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Floods and Their Impact on Cultural Heritage—A Case Study of Southern and Eastern Serbia

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Abstract: This paper analyzes flood impact on the historical objects and cultural heritage in Southern and Eastern Serbia. The basic research problem is the lack of systematized databases regarding the flood impact on the cultural heritage, in addition to the lack of official manuals or other types of educational material dealing with the management of the assets with monumental properties in flood situations. The goal of the paper is to indicate this problem to the professional and wider public through systematization and classification of the observed damages on the buildings. The paper first provides a brief overview of the development of flood protection throughout history with particular reference to the research area. In addition, the history of floods in Serbia is also analyzed in order to point to the frequency and scale of this problem in the researched area. Through the research of archival materials in the appropriate institutions as well as direct recording of assets in the field, the degree of flood impact on historical objects in the territories of Southern and Eastern Serbia is determined. It refers to both declared cultural monuments and those that are still undeclared but possess certain monumental properties. Only the material damages on the immovable cultural assets have been analyzed. The protection of the movable cultural assets has not been taken into consideration, although it represents a very important aspect of every flood damage. A classification of the damages observed on these types of buildings, which occur as a direct or indirect consequence of floods, has been carried out. Examples of structural damage are presented in the paper (such as fissures, cracks, bucklings and collapse of parts or overall objects). Examples of the damages that do not threaten the stability of buildings are also presented. Here, they are divided into two groups—moisture-induced damages and biodegradation. The paper also gives examples of the damages induced by direct or indirect impacts of floods. It is from these examples that general lessons can be drawn, namely those that would be applicable to the endangered categories of cultural heritage. The classification is conducted for the purpose of better planning of preventive or rehabilitation strategies and measures for the preservation of architectural cultural heritage. Recommendations for dealing with heritage assets in the case of floods are also given.

Keywords: cultural heritage; destabilization; flood; risk management; structural damage; vernacular architecture

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1. Introduction

The impact of climate change on the world around us is more and more evident. Above all, the increase in temperature at the global level affects a series of meteorological phenomena such as changes in air humidity, adverse weather, hurricanes, floods, etc. Since the projections of the air temperature increase show that this trend will continue, of great importance is to study the correlation between the meteorological conditions and weather problems and the state of cultural heritage [1]. The knowledge obtained in this way can be very useful for timely protection of heritage and for quick repair of possible damages.

The study of the impact of climate change is primarily based on the study of its effects on human health, water and food supply, changes in ecosystems and social aspects [2–4]. However, the effects on heritage must be taken into consideration as well. It is well known that all the material aspects of our environment, including cultural heritage, are inevitably affected by climate change and its related consequences. At the same time, we must keep in mind that cultural heritage is a non-renewable resource as well as our legacy to the future generations, while its durability depends on environmental conditions and all of its factors.

Floods, as one of the consequences of climate change, can seriously threaten the life and livelihood of people in the affected area. Although in the defense and subsequent remediation of damages the primacy is surely given to saving human lives and human health, the restoration of the object stock is also a very serious undertaking. The rehabilitation of homes and the return of their residents are undoubtedly the primary issues, but we should not be neglecting the assets that are testimonies of the past, either. Their protection and subsequent damage repairs and restoration should be clearly defined. In no way should they be less important than salvaging other architectural forms.

The basic research problem is the lack of systematized databases about the flood impact on the cultural heritage, which would represent a starting point for further research in the field of cultural monument protection. The goal of the paper is to indicate this problem to the professional and wider public, through systematization and classification of the observed damages on the buildings. Namely, the systematization of data regarding material damages, with a clearly defined classification of the observed damage, would be a good starting point for the formation of a comprehensive base from which guidelines for the protection of assets with monumental properties can be derived. The formation of flood prediction models and flood scenarios, in conjunction with such guidelines, would be an appropriate model for the prevention of flood damage.

Thus far no research has been conducted on the extent and type of damage to cultural assets from floods in Serbia. This surely leaves some empty space for present research studies. Consequently, regarding this situation, in the literature related to the researched area or even the whole territory of Serbia, the only available data on damage to cultural assets can be obtained from monographs referring to particular assets, most often cultural monuments of great or exceptional importance. In such monographs the issues analyzed include the history of a given object, the damages induced in the course of the general history, including that of the wars on the given territory, as well as the changes made to the buildings due to additions or alterations of individual parts. Possible damages from floods are only briefly mentioned, without detailed analyses and explanations. Data regarding the rehabilitation of the flood-damaged assets can be found in the form of reports stored in competent protection institutions; they are not publicly available. The presentations of the flood-damaged assets with monumental properties have been treated fragmentarily in the referential literature, i.e., through case studies of individual objects. In short, they are not presented in such a way as to be accessible to the wider scientific public. Moreover, the studies of this type have not been carried out in the territory of Serbia at all. None of the existing studies give an answer to the issue of damage of cultural heritage during floods. The novelty of this paper is in a systematized survey of flood damages, all summed up here and accessible to the scientific public. In other words, the classified presentation in this paper is all the more important because all recorded damages to historic objects, which occurred exclusively as a consequence of floods, can be found in one place.

The practical contribution of the paper lies in launching the process of forming the database of this type, which would serve as the foundation for solving the specific problems as well as a starting ground for further research in this field. By expanding the researched area in a territorial sense to other districts in Serbia, a very significant base has been acquired. It is from this base that a detailed guidebook on managing the cultural assets, for a specific case of damage, could be derived. Continuing recording and analysis of flood damage on the buildings can help in proposing a global framework for solving of individual problems of vulnerability of cultural heritage that is exposed to such a natural disaster.

2. Materials and Methods

As already stated, the main goal of our research is to collect and classify data on damage to the assets with monumental properties, which have occurred as a direct or indirect consequence of floods.

The first part of the research involved exploration of the relevant archival and historical materials deposited in the Institute for the Protection of Cultural Monuments in Niš. The permission to use data from the competent institution for the protection of cultural monuments was obtained in writing. This was followed by a detailed analysis of the complete graphic, textual and photo documentation of this institution. The research analysis of the data comprised, first of all, the selection of the cultural monuments on which damage was recorded and accompanied with existent reports. In addition to the data regarding the buildings, also explored were the data referring to the damage reports submitted by the building owners themselves, namely, the damages induced by various factors. After obtaining a full picture of all the recorded damages to the protected cultural monuments as well as to those with monumental properties, the detected and singled-out damages were those caused by water impact during and after floods. Therefore, systematization and recapitulation of the collected historical materials and of previous research studies were carried out. By synthesizing the data on damage obtained from the Institute for the Protection of Cultural Monuments in Niš, as well as data on floods, the locations in question which were characterized as those with a higher risk of flooding were selected for the field research which was then carried out on them.

The research of the field assets was realized by observing specific and targeted buildings. The empirical method, i.e., observation method, provided a clear picture of the damage done to the buildings. The basis for the analysis and conclusions was the author's personal experience in the field of protection and evaluation of the assets with monumental properties and architectural heritage as well as the research and extensive practical experience of the co-author in assessing the building state and value.

Likewise, another applied method was that of interviews with the building users from which data were obtained on the intensity of the floods and the exact time of their occurrence, the size of the damage and the time spent on the rehabilitation of the assets. Photo documentation of the damage was recorded. Descriptive data were collected. In some cases, architectural sketches and drawings were created (Figure 1).

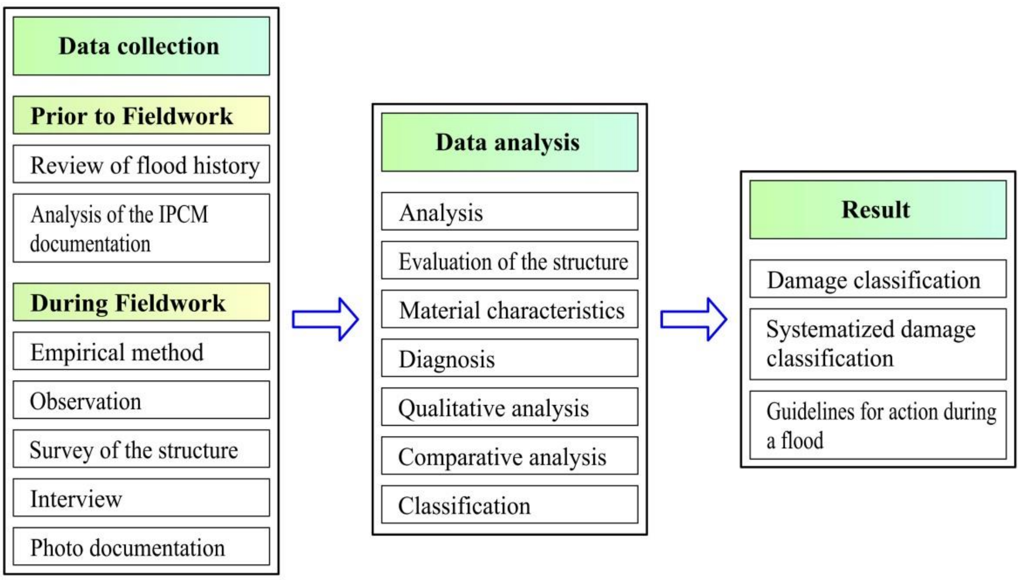


Figure 1. Methodological Flowchart of the Study.

The collected data were then analyzed. A comparison was made of the collected material. The damages caused to the buildings of the same type were compared with each other in order to establish the similarities. The observed damages were classified, with respect to the type, into structural and non-structural. Within each grouping, a further subdivision was developed. Detailed conclusions about the states of the given assets were formed on the basis of the collected facts and empirical knowledge of the researcher.

3. Previous Research

Floods, protection against them and risk management are today increasingly frequent research subjects of many researchers and experts. Likewise, many experts have been involved in the research of climate change effects, and primarily of floods, upon cultural heritage. As results of these research studies, several publications have been published that are thematically very different. A certain number of papers provide a survey of the previous research as very useful data for further research in this area [5]. In some papers, the impact of climate change on heritage from the perspective of tourism is considered [6]. Some of the papers deal with the impact of floods on heritage with reference to concrete historical entities [7–9]. Flood risk maps and the idea of preventive conservation of heritage are also some of the research subjects [10]. In addition to the papers that deal with the impact of floods on heritage, some others give suggestions for mitigating the post-flooding consequences, such as wall drying with significant painting [11]. Some of the authors deal with mechanisms of resistance of traditional architecture to catastrophic events, including floods [12]. Some other authors point to the importance of monitoring the danger of flooding the heritage [13]. The impact of flood risk on the movement of the residential land market in the area of cultural heritage is analyzed [14]. Some other themes include the sustainable development of protected assets and the UNESCO strategy [15], the recovery of the world cultural heritage landscapes after floods [16], etc. What they all have in common is the interest in securing the future of cultural heritage under changing climate conditions [17]. A large number of studies deal with different angles of infrastructure biodiversity [18,19] improvement due to contact with water [20–22].

4. History of Flood Protection

If we look back in history, we see that floods have always presented a great challenge to human communities. The problem of overflowing rivers and flooding of dwellings located in floodplains has been present since the earliest history of sedentary society. In the days of nomadic communities, people learned to live with periodic floods. These, however, presented not such a significant problem to the nomads since these societies moved very often, leaving behind the areas that for one reason or another became unlivable. Later on, the situation changed, and floods became bigger problems once the development of the societies meant a transition from the nomadic lifestyle to a sedentary one. Because of the significant agricultural potential, the societies chose, for their dwellings, floodplains in the plains and along the riverbeds. It was important to stay stationed next to the fertile land and to benefit from the soil itself as well as from other resources, i.e., abundance of fish and wild animals that inhabited these areas. In relation to that, efforts were made to keep water during floods outside important parts of settlements [23] (pp. 30–32).

Increasing population in settlements also meant an increasing need for enlarging agricultural production. All large fertile plains were full of crops, so that uncontrolled flooding became less and less acceptable. It was very important to monitor the behavior of rivers and to try to determine, if possible, the pattern of their behavior, and in this way to avoid major damages. One of the early approaches to flood safety was irrigation systems. The idea was to divert the excess river water in a controlled manner to the fertile land for the purpose of irrigation, which would reduce the risk of flood. Such systems were also used for the purpose of draining wetlands along the rivers in order to obtain larger areas of arable land. Thus, irrigation works were simultaneously connected with the efforts to reduce damage from periodic floods. Ancient Egypt and Mesopotamia are good examples of irrigation systems that, in addition to other structures, were also used as a form of flood protection. In Mesopotamia, canals were built for the flood protection of settlements and for channeling the water flow in the desired direction. The canals would direct water to the green plains. The people used embankments to prevent field waters from reaching the settlements. Accumulation basins were also built, which retained a good part of the water during floods. This water would later be used for irrigation by means of a system of canals [24].

In later history as well, flood protection was continuously worked on. Towns and cities were positioned, for strategic or economic reasons, by the rivers on floodplains. Ancient Rome, considering its engineering propensity, carried out extensive works on flood protection [25]. The Tiber changed continuously through engineering projects since the 6th cent. BC by means of open canals re-directing the course of the nearby brooks into the river [26]. The embankments around the Tiber were another very important element of flood protection.

In the Middle Ages, in Rome, as well as throughout Europe, the ancient methods of flood defense were almost forgotten. The drainage canals that had existed before were blocked and out of use and garbage was piling up in the rivers. Hence, floods were much more frequent and so were the damages they caused. It was only in the period of the Renaissance that there was renewed interest in the flood defense system. The canals were again kept clean, so the number of floods and flood damage considerably decreased.

The need to mitigate the periodic flooding grew later, during the Industrial Revolution. In the fertile swamps of Northern Europe, especially in the Netherlands and Eastern England, large-scale draining of land was undertaken in order to meet the needs of agricultural production [23] (p. 33). The Dutch thus became experts in the construction of embankments as a form of defense against floods as well as in the construction of drainage networks.

The Industrial Revolution brought about an increasing use of dams in order to meet the needs of water energy exploitation. A better understanding of the mechanics of materials as well as knowledge from hydrology and hydraulics led to an increase in the size of dams and embankments. This opened new questions. The costs of construction and maintenance of embankments and dams started to pose a problem all over the world. Due to the lack of resources for this maintenance, especially in periods of wars or other crises, primarily economic ones, the condition of the canals became worse, which resulted in many floods. In the 12th century, for example, a tax was introduced in England to the people who lived in floodplains so that the collected tax money was used for repairs and maintenance of these canals [23] (pp. 34–35). It was also very important to coordinate the maintenance of these systems and their influence upon other areas. Large floods, which occurred despite the existing defense systems, revealed the vulnerability of defense systems. They also revealed the necessity of increasing investments in embankments, defense walls and other structures, as well as the importance of timely flood warnings. In addition to protection, people also began to think about flood risk assessment [23] (pp. 37–38).

Analyses of flood damage and costs necessary for protection were carried out. National flood responsibilities were introduced [23] (pp. 37–38), while flood management was reviewed. In addition to defense, the focus was also on education as well as early warning systems. In this way, flood risk assessment, risk management and protection became parts of planning documents. The flood impact was viewed from many new aspects. The main focus was on the flood risk monitoring and a sustainable protection system.

History of Flood Protection in Serbia

Water level monitoring as a form of insight into the behavior of rivers in Serbia most likely dates back to the ancient period, although no exact data exist to confirm it. Thus, for example, judging by the traces on the right bank of the Danube, it can be concluded that during the construction of Trajan's bridge, in the period of low water, the Danube was diverted behind the present-day town of Kladovo in order to build the foundations of pillars in the riverbed [27]. This was certainly an undertaking that could not have been carried out without certain monitoring of the water level and determination of the duration of low water. The remains of infrastructurally very well-equipped cities from the Roman and Byzantine eras on Serbian soil testify to a high level of hydrotechnical knowledge, while Sirmium's irrigation and drainage systems testify to the need for water management.

Records of the damage caused by floods can be found in the records of Serbian medieval monasteries. There are records of the overflowing of the Danube in Belgrade in 1770, then in 1793 in Sremski Karlovci. The flooding of the Studenica Monastery in 1864 was even recorded on the memorial stone in the churchyard. Afterwards, notes and records became increasingly frequent, more detailed and more systematic.

The first systematic hydrological monitoring on the territory of Serbia began in the first half of the 19th century. The first water measuring station in this region was established in 1812 in Novi Sad, on the right bank of the Danube. It was followed by a whole series of water measuring stations such as Bezdan (1856), Zemun (1859), Slankamen (1888), Novi Bečej (1855), Senta (1860), etc. [27].

The first flow measurements on the Danube, as evident in the extant data, began in 1924 near Bezdan, Slankamen and Ritopek. The period between the two world wars was marked by active work of the hydrological service.

5. Research Framework

In this paper, flood impact on cultural heritage is analyzed. The area encompassed by the research is the one that territorially coincides with the area under the jurisdiction of the Niš Institute for the Protection of Cultural Monuments, an institution entrusted with the care of immovable cultural assets in its territory. Almost all of Southern and Eastern Serbia falls under this jurisdiction. These are the Bor District (comprising the municipalities of Kladovo, Majdanpek, Negotin and Bor), the Zaječar District (comprising the City of Zaječar and the municipalities of Boljevac, Sokobanja and Knjazevac), the Nišava District (comprising the City of Niš with its associated municipalities as well as Ražanj, Aleksinac, Merošina, Doljevac and Gadžin Han), the Toplica District (Prokuplje, Žitorađa, Blace and Kuršumlija), the Pirot District (Pirot, Dimitrovgrad, Bela Palanka and Babušnica), the Jablanica District (City of Leskovac, Bojnik, Lebane, Medveđa, Vlasotince and Crna Trava), and the Pčinja District (City of Vranje, Bujanovac, Preševo, Vladičin Han, Surdulica, Bosilegrad and Trgovište) [28] (Figure 2a,b).

(**a**) (**b**)

Figure 2. (**a**) Researched area; (**b**) review of the recorded buildings. Number 1 denotes the church in the village of Zavoj, while number 2 denotes the church in the village of Boljev Dol. The squares mark the recorded assets with elements of vernacular architecture.

6. Types of Floods in Serