for a long time, as its toll was the loss of human lives, which is incomparable to any other damage. I wish to express my sincere condolences to the families of the victims and appeal to all of you to draw lessons from this experience, which the affected communities in Serbia have paid a heavy price for. It is time to jointly take advantage of this opportunity to improve practices, at state and local levels, for future flood events in the field of prevention, preparedness, response and reconstruction.

The four aforementioned activities, present a well-known axis that describes the concept of integrated risk management. For many people, especially for residents in flood-prone areas, it may sound like a phrase, repeatedly uttered by numerous national and international experts and officials. Currently; however, it is unanimously recognized as the only possible way ahead that requires the use of all available and coordinating activities for prevention or mitigation of a potential natural disaster. The mission of all of us dealing with flood protection is to bring this integrated strategy to life, through risk communication and risk dialogue. And how can we achieve this? Every page of the Manual describes it!

The authors remind us that we live in a constantly changing environment, subject to an array of varying conditions, both natural (geomorphological changes) and human (land use); however, certain natural laws remain unchanged, particularly those related to flooding, torrential and erosion processes. These processes and phenomena are sporadic and not fully predictable. Their causes can be human (urban construction), or environmental (weather conditions). Due to the multiplicity of factors affecting such events it is not and can not be an exact science that guarantees the safety of individuals and property. However, by applying sound engineering principles that provide a predictable range of parameters and by implementing well-designed protection measures, that will take into account the remaining residual risk and possibility of overloading cases (e.g. due to undesired climate change scenarios), by continuously enforcing life-cycle management practices, inspection and maintenance of implemented measures, the risks of injury and loss of property can be significantly reduced.

The Manual places particular emphasis on torrential and erosion processes and phenomena. Even during the recent catastrophic floods these events were the cause of more than half of the total dam-

age. Due to their specificity, especially because they are difficult to predict at local level, these are rapidly developing processes with very short warning time, thus the possibility to act before the event represents a significant risk to human life and requires a specific approach, unlike management of flooding of large rivers. The Manual offers a number of practical, tested solutions that successfully address this problem. Of course, we aren't at the very beginning of the process. Protection from torrents and erosion has a long standing history in the former state of Yugoslavia, especially in Serbia. The floods in 2014 reaffirmed our belief that the concept of "living with torrents" requires continuous and consistent systematic implementation of adequate preventive and preparedness measures.
And finally, the common thread are people, residents of local communities, members of civil associations, experts, decision-makers at local and national levels. All we need in the aforementioned current and projected solutions for flood risk reduction is to recognize the challenge and, above all, a great deal of patience, mutual respect among communities at risk and cooperation in the search for synergies to improve the current situation. In this way we will achieve that our descendants inherit a more secure living space and a better governed system of protection against natural disasters.
Full protection against natural disasters can't be achieved. There is always some risk which has to be assumed by either the society or an individual, which is why early warning, awareness-raising and public education regarding natural hazards and possibilities for self-protection are of the utmost importance.
Of course, the Manual does not provide answers and solutions to all the challenges - such a publication do not exist - but it certainly provides a comprehensive overview of the flood and torrential issues and contemporary overview of practical, daily enforcement of integrated flood, torrential and erosion risk management practices. I am therefore certain that it represents valuable practical support and guidance, especially for local communities and interested civic associations, and all other actors in Serbia, which contribute, within their competence, to this field, seeking to make further progress in reducing the risk of disasters.
Maybe this is not a usual foreword. I wrote it while I was still under the strong impression of the consequences of the floods in May 2014 that also hit Bosnia and Herzegovina, where I spent 18 days assessing the damage and drawing up recovery needs plans and handled other information regarding the scope of damage and consequent losses in Serbia and other affected countries, including Slovenia. Nowhere is the state of field prevention perfect. An important development factor, propelling this area in recent years, is without doubt the EU Flood Directive from 2007. Also, the EU Civil Protection Mechanism contributes significantly to a more comprehensive and cooperative approach in Flood Risk Management. If there is a field where the flow of ideas, knowledge, experience and mutual assistance is so open and borderless, it's flood risk management. Together we can do more; of course; however, each one of us needs to do their "homework" first, and this publication is a practical guide on how to achieve this.
I congratulate the authors for their outstanding work; I hope the readers are prompted to take active participation in flood risk management practices, especially at local level, to mitigate torrential and erosion risks. I wish all the best to the entire Serbian nation: "May you enjoy a long floodless period that will allow you to implement recommendations from this Manual before the next flooding event occurs".

Good luck!

Jože Papež*, **
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III

The devastating floods that hit Serbia in May 2014 reinvigorated public discourse on the necessity of introducing programs to prevent and ameliorate the effects of natural disasters at the local level as well as raise awareness among local communities that are affected by such disasters.

The goal of the program activities is to develop resilient communities which are empowered to better respond to natural disasters. To achieve this goal, it is necessary to increase public awareness of the importance of risk preparedness as a means for effectively responding to natural disasters. This requires the development of a system of prevention as well as a systematic approach to risk analysis and vulnerability to disasters.

The Organization for Security and Co-operation (OSCE) views security in a comprehensive way, thereby addressing issues related to environmental protection from a security perspective. In line with the need to bolster local authorities' knowledge of flood risk reduction and the accompanying legal framework, the OSCE Mission to Serbia organized training sessions which engaged leading national flood protection experts. The Mission also supported the development of this Manual, which represents a key component of the training.

Through a historical review of the most significant torrential floods and existing strategies for flood management, as well as an examination of the legislative framework that prescribes the competencies of local self-government units in preventing and managing flood risks, the Manual highlights the strategic importance and role that local authorities have in creating "communities resilient to floods". A specific chapter of the Manual is dedicated to ways of linking civil society organizations with elected officials in order to raise awareness in local communities of building a "culture of preparedness".

Over the past several decades, practices have shown that communities that are prepared "bend but don't break" when disaster hits. We are confident that this Manual will assist local authorities in formulating adequate and necessary local risk responses.

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1. Introduction to Challenges of Torrential Floods

Floods in large rivers and torrential floods are the most common natural disasters in Serbia, the reason being the position and terrain of Serbia. This is why the defence against these natural disasters has been organised institutionally ever since the 19th century. The state, through its specialised agencies and public enterprises, organised defence against floods in large rivers and protection of international and other major roads.

The local self-government has always had a role in the system of flood control, from participation in the national system of protection against large-river flooding to torrential flood control in its territory. This involvement has grown steadily in line with the development of vulnerable infrastructure and facilities under direct administration of local self-government.

The existing protection system has weakened due to the increase in the number of unprotected facilities, lack of funds for the construction of new protection systems and the maintenance of existing ones. In spite of this fact, the existing flood and torrent protection system withstood the catastrophic flood caused by the Danube in 2006. The question is: what are the limits of the protective capacity of the existing system?

In Serbia, the Law on Waters and corresponding by-laws prescribe the obligation of local self-governments in the field of flood defence. There have been numerous problems in complying with this obligation due to deficiencies in the legislation that excluded the occurrence of torrential flooding, while assigning too many responsibilities to local communities. At the same time, training in protection against floods and torrential floods has been reduced to a negligible level. The occurrence of torrential floods or torrents requires full readiness and organisation of this complex activity at the local level.

In Serbia, there is neither a local self-government nor an individual who has missed the experience of flooding or torrential floods, because these kinds of natural disasters occurred rather frequently in the past.

The role of local self-government in flood protection is of the utmost importance, and a well-designed organisation and clear division of responsibilities in the preparation and implementation of defence may significantly reduce the risk of enormous damage and human casualties.

The Law on Emergency Situations of the Republic of Serbia (*Official Gazette of RS*, no. 111/09) defines more precisely the role of all public administration actors during emergencies. The role of local self-governments in responding to emergencies, including flooding as regular occurrence, has been clearly defined.

Emergence of floods and torrents

River floods are natural phenomena that go far beyond the framework of water management and water engineering. It is known that rivers and floods have had a significant impact on the development of human society throughout history of humankind. River flooding and inundation of river valleys are among the oldest human experiences, as well as their antipode - drought. Floods in large rivers continue to bring fertility to soil nowadays. In many countries there are ritual ceremonies that celebrate the return of the annual cycle of floods and when floods are late or absent, there is hunger and suffering of people and domestic animals. Today it is necessary to bear in mind that global and climate changes are among the greatest challenges of our time. Floods caused by heavy regional rainfall are becoming more frequent, more intense and can exceed the recorded disastrous floods.

On the other hand, torrents are a result of high-intensity rain falling from clouds known as cumulonimbuses, which also cause hailstorms. Hail affects a relatively narrow area of 100 m to 300 m, while rain from these clouds covers an area of 10 km^2 to 30 km^2. An alarming issue is the emergence of cumulonimbus cloud systems that cover areas greater than 600 km^2, with extremely high amounts of precipitation in a short timeframe (1-5 hours), which would be more typical for tropical climates. In a very short period of time, such rainfall turns relatively large rivers into destructive torrents that, aside from destroying everything in their way, cause human casualties.

Numerous methods and types of facilities have been developed for the regulation of rivers and torrents, increasing their protection efficiency over time. This does not mean that the hazard of torrents and floods has been eliminated. It has only been reduced, and there is always a probability of an event that will surpass the capacity of the constructed protection system.

Given the prevalence of hilly and mountainous areas in Serbia and a developed hydrographic network, torrential floods occur very often, almost every year. It is known that large amounts of water appear in the upper part of a basin, while flooding happens in river valleys, in the downstream reaches. In this regard, it should be noted that the lower parts of most torrential streams in Serbia, with developed river valleys, have considerable social and economic importance. Large numbers of urban and rural settlements are located in the valleys, as well as important transport infrastructure. Most river valleys are used for agricultural purposes, while industrial zones are often found near these settlements. This means that floods impose a hazard to valuable property in adjacent areas - settlements, roads, agriculture and industry.

One should bear in mind that the notion of floods has a much broader meaning in the context of torrential floods than in the context of floods in large rivers. Hence, it is more appropriate to use the term "torrential processes" than floods, because it is indeed a set of phenomena that appear in torrential streams and riverbanks, during which a surge of large flood waves sequentially occurs. In addition to the usual manifestation of flooding (due to a high water overflow from riverbeds), the phenomena of torrential lava flows, rockfall and landslide occur simultaneously. The torrential waves are associated with another phenomenon, which has tremendous influence on the scale of the phenomena that may be called a flood only conditionally.

In fact, due to the sudden appearance of flood waters, torrential flood waves have a very steep wavefront, which has huge destructive power. The wavefront crashes trees, undermines banks, creates landslides and rockfalls. The debris carried by the torrent destroys everything in its path. Only well-designed and constructed flood control facilities can withstand and perform a function of protection from the rush of mass, which is called "torrential lava", because it truly resembles this phenomenon.

The hydrological regime of torrential streams is also specific. The torrential character of the hydrological regime is manifested in a wide range of flow and the characteristic form of flood hydrograph. The ratio of flood water and low water flow is $Q_{max}/Q_{min} \sim 10^3$, unlike large alluvial watercourses where $Q_{max}/Q_{min} \sim 10$. On the other hand, the duration of flood water is very short – a few hours at most. Hydrographs of torrential waves have a short time base, with particularly short rise time (rising limb) due to the rapid formation and sudden arrival of flood waters. The curves of torrential flow duration in the course of the year also have a characteristic form, with very short duration of floods (a few days a year) and long duration of low and average waterflow.

Within the category of small watercourses, the torrential character of the hydrological regime is manifested primarily through rapid concentration and short duration of floods. Flood waves on smaller streams have typical characteristics of torrential waves, with sudden arrival and short time base. The biphasic nature of torrential floods is particularly pronounced due to the large quantity of suspended and bed load, transported in waves, which prevents observation and analysis, common in large rivers.

Unlike conventional torrents, the torrential nature of floods is not always equally pronounced among the category of small watercourses. Depending on the distribution and intensity of precipitation in the basin, the flood genesis may be different in terms of space and time. Therefore, there are flood waves with a longer time base and a smaller maximum flow, but there are also typical torrential flood waves, with its specific hydrograph form. There has been a long-standing belief that the torrential character of flooding was typical for flows over larger surface areas of approximately 100 km^2. However, distinctive devastating floods of catastrophic scales and flows within catchment areas exceeding 1000 km^2 have occurred in recent years. The occurrence of torrential floods causes damage to riverbanks. In case of minor overflows of flood waters, which occur frequently, the damage is not too extensive. However, from time to time extremely large torrential floods occur in the flood regions of Serbia, causing human casualties and significant financial losses.

2. Erosion and Erosive Areas

Torrential floods and soil erosion are inseparable natural phenomena that have shaped the landscape long before the appearance of life on Earth. Evident climatic and meteorological factors, such as shower rains and storms, cause torrential flooding, characterised by their destructive nature, sudden appearance and short duration. On the other hand, there are some imperceptible climatic factors that emerge in the form of soil erosion processes. Erosion is slow and less noticeable until the moment it strips the soil covering entire provinces, states and even parts of continents. Traces of civilizations that have disappeared due to erosion can be found worldwide.

Not every type of rain or wind has enough energy to move the soil particles. People gave names to each type of rain and wind according to their characteristics. Drizzling rain dews the ground and sticks to clothes, but has no runoff. Light rain is something that every farmer wants, because almost every drop of rain ends up in the soil, but there is hardly any surface runoff. Downpour is the kind of heavy, high-intensity rain - more than 30 mm per hour. Such rain has strong energy upon impact. Raindrops of this type of rain have a diameter of 1.5 mm to 7 mm, and every drop is a missile falling to the ground at the velocity of 3 to 6 m/s (Figure 1). The average diameter of drops in such rainfall is about 3mm in our climate. Figure 1 shows the impact of a raindrop falling on the

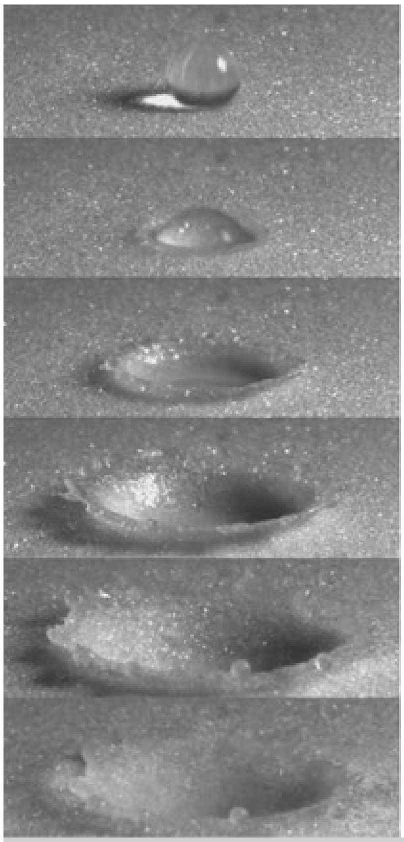

Figure 1: Impact of a raindrop falling to the ground

ground surface. It should not be considered any differently than a missile, because the effect of destruction is visible.
During a downpour, every second between 10 and 30 tonnes of such missiles fall to the ground per each square kilometre of surface. Since the surface of a typical rainy cloud that releases showery precipitation is usually about 10-30 km^2, it is not difficult to calculate the total amount of precipitation.
Showers erode flat land, whereas on steep land nearly all water flows off together with sediment, even when it falls on completely dry and permeable soil. Although it seems illogical, it should be understood that regardless of the permeability and dryness of soil, everything that cannot be absorbed runs off. Hence, in our regions it is not rare to have torrents on sandy terrains with the highest capacity and speed of absorption. Wind also has various names, from *breeze* to *storm*. Strong storm winds blow in our plains, but there are also occurrences of *tornado*. The power of winds in plains is huge; it often happens that such winds blow seeds out of the soil, while the removal of small soil particles is an easy task. Unlike water, wind is capable of transporting the eroded deposits to another continent, so it is not rare that wind brings the red dust from the Sahara to our region.
All eroded material is carried by the power of wind and water. In Serbia, there are both forms of erosion, but as regards the transport of eroded particles, wind has a transit role, since every wind-eroded particle at some point is covered by water and taken away to the watercourse.
Ever since the ancient times people have been trying, whenever possible, not to settle the way of devastating torrential flooding, and where this has been impossible, they built more or less efficient flood protection facilities. Bare surfaces are ideal for a smooth flow of water during heavy rain. As there are no obstacles that would reduce the speed of flow, water increasingly erodes the soil, creates gullies and forms torrential flood waves.

2.1. State of Erosion and Torrents in Serbia

The intensity of erosion depends upon four main factors. Three factors are natural properties of the region: geological and soil foundation, terrain and climate, while the land use is a factor largely controlled by people, due to which it is subject to dynamic and rapid changes.
The EPM method (Erosion Potential Method) is used for classification of erosion processes in Serbia. According to this method, erosion is classified into five categories that have their quantitative characteristics (Table 1). It is a current state that can easily be altered by some planned or irresponsible change of land use. The map of erosion in Serbia is shown in Figure 3.
The comparison of the state of erosion and sediment production and planning of necessary works require zoning or some kind of division of territory. In Serbia[1], the basic unit for analyses and comparisons is the river basin. The percentage of erosion, according to the EPM method, for different basins in Serbia is given in Figure 2.

1 According to the effective Law on Waters (LoW), Serbia is divided into river basin districts, which, unfortunately, do not fully take into account river basin units as basic water management units. One example is the separation of the river basin district in the territory of the City of Belgrade, that violates all the norms of basin management organisation in favour of administrative organisation. The previous LoW considered basin districts as basic water management units at a far greater extent. Article 3, paragraph 15 of LaW reads: "River basin district is an area consisting of one or more neighbouring river basins and sub-basins or their parts in the territory of the Republic of Serbia, together with associated groundwaters, which is designated as a basis for water management." The EU Water Framework Directive (WFD), in Article 2, paragraph 15, defines a river basin district as "the area of land and sea, made up of one or more neighbouring river basins together with their associated groundwaters and coastal waters, which is identified under Article 3(1) as the main unit for management of river basins". Article 3(1) of WFD further elaborates this: "Member States shall identify the individual river basins lying within their national territory and, for the purposes of this Directive, shall assign them to individual river basin districts. Small river basins may be combined with larger river basins or joined with neighbouring small basins to form individual river basin districts where appropriate." The "parts of basins", stated in the LoW constitute an outdated concept of water management. It can be said that this is a step backwards compared to the previous LoW. Thus, the degree of non-compliance of the new LoW with the WFD has been increased compared to the previous LoW.

Erosion category	Range of values	Mean value	Qualitative description of category
I	Z > 1.0	Z = 1.25	Excessive
I I	0.71< Z <1.0	Z = 0.85	Strong
I I I	0.41< Z<0.7	Z = 0.55	Medium
I V	0.20<Z<0.4	Z = 0.30	Weak
V	Z < 0.19	Z = 0.10	Very weak

Table 1: Categorisation of erosion by the coefficient of erosion

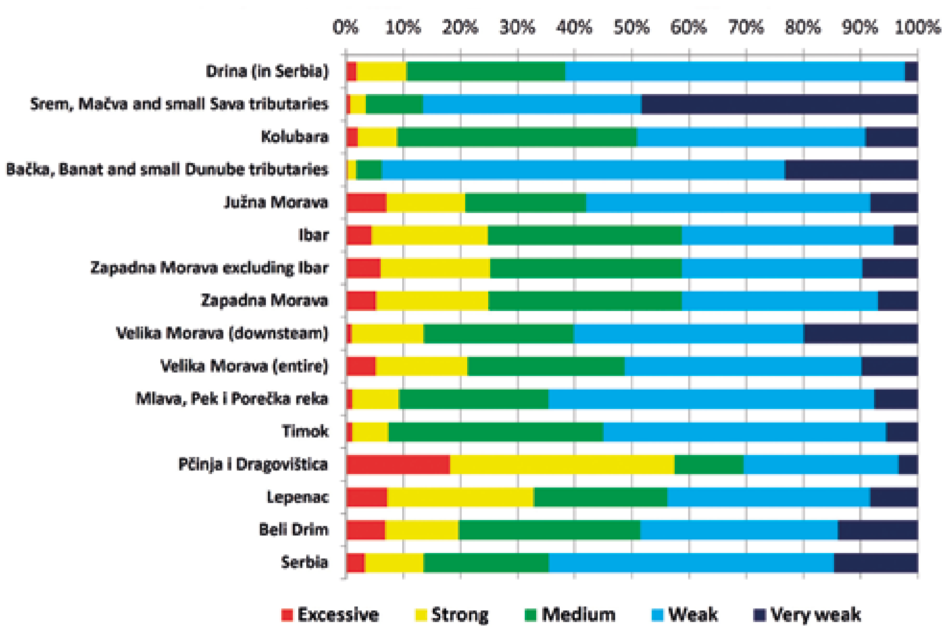

Figure 2: Percentage of erosion by category and basin in Serbia

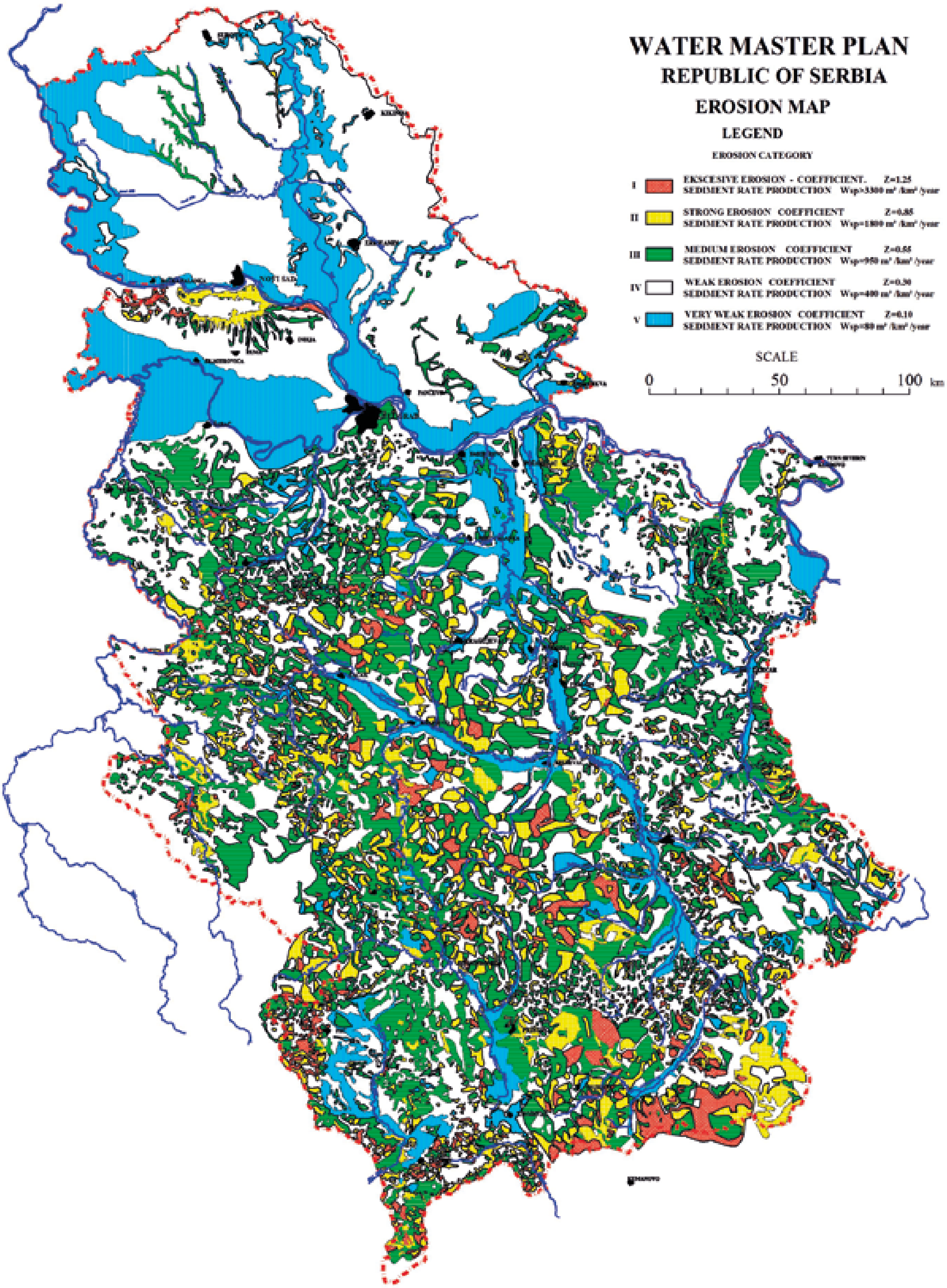

Figure 3: Republic of Serbia - Erosion Map

2.2. Erosion Register Sheets and Areas at Risk

Knowing hazard-prone locations and available resources constitute the basis for the defence against torrents and floods. The media often show images of suffering people and their destroyed property, while their reports contain inevitable terms such as: *suddenly*, *unexpectedly*, *unprepared* and the like. Unlike floods that develop slowly, torrential floods arise quickly, but certainly do not belong to the group of completely unpredictable phenomena.

Unpreparedness of local communities for timely response in the event of torrents is a major cause of suffering and damage.

The construction of a torrential control system lags behind rapid urbanisation and an increasing number of facilities remain unprotected from torrents. We should also mention the so-called "rationalisation" during the construction of roads and other infrastructure facilities that were built without necessary protection from torrents, which were planned to be built in "better" times. Often two or three decades pass before a devastating torrential flood occurs, destroying all unprotected places and initiating landslides. Individuals entrusted with the organisation of defence in local self-governments often do not have sufficient knowledge in the field of flood and torrential flood protection. They are bound by laws to have flood protection plans yet this task usually boils down to copying plans from other municipalities, and as a rule, plans are taken over from municipalities with completely different characteristics of watercourses and different challenges. That is why this course focuses on issues that do not require a lot of expertise, but require careful record keeping of challenges and assessment of defence possibilities in particular areas.

Previous experience in the application of this method has shown that a basic hydrographic map containing a hydrographic network of all rivers, creeks and gullies, as well as roads and settlements, should be prepared for the area of a particular local community. It is also necessary to mark routes and points of important infrastructure facilities: water supply, electricity network, telecommunications and others.

The next step is to divide the territory into smaller units. The existing division into villages (local communities), neighbourhoods and others should be used. For each separate unit, it is necessary to appoint a Civil Protection Commissioner (hereinafter referred to as Commissioner), who is assigned in the system of defence against floods and torrents in his or her area. The best option is when the Commissioner lives in the respective area and knows it well. A map detail showing the assigned area should be prepared for the Commissioner.The Commissioner's task begins with a baseline recording of hotspots and problems. A map should contain well-known locations where congestion, flooding or landslides occur regularly. The Commissioner particularly marks the houses and parts of a settlement that are regularly or occasionally flooded or at risk of torrential flooding. It is especially important to register various landfills and dumps.

All the national infrastructure facilities at risk of some local water flows, which are classified as " class 2 watercourses" according to the effective classification system, should also be recorded. It is desirable to take a photo of each of the critical places, which nowadays should not be a problem. This will be illustrated with a few examples (Figures 4, 5).

The Commissioners constitute a group of people who must undergo a short training. Practice has shown that their educational background is not crucial, while knowledge of problems in their communities is more relevant. They are also re-

Figure 4: A typical example of the congestion of bridge opening that impedes the flow of water

Figure 5: Characteristic method of increasing the transportation capacity of railway culvert by reducing the opening

sponsible for constantly monitoring the situation in the beds of rivers and creeks and timely notification of the authorities in case of any congestion. To standardize data collected by the Commissioners and other participants in the system of protection from floods and torrents, a set of forms called "Erosion Register Sheets" have been prepared, which have already demonstrated their advantages. In municipalities that have introduced this form, the floods and torrents that occurred in May 2014 did not cause catastrophic damage, and consequently they did not appear in the media.

The Erosion Register Sheet contains data that currently falls within the competence of the Ministry of Interior of the Republic of Serbia - Sector for Emergency Situations, which is a significant improvement in the administration of registration system, because often there is not enough people to handle the large workload at local community level. The Sector for Emergency Situations most often holds the lists of manpower and machinery for the purpose of mobilisation, which may also be used for the purpose of their engagement in the defence against floods and torrential flooding. However, these lists often do not contain additional specialised information for the needs of defence against floods and torrential flooding, therefore their updating is crucial, as well as the updating of data in the Erosion Register Sheets and municipal operational plans for the protection from floods in II class waters.

The Erosion Register Sheet is updated once a year, to record possible changes in the field. The most common changes recorded are the development or neglect of certain locations, construction of new bridges and culverts, other works in the watercourse or the occurrence of landslides that fill the riverbed or threaten to fill the riverbed and thus reduce the longitudinal slope. Experience has shown that the state map in the scale of 1:25.000 is best for cartographic records.

A small number of municipalities are able to use electronic maps and advanced GIS systems, while the majority are focused on traditional analogue maps printed on paper, which does not diminish the quality of collected data.[2]

Data recorded in the Erosion Register Sheets by the Commissioners are divided according to the appropriate forms and can be grouped into following sections:

- Marking critical sections and locations in torrential watercourses for a certain area;
- Detailed textual description of parts of a settlement at risk of torrential flooding, including the number of inhabitants, residential and commercial properties in the inundation area;
- Determining the position of bridges, culverts and other facilities in torrential watercourses, including basic dimensions of these facilities;
- Recording material resources for flood protection (equipment, machinery, etc.);
- Recording accommodation capacities in case of evacuation, and movable property (gymnasiums, schools and other institutions where evacuated people may be accommodated).

Particular vulnerable spots, sections from the Erosion Register Sheets, or facilities that may hinder or completely prevent the flow of upcoming torrents, must be entered in the hydrographic map, prepared aforehand (preferably in electronic form, with geo-referenced data). The advantage of electronic data is the simplicity of upgrading and use during operational defence. Each piece of information entered into the map (whether paper or electronic) must be unambiguously and clearly named, avoiding the use of codes for designated points.[3]

2.3. Erosive Sediment Production

Erosive sediment production implies a shifted and transported volume of material, resulting from the effect of climate factors on the surface layer of soil. The abstracted relation between the erosion categories and the erosive sediment production is a twofold increase or decrease in the volume of sediment within one category of erosion.

The quantity of erosive sediment production is usually expressed in specific and total annual values for defined basin units. Specific sediment production is expressed in m^3/km^2 per year, or as the volume of eroded and transported soil yielded in the area of one square kilometre in the course of one year. Total production for the whole basin is expressed in m^3/year or as all eroded and transported soil from the basin during one year. The specific production of erosion sediment is a practical value, because it indicates the intensity of erosion processes regardless of the size of the basin and is commonly used to compare the situation before and after the works, as well as the expected results of the planned works.

2 The disadvantage of electronic data is a possible interruption in the supply of electricity, and the operation of such systems is limited by the battery life of portable computers. Therefore, it is necessary to have at least one hard copy of (analogue) maps and the Register.

3 The maps should not include codes that are known only to one person or a small number of people, but descriptive attributes denoting a kind of object and describing a location. For example: "the bridge next to the old oak tree", because it is the name commonly known in that territory. In case of engaging a unit of the Sector for Emergency Situations, army or volunteers who are not from the area, all local residents will be able to direct them to a specific location.

Shifted sediment can be expressed as the thickness of removed soil layer. When the intensity of erosion reaches 1000 m^3/km^2 per year, it corresponds to the reduction of one millimetre of the fertile soil thickness. That intensity of erosion destroys fertile soil in the period of 200-250 years. In current conditions, the intensity of erosion can vary from 100 m^3/km^2 to 4000 m^3/km^2 per year. Figure 6 shows the average dependence of soil layer duration as a function of the intensity of erosion in Serbia.
The two curves intersect in the zone of erosion intensity of about 500 m^3/km^2 per year (and duration of soil of 500 years) and present the current state. Other two values are marked in the diagram. The right-side value in the diagram shows the state in 1952, when extensive works began and when the intensity of erosion was about 1400 m^3/km^2 per year (duration of fertile soil is about 150 years). The left value is a projection, i.e. it is a possible and achievable value after anti-erosion works.
Therefore, if anti-erosion works and the implementation of administrative anti-erosion measures are continued, it is possible to extend the duration of the soil layer for 1000 years, and reduce the intensity of erosion to about 250 m^3/km^2 per year. Such a state would provide sufficient additional time to find more functional ways of controlling erosion and its reduction to an absolute achievable minimum, which is about 70 m^3/km^2 per year.
The diagram shows that the current erosion processes in Serbia are alleviated and are in the stage of equilibrium. In fact, any incautious change of situation in the field may cause a sudden intensification of erosion and a quick return to the situation before the anti-erosion works were undertaken.

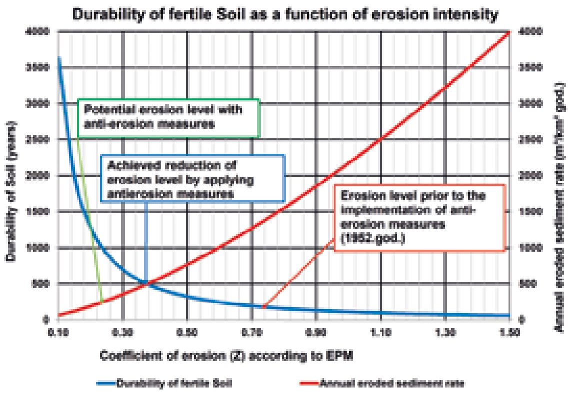

Figure 6: Dependence of soil layer duration as a function of erosion intensity

2.4. Identification of Areas at Risk of Erosion

Erosive areas and zones are often considered to be the same, but in fact erosion zones are surfaces affected by various classes and categories of erosion, classified according to the appropriate methods of mapping erosion processes, while erosive areas are surfaces where a strong erosion process may not be necessarily developed, but which may become focal points of erosion if some of the factors relevant to the development of erosion change. To put it simply, a particular area may have natural predisposition to the development of erosion processes and this characteristic is permanent and cannot be influenced by any works or measures.
Although the provision that declares an area an erosive location has been in force for a long time, the concepts of erosion processes and erosive areas are often equated or confused with each other. This creates difficulties for local self-governments, because they have to implement activities outlined in the provision. Moreover, local self-governments face the problem of very expensive works for recovery of erosion-affected land for reasons of complexity, difficult accessibility of the terrain on which the works are performed and high expertise required in the design and execution of works. Development of erosion processes in the erosive areas is mitigated by applying non-investment anti-erosion measures imposed on the owners and users of land in the erosive area.
Experience shows that there is no reason for concern as regards such measures, because the revenues obtained from treated areas have increased several times. The areas where administrative anti-erosion measures were implemented are known today for the production of hazelnuts, blueberries, blackberries, raspberries, medicinal herbs and other profitable products. The inhabitants developed novel successful solutions on their own, which were later adopted as standard practice.
Certain measures that could drastically change the conditions of land use and planting can be imposed only in extreme cases. This refers only to highly eroded arable land, which has to be excluded from agricultural production for a longer period of time and protected with multi-annual forest vegetation.
In the past, the state supported the implementation of anti-erosion management programmes by allocating free planting material to land owners and users. In this way, forests and orchards were planted in parts of Serbia severely damaged by erosion, on plots where the application of administrative measures could drastically reduce the intensity of erosion.
In places where erosion reached large proportions, administrative measures are useless until some

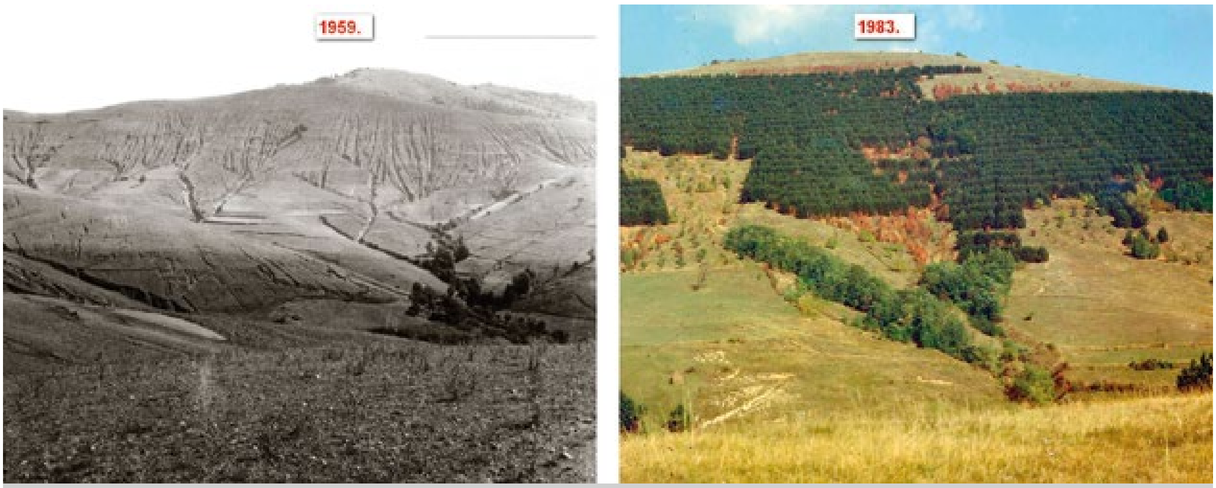

Figure 7: Severely gullied slope of Stara planina before and after thirty years

expensive technical, biotechnological and biological works have been performed. This is illustrated by details from Stara Planina and Trgoviški Timok, where erosion processes reached extreme proportions. Illegal logging on a typical erosion-prone land plot contributed to the development of a range of deep gullies. This area was forested by applying a combination of biotechnical works for the consolidation of gullies and reforestation. Figure 7 shows two periods, before and after biotechnical works, and speaks for itself. The problem characteristic for erosive areas is not the current intensity of erosion, which is the result of applied anti-erosion measures, but the observance of limitations in land management of erosive areas.

More specifically, the significant part of anti-erosion works is afforestation of erosive areas, along with a set of technical and biotechnical works. Today, the once barren gullies and slopes have been converted into high-quality woods as shown in the photos. After half a century, the forest has grown and people have forgotten that this area was prone to erosion. An illusion has been created that the risk of erosion and torrents no longer exists, and many buildings have been built in the erosive area.

In the basin of Trgoviški Timok, in Stara Planina Mountain, a ski centre was built in the forested area where the erosion processes were mitigated. It is an area extremely prone to erosion, located on the crumbling red sandstone, which is somewhat more resistant to erosion than sand.

All forest trees located on the route of the ski trail and ski lifts were cut down and no anti-erosion protection measures were applied. After the snow melted, the first heavy rains stripped a thin lay-

Figure 8: a) A detail of gully on the ski trail near Babin zub from July 2007; b) The same location in August 2007

Figure 9: A detail of gully on Čestobrodica

Figure 10: Čestobrodica – an illusion of a "good" forest

er of soil and uncovered decomposed sandstones. Figure 8 shows the state of erosion of the same location: the photographs were taken successively, in July and August 2007. Only one strong torrential rainfall was sufficient to deepen the shallow gullies to more than two meters.

The repair of damaged ski trails and development of appropriate anti-erosion protection cost several times more than the timely anti-erosion measures would have cost. A similar situation occurred with the roads leading to the ski centre, while the anti-erosion and anti-torrential works are still ongoing.

Natural terrain susceptibility to erosion is the basis for determining erosive areas. If this is not done and erosive areas are not declared, there is no possibility to impose an obligation for implementing administrative measures, but that does not mean that an erosive area has ceased to exist. The biggest challenges are found in the field of forestry. Intensive logging on the steep slopes of erosive area deepens the gullies (Figure 9) that were formed during the period of over-exploitation in the first half of the twentieth century. The whole area under decomposed red sandstone was forested during the past half century, so that at first glance it appears that this surface is well protected and that there is no danger for the development of erosion (Figure 10).

The composition of soil in certain locations in Serbia is such that that the development of erosion requires only minor terrain slopes. Agriculture in an erosive area requires compliance with anti-erosion land management practices. Ploughing the slope of sandy soil destroys the arable land and turns it quickly into a deep gully, although the slope may not be too steep.

Erosive areas are well identified and shown on maps of 1:25000 scale, while small scale general maps show the percentage of distribution of the occurrence of erosive areas.

The map of erosive areas is an important document, because it clearly identifies areas where a minor change of land use changes the intensity of erosion processes. Such areas must be managed only in the manner that mitigates the intensity of erosion, often with additional application of protective anti-erosion works. This approach to land-use management is called "integrated" and is prescribed by law for the areas proclaimed as prone to erosion.

Figures 11 and 12 show maps of erosion and erosive areas in the basins of the rivers Belica and Jagodina, tributaries of the Velika Morava River near Jagodina. The erosion maps clearly show that there are no extreme erosion processes in that area, but that moderate and weak processes are equally frequent. The plain area is under very low erosion.

Erosive areas appear also in plains, because their loess[4] and sandy soils are susceptible to erosion. The upper part of the basin is also an area extremely prone to erosion, however, it is currently affected mainly by weak erosion, as a direct result of anti-erosion protection works and applied administrative anti-erosion measures.

Serbia is characterised by relatively large erosive surfaces. The areas of Grdelička klisura *(gorge)*, Deliblatska, Ramsko-golubačka and Subotička peščara *(sandlands)* are entirely susceptible to erosion. A relatively small part of the territory of Serbia is characterised by a low prevalence of erosive areas.

4 Loess is a type of sedimentary geological formation of weak binding properties, especially in the presence of moisture, and therefore is extremely susceptible to erosion processes.

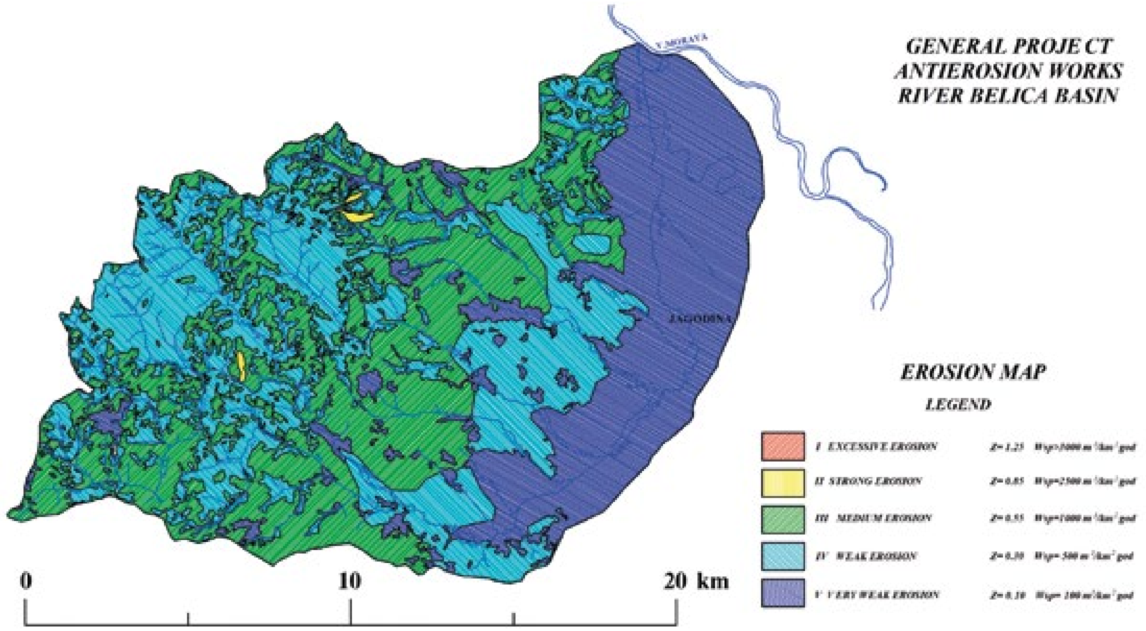

Figure 11: Map of erosion of the Belica River Basin

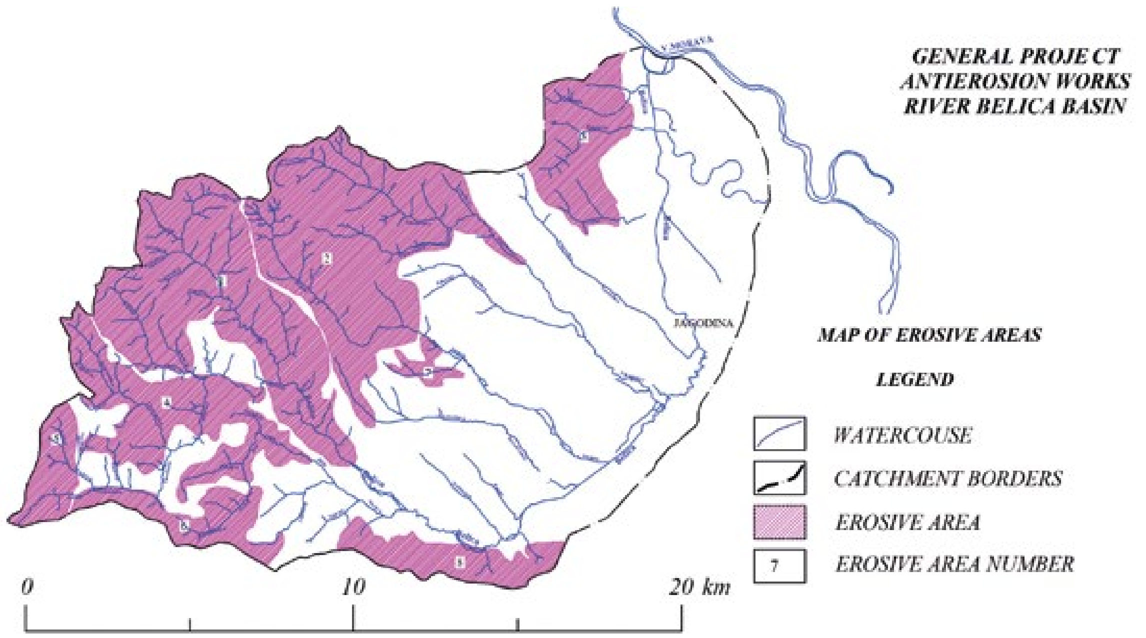

Figure 12: Map of Erosive Areas of the Belica River Basin

3. Floods

Almost all ancient civilizations of the world have a myth of a great flood or deluge, which does not mean that the event actually happened, but points to their high awareness of flooding as a real and adverse event that had an impact on all segments of their societies. This is not surprising given the fact that the earliest beginnings of civilization were closely linked to the valleys of rivers that supplied water used for drinking and agricultural production, provided transportation routes and constituted a natural barrier against the hostile attacks of surrounding tribes.

The saying: "A good servant but bad master", which certainly refers to water, becomes fully understandable during of floods, because victims have limited time, space and restricted activities when faced with the surge of flooding. For these reasons, ancient civilizations paid great attention to the prevention of floods through the regulation of watercourses, construction of embankments and roads providing an escape route from flooded areas.

Not all civilizations were adamantly opposed to and negative about floods. Flooding of the Nile provided the ancient Egyptian civilization with food by bringing fertile silt rich with humus substances from the upper course of the river to the area of inundation, thus significantly increasing the fertility of agricultural soil. It secured a double harvest with natural soil fertilisation, as well as good organisation of agricultural production due to the regularity of flood occurrence.

Floods are only one manifestation of evident climate change, felt by all of us. Altered patterns of propagation, duration, intensity of precipitation and periods of drought indicate changes in the total data input into the equation of water balance. According to current data, the annual amount of precipitation has not changed to a greater extent, but the extremes have become more pronounced and more frequent. Therefore, the impact of climate change must not be disregarded or interpreted as irrelevant.

Floods, occurring as a stochastic5 phenomenon, due to their unpredictability and speed of development, and pronounced time limitation for organised human response, cause tremendous damage, not only financial damage, but also an irreparable loss of human lives.

In addition to measures, activities and works, the speed of response to flooding is crucial for reducing flood damage.

Protection plans with exact data, computer models of potential events and experiences of past events

5 Stochastic phenomenon is an event whose occurrence is not determined either in terms of time or quantity, and in mathematical terms, the phenomenon is observed as an event subject to the laws of probability. The word comes from ancient Greek and means the skill of guessing or learning about what is probable.

must be elaborated in detail and based on realistic requirements, but also considering realistic possibilities, in order to be feasible when needed.
In order to minimise the risk of losing human lives and damage incurred from flooding, the term flood must be precisely defined and explained. Experts define a flood as follows:

"Flood" means the temporary covering by water of land not normally covered by water. This shall include floods from rivers, mountain torrents, Mediterranean ephemeral water courses, and floods from the sea in coastal areas, and may exclude floods from sewerage systems.

This definition is set out in the Directive on the assessment and management of flood risks6 (hereinafter referred to as Directive). It should be noted that floods that occurs due to leakage of water from sewerage systems7, whether atmospheric, industrial or sanitary, are not treated as floods.

3.1. Causes and Types of Flood

According to the general definition of floods set out in the Directive, floods can be divided by the location of occurrence into the floods appearing in:

- rivers
- brooks
- torrential watercourses
- coastal areas, caused by the sea and coastal waters.

Floods caused by the sea and coastal waters may be caused by tidal waves, which are the result of the gravitational attraction of the Moon or the combined effects of gravitational forces exerted by the Moon and the Sun, but also by a drop in air pressure in the coastal zone due to the cyclonic activity and strong winds from the sea to the mainland or by a tsunami.
There are numerous causes of floods in river valleys, and they can be divided into three main groups:

- those that occur as a result of natural phenomena
- those caused by anthropogenic activities and
- those that are the result of a combination of natural and anthropogenic factors.

Rainfall and melting of snow that occur in the upper parts of the basin are the most common causes of flooding both in large rivers, torrential watercourses and creeks. In addition to rainfall, the occurrence of floods in the winter can be influenced by ice concourse8 and formation of ice barriers, which reduce or completely stop the flow through the waterbed.
Anthropogenic activity is mostly related to the activity in the waterbed, but also in the basin. Deforestation, construction of buildings and roads, channelling and other activities increase the velocity and quantity of runoff waters from the basin, and shorten the concentration of water in the main riverbed, i.e. increase the coefficient of runoff from the basin area (Figure 13 a) and b). Also, the regulation of riverbeds, by "cutting off the dead branches" (stagnant waters or dry armlets), and the construction of facilities on the banks, or even in the waterbed, reduce the time of flow through the waterbed, but also reduce the flow profile, which inevitably leads to increased water level in the waterbed. Certain anthropogenic activities, such as, for example, stripping slopes cause the occurance of occasional floods due to sliding slopes or even entire hillsides, which end up in the waterbed and create a dam. The impact of humans on nature is also responsible for damming or narrowing of river beds (sluices, dams, bridges), which causes the formation of floodplain lakes upstream of the barrier, while the uncontrolled construction of facilities in inundation areas reduces the high water flow rate. Moreover, improper handling of water management structures, such as dams, can cause flooding.
In addition to these primary anthropogenic impacts, other activities, such as the disposal of construction debris and other waste in a riverbed, can contribute to flooding (Figure 14a). They reduce the capacity of riverbeds, but also increase the possibility of the formation of "jams" on the narrow parts of the watercourse, such as bridges or other structures in the waterbed. Also, flooding could be influenced by the discharge of waste water (Figure 14 b), when suspended solid waste particles settle to the bottom of the watercourse and cause a narrowing of flow profile, but of particular importance are waste waters polluted with organic substances, which cause an overgrowth of aquatic vegetation, which in turn reduces capacity. Constructions located on the waterbed but also floating structures (rafts, barges, etc.) can have an impact, but also the reduction of free space enabling the flow of water through inundation areas.

6 Directive 2007/60/EC of the European Parliament and of the Council on the assessment and management of flood risks

7 Floods caused by raising the level of groundwater, which is manifested by the appearance of temporary aquatorium on the surface, are not covered by or not mentioned in the Directive. These floods are the result of large quantities of water sediment, melting of snow cover on the surface, or a combination thereof. The levels of groundwater may rise due to the increase in levels of watercourses. One of the well-known examples is the case of raising the water level in the lake Vračevgajsko due to the rising water level of the Danube River at the distance of about 10 kilometers.

8 Ice concourse means retention, accumulation and sliding of icebergs in the places where a stable ice crust has been formed on the watercourse, either along the coast or through the entire watercourse. The icebergs, which are brought by the river flow to the stopping place, "slide" and stick underneath the formed ice crust. Over time, such "sliding" and stopping can block a large part of the transversal profile and cause massive flooding upstream of the thus formed ice jams.

Figure 13: Anthropogenic impact: a) deforestation; b) construction of infrastructure

We should not forget human impact on climate change that result in an increase in frequency, but also in the intensity of extreme precipitations, which directly affects the water runoff from the basin and consequently on flooding.

Floods resulting from an overflow of water out of the riverbed primarily refer to the flooding of rivers in plain areas, where the main characteristic of flood water is its depth or elevation it reaches. Floods in mountain watercourses and creeks differ from the aforementioned owing to an additional characteristic of flood waters, which is the velocity of water in the flooded area. These floods often have a significantly lower height of flood water, but its velocity causes most problems, especially in cases when communities must be evacuated.

Unlike the two aforementioned types of floods, torrential waters, apart from the depth of water (which is often irrelevant) and water velocity, have additional characteristics, such as type of torrential mass and amount of transported material. According to statistical data, periods of flooding in Serbia differ mainly by size and nature of the basin, i.e. by the main cause of flooding. Flooding occurs on large lowland rivers usually in the period of early spring and spring, depending on the temperature in the upper flows of the rivers or the size of the snow layer in the upper zones of the basin. Flooding of creeks with small basin areas occurs in the periods of prolonged and intense rainfall, mainly in spring and autumn, depending on weather conditions in the basin. In contrast, small and torrential watercourses are prone to flooding in summer, because strong showery rainfall is most frequent during this season, although late-winter and early-spring flooding is not rare

Figure 14: Anthropogenic impact: a) disposal of waste into a riverbed; b) discharge of waste waters

Age band	Total	Total (%)	EU	EU (%)	USA	USA (%)
0–19 years	33	13.4	8	8.4	25	16.4
20–60 years	98	39.7	47	49.5	51	33.6
> 60 years	41	16.6	24	25.3	17	11.2
Not reported	75	30.4	16	16.8	59	38.8
Total	247	100	95	100	152	100

Table 2: Distribution of flood fatalities according to age

Source: Jonkman, S. N. and Kelman, I. (2005): An analysis of the causes and circumstances of flood disaster casualties, Disasters 2005, Vol. 29, No 1, Blackwell Publishing, p. 75-97.

Gender	Total	Total (%)	EU	EU (%)	USA	USA (%)
Male	145	58.7	72	75.8	73	48.0
Female	62	25.1	22	23.2	40	26.3
Not reported	40	16.2	1	1.1	39	25.7
Total	247	100	95	100	152	100

Table 3: Distribution of flood fatalities according to gender

Source: Jonkman, S. N. and Kelman, I. (2005): An analysis of the causes and circumstances of flood disaster casualties, Disasters 2005, Vol. 29, No 1, Blackwell Publishing, p. 75-97.

for these types of watercourses, due to the rapid melting of snow.

A special type of floods is flooding caused by ice or ice concourse and formation of “ice jams” in the watercourse - ice barriers.

3.2. Torrential Floods

Challenges imposed by torrential waters and torrential floods, as opposed to ordinary lowland floods, assume a new aspect since torrential waters do not only consist of water, but also of drifted, dissolved, worn and floating materials.

In addition to financial damage, floods cause human casualties, which are an irreversible loss and the worst possible harm caused by flooding. Torrential floods cause the highest number of fatalities in comparison to other kinds of river flooding[9].

Table 2 shows a distribution of flood fatalities by age. It is evident that the age group between 20 and 60 years in the EU countries accounts for nearly 50% of all the victims, but it also makes up largest age group sector of the population, in general. The next group, consisting of people older than 60, accounts for more than 1/4 of all victims in the EU, and given its much smaller size compared to other groups, it can be concluded that it is the most vulnerable. The reason lies in their age and diminished physical capabilities. Data from the US differs significantly from EU data, primarily because the number of flood victims in the group of people under the age of 20 is more than double, while the distribution of victims by age groups more or less portrays the distribution of the general population. This suggests that in the United States there is no particular age-related vulnerability.

If we observe the gender of flood victims (Table 3), we notice that the number of female victims is much smaller than the number of male victims, which is more evident in the EU than in the USA. Thus, the number of male victims of floods in the EU is more than 3/4 of the total number of victims, while in the USA this percentage is smaller. Given that the number of US victims with unreported gender is greater than 1/4, we can con-

9 Tsunami caused by undersea earthquakes lead to the highest number of victims.

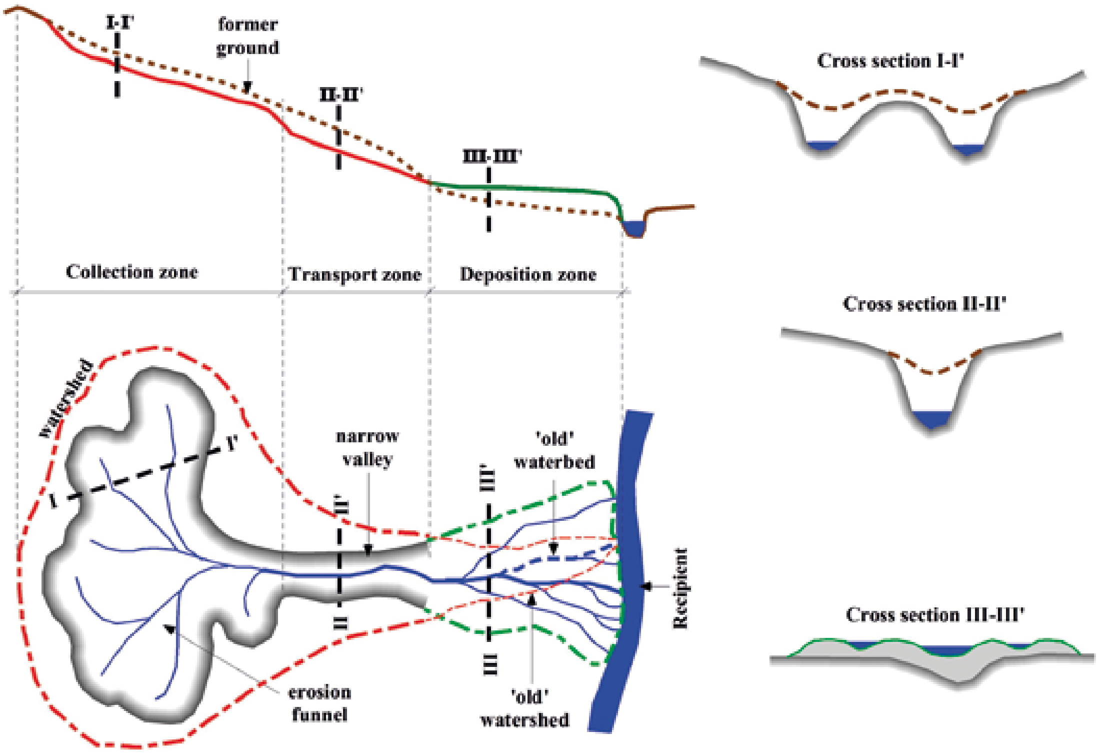

Figure 15: Schematic presentation of torrential watercourse with longitudinal and cross sections

clude, by approximation that the male-female victim ratio in mathematical relations is 2/3:1/3.[10]

Torrential watercourses during the period of regular flow of water in watercourses can be observed from the air, and their characteristics are large, barren or sparsely vegetated rocky and muddy alluvium on the banks of the river, meandering riverbeds, a pronounced lack of vegetation, numerous gullies stretching toward the main flow of the watercourse and other clearly visible processes. In general, a torrential catchment has three main zones: a zone for collecting debris ("collection zone"), a zone for transporting debris ("transport zone") and a zone of depositing debris ("deposition zone") (Figure 15).

The zone for collecting torrential debris, or "collection zone", is the highest zone of the torrential catchment area; it's an erosion zone where the pluvial and fluvial erosion (through erosion processes of rainfall and water flow) separates the torrential debris and collects it in the tributaries and the main watercourse. This zone is characterised by surface erosion in the "collection zone" and deep waterbed erosion of tributaries and main watercourse, with the velocity of torrential waters and transported debris increasing towards the transport zone (Figure 15).

The transport zone ("neck of the torrent"), is a zone or the bed of the torrential watercourse that transports debris collected in the upper part of the catchment area, from the "collection zone". This zone is characterised by deep erosion in the bed of the torrential watercourse. In this zone, the torrent achieves its maximum velocity thus generating its destructive energy (Figure 15).

The deposition zone is an area where the torrent loses its velocity and destructive power, therefore "depositing" the debris brought by the torrent. This zone is characterised by the alluvium deposited by torrential water, frequent alterations of the main waterbed, as well as a lot of meandering and formation of more armlets of torrential flow. It is not rare to have cases of "hidden" subsurface flow through the alluvium, if the torrential debris contains mainly boulders, debris and gravel. The entire torrential flow is strong, as a rule, and only in rare cases, when the water surges through a large flat valley after the transport zone, the torrent can slow down after the "deposition zone".

The initial steep wavefront has the greatest energy; it carries the largest amount of debris including stone blocks, debris, trees, and everything its destructive power has destroyed and carried downstream. Figure 16 shows the steep waterfront.

10 For research purposes, the authors Jonkman and Kelman did not succeed in obtaining more precise information on the gender of flood victims.

Figure 16: Steep waterfront

Figure 17: Tekija – Deposited material drawn and transported by a torrent (Source: Photo: Ognjen Zorić, retrieved from: http://www.vesti-online.com/Vesti/Srbija/434365/Crkva-zaustavila-bujicu-u-Tekiji)

Therefore, flooding caused by the overflow of high waters from the riverbeds of small rivers should not be considered a torrential flood unless it carries large amounts of debris. The threshold value for ordinary flood waters as opposed to torrents is the value of the volume weight of flood waters. If this value is less than 1200 kg/m^3, then we refer to ordinary river flooding, and anything above this value indicates torrents and torrential floods. The volume weight of torrential water can reach more than 1700 kg/m^3, although floods that exceeded this value have also been recorded.[11]

The very fact that torrents carry large amounts of various bedload and floating debris, including mud, gravel, but also stone blocks, trees and everything else the destructive streaming demolished on its way and brought downstream, gives torrents a growing destructive force. Such a destructive force creates further new destruction that continues on until it reaches the deposition zone, where torrents begin to lose power and velocity and the transported material is deposited (Figure 17).

The initial movement of debris in the collection zone starts with the impact of raindrops hitting the ground, i.e. the mechanical separation of soil particles from the substrate, which leads to pluvial soil erosion. The power of particle transport by water is based on the reduction of the friction between the particle and the soil, more precisely the apparent weight loss of the particle immersed in water, based primarily on the Archimedes' principle.

Further movement of torrential waters and the expansion of relevant drainage areas, increases the torrential mass and its energy. Thus strengthened, the torrent separates, moves and carries other debris, objects and larger pieces, as well as other objects on its way. Upon entering the transport zone, the energy becomes concentrated and extremely powerful, and the steep waterfront destroys and/or carries everything on its path. After leaving the transport zone, the steep waterfront weakens and expands, losing its speed and strength, so that the heaviest material, such as boulders and debris, is "deposited" first, followed by other, lighter material. Floating debris is usually trapped in places with barriers such as bridge structures, road narrowing, transmission poles, forests or other obstacles on the torrent path, sufficiently resistant to dynamic impact of torrential water and solid material carried and transported by the torrential flow. The retention of the floating debris causes a significant back water[12] upstream of the place of "congestion", thereby increasing the level of flood waters. The "congestion" often causes the destruction of bridges and other structures in the riverbed affected by "congestion", which leads to secondary destructive effects of torrential flooding.

The basic parameters of torrents include:

- shape of torrential catchment

11 Torrential waters in Georgia, on the watercourses from the Caucasus, are often a combination of very small amounts of the torrential water that moves large stone blocks of size greater than 1 m3. Such torrents have an enormous destructive force and in such cases special structures are constructed such as trussed partitions, able to stop massive stone blocks and let the water pass at lower speed and with less power.

12 Back water is a term that describes a phenomenon of water-level rise in a watercourse due to the increase in water levels downstream. Back water causes the slowdown of flow. Back water usually occurs upstream of the reservoirs or upstream of the confluence of smaller watercourses into larger ones, but it may occur also upstream of the obstacles in the waterbed (bridge piers, ice barriers, transverse facilities for regulating navigation, etc.).

- density of the tributary network
- relief of torrential catchment
- geological and petrographic[13] conditions and soil conditions
- condition and type of vegetation cover
- state of erosion processes in the catchment
- climatic characteristics of the catchment and
- anthropogenic impact.

Shape of torrential catchment is the ratio of the catchment (watershed) perimeter and the length of main stream, and provides the shape of the catchment area. Accordingly, the torrential nature of a watercourse increases with the increase in perimeter and decrease in the length of the main stream.

Density of a tributary network is a parameter that indicates an increase in the speed of concentration along with an increase in the density of network tributaries, because the time of flow downslope, where the speed of water movement is lower, is reduced. Thus, we distinguish four main groups according to the density of the tributary network:

- Du < 0.5 [km/km^2] – low density of tributary network
- Du = 0.5 to 1.0 [km/km^2] – medium density of tributary network
- Du = 1.0 to 2.0 [km/km^2] – high density of tributary network and
- Du > 2.0 [km/km^2] – very high density of tributary network.

Relief of the torrential catchment area is one of the most important parameters that includes: average height of catchment, average catchment slope, average height difference, potential run-off volume during heavy rains (larger than 30 mm/day), potential run-off velocity of flood waters during heavy rains, erosion energy of relief coefficient and geomorphological/erosion coefficient of catchment. The torrential nature of a catchment may increase or decrease, depending on all these parameters.

Geological and petrographic conditions of the catchment are expressed by the coefficient of water permeability, and depending on the rock masses that constitute a geological substrate of the catchment, there are: highly permeable substrates (gravel, sand, etc.), moderately permeable substrate (flysch, marl, shale, etc.) and highly impermeable substrates (clay, clay-oil shale, volcanic rocks, etc.). The impermeability of water directly affects the runoff from the catchment, and the watertight rock masses are responsible for the increase of the torrential nature of catchment.

13 Petrography is part of the scientific field of petrology and deals with the classification of rock masses, their description and spatial distribution.

Vegetation cover in the catchment consists of three basic types: forest vegetation, grass and shrub vegetation and terrain without permanent vegetative cover (arable land, larger concrete surfaces). The increase of forest vegetation areas decreases the torrential nature of the catchment, while the increase of areas without permanent vegetation cover also increases the runoff from the catchment, and hence its torrential nature.

State of erosion processes directly affects the torrential nature of the catchment area because a catchment with larger eroded surface has a higher torrential potential. While determining this parameter, we should take into consideration the surface affected by erosion processes in the catchment, but also many other elements, including the type of erosion processes, intensity and coverage, soil and geological condition of the catchment and forest degradation.

Climatic characteristics of the catchment are basic input parameters for studying the torrential nature of catchment, because the runoff regime in the catchment is determined mainly on the basis of rainfall and snowfall, and to a lesser extent, wind, air and soil temperature and humidity.

Anthropogenic impact is ubiquitous because human impact on all segments of nature is present to a large extent. The increase in agricultural areas, deforestation, rapid urbanisation, transport infrastructure, but also technical, biotechnical and hydrotechnical activities directly affect the increase or reduction of all parameters of the torrential nature of a catchment.

3.3. Structures for Protection from Adverse Effects of Water

Structures for protection from adverse effects of water or flood defence structures may be divided into two main groups according to their effect on flood water. These can be structures for passive flood defence and structures for active flood defence. Structures for passive flood defence, as their name implies, do not cause a reduction in the flow of water but defend, with their massive size, the population and property from the flood wave. In contrast, structures for active flood protection are intended to either "reduce the flow" to a level that will not cause destruction in the lower course, or at least diminish it, but also to "buy more time" to respond to the upcoming flood wave.

The term flood defence is usually associated with embankments, but apart from them there are other structures that prevent the overflow of flood waters in the protected area.

There are several types of embankments, depending on their location and purpose including: main,

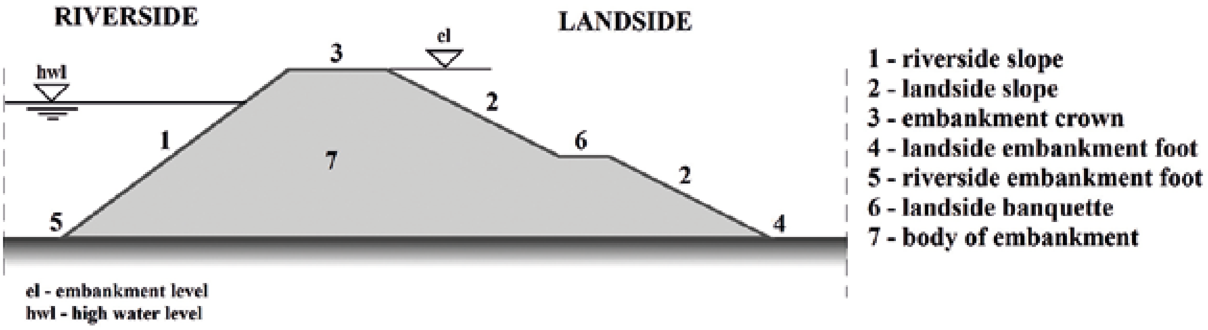

Figure 18: Embankment - geometrical parts of embankment

edge, backwater, connecting, transversal, secondary line and tertiary ("summer") embankments (Figure 19), but all of them have a similar geometry and the following elements: embankment crown, landside slope, riverside slope, landside and riverside embankment foot, and in some cases: landside banquette, spillway, slope protection, drainage structure (canal, filter, cover and pipe), etc. Figure 18 shows the outline of and embankment and description of its geometrical parts.

Main embankments are linear structures stretching through a river valley and separating a large landside area from the riverside or inundation area. They are built to provide protection from high waters with a certain exceedance probability (design water), and have a safety margin between the level of embankment crown and the level of design water (protection level). The main purpose of the main embankment is protection of settlements from floods and major economically important areas. The construction of main embankments narrows the flow profile in the embankment zone, which leads to significant changes in the natural water regime, thus increasing the level of flood waters in the embankment zone, but also upstream due to back water (Figure 19).

Edge embankments have a role similar to main embankments, but differ in shape since they are constructed in form of a ring around the defended area. This form of protection, being considerably cheaper, is used for smaller settlements or industrial complexes and their impact on the water regime is much lower than in case of main embankments. Edge embankments have a local impact and protect an area in the immediate vicinity of the embankment (Figure 19).

Backwater embankments stretch along tributaries that flow into a watercourse in which the main embankment has already been constructed. Their function is to prevent the penetration of backwater from the main watercourse through the bed of the tributary to the landside area. They

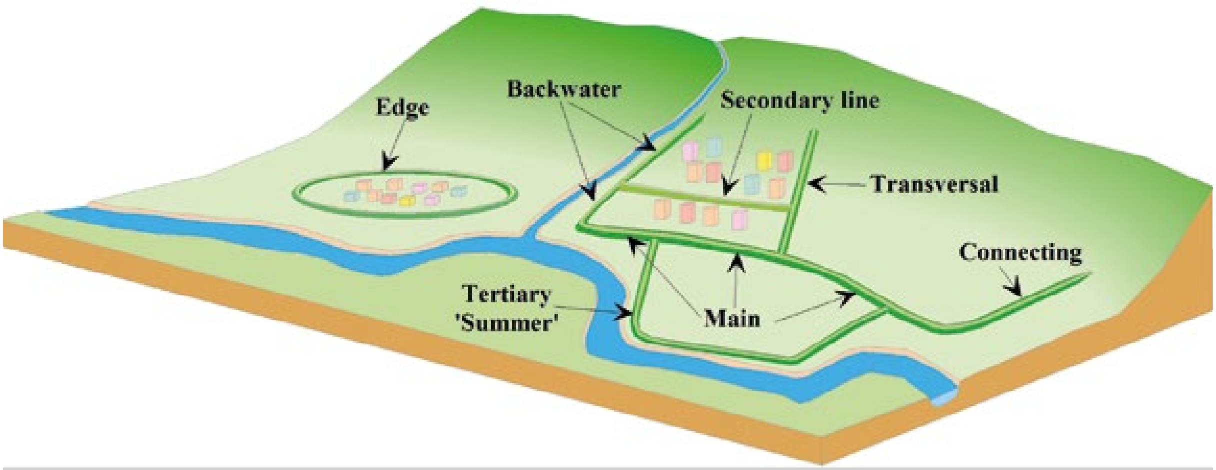

Figure 19: Embankment - type of embankments according to their location and purpose

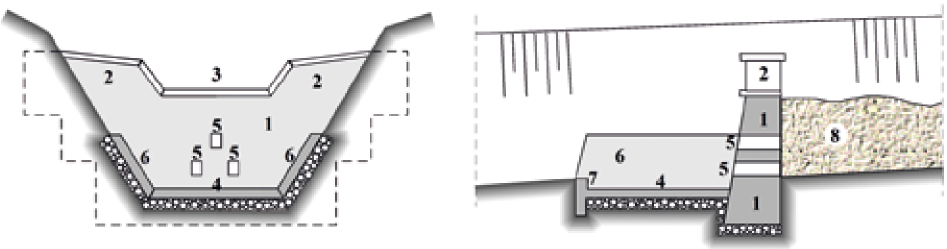

Figure 20: Basic elements of check dam

always have geometrical characteristics similar to those of the main embankments (Figure 19).

Connecting embankments are usually parts of main embankments, and their purpose is to connect the main embankments with a high, flood unaffected terrain and thus completely shut the landside area (polder). Geometrical characteristics and properties are similar to those of main embankments (Figure 19).

Transversal embankments are built to "partition" the landside area into several sections or polders, and serve as additional protection of polders in case water breaks through the main embankments. In case a breach of flood embankment occurs, only the polder positioned towards the damaged embankment is at risk. Polders are positioned vertically in relation to the main embankments (Figure 19).

Secondary line embankments have a role similar to transversal embankments - to additionally strengthen the system of flood control in case the main embankment is breached. They represent the "second line" of flood defence and are usually built on higher terrains of a landside area, further separating the most important parts of the landside from potential flood waters. They are parallel to the main embankments and lie on transversal and backwater embankments (Figure 19).

Tertiary ("summer") embankments are constructed on the unprotected side of main embankments, but the design waters are significantly lower for them, and they serve as protection from floods with shorter return period for agricultural land. In case of flood waters with levels higher than those designed for summer embankments, the defence of such an area is abandoned. Design waters are defined mainly by high waters during the vegetation period, and the dimensions of this embankment are much smaller than the dimensions of the main embankment (Figure 19).

Water walls and vertical protection walls are structures built in dense urban areas, in locations with insufficient space for the construction of less expensive structures - embankments. They serve the same purpose as embankments, for passive defence against flood waters, but also for protection from bank erosion, because they are constructed mainly on narrow parts of the watercourse. Water walls are mostly concrete structures made of monolithic concrete with rubber joints or concrete blocks, although some water walls are built from stone, brick or anchored steel sheet piles.

Flood control facilities located on the riverbed and outside of it, are usually multi-purpose facilities, one of which is flood protection. They are also used to improve water exploitation, pro-

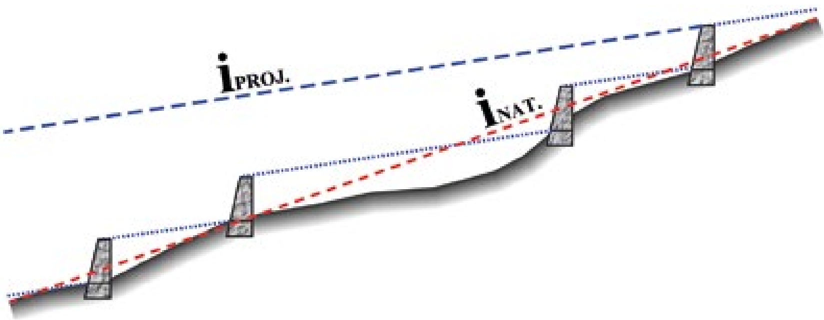

Figure 21: Schematic presentation of the installation of typical check dams depending on the waterbed inclination

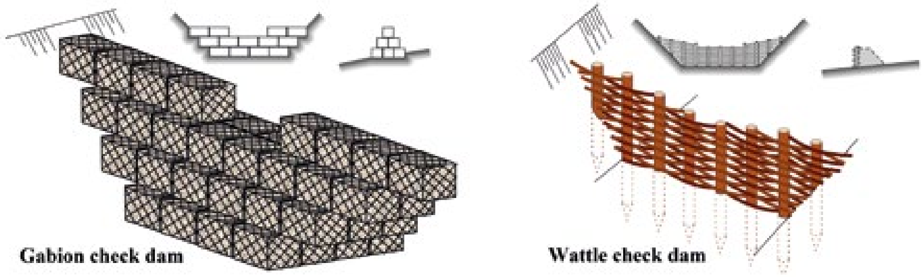

Figure 22: Check dams made of gabion a) and single wattle b)

tection from erosion, but also for non-technical purposes to improve the landscape of settlements in which they are built. On large navigable watercourses, they are used for maintenance of navigational depth or facilitation of navigation. Flood control facilities are therefore divided, by design flow, into facilities for the following design waters:

- low water – in large navigable watercourses, for the purpose of facilitating navigation at low water levels (large navigable watercourses);
- medium water – in watercourses where stable sediment condition and erosion protection are to be established (non-navigable watercourses) and
- high water – in watercourses where flood and torrent control is of primary importance (small watercourses).

In terms of flood defence, flood control facilities serve to ensure a flow of high design waters by providing a flow profile, and by removing barriers on the path of the flood wave. Facilities may be located in:

- urban area, in form of riverbeds with slope protection both for low and high waters, or just for low waters, and other facilities and
- rural area, in form of excavated profiles, where slope protection is carried out only in locations of strong meandering of the watercourse at risk of erosion of the outer (concave) banks.

However, flood control facilities in torrential watercourses differ from facilities in small and medium non-torrential watercourses. The regulated torrential riverbeds without transverse structures are called torrential channels, while the controlled torrential riverbeds with transverse structures are called flash flood beds

Check dams are massive gravity, transverse structures designed to stop the coarse bedload of flood waters, reduce the riverbed inclination and dissipate the kinetic energy of water.[14] They may have different forms and are constructed from various materials, but they all have the same basic elements that include: torrent barrier body, barrier wings, overflow mouth and energy dissipation structure. Also, among the basic elements of check dams are barbacanes or dam openings that serve for passage of low waters. In non-monolithic permeable barriers, the entire torrential barrier body has the function of barbacanes (Figure 20). Dams in torrential watercourses are mainly typical, built from the same materials and with uniform geometrical characteristics and dimensions. The height of dam depends on the desired riverbed slope and distance, as shown in Figure 21.

Various materials are used to build check dams, such as concrete and precast concrete elements, carved and rough stone, gabion elements, bricks, steel piles, and for lower facilities also wood and earth materials. Figure 20 shows a typical check dam that can be made of concrete, precast concrete elements, stone or brick. Figure 22a) shows a gabion check dam[15] and 22b) shows a wattle check dam (with, or without earth charging) for gullies and small torrential riverbeds (single wattle).

Chute spillways are constructed in areas where it is necessary to level a difference in elevation, or reduce the riverbed inclination and allow dissipation of the kinetic energy of water. The geometric shape of the chute spillway is an inclined plane in which the violent torrential flow occurs, entering the roller basin at the end of the chute spillway where the hydraulic jump slows the flow. The steep plane may be uneven or with large pieces of ragged stones or concrete dentils, or complete-

14 Dissipation of kinetic energy is the process of reducing or spending the kinetic energy of torrents on the processes of friction and turbulent flow in the facilities that have structures for dissipation, such as free overfalls and roller basins.

15 Gabion (gabion block) is a precast construction element in the form of a block (cuboid), with wire mesh sheath and crushed stone filling. It has a very wide scope of application and, among other things, is used for building check dams.

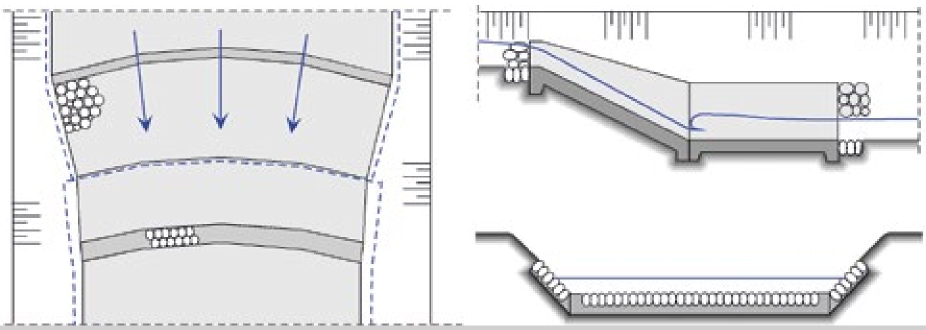

Figure 23: Chute spillway

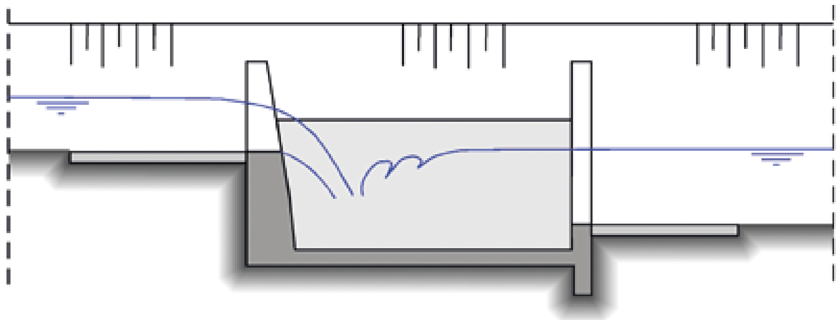

Figure 24: Cascade

ly flat, like spillways. The main characteristic of the structure is the change in slope inclination at the end of the chute spillway and at the beginning of a roller basin. A hydraulic jump or dissipation of the kinetic energy of the water and the transition from torrential to slow flow occur in the roller basin.

Cascades are transverse structures in the watercourse designed to reduce the inclination of the riverbed bottom, that is, to overcome the elevation difference. In contrast to chute spillways, where the steep plane is used for the formation of a spillway and the roller basin for dissipation of the kinetic energy of water, in case of cascades, the free fall of water is used for delevelling, while the dissipation of energy occurs in the free overfall (Figure 24).

3.4. Active Flood Defence

"Active" facilities influence primarily the hydrogramme of flood waters by "lowering" their maximum discharge, while increasing the duration of flood waters flow. Roughly, we can divide them into reservoirs, retention basins and lateral overflow channels (channels for high waters).

Reservoirs are large facilities that can serve several purposes, but in case of surge of flood waters, their function is to hold back those amounts of flood waters that could cause major damage downstream. Their main characteristic is the volume of space for receiving flood waves, and they can be divided into two parts: reservoir dam and reservoir storage space. There are no facilities in the storage space, but some preliminary work is performed to remove vegetation and reinforce the shores of the storage space. The reservoir dam is designed to retain water and control its discharge from the storage space, and its basic parts include the body of the dam, bottom outlet, overflow structure, control room and lock chamber (Figure 25). Depending on the type of construction, dams can generally be:

- gravity dams that create a structural stability of the body of the dam, by resisting the hydrostatic pressure with their mass and friction on the base;
- arch dams that lean on the bottom and rocky coastal sides on which they are built, thus transferring the hydrostatic pressure to the rock mass in the valley in which they are constructed;
- buttress dams that create structural stability by resisting the hydrostatic pressure wi-

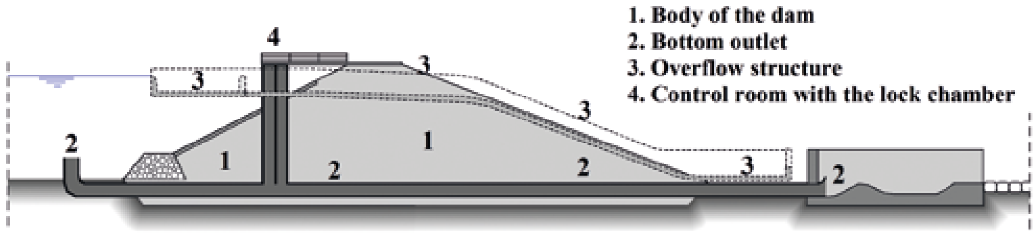

Figure 25: Reservoir dam – basic elements of dam

th their triangular geometry and deep foundation support.

There is a variety of materials used for the construction of the body of dams: arch and buttress dams are made of reinforced and prestressed concrete, but also of steel structures, while gravity dams can be built from concrete, stone and earth materials, and a combination of these materials.

Bottom outlet is a conduit with inlet and outlet openings with valves, which serves for controlled release of water from the reservoir and its discharge. The control room is usually considered a part of the bottom outlet, but it is a separate element of the dam, which is directly connected with the bottom outlet. There are also dams with bottom outlets separated from the system of reservoir water regime management, so their bottom outlets are used only in cases of complete outlet discharging of the reservoir. Examples are dams of hydroelectric power plants, which have special structures for use of water power for electricity production (HE Iron Gate I and II), as well as dams with overflow (Tisa – Novi Bečej dam), where an overflow sluice is used at the same time for the regulation of the operation mode and the outlet of flood waters.

An overflow structure refers to the part of a dam that serves for overflow of excess water that cannot be discharged through the bottom outlet, i.e. it is used when space for receiving flood waters is full. It protects directly the body of the dam from overflowing, i.e. from being damaged or destroyed due to the water flowing over the crest of dam. The overflow structure consist of an inlet shaft, or overflow basin, spillway, or conduit and outlet structure with a roller basin or free overfall depending on whether the overflow structure consist of shaft or lateral outlets.

Lock chambers are used to regulate the operation mode of reservoir and are connected with bottom outlet valves or regulation valves. If a dam has an overflow, the mode of operation is regulated with chute spillways, and the lock chamber is used only for discharging the reservoir (if possible).

Retention basins are single-purpose facilities for regulating water regime and "lowering" the hydro-

Figure 26: a) Frontal retention basin Veliko Središte and b) lateral retention basin Ljutovo

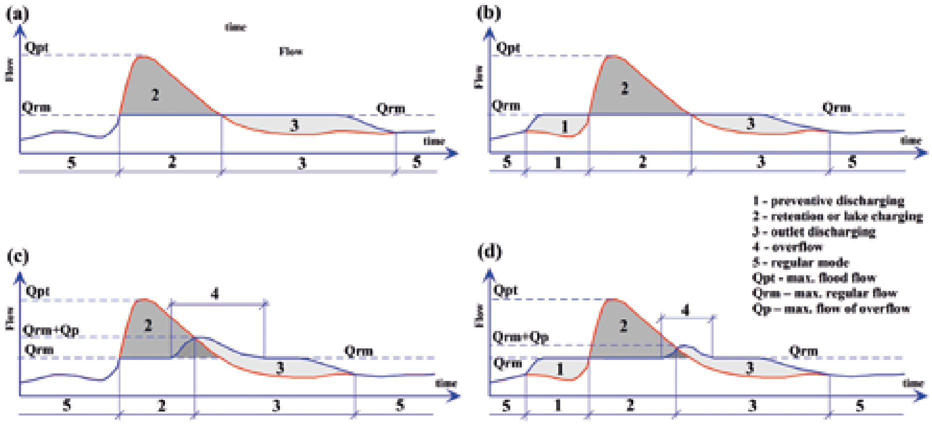

Figure 27: Transformation of flood wave hydrogramme in retention basins depending on the capacity for receiving flood waters and operating evacuation structures

gramme downstream of the retention basin. Thus, the retention basin receives the peak of flood wave in its own storage space and thus reduces the flow and flood water levels downstream. The height of facilities (dams and sluices) for the formation of retention basin is usually less than the height of reservoir dams, and thus the volume of retention basin is usually smaller than the storage space of reservoirs.

Retention basins located on the main stream are called frontal retentions, and they retain the flood wave with a constructed facility, dam or sluice. The flow regime is ensured by free outlet through the overflow structure or by regulated outlet through the lock chambers and bottom outlets. Figure 26 a) shows an example of frontal retention basin Veliko Središte.

Lateral retention basins are confined with embankments and located in plains, and those in Serbia usually do not have a unit for receiving flood waters, but the water is spilled over the embankment crown or, in rare cases, if necessary, a part of the embankment is destroyed for faster receipt of flood water. In Hungary, in the midstream of the river Tisa, several lateral retention high-capacity basins, for receiving flood waters, have been built and their integral parts are the sluices for letting the water in and out of retention basin. Figure 53 shows an example of lateral retention basin confined with the main and tertiary embankment and Figure 26 b) shows an example of the lateral retention basin Ljutovo.

Figure 27 shows different cases of transformation of flood hydrogramme in retention basins. These are:

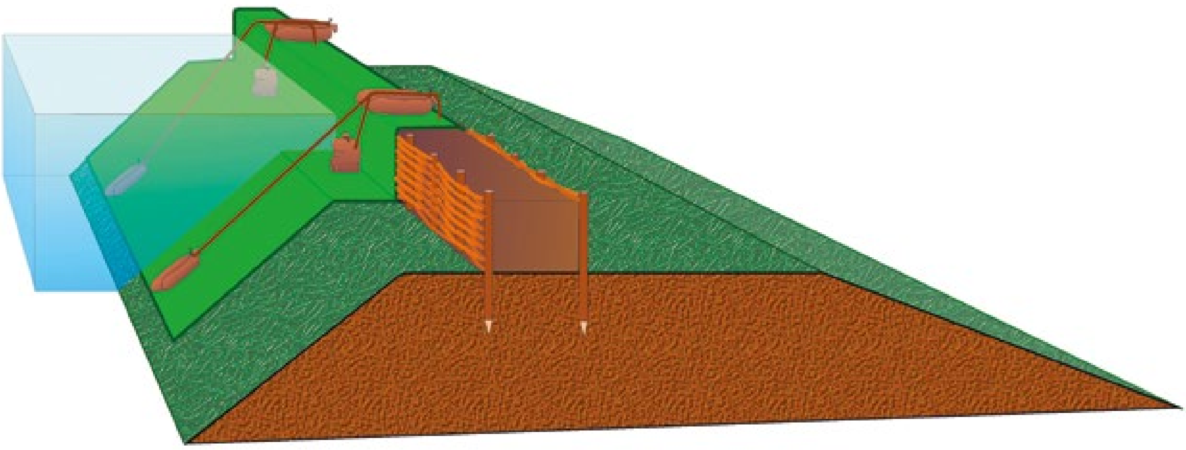

Figure 28: Temporary wattle dyke made of wattle and compacted earth

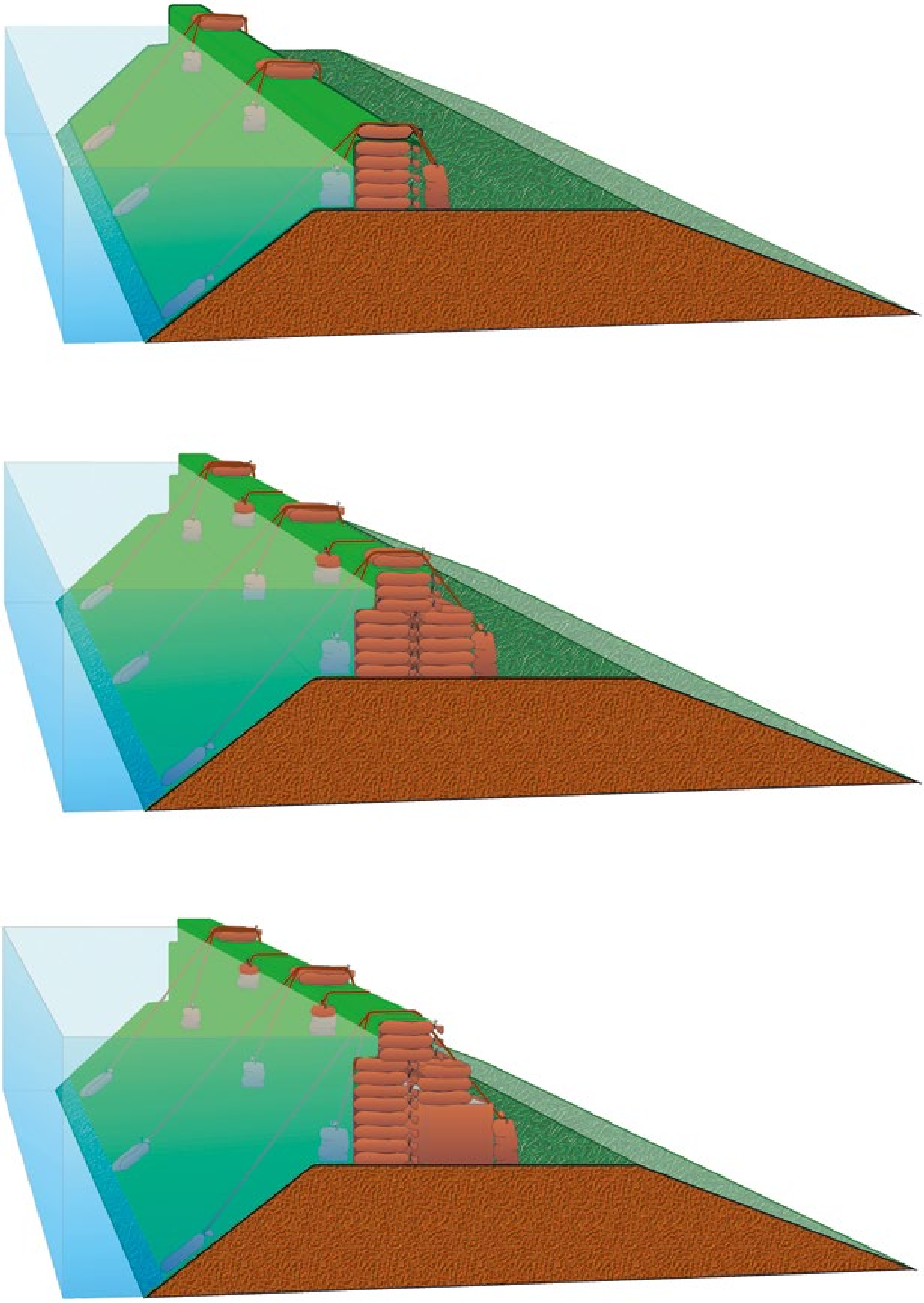

Figure 29: Sand bag dykes, depending on the level of flood water

a) retention basin with sufficient capacity to receive a flood wave, without preventive discharging;
b) retention basin with sufficient capacity to receive a flood wave, with preventive discharging;
c) retention basin with limited capacity to receive a flood wave, without preventive discharging;
d) retention basin with limited capacity to receive a flood wave, with preventive discharging.

Overflow channels are constructions designed to steer a portion of floodwaters through an artificial channel to achieve higher flow capacity of certain locations at risk of floods. An overflow channel can be located parallel to the main stream (lateral channel), so that water flows from this channel again into the same river course, or it can be transversal in which case the water flows into another watercourse. Most often they are built at locations where the flow capacity on the main riverbed cannot be increased (for example, uncontrolled construction in the bank area of the main watercourse).

Temporary facilities for flood defence are installed in sections at risk in case the protective capacity of the facility is exceeded, in embankments or walls. These facilities include temporary wattle dykes, dykes of sand bags or other material and demountable barriers.

A temporary wattle dyke is no more than 60 cm high, placed on the crown of the earth embankment by pitching two or three parallel wattle dams along the embankment at a distance of one meter and filling the space between them with compact earth material (Figure 28). They serve as temporary "superelevation" in case of an occurence of a flood wave that exceeds the level of the embankment crown. The longevity of such a dyke is short but can be prolonged by using PVC foil, which is placed along the riverside of wattle dams and down the riverside embankment slope; and can also be reinforced with sand bags. The construction requires a lot of manpower and manual work, and after removing these temporary wattle dykes, it is necessary to repair the embankment crown damaged by piling wooden poles. This method is very rarely used.

Figure 30: Demountable barrier in use

Embankments made of sand bags or other material, like the aforementioned ones, are not durable and are placed only if the level of the embankment crown is not sufficiently high as compared to the level of flood wave. They are described in literature mainly as single row – of maximum height 50 cm and double row – of maximum height 80 cm, but they can be even higher in practice, although in such cases it is necessary to reinforce them by placing some ballast on the riverside to ensure the stability of sand bag dykes. Protection against leakage of sand bags is ensured by PVC foil, but always placed on the outer side of the embankment (towards the water) to keep the sand bags dry as long as possible and minimise leakage. Also, the PVC foil should not be placed between the base and the sand bag dyke, because the roughness of this contact is very important for the stability of the embankment. In single-row sand bag dykes, the ties of bags should always be placed towards the landside because they may untie. If a double-row dyke is built, the ties in the inner row should be placed in the direction of the front row, because if they untie the sand has no place to leak out of the bag. Figure 29 shows drawings of sand bag dykes, depending on the amount of flood water, with PVC foil (one-row, double-row and double-row with a ballast of "jumbo bags").

Demountable barriers and temporary dams are also temporary facilities intended exclusively for certain locations that have been prepared for their installation, aforehand. Demountable barriers are in mostly constructed of support pillars, placed in a pre-installed foundation, that the demountable support slots into, in between the space is filled with standard panels that completely contain the area (Figure 30).

The panels are usually made of aluminium alloy (although other materials are also used) to provide lighter weight to the construction, prevent water corrosion and ensure the carrying capacity of such elements and the entire protection system. They can be vertical and inclined, reinforced with props or without, depending on the location, structural characteristics of elements and barrier height. Demountable barriers can be installed on earth embankments also, previously ensuring deep anchoring and PVC wrapping to prevent leakage into the contact layer, but also the extension of the water stream trajectory through the body of the embankment.

3.5. Flexibility of Flood Management Strategy

Addressing flood- related challenges from different perspectives has assumed a whole new dimension, especially in the light of evident climate change, because of which adjusting to the effects of extreme events and strengthening resistance to them proved to be the only option. In this context, we can distinguish the following six groups of most important segments of the new strategy:

- "give more space to rivers"
- construct retention basins that will retain flood waters in the upper basin
- restore natural flow regimes
- restore old retention basins and extensive land use
- prepare for flood risks – "living with floods" and
- technical flood defence with embankments and protection barriers.

"Give more space to rivers" should provide an answer to the question related to the best ratio between urban development in the zone of waterways and open spaces. The concept of open space implies free and unoccupied surface needed for the flow of flood waters without harmful consequences for urban development of a community. Increased population influx to urban zones requires additional space and construction, but that space must not include areas on the path of the flow of flood waters. During urban planning and design, it is necessary to take into account the needs of water, i.e. these activities must comply with requirements defined in flood zone maps. Moreover, to protect urban zones, which already occupy a large area needed for passage of flood water, sufficiently broad inundation areas must be provided in rural areas, moreover, riverbeds must be expanded for flood waters.

Construction of retention basins to retain flood waters and "lowering" of hydrograph in the upper course is certainly one of the most important points of the new strategy, but it must be taken into account that retention spaces cannot be made at any location. Although retention basins have long been known and used as a type of flood control, this option has not been used for a large number of torrential streams. Retention spaces in mountainous basins can be created in places in which there is a widening in the valley and a small slope of the channel bottom, because otherwise it will not be possible to provide space sufficiently large to retain flood water, without building high dams.

Restoration of natural flow regimes is a measure that allows the meandering of watercourses, thus prolonging the flow time or the time of concentration, while the hydrograph changes its shape to a milder rise, lower peak, longer lag time and longer recession time. This measure involves the suspension of construction and other works in the riverbed and on the banks and ban of further construction. Also, if it's technically feasible and at low cost, facilities should be removed from the riverbed and banks. This measure includes administrative measures that restrict the use of land along the watercourse for specific purposes, such as intensive agricultural production, construction of residential buildings or industrial plants.

Restoration of old retention basins and extensive land use is a measure quite similar to the construction of retention basins in the upper courses, but refers to the restoration of old, abandoned riverbeds or stagnant waters in the middle and lower courses, to receive the surge of flood water. Stagnant waters have often been drained and exploited for agricultural production, and their surface has been separated from the riverbed with embankments. These areas should be "returned to rivers", so to speak. the embankment between the stagnant waters and the watercourses should be reconstructed for average flow conditions or floods with short return periods. Administrative measures should be prescribed to limit the agricultural activity in new retention basins to extensive activity, and compensate owners for future flood damage.

"Living with floods", an activity of a new strategy that should be based on the concept of constant training and raising awareness of the population that lives or works in flood risk areas about floods, flood hazards and risks, flooding effects, evacuation routes, type of assistance in the event of flooding, use of new construction, waterproofing and other materials and resources, safer use of home and work surfaces, flood insurance, etc.

The last point of the new strategy relates to the **technical aspects of flood defence** - embankments, demountable barriers, check dams, overflow channels, reservoirs, existing retention basins, but also about maintaining them in proper functional condition.

4. Flood Risk

The stochastic nature of flooding implies the possibility of its occurrence in different areas, in different seasons and time periods, with different intensities and duration, thus making the assessment of potential adverse consequences of flooding largely unreliable. There is no specific, universally accepted and single methodology for determining the risk of flooding in hazard-prone areas, and risk analyses are performed mainly on a case-by-case basis, according to some empirical rules or for specific purposes.

The term flood risk is often confused with the term flood hazard. A risk is not the same as hazard, and it also differs from damage potential. A risk is dimensionless, or a combination of the probability of occurrence of a hazardous event or a hazard itself. Therefore, flood risk is a combination of a probability of occurrence of a flood event with a certain flood return period and the potential adverse consequences of this flood event on human health, the environment, cultural heritage and economic activity.

The following example explains, in more simple terms, the difference between hazard, risk, damage potential and actual damage:

Playing card games is not a hazard, because there is no danger to the players. However, a proposal to play for money is an introduction to a hazard, or the beginning of gambling. The player who refuses is not exposed to hazard at all, while the player who accepts it has accepted gambling and becomes exposed to hazard. Hazard is therefore the existence of a justified possibility of the occurrence of an undesired event, which is loss of money, in this case.

This raises the question of the existence and magnitude of risk. The answer to this question depends on the number of players, arrangement of cards, value of cards a player holds in his or her hands, status and arrangement of the remaining undivided cards, or cards in the deck: in other words, it depends on a large number of unknowns, which are related to the most important risk value, and that is the probability of occurrence of an unwanted event - in this case, the loss of money.

For example, in the blackjack[16] game, a player has a sum of 17, and needs to determine the probability of getting a king, queen or jack, needed to increase the sum to 21, 20 or 19, but also the probability

16 A card game of blackjack is played with the cards having a value from 7 to 10 and the cards of "blackjack" or 11, which have the highest value, thus exceeding the value of kings, queens and jacks. Jacks, queens and kings have the values of 2, 3 and 4 respectively. The winning sum of card values in blackjack is 21. The players are dealt one card in each round, until the player declares that he or she wants another card. When he or she is satisfied that the sum in his or her hands, he or she makes it clear that they do not want another card, and if the sum of his or her cards exceeds 21 (except in the case of "dry blackjack"), the player exits the game and lowers downs the cards without showing them to other players. The winner of the game is the player who has the highest sum of card values. After each dealing round, the players have the option to raise the bet, and the players who want to continue the game must "follow" him or her and post the amount equalling the rise.

that the new sum will be sufficient for winning the game. Determining the total probability for a positive outcome is a product of the probabilities of all events that influence the positive outcome for the player. At that point, the player has to think about a large number of unknowns that depend on the probability:

- *that his or her present sum is the highest;*
- *that in the next dealing round he or she will get a king, queen or jack;*
- *that the desired cards are among the undivided ones;*
- *that the increased score will be sufficient to beat other players, etc.*

Hence, the total probability of a positive outcome is obtained by multiplying all necessary probabilities of a positive outcome. Since the probability is expressed as a ratio between the desired outcome and all possible outcomes (1/n), it can be concluded that by multiplying all these probabilities, which are much smaller than 1, we obtain the total probability of a positive outcome, which is very low. Given that the probability of a negative outcome is the reciprocal value of the total probability of a positive event, we can say that the risk increases proportionally with the decrease in the probability of a positive outcome. If there are bets on the table, then the risk assumes a whole new dimension. If the player chooses to "follow" the bets, the risk turns into potential damage, and it is a product of the value of the bet on the table and the risk of not winning the game. The potential damage is increased by increasing the bet on the table and by increasing the risk of an adverse outcome. Actual damage occurs only when the game is played or when another player takes all the bets from the table.

4.1. Flood Damage

Floods have diverse negative impacts and cause damage, but the greatest harm is certainly the loss of human lives. Other damage can be divided into material and non-material, and direct or indirect damage.

Material damage can be expressed in quantitative form, either in exact numbers (for example, the number of destroyed buildings or the number of dead cattle) or monetary values (the cost of lost property at current market prices).

Non-material damage is damage that cannot be expressed in quantitative terms, either in numbers or monetary values. This includes flood damage suffered by entities that were prevented from being fully operational due to floods, for example lost school classes or unfinished non-financial jobs resulting from the inability to use certain public services.

Direct damage is damage caused by flood water or torrent, and it can be directly attributed to flooding, while indirect damage is incurred indirectly, due to the impossibility of working, performing other tasks outside the flooded area or, for example, due to an increase of expenses caused by the inability of using a shorter (flooded) road.

A special parameter is the maximum possible flood damage, i.e. the damage caused by the highest-level flood ever recorded, according to the worst case scenario. In this scenario and considering the elevation of flood water, all the users/receptors would suffer the greatest possible damage. This parameter, although only computational, is used for comparison of the actual damage caused by floods that have occurred. More precisely, actual damage that approaches a possible maximum should be the subject of future activity to increase the resilience and safety, as well as to reduce vulnerability and susceptibility.

4.2. Flood Hazard

Flood hazard is a dimensionless qualitative fact, because it only determines the existence of a hazard, without quantitative indicators of that hazard. In other words, in regards to flood hazard, as long as it is described with the terms "exists" or "does not exist", we refer to a hazard. The term hazard has already been introduced into the national risk management terminology, although it refers to a dangerous event that may or may not occur.

Hazards can be generally divided to:

- geological - earthquakes, tsunamis, volcanic eruptions, landslides, etc.
- climatic - cyclones, tornadoes, hurricanes, floods, droughts, storms, snow storms, etc.
- biological - epidemics, environmental pollution, devastation of forests, pest infestation, etc.
- chemical and nuclear - chemical accidents, nuclear disasters, industrial disasters, etc.
- anthropogenic - traffic accidents, building demolition, fire, electric shock, etc.

Historical data largely contribute to better assessment of hazards by indicating the events that might happen in the future. However, a hazard is not an actual event, but rather a threat of occurrence.

4.3. Receptors and Emitters

Receptors are all entities (all of which may suffer damage from hazards, such as: population, facilities, material and non-material assets, services, conditions and processes) within the hazardous zone, which in case an event occurs would suffer material or non-material, direct or indirect damage. The receptor who suffers damage as a result of an event, and emits harmful effects onto other receptors, due to alterations induced by the event, is called an emitter (the term receptor will be used henceforth, regardless of whether it is only a receptor or also an emitter).

4.4. Risk of Floods and Torrential Floods

A risk is a probability of occurrence of an event that is uncertain in terms of time, space, quantity and quality. Risk is a vector in a multidimensional vector space in which anthropogenic impact is possible only in certain, limited number of dimensions.
This vector space has a number of dimensions, and the most important are: probability of event, consequences of events, multiple temporal determinants time, scope of hazard, susceptibility to event, exposure to event, safety of receptors, possibility of receptor management, etc.
UNDP defines risk as the probability of harmful consequences, or expected loss of lives, people injured, property, livelihoods, economic activity disrupted (or environment damaged) resulting from interactions between natural or human induced hazards and vulnerable conditions. Risk is conventionally expressed by the equation:
Risk = Hazard x Vulnerability
Acceptable risk is the risk value at which the decision-makers accept harmful consequences, and based on that risk value, the design return period is determined. Data on the design return period or the design probability of an event is one of the most important parameters of risk, because the decisions adopted by decision-makers will differ for different return periods.
Flood risk is a function of a large number of parameters and is determined separately for each receptor. The flood risk of receptor i is expressed as:
$Ri = f(P_m, Z_i, S_i, v_i, p_i, T_i, t_i, t_{gi},...)$
where P_m = design probability of event, Z_i = depth sensitivity of receptor i, E_i = exposure of receptor i, S_i = safety of receptor *i*, v_i = velocity of water to which receptor *i* is exposed, p_i = specific weight of flood water, T_i = duration of flood affecting the receptor *i*, t_i = daily temporal determinant of flood event, t_{gi} = annual temporal determinant of flood event.
Depth sensitivity of flood risk receptor Z_i is a function of the depth of flood water h and the type and properties of receptor *i*, which is exposed to flood water. It is expressed in percentages of harmful effects on the receptor, and its dependence on flood water depth constitutes a non-pecuniary damage function for the receptor *i*. Example of various levels of depth sensitivity may be found in the field of housing, because the sensitivity of buildings varies according to construction material, and therefore a house built of earth material (adobe, mud) is considered to be 100% sensitive, because it has no resistance to flood, while the sensitivity of a house built from brick in flexible mortar increases linearly with the depth of water, but does not exceed 30%.
Depth sensitivity is a particularly important parameter for the population of different age groups, and therefore in case of quiet flood waters we distinguish the following depth zones:

- 0.0–0.5 m – possible movement of population and carrying of small children through water;
- 0.5–1.5 m – possible standing in water and to some extent holding small children in arms;
- 1.5–4.0 m – possible access of boats to house roofs and provision of help to affected population;
- > 4.0 m – all activities are hindered except those in high multi-storey buildings.

Exposure of receptors is a special characteristic, unique to each type of receptor. This risk parameter also has a positional characteristic, especially in torrential waters, when the velocity of water plays a major role. Exposure is also a function of population size in the flood area, so that an increase in population leads to an increase in exposure.
Safety of receptor Si is a parameter that indicates the position of the receptor in the potentially flooded area. In fact, if the receptor is located in the zone protected with embankments dimensioned on the basis of return period equal to or longer than the return period of design risk, then the receptor's risk has to be reduced by the safety provided by the embankment. Since safety is a dimensionless parameter of the same type as risk probability, it is integrated into risk probability, so that further probability is calculated as a reduced probability of flood event. No embankment should be considered absolutely safe, but safety is to be observed in the function of embankment condition. If the embankment is well maintained and fully functional, its safety is considered to range from 99% to 99.9%; if its maintenance has not been kept up, but was repaired, safety equals to 95%, and if it has been poorly maintained, but fulfils basic functionality requirements, its safety is 90%.
Reduced probability is calculated according to the formula:
$P_r = P_n (1 – S_i)$
where P_n = design risk probability, and P_r = reduced risk probability. If there is a second line of defence, additional safety of the second line of defence is included in the reduction of design probability according to the same principle.
The concept of time is a three-fold parameter in risk determination. Duration indicates the time period within which the flood affects the receptor, which is of high importance, for example in case of vegetation. Also, in terms of human lives, it makes a difference if flood occurs during the day or at

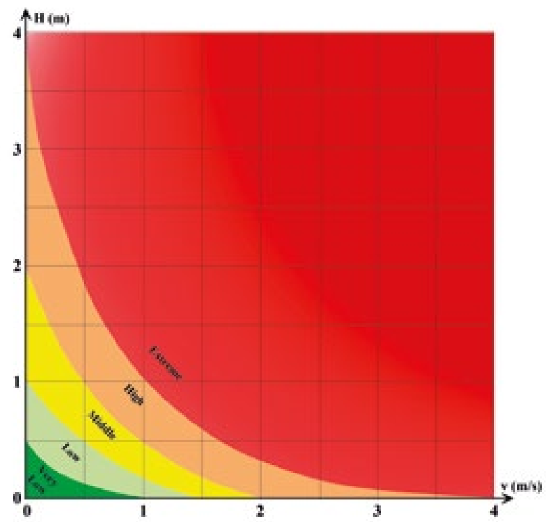

Figure 31. Diagram of risk depending on the depth and velocity of flood water

night, because night floods are considerably more dangerous for the population. The annual temporal determinant is important because of the period of year in which flooding occurs. For example, if a flood occurs in the winter, which is a non-vegetation period, there is no direct damage to spring crops, while indirect damage consists of an increase in the cost of re-working the land. In contrast, if the same crops are exposed to flood in the summer, before the harvest, direct damage is significantly higher and closer to total damage.[17] Also, if flood affects a residential building in the winter, indirect damage will be much higher, due to the long-term inability to use the building for housing, than it would be in the spring or summer, when the wet walls dry faster.

Water velocity is not as significant in case of floods in large rivers as it is in case of torrential streams. As already mentioned, in case of floods in large rivers, the largest mass of water flows through the main riverbed, where the velocity is at its peak. The flow in inundations is significantly lower, and the velocity is also much lower. In large rivers, water velocity is important only in cases when the embankment is broken, particularly in the damaged zone because the water in these locations has full destructive force. In torrential floods, as opposed to flooding of major rivers, the water velocity and the specific weight of flood waters are the main destructive factors. The importance of this relation is best illustrated in the diagram of risk depending on the depth and velocity of flood water (Figure 31).

17 There is no total damage on agricultural fields, because if the 100% of crops are destroyed immediately before the harvest, the damage is calculated as total value of production reduced by harvest costs.

4.4.1. Input Data for Determination of Flood Risk

Input data for the creation of a map of vulnerability, risk and damage potential can be divided into topographic, hydrologic and hydraulic, cadastral, planning and technical, social and economic.

Flood risk analysis is a complex, comprehensive and demanding process, which requires a large number of different types of data, and is characterised by sub-processes that are interconnected in many aspects. Determination of a three-dimensional basin terrain model is among processes that require most comprehensive input data.

An analysis of topographic data should result in a three-dimensional basin terrain model (3D model). Special attention is paid to the lines of water concentration, or temporary and permanent water flows in the basin, as these data are of paramount importance for the development of a good hydraulic model for a watercourse. 3D terrain models can be created in two basic ways. The first way is to apply the methods of profile, according to which typical land profiles with elevation are created on the basis of a linear sequence of points, and the terrain between the two profiles is determined by some of the methods of approximation. Another way is to create a TIN terrain model (Triangular Irregular Network) based on a large number of elevation points, and the terrain between the three adjacent points is determined in the form of irregular triangles, which are the terrain plains, each of them limited with three adjacent points. The network of such irregular triangles is the terrain model, and its accuracy depends on the density of points and additional points coverage of topographic objects, such as embankments, roads, channels, plateaus, passages and other forms of the physical model of terrain, where the terrain changes abruptly. The profile based model is not suitable for 3D basin terrain models, but only for 3D models of waterbeds and coastal plateaus to the point of elevations. The approximation of terrain surfaces at large distances is applicable to long linear topographic forms, where there are evident similarities between the profile features, such as the lines of thalweg (the line of the lowest points of the riverbed), coast, embankment and the like.

Hydrologic and hydraulic data are derived or extracted from the mutual relations of topographical, meteorological and hydrogeological data, as well as data on the type and condition of riverbeds. Based on a series of meteorological and climatic data on rainfall, air and soil humidity, intensity, frequency and direction of winds, evapotranspiration, etc., the designed level, intensity and duration of precipitation are determined, by statistical processing, for a given exceedance probability.

During further processing, the specific runoff from the basin is determined by using topographic properties, as well as a set of data related to the surface (vegetation, soil substrate, geological substrate, degree of development, erosion processes, etc.). Such processing involves the application of a numerical rainfall-runoff model, by which the design precipitation is transformed into runoff.
In further procedure, the design flood is determined from basin runoff using hydraulic models and the terrain model, and depending on the type of hydraulic model used for calculation, the design flood may have: water stage, depth of water, water velocity, temporal distribution of flooding, as well as the simulation of the propagation of flood wave.

4.4.2. SWOT/PESTLE Analysis in Receptor Identification

The criteria for determining the risk of flooding are expressed as consequences of the harmful effect of flood water on human life and health, as well as on the particular tangible or intangible goods exposed to such harmful effects. As already mentioned, depending on the direction of their effect, the criteria may be the receptors or emitters of flood risk. They can be roughly divided into population, property and environmental receptors. Generally speaking, the most complex part in risk determination is to determine receptors and emitters. This process is complex due to the large amount of data, their diversity and significantly different effects of flooding on them. Therefore, this process requires a multidisciplinary approach and the participation of a large number of different professions.

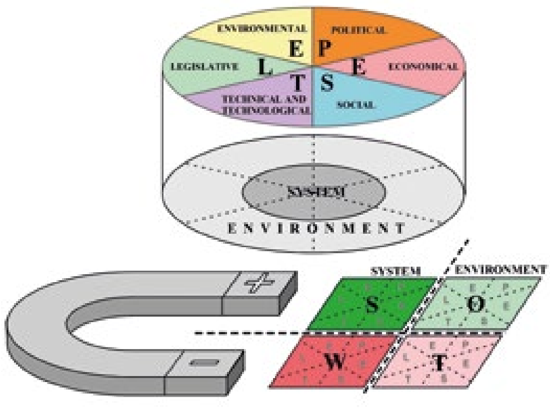

Figure 32: Outline of SWOT/PESTLE analysis process in the procedure of determining receptors (Source: Multi-criteria analysis of variants of the reconstruction of water intake structures, R. Bajčetić, Master Thesis)

The process itself is based on a SWOT/PESTLE analysis, which consists of two filters for information and facts (Figure 32.)
The first, input filter is PESTLE analysis, which requires a full multidisciplinary approach to the process. The name is an acronym of the words: Political, Economic, Social, Technical, Legal and Environmental, which explains the necessity of a multidisciplinary approach. In this way, certain issues are observed from all these aspects. PESTLE filter is used to analyse the impact of floods and extract all the factors influenced by floods. In the next procedure, using SWOT analysis, all factors are broken down into those subject to a positive impact of flooding and those subject to its negative impact. Factors are also divided on the basis of whether this influence is direct, i.e. whether it derives directly from flooding, or indirect. Positive effects from the system and environment are strengths and opportunities, while negative effects are weaknesses and threats (Strengths, Weaknesses, Opportunities, Threats). If identified factors may suffer direct or indirect damage from hazards, then they are obviously receptors.

4.4.3. Determination of Risk from Floods and Torrential Floods

There is no single methodology for determining a flood risk, but one of the most complex and comprehensive models has been developed by the Ministry of Environment of the Czech Republic. According to this model, the assessment of risk and flood damage potential is conducted according to three scenarios, for the return periods of 5, 20 and 100 years, and the receptors are grouped into four main groups[18]:

- **economic criteria**, expressed as total direct and indirect material damage;
- **environmental and cultural protection criteria**, in the context of environmental protection, expressed as the processes of erosion and accumulation of material, discharge of harmful pollutants due to flooding, as well as the effect of flood waters on protected biotopes, and in the context of cultural environment, expressed as flooded buildings under protection;
- **population criteria**, expressed as overall harmful effects on direct needs and living condition of the population in the inundated area, and
- **social criteria**, expressed as damage caused by the inability to use various public

18 Ministerstvo životního prostředí (2011).

services such as schools, medical centres, theatres, cinemas, town services, etc.

In Great Britain, only the scenario for the return period of 100 years is used for assessing vulnerability, flood risk and potential damage at the national level, and thus a general threat of flooding from watercourses and flooding caused by tidal waves is established.

In Germany, several methodologies are used. Thus, in Bavaria a method based on land use is applied, while in Baden-Württemberg the methodology is based on spatial planning documents and extensive historical data on floods and damages. Methodology developed at Hamburg University of Technology interprets the maps of vulnerability, risk and potential damage only as part of a complex system that supports the decision-making process on the prevention or mitigation of consequences from harmful effects of water.[19]

In 2008, the European Commission established the need for launching a project that would solve the problem of natural hazard events, and hazards caused by human activities. In this respect, on 1 January 2009 the project SAFER (Services and Applications For Emergency Response), was officially launched, as a separate part of the initiative GMES (Global Monitoring for Environment and Security)[20]. In addition to flooding, the SAFER project also covers earthquakes, landslides, storms, fires, technological disasters and volcanoes.

The methodology developed by Infoterra, the coordinator of several private companies for the purpose of SAFER project, proposed a uniform structure of the process. According to the required accuracy and importance of particular potentially flooded areas, there are three basic levels of assessment models.

The first basic level is BEAM (Basic European Asset Map), resulting in the development of a monetary map of damage distribution in flooded areas in large scale, that has has a presentational character. The input data are less precise surfaces of large scale with rough data regarding the type of land use. Monetary damage values are presented in a few plan ranges, for all receptors together.[21]

A more precise and detailed level is HiRAM (High Resolution Asset Map). It focuses on important facilities in the context of flooding, highlighting particular analyses of settlements by districts and land use with far greater precision, and it is of tremendous help in the preparation of local development plans, and for determining priorities and directions of the potential evacuation of population.

The most detailed level that covers the smallest area unit is AM+ (Asset Map PLUS). In urban zones, the smallest details are individual buildings, and on agricultural and forest lands, these are plots or crops. AM + uses the real estate cadastre data for each building or land plot, which is justified in the case of mapping risks and potential damage to endangered cultural and historical sites of paramount importance.

Two projects related to flood risk assessment have been implemented in Serbia to date. The first project is part of a larger project Danube Floodrisk, aimed at determining vulnerability and risk and their mapping for the main riverbed of the Danube River, without assessing the tributaries. The risk of flooding was assessed by taking into account the probability of flood waters and extreme floods, or events that exceeded the 100-year and 1000-year probability of occurrence. Zoning of inundation areas was carried out according to the depth of water in these zones, for the determined probabilities. The second project is SoFPAS - Study of Flood Prone Area in Serbia, which covers the territory of Velika (Great), Zapadna (West) and Južna (South) Morava with 17 tributaries. The data on population, land use and infrastructure were obtained partly from local self-governments and partly from other institutions, such as the Republic Geodetic Authority (RGZ) and the Statistical Office of the Republic of Serbia (RZS). The Corine Land Cover maps[22] were used outside of the settlements. A common trait of both projects is the 1D flood model, with water depth as its single dimension, while the velocity of water in the inundation areas was not determined.

In some national methodologies in the European Union, potential damage is equated with risk, by multiplying the non-pecuniary risk and dimensionless value by the market value of the receptor, thus achieving the monetisation of risk. The important question is how the qualitatively expressed damage, or non-pecuniary damage, can be monetised or how we monetise the value of lost human lives.

19 Pasche, E., Lawson, N., Ashley, R., Schertzer, D., (2008).

20 http://www.emergencyresponse.eu.

21 Muller, M., Assmann, A., Kraft-Holzhauer, V. (2010).

22 Federal Environment Agency (2006).

5. Torrents

5.1. Overview of Major Torrential Floods in Serbia

Serbia is naturally predisposed for the formation of torrents and torrential floods. Relief, geologic substrate susceptible to erosion, climate characterised by high intensity rains and parts of the country with strong winds – all these conditions are suitable for the appearance of torrents, not only in the mountains but also in the plains.

Torrents were not considered a problem as long as the value of endangered assets was small. The development of railway and road networks implied a "conquest" of river valleys where entire settlements were constructed. Torrents imposed the necessity of constructing facilities for protection against torrential floods, which were later extended to anti-erosion works.

People living in flood-prone regions, where flood protection systems had been built, were convinced that they were protected from torrents. This was partly true, but only until the occurrence of floods that exceeded the level of the protection system, designed for the probability of a hundred year flood (1%).

Torrents caused damage in parts of Serbia covered with small-scale protection systems. This can be seen in Figure 33, which shows comparative maps of the density of anti-erosion works and the areas of Serbia often affected by torrential floods in the past decades. Media usually reported about these torrential floods, but the damage record system was such that only major and catastrophic damage was registered. If all the damage, no matter how small it may have been, were registered, the total annual amounts would be large. Therefore, statistical data includes only the information on paid insurance claims. Due to the policy of insurance companies according to which the basic insurance of buildings does not include the insurance against inundations and torrential floods, which requires additional insurance, a high number of people did not insure their homes from floods and torrents.

It is clear that torrential floods often occur in the areas that are not sufficiently covered with runoff and anti-erosion works, but it is also obvious that there are catastrophic torrential floods in streams that are covered with protective works relatively well.

The question is where to begin with the presentation of torrential floods that affected Serbia. It should be understood that the problem of torrents has always existed, but only the appearance of railways brought it to light. In fact, before that point land transport was performed in carts and caravans of cargo-bearing animals. Torrents interrupted roads also in those times, but no one was bothered about waiting a day or two until the road, demolished by floods, was repaired, because travellers could not travel further than twenty to thirty

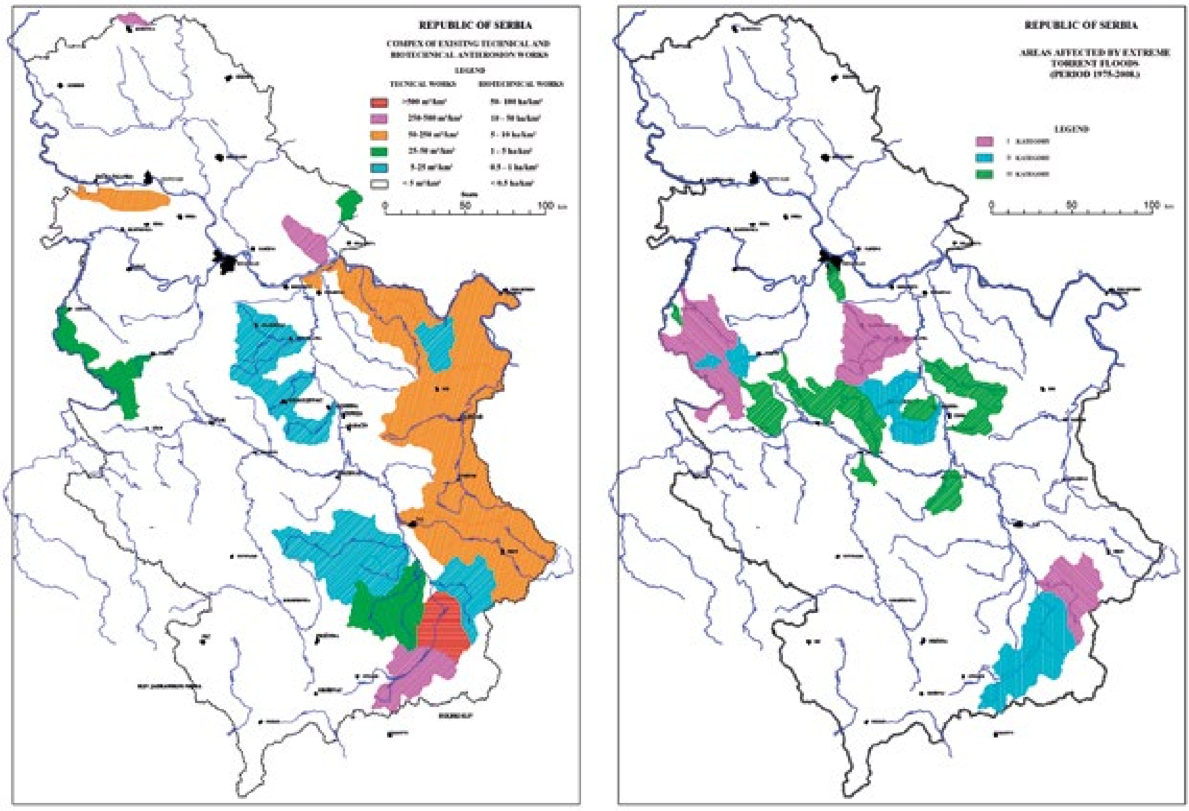

Figure 33: Comparative presentation of the coverage of Serbia with anti-erosion works and the areas with frequent torrential floods

kilometres a day. Roads did not have to meet strict technical requirements imposed by the railways. Railway tracks were placed mainly in river valleys, which caused accelerated urbanisation and occupation of these areas. Motor traffic required the construction of new roads, which, together with railways, cut a number of torrent flows. This led to a situation in which settlements were destroyed by the arrival of each torrent.

The current state of erosion is the result of anti-erosion and torrent control works over decades, due to which significant progress was made compared to fifty years ago. The average erosion rate was reduced by one and in some areas by two categories. Since erosion is an existing phenomenon and process, in order to maintain the present state, we need to maintain the existing system of protection, while the improvement of situation requires additional work. These are works that have been performed for decades and are necessary, because large areas are still under the processes of excessive to medium erosion.

Besides all this, there is a constant threat of intensified erosion processes, with all the accompanying problems, due to lack of maintenance of the existing anti-erosion system and non-application of administrative measures in the erosive areas. By executing works and application of measures, the rehabilitated areas have now become highly agriculturally productive, especially for fruit growing.

Simply put, torrent control works (check dams, sills, regulations, etc.) serve as the “skeleton” of the system and prevent changes in torrential riverbeds, while biological and biotechnical works (forestation, grassing, orchard planting and application of administrative anti-erosion measures, etc.) are the “suit” of integral protection against torrents and erosion.

As each material has its limitations in its endurance, such is the case with protective systems against torrents and erosion. These limits of endurance depend on the regulations based on which a protective system is designed, as well as the degree of development of the system or the degree of its complexity. A large number of such systems in Serbia are well-designed, but incomplete, for many reasons.

After every major torrential flooding that has caused huge damage, analyses were conducted with the aim to establish a liability scheme. It occurred most often that no precise data regarding rainfall was available, thus only rough estimates could be made. A retrospect of the torrential floods that have caused major damage in recent decades has been prepared. There have also been countless minor torrential floods that destroyed one or two houses, demolished a less important bridge, destroyed several agricultural fields, but unfortunately they are known only to the affected people, who were usually not insured, and therefore there are no records of damage. Table 4 gives a chronological overview of some major torrential floods in Serbia.

Date	Torrent/Basin	Place/Municipality	Description of damage
23/07/1964	Korbevačka reka/ Južna Morava (South Morava)	Vranjski Priboj/Vranje	Two bridges and one torrent barrier were destroyed and a dozen houses were flooded.
26/07/1975	Korbevačka reka/ Južna Morava (South Morava)	Vranjski Priboj/Vranje	A railway bridge was destroyed just before the arrival of the train (13 passengers killed).
02/07/1983	Sejanička reka/ Južna Morava (South Morava)	Grdelica/Leskovac	The urban area of Grdelica settlement was affected and the textile plant in Grdelica was completely destroyed.
26/06/1988	Vlasina/Južna Morava (South Morava)	Svođe/Vlasotince	Four persons were killed, several thousand houses were destroyed or damaged, the lateral side of the Vlasina dam was breached, 32 bridges were destroyed, and drinking water plant Ljuberađa was seriously damaged. Estimated damage about USD 1 billion.
26/11/2007	Vlasina/Južna Morava (South Morava)	Vlasotince, Šišava, Sredor, Nomanica, Konopnica, Gornji Orah, Prisijan, Kruševica, Donji Dejan/Vlasotince, Babušnica	Several thousand houses were flooded, one bridge and road near Ljuberađa were damaged.
26/11/2007	Kosanica, Toplica /Južna Morava (South Morava)	Kuršumlija	A large number of houses and several dozen hectares of agricultural land were flooded.
26/11/2007	Jablanica/Južna Morava (South Morava)	Lebane/Lebane; Vinarce, Bunibrod, Priboj, Pečenjavce, Živkovo, Managovac, Leskovac/Leskovac	A dozen houses and large agricultural surfaces were flooded in the Municipality of Lebane; several hundred hectares of agricultural land and a large number of houses were flooded in the Municipality of Leskovac.

Date	Torrent/Basin	Place/Municipality	Description of damage
13-15/07/1999	Lugomir, Belica, Lepenica, Jasenica, Kubršnica, Crnica and Ravanica/ Velika Morava (Great Morava)	Jagodina, Paraćin, Kragujevac, Batočina, Aranđelovac, Topola, Smederevska Palanka, Paraćin, Despotovac	Several hundred houses and large agricultural surfaces were flooded; some roads and bridges were damaged.
13-15/07/1999	Kolubara, Tamnava, Ljig, Peštan, and Topčiderska reka/ Sava	Valjevo, Mionica, Lazarevac, Ub, Ljig, Obrenovac, City of Belgrade	In all municipalities, a large number of houses were flooded and large areas of agricultural land were also subject to damage. Some roads and bridges were damaged, while numerous landslides were activated.
13-15/07/1999	Skrapež, Bjelica, Ribnica, Gruža, Despotovica, Dičina and Rasina/ Zapadna Morava (West Morava)	Kosjerić, Požega, Knić, Kraljevo, Čačak, Kruševac	Several dozen houses were flooded, as well as large surfaces of agricultural land. Some roads were damaged and blocked, while the occurrence of landslides was recorded.
13-15/07/1999	Several streams/ Danube	Veliko Gradište, Golubac	A dozen houses and a dozen hectares of agricultural land were flooded. Due to the activation of some landslides, traffic was discontinued on the road Veliko Gradište – Ram.
19-21/06/2001	Obnica, Jablanica, Ljig, Kolubara, Cerski circumferential channel /Sava	Valjevo, Šabac	A large number of houses and agricultural surfaces were flooded. Some roads were destroyed.
19-21/06/2001	Jadar, Krivaja, Žeravija, Štira, Ljuboviđa, Drina/ the Sava (Drina) Basin	Krupanj/Krupanj, Pecka/Osečina, Lešnica/Loznica, Ljubovija/Ljubovija, Badovinci/Šabac	A large number of houses and agricultural surfaces were flooded. Numerous landslides were activated and some roads were damaged.
15/05/2010	Pčinja, Tripušnica/ Pčinja	Trgovište/Trgovište	Two inhabitants of Trgovište were killed. A large number of houses were damaged or destroyed. Several bridges were destroyed and large sections of roads were damaged.

Date	Torrent/Basin	Place/Municipality	Description of damage
14-17/05/2014	Obnica, Jablanica, Gradac, Kolubara, Peštan, Ljug, Tamnava, Kolubara, Topčiderska reka, Sava, Cer circumferential channel, Bosut/ Sava	Valjevo, Mionica, Ub, Koceljeva, Ljig, Lajkovac, Lazarevac, Obrenovac, Šabac, Sremska Mitrovica, Šid	In the catastrophic floods in the Kolubara River basin 24 people were killed, with four people missing. Tens of thousands of residential and other buildings were flooded, a large number of bridges were destroyed, and large parts of transport infrastructure were damaged or destroyed. The open coal pit Veliki Crljani was flooded and a huge material damage was caused. In Šabac, the overflow water of the Sava River flooded dozens of houses and dozens of hectares of agricultural land. The penetration of the embankment in Croatia, on the left bank of the Sava River, caused flooding of a large part of the settlement Jamena in Srem and thousands of hectares of forest land mainly, but also several hundreds of hectares of agricultural land.
14-17/05/2014	Likodra, Jadar, Ljubovića /the Sava (Drina) Basin	Krupanj/Krupanj, Lešnica/Loznica, Ljubovija/Ljubovija, Mali Zvornik/ Mali Zvornik	Two persons were killed in Krupanj, hundreds of houses were destroyed; the road infrastructure was almost completely destroyed and traffic was discontinued in all surrounding settlements, numerous bridges were destroyed, a large number of landslides were activated and the electrical network was damaged significantly. In the Municipalities of Loznica, Mali Zvornik and Ljubovija a large number of houses were flooded and large surfaces of agricultural land were inundated, while numerous landslides were activated.
14-17/05/2014	Tributaries of the Velika (Great) and Zapadna (West) Morava Basins	Paraćin, Jagodina, Ćuprija, Svilajnac, Smederevska Palanka	In the territory of these municipalities, flooding caused huge material damage with several thousands of flooded residential and commercial buildings and several thousand flooded agricultural land plots and forest. Some infrastructural facilities were also destroyed, while many other were severely damaged.
15-16/09/2014	The Danube River Basin	Tekija, Podvrška, Velika Kamenica, Grabovica and Karataš, Kladovo/ Kladovo, Negotin/ Majdanpek	Torrents of small basins caused huge destruction of settlements and overall infrastructure in the territory of Kladovo Municipality, but also in the surrounding municipalities. One person was killed in Podvrška.

Tabela 4: Učešće subjekata u sprovođenju protiverozionih radova i mera

6. Obligations and Possibilities of Local Self-governments

6.1. Division of Competences and Obligation of Participation in Anti-Erosion Works and Measures

Serbia is faced with an array of challenges regarding numerous torrential gullies and streams resulting from high intensity short duration torrential rains that generate strong and devastating effects, which is the main reason why the problem of torrent control in Serbia was a priority even during crisis and general scarcity in the country.
Erosion and flood protection is a precondition for stable and sustainable land use and a safeguard against frequent and devastating torrential floods. Therefore, it must be incorporated into strategic plans from state level to the level of local self-governments and individuals. Primarily, legislation needs to be regulated in order to ensure coordination of all areas of human activity that are not predominantly in the water sector. It is also very important because certain activities may diminish the effects of anti-erosion works and measures. In fact, anyone who uses land in any way must be obliged to participate in the implementation of an anti-erosion protection system.

The effects of torrent control and anti-erosion works cover entire catchment areas. The task and the main goal of these type of works are to reduce the intensity of erosion and the transport of sediment. In addition to reducing the intensity of the siltation of watercourses and reservoirs, and protection of roads and other national and local infrastructure facilities, an increase in the productive capacity of land may yield significant results.
In the period from 1930 to 1965, the complex works related to torrent control and anti-erosion were financed through provisions set out in the Law on Torrent and Erosion Control, regardless of the primary protective purpose of executed works and implemented measures. The implementation of initiated and planned works was continued, but problems arose due to vaguely defined obligations that were transferred, under the Water Law, to beneficiaries of the protective works.
These refer primarily to a complex of biological and biotechnical works implemented on landplots where the respective owner uses the landplot, collects income and has all tax and other obligations. That is why the previous laws also defined the obligations of the users and owners of erosion-prone land to participate in the implementation of this type of work. These provisions are also included in the current Law on Waters.
Local self-governments, both according to previous legislation and current Water Law, have an

explicit obligation to proclaim "erosive areas" on their territory and to prescribe and implement anti-erosion land management measures, which belong to the group of non-investment measures implemented by land owners and users.
Since the protective effects of anti-erosion works directly or indirectly protect various facilities, settlements, roads, etc., the obligation of all entities to participate in the planning, financing, construction and maintenance of these works has been defined.
As the need for participation of individual entities in the development and maintenance of anti-erosion system varies from case to case, only an estimate of required participation and division of obligations in creating and maintaining the anti-erosion system can be made. The estimate has been made on the basis of previous practice and expected changes arising from the provisions of the Law on Waters. The obligation of local self-governments is to prepare operational plans for the protection of II class waters, which are usually torrential nature. The methodology for developing these plans includes all basic data falling under the purview of public water-management enterprises, obliged to prepare these basic data until 2017. Local self-governments are faced with numerous problems regarding this issue. More specifically, the methodology for this type of plans includes categories indefensible and unpredictable, which often define an inability to defend against torrents. There is also an obligation to cooperate with designated persons who have been assigned responsibility for I class waters in the municipality under the national operational plan.
The commanders of headquarters for emergency situations covering defence against all possible events often do not have a sufficient number of qualified people who would respond properly to the warning of possible torrential floods.
The national operational plan is prepared for I class waters and is not suitable for small torrential watercourses. It is possible to defend against the floods in the Danube, Sava and other major river basins, because there is a "time lag" lasting between 3 and 30 days due to the slow arrival of the flood wave, good forecasting methods and inter-state cooperation in the field of flood and exchange of information on flood waves.

6.2. Obligations of Local Self-government in Determination of Flood Zones

The Law on Waters (LoW) prescribes that flood zones shall be determined by the state through public water-management enterprises, but this process is still in its infancy and the date of its completion is unknown. On the other hand, local self-governments are obliged to include and define flood zones of limited use in their urban (general and regulatory) and spatial plans, in particular because areas along watercourses are most attractive for construction of buildings and roads.
This obligation has been repeatedly postponed with the justification that the cost of flood zone determination is high and exceeds the budget available for urban development planning. This is why potential flood areas are minimised in the process of urban planning, especially in case of unregulated torrential watercourses.
Throughout Serbia there are numerous buildings constructed very close to riverbeds, and only after a flood or torrent occurs it is proclaimed that they are located in a flood zone or zone of torrential destruction. Torrential floods that affected European countries over the last decade have revealed a number of misconceptions about the uniformity of principles for determining flood zone for major watercourse and torrential/unregulated watercourses.
Major watercourses have been regulated for centuries, primarily for waterway transport and also for flood protection. Riverbeds were narrowed by the construction of embankments on natural flo-

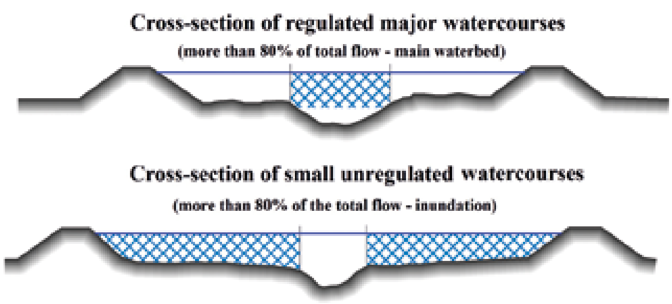

Figure 34: Scheme of waterbed levels in the period of maximum flow of major regulated watercourses and small unregulated watercourses

Figure 35: It is easy to record and photograph the inundation of agricultural land

Figure 36: Flooding of roads

odplains. Thus, large spaces were made available for other purposes, and conditions were created for safe navigation even during high waters that spilled over to the inundation area.

On the other hand, torrential watercourses were regulated by systems of solid structures (dams, regulations or other) or were not regulated at all, because there were too many of them. Figure 34 shows the comparative schemes of waterbed levels in the period of maximum flow of major and small watercourses.

The hatched areas indicate the space with the flow of high water reaching almost the total flow. The inundation area of major watercourses is mainly used for forest production and the flow velocity in these parts of the waterbed is low. The construction of structures that impede the flow of water is prohibited in the inundation area of major watercourses. It is quite different with torrential watercourses. In the season of low and average flow, these are small rivers and streams with the water depth of several dozens of centimetres and proportionally small width of waterbed. When a torrential flood arrives, it spills over to the inundation area, where almost the entire flow runs.

In case of unregulated torrential watercourses, the flood zone is the area of inundation. Practice has defined the criteria of flood vulnerability according to the flood return period. These are usually 10% (once in ten years), 2% (once in fifty years), 1% (once in hundred years) or longer return periods. These different criteria are conditioned by potential flood damage. This is the basis for planning the use of land along watercourses, and the required protection structures if space is needed for important buildings.

Regarding major regulated watercourses, potentially flooded areas are on the landside. That fact is understood only when the protection structure is penetrated. It is quite reasonable to ask what local self-governments can do about it, since it requires preparation and development of the aforementioned survey maps, as well as supporting hydrologic and hydraulic data. The Law on Emergency Situations prescribes the obligation of developing a risk map, which includes flood risk. It is impossible to create the map without a previously determined flood zone.

Local self-governments can perform a significant part of the work in this area, the results of which will mitigate the effects of gross errors that have not caused major damage. All local self-governments, without exception, are subject to risk of flooding and damage caused by small torrential watercourses repeatedly each year. Each of these floods has a clearly recognised scope and coverage of flood zone. Witnesses to these floods are residents of flooded areas and people from the local self-government responsible for flood protection or damage assessment. Moreover, today we usually have diverse photographic documentation.

Based on the knowledge of the area, there is no reason not to record flood information and include it in maps and plans. These recorded floods can be divided into several classes:

- I class flood zones include areas flooded regularly each year;
- II class includes areas flooded each five or ten years;
- III class includes areas flooded once in fifty to hundred years.

The nature of flood in the classified flood zones should also be taken into account and can simply be described as:

- flood
- destruction
- devastation.

This is the basic classification of flood risk, which may be carried out easily by any local self-government.
Regarding large rivers, local self-governments should cooperate directly with the public water-management enterprise responsible for the sector of protection structures for a particular local self-government. Since large agricultural areas and parts of settlements are usually below the high water level and there is always a risk of embankment breach, local self-governments must assess the flood risk for in the areas of their responsibility and important facilities.
The Commissioners should mark the maximum flood level, as well as the locations of alluvium and sites of torrential destruction. It is preferred to take photographs to exclude subjective errors. Several examples in the following photographs will help explain the possibilities of preliminary orientational determination of flood zones (Figure 35).
Floods entering into settlements are particularly dangerous, because they first inundate the roads that are often the only way for evacuation and delivery of aid (Figure 36).
Torrential alluvium is especially dangerous because all the sediment remains in the waterbed that loses the run-off ability; torrential alluvium should, therefore, be recorded in places where it regularly occurs.

6.3. Obligations of Local Self-governments and Recommendations for Reducing the Risk of Torrential Floods

Administrative obligations of local self-governments consist of the adoption of local legal acts determining prohibitions and obligations:
Prohibitions:

- Prohibition of pruning deciduous trees (for fodder)
- Prohibition of growing arable crops on steep fields
- Prohibition of ploughing on slopes
- Prohibition of clear-cut harvesting of forests on slopes
- Prohibition of grazing on degraded pastures

Obligations:

- Obligation of ploughing along the contour line
- Obligation of converting degraded fields into meadows
- Obligation of amelioration of degraded pastures
- Obligation of afforestation of bare terrain
- Obligation of planting multi-annual instead of annual crops on degraded land
- Obligation of anti-erosion land management
- Obligation of anti-erosion forest management.

These measures are prescribed for each plot located on the erosive area and the data are entered in the plot section of the table. The measure that is most appropriate for anti-erosion land management is prescribed, without reducing the income of land users.
Recommendations to local self-governments for reducing the risk of floods and torrential floods may be grouped into:
Keeping records in lists and cadastres:

- developing a list of available communication resources in case of flood or torrential flood;
- compiling a list of construction and transportation resources for urgent works and transportation of materials;
- developing a list of resources for transportation of people;
- developing a list of accommodation capacity in case of emergency reception and accommodation of evacuated people and
- compiling a list of available human resources potential in the territory of local self-government, with detailed specification according to expertise and field of specialisation.

Biological and technical works in the basin:

- performing the afforestation of slopes in the territory of local self-government, in cooperation with competent institutions;
- registering and classifying the processes of erosion and landslides in the territory of local self-government;
- stopping erosion processes and repairing soil;
- rehabilitating gullies by using wattle and check dams;
- building, in certain locations, structures for the reception of high and torrential water waves (reservoirs, retention basins);
- reducing waterbed slopes with structuresin waterbeds: cascades, check dams, chute spillways etc.;
- protecting the banks of watercourses from erosion processes and allowing the flow of torrential waters and
- regularly maintaining the waterbeds for low and high waters.

Administrative and planning measures in potential flood zones and basins

- providing and marking the routes of evacuation from potential flood zones to safe ground;
- restricting or prohibiting the use of public space in potential flood zones and its occupation with permanent and temporary facilities;
- ensuring absolute mobility (and passability) in the streets along the banks of torrential watercourses;
- prohibiting the disposal of building materials, firewood, coal and other bulk materials in public spaces and streets;

- prohibiting parking and leaving cars on and along the roads in the zone near waterbeds and in the streets where torrential floods have already occurred;
- removing and rehabilitating illegal landfills and protecting municipal and town landfills against inundation and torrents;
- explicitly defining potential flood zones and erosive areas in the territory of local self-governments in urban planning documentation;
- defining possible activities and landscaping, including strict and detailed prohibitions, in urban planning documentation;
- identifying facilities that may impede the flow of torrential waters and establishing rapid mechanisms for their removal to allow unhindered flow
- while building bridges, place bridge support structure in the major waterbed, or in part of the waterbed where the high velocity and flow of torrential mass are not expected, and where there is no transport of drifted material;
- in the zone of existing bridge piers, construct facilities for directing torrential waters and protection of bridge support structure.

General recommendations:

- In order to achieve a high level of training and preparedness for flood events, local self-governments should train the population to respond to floods and torrential floods.
- At the level of national education policy, it is necessary to introduce civil protection training in school curricula, which would consist of short and overview lectures and crucial practical training including evacuation drills and procedures in the case of various natural disasters.

6.4. RHMSS as Support to Timely Response to Torrents – Possibilities and Limitations

The source of data for planning flood defence is the observation system of the Republic Hydrometeorological Service of Serbia (RHMSS). The system is divided into two parts: meteorological and hydrological. The obligations of RHMSS are determined by laws and include all required weather and hydrological forecasts. All data and forecasts are publicly available on the RHMSS website:
http://www.hidmet.gov.rs/ (Figure 37).
Links are available to water level reports for all hydrological stations in Serbia, divided according to river basins. By clicking on the station, the map shows detailed information about the station. It is important to know whether the data are sent automatically or recorded otherwise. Today, stations rarely have only a staff gauge that is read once a day. The main problem related to the network of hydrometric stations is that data is measured only in major watercourses and rivers. Less than ten hydrometric profiles are located in watercourses with basin area under 100 km², and this type of

Figure 37: RHMSS website at: http://www.hidmet.gov.rs/

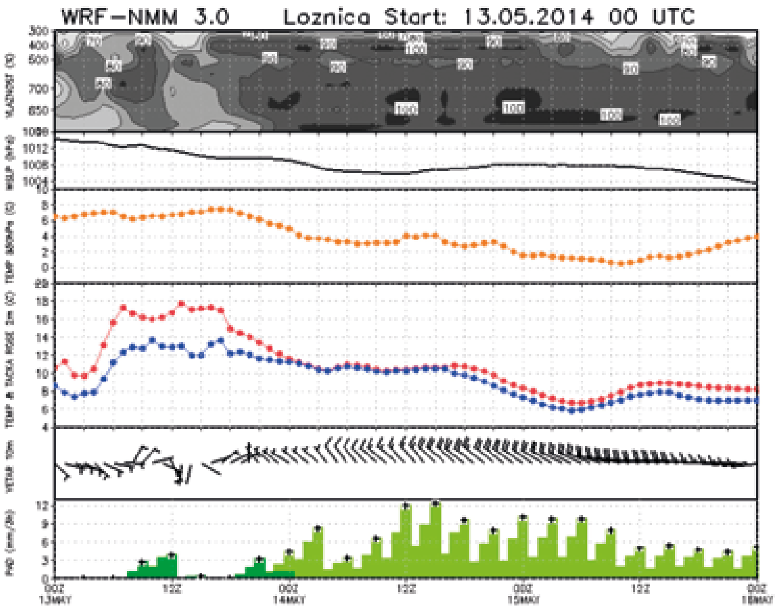

Figure 38: WRF–NMM forecast for Loznica from 13 to 15 May 2014

watercourses is the basis for any defence planning against torrents.

Meteorological observation is established also in thirty stations for meteorological observation and measuring the intensity of rainfall. There are also a large number of traditional pluviometers that are sufficient to obtain accurate data on total rainfall.

The RHMSS website also provides links for regular weather forecasts, that do not contain extensive data and are intended for the general population. They provide simple information (sun, rain, wind, etc.).

There are two particularly important links - meteoalarm and hydroalarm. Hydroalarm provides very important in relation to major river floods, but it is not useful in case of torrential floods. Meteoalarm is important, because it warns about the presence or arrival of a meteorological phenomenon (high or low temperatures, showery rain, strong wind or storm, etc.) by region. This is useful information for municipalities in the region, because it allows the planning of specific projects and possible activities for the prevention of hazards, such as torrents after heavy rains.

Web pages with numerical forecasts are particularly important for local self-governments. Experts and competent individuals are advised to choose the meteogram, with two types of forecasts, according to ETA and WRF-NMM models. Both models are recognised worldwide and are the result of the development of numerical forecasting, which is called the “Belgrade school” in the world, according to the place of origin.

The ETA model provides a five-day forecast for 29 locations in Serbia and 46 throughout Europe. It has a time step of 6 hours and forecast reliability is 85%.

The WRF-NMM model provides a three-day weather forecast with a time step of one hour. Unlike the ETA model, this model indicates the type of precipitation (rain, snow, ice, etc.) by different colours. Reliability of this model is close to 95%. Figure 38 shows the WRF-NMM meteogram for Loznica.

The RHMSS website has a page with radar images, which has been used in Serbia for a long time, but its purpose was primarily hail defence. The whole system of anti-hail radars was taken over by the Department for Emergency Situations, but those radar images are also available on the website. That page also provides links to radar images of the neighbouring countries. It is best for west municipalities to use also the Croatian images, because they cover the area from Ljubljana to Belgrade. Presently, RHMSS has only two meteorological radars used for observation of rainfall and flood forecasting. The forecast time step is three hours.

Radar images are presented only as images and cannot be used for analysis, although it is important to have the possibility of monitoring the movement of cloud cells with a time step of 15 minutes. Different reflections of clouds, expressed in Db, are marked with different colours in the image. The maximum reflectivity detects even the most dangerous cells.

Figure 39 shows a radar image from the period of heavy rainfall on 14 May 2014, with noticeable locations of strong cloud cells.

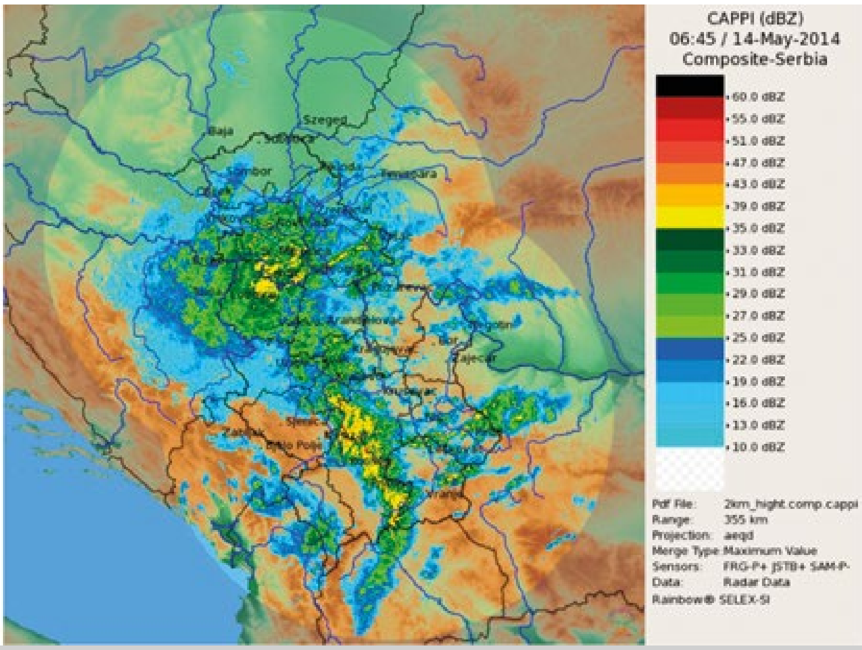

Figure 39: A composite radar image dated 14 May 2014.

This possibility is not a new one. After the catastrophic torrential flood of the river Vlasina on 26 June 1988, just two pluviometer stations withstood the disaster, while all the rest were destroyed along with the houses. Attempts to analyse data on rainfall based on the surrounding stations did not give any result, because the obtained values were extremely low.

Then a proposal was accepted to reconstruct the rainfall on the basis of recorded radar images. The favourable circumstance was that a group of radar meteorologists worked together with torrent experts and developed the methods that helped in this complex task. Based on these methods, it was established that the rain had started around 13.00h and ended around 17.00h and that during those four hours an average of 150 mm of rain fell on the surface of approximately 300 km^2.

This was the basis for the development of a method for timely warning of showery rains, by using radar observation. Unfortunately, this method is still not widely used in Serbia, mainly due to the unclear explanation that this is about "insignificant" and small torrential floods and that it is unnecessary to staff the radar observation centres, because this task requires different data processing than hail observation, which directly implies the engagement of new staff and equipment to do the job.

Countries that have adopted this concept went in the completely opposite direction. Numerical methods are adapted to large rivers and what happened was expected. In fact, when small cloud cells are focused, there is a large amount of data arriving every second and the computer gives a precise forecast an hour or two after torrential floods and damage. Our experience shows that the precise calculation is a wasted effort and it is better to immediately obtain a less precise value, but sufficiently accurate for a timely response, because it gives two to four hours for a response.

6.5. Real-Time Warning of Torrential Floods

Within the framework of the European project Monitor 2, we implemented the first system for early warning of torrents on the River Topciderska. This river was selected due to the fact that its basin was long observed and that it regularly flooded the industrial zone and railway.

Two automatic pluviometers were installed in the basin, and two automatic water gauges were placed in the river (Figure 40). All gauges regularly send data to the central computer, and in case of a dangerous and recognisable situation the system will activate the alarm. The system has been in operation since 2011 and has been constantly improved. All data are available via the internet, in all mobile and non-mobile devices.

The system for early warning of torrential floods on the Topciderska River (Figures 40 and 41) has activated early warning alarms on three occasions in accordance with the levels of rainfall and water at the hydrological stations. This early warning system allowed the competent services to have enough time to respond and evacuate the population, which prevented the loss of human lives due to flooding. The red line in Figure 41 indicates the water level at the hydrological station Ripanj-rampa.

The early warning system was implemented with modest resources and was ranked third, among nine project participants, by the council of Monitor 2 project. The two better ranked project teams had incomparably larger budgets for implementation.

The philosophy of early warning of torrential floods in real time allows stakeholders to build their own system of timely warning of torrents that may cause damage.

For example, the system installed in Italy, near Bolzano, protects the town of Alice and large apple plantations with the most expensive irrigation and protection systems.

The existing passive system for torrent protection did not withstand floods on several occasions, which resulted in a huge damage in the town and apple orchard. Each local self-government or endangered economic operator may decide to install an early warning system.

The unpredictability of torrents is only a justification for a failure to act. It is clear that in Serbia there have not been sufficient funds to build a system for the regulation of torrents and protection from erosion for a long time. The early warning system has been challenged under the pretext that it is unpredictable, which may be true only for someone unaware of the underlying processes of this kind of phenomena.

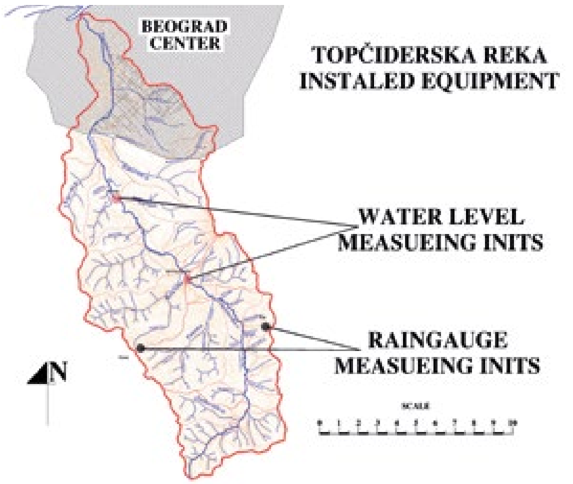

Figure 40: Location of telemetric water and pluviometer stations in the real-time torrent warning system

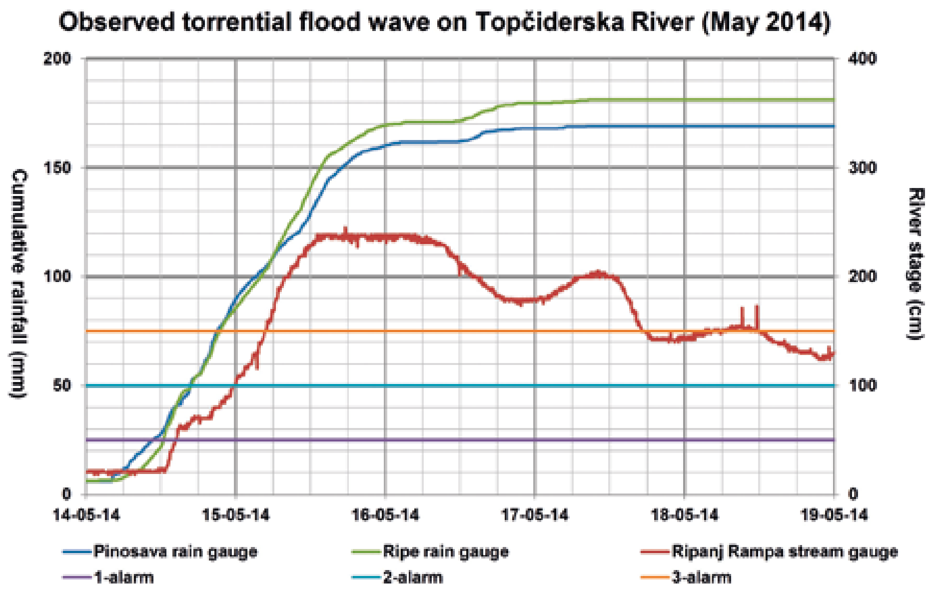

Figure 41: Recorded torrent wave of the Topčiderska River

7. Role of Civil Society Organisations in Flood Issues

7.1. Availability of Information

Complete, accurate and timely information is a basic precondition for public participation in decision-making processes in the field of waters and the environment, and it is possible only if there is free access to information. This right can be exercised either in an active or a passive way.

Passive provision of information is an obligation of authorities, which have to respond to requests for the provision of information of public importance.

Active provision of information is also an obligation of authorities, but it is performed without special requests.

The Convention on Access to Information, Public Participation and Access to Justice in Environmental matters (Aarhus Convention, hereinafter referred to as the Convention) was signed on 25 June 1998 in Aarhus (Denmark). It is based on three pillars: access to information, public participation in decision-making and access to justice.

Access to information:

Every citizen has the right to a full and easy access to information on the environment. The authorities have an obligation to collect and disseminate information in a timely and transparent manner, and there may be exceptions only in special cases, such as defence, classified state information or commercial confidentiality, which is specified by national legislations.

Public participation in decision-making:

The public must be informed about all relevant projects, and must be given the opportunity to participate in the decision-making process. Decision-makers are free to use the knowledge and expertise of the public. Public participation is a good opportunity to improve the quality of decision-making in the environmental field, promote good results in this field and guarantee procedural legitimacy.

Access to justice:

The public has a right to a judicial or administrative process and justice against any party in the event of infringement of or non-compliance with the Law on Environmental Protection and principles of the Convention. More on this is available in the handbook for public authorities on access to information of public importance in the field of water and the environment. (Ignjatović, J., Đorđević, S., 2006).

What is the information of public importance?

Information of public importance is the information held by a public authority, created during or relating to the operation of a public authority, contained in a document and concerning anything the public has a justified interest to know.

"Justified public interest" exists also when the information held by a public authority concerns a threat to or protection of public health and the environment.[23]

Withholding information of public importance or giving false information, or acting contrary to the law, is a criminal offence punishable with up to 1 year of imprisonment.[24]

7.2. CSO in Serbian and International Legislative Frameworks

Civil society is a form of organisation, limited to the non-profit and non-governmental sector, based on voluntary participation, with full autonomy and independent institutional structure, which has private and public interests in the public sphere of society.

Organising and associating, based on the Charter of the United Nations (UN), are among the fundamental human rights and freedoms, as confirmed by the Constitution of the Republic of Serbia as the right of association and organisation.

The Constitution of the Republic of Serbia, Article 55 paragraph 2:

"Associations shall be formed without prior approval and entered in the register kept by a state body, in accordance with the law."

The field of civil society organisations (hereinafter referred to as CSOs) is covered by the legislation of Serbia through several laws, but we can single out three of them with indicative titles: Law on Associations (Official Gazette of RS, no. 51/09), Law on Volunteering (Official Gazette of RS, no. 36/10), Law on Endowments, Funds and Foundations (Official Gazette of RS, no. 88/10). Also, the Law on Agricultural Water Users Associations will regulate the establishment and operation of water users in agriculture.

The Law on Associations regulates the issues of establishment and legal status of associations, funding, and other issues of importance for their functioning. Moreover, it is important to mention the Office of the Republic of Serbia's Government Office for Cooperation with Civil Society, whose establishment (in 2011) and mandate were defined by a decree.

23 Đorđević, S., (2006).

24 The Criminal Code of RS, Article 268: "Whoever contrary to regulations withholds information or gives false information on the state of the environment and events, required for the evaluation of environmental hazard and undertaking measures for the protection of human life and health, shall be punished with fine or imprisonment up to one year."

7.3. Water Framework Directive – Effects on Floods and CSO

The aim of the Water Framework Directive (WFD) is to promote sustainable water use based on long-term protection of available water resources and adaptation to the natural condition of water in the environment, and to meet the needs of current generations without prejudice to the needs of future generations. According to the Water Framework Directive, water management consists of three main segments, as follows:

- water services, which include all public and private services of abstraction, impoundment, storage, treatment and distribution of surface water or groundwater, along with waste-water collection and treatment facilities and services of monitoring, identification, prevention and control of flood waves, excessive and torrential waters;
- water uses refers to water services together with the occurrences and events having a significant impact on the condition and status of water according to the analysis of pressures and impacts. Water uses are disaggregated into households, industry and agriculture according to the recovery of costs of water services and areas of protection from waters, protection of waters and water use;
- other activities do not have a significant impact on the status of waters and they are not water services, nor do they have a significant impact on water use, but can affect water management.

As can be seen from the organisation of water management, the activities of flood prevention and control of flood waves are the integral parts of the core segment - water services, as well as other segments of the protection from waters.

CSOs can be found in all three segments, because they can be stakeholders in all of them. The segment of other activities can be directly related to CSOs, because it is a field of civic initiatives and projects.

7.4. Example: Cooperation between CSOs and Public Sector in the Field of Waters in Japan

The Shingashi River Basin, with numerous springs, is a good example of CSO participation in planning and decision-making on issues related to water and water management. This basin is now practically a suburb of Tokyo, but during the Edo and Meiji periods of Japan it was one of the most developed economic centres. The basin was so important because of ample possibilities of water transport, which contributed to the intensive development of trade and crafts.

The economic power declined sharply after the construction of railway in 1910, which lasted until the period of industrialisation and rapid urbanisation in 1970s, when larger part of the basin area became a suburb of Tokyo.

Rapid urbanisation of the area led to a reduction of "open space" and excessive building, which produced an increase in runoff, but also a shorter time of concentration, so that floods of the Shingashi River were increasingly more frequent. Also, along with urbanisation, which generated large quantities of sanitary water, in 1970s a great industrial boom produced a new negative consequence - water pollution.

After numerous complaints of the basin population to emerging problems, the Office of the Ministry of Land, Infrastructure, Transport and Tourism of Japan (hereinafter referred to as MLITT) in 1980 established a directorate for the conservation of the Shingashi River, Kawadukuri Kondankai, with five sub-basins.

Although the Office contributed to a partial resolution of the problem, progress was not as big as expected, and MLITT sought to improve the system of management. The first interested and organised group of citizens, or CSO, which advocated for improving the quality of river basin management was established in 1990 and since the establishment had been trying to influence the Office to improve the system of river basin management. MLITT had organised a number of meetings, which resulted in a gradual alignment of views on management objectives and methods, necessary activities and management resources. Other stakeholders were also joining negotiations, so that several CSOs were involved in the last phase of management.

The final agreement on the joint management of the Shingashi River Basin was reached in 1997, and at the initiative by MLITT, the Office and the interested CSOs set up a joint temporary body for river basin management - Shingashi River Basin Kawadukuri Network (SRKN). This body was initially tasked to identify problems in all five sub-basins. The main activities initially included the identification of problems in the basin, organisation of study visits aimed at learning about all the issues related to the basin and the organisation of lectures and panel discussions.

Shortly after the establishment of SRKN, a need arose to establish a standing body for river basin management, which would assume the competences of SRKN in addition to a set of new competences and tasks, through converting the temporary management body into a permanent one. The name of this body is Shingashi River Basin Forum (SRBF).

Upon establishing, the SRBF immediately began with information related activities, and therefore launched its local newspaper, financed by MLITT. In addition to this newspaper, brochures with a detailed explanation of procedures in case of flooding were printed. Also, CSOs were assigned to promote sustainable river basin management, environmental protection, and train students on the procedures before and during floods, in cooperation with SRBF.

Meanwhile, SRBF has assumed some other competences and now participates in:

- Development of river and river basin management plans;
- Drafting a rulebook on water permits;
- Issuing water permits;
- Compiling a list of priority activities in the basin;
- Establishing a network of monitoring stations for water quality control;
- Establishing a network of hydrological stations;
- Developing operational plans for flood protection;
- Bodies (headquarters) for flood protection.

A few years after the establishment of SRBF, the MLITT Minister said:

"It is impressive to which extent the awareness of citizens has changed and how the public has reached a consensus after many of our mutual meetings."

7.5. Recommendations for CSOs Related to Flooding and Flood Risk Reduction

Recommendation No. 1

All CSOs that have participated in the preparation of management plans should be involved in raising awareness of flooding and flood risk, which involves:

- Public presentations of adopted plans, to present potential flood zones and degrees of flood risk;
- Presentation of technical measures aimed at risk reduction, by promoting advanced flood risk reduction techniques and solutions, and new technical measures, and showing and explaining the limits of potential evacuation, as well as evacuation corridors, routes and priorities;
- Placement of signs on buildings in busy areas, which implies the placement of clearly visible plates indicating extreme historical water levels, which has proven to be a good step in developing awareness of flooding and flood risk.

Recommendation No. 2

Associations of construction and urban planning professionals should include in their regular activities the following:

- Informing the population about the measures to reduce flood risk to property, and the

techniques of building facilities that reduce the flood risk;
- Lectures and brochures about the use of building materials in the construction or adaptation of the facilities in flood zones, reorganisation of space and organisation of housing with lower risk to residential buildings, role of drainage and waterproofing in flood protection and mitigation of flood consequences;
- Taking active part in the creation of urban development plans, by advocating for ideas and plans that reduce the flood risk, such as "giving more space to rivers", anti-erosion and torrent control measures applied in the upper parts of the basin, construction of retention basins for reception of flood waves, etc.
- Participation in the development of water management plans from the scientific and technical aspect, by additional research of heavy rainfall, runoff, flow and other factors that reduce the flood risk.

Recommendation No. 3

Professional associations of health workers, but also individual health workers, should participate in preventive activities in flood zones, but also in the activities during the event. Preventive activities consist of training people on dealing with victims, administering first aid in case of drowning, acting in case of hypothermia, preventing the occurrence and spread of infectious diseases, and hygiene and sanitation needs in the flood-affected area. Also, one of the ways of CSO involvement is training on procedures in case of breakdown or chemical and biological accidents caused by floods, including the procedures of treating people affected by poisoning, chemical burns or other adverse consequences of accidents.

Recommendation No. 4

Civil society organisations dealing with housing and environmental protection are most common in this context, and they participate primarily in preventive activities, especially with respect to planning documents of local self-governments and urban development plans. They should act towards providing enough space for the flow of flood waters, through proposals and appeals to prevent the expansion of residential areas in floodplains. The easiest way is to propose the use of such sites as parks or recreational sports areas. A particularly important CSO activity is to prevent the expansion of industrial buildings in flood zones, which will prevent the possibility of future chemical accidents in inundation areas. It is also important to provide corridors for wildlife evacuation from the inundated zones to unaffected area, which should also be an integral part of the planning documents of local self-governments.

Recommendation No. 5

Media advertising is also an important area of CSO activity, which can be used for disseminating information of interest to potential flood zones about flood hazards and risks, reasonable acting in the event of floods, preventing panic reactions to flood-affected population, etc. All panel discussions and lectures about floods, organised by CSOs, should be covered by high-quality media reports, because in that way new knowledge can reach also those who did not attend these events. Using social networks is also a form of information dissemination, and the information about floods and reasonable acting at the time of their occurrence is of great importance.

Recommendation No. 6

CSOs should participate in the establishment of specific informal associations of the population of potentially flooded areas. The main goal of such associations, in addition to the timely dissemination of information and knowledge about the floods, is the self-organisation of the population with the purpose of acting in accordance with the operational plans for flood protection. Good and quick response of flood defence headquarters is only half of successful defence. The second half refers to the organisation and cooperation of the population, which minimises the risk of casualties. One of the forms of such actions are Interactive Learning Groups (ILR), which target the population of potentially flooded areas, while dissemination of information and knowledge is performed through panel discussions, lectures, round tables, but also through the media and social networks.

Recommendation No. 7

Mutual cooperation between CSOs is of great importance and initiates their networking. The Government of the Republic of Serbia has made another important step in this direction and that is the establishment of its Office for Cooperation with Civil Society, with the aim of facilitating the involvement of CSOs in decision-making processes at the local, regional and national levels. Also, the Aarhus centres that exist in Serbia and cover the entire territory of the Republic of Serbia are of great importance, because they constitute a direct link between the population and authorities. The next step towards establishing a well functioning CSO network should be their intensified association in order to act jointly, which is of utmost importance in the event of flooding.

8. Literature

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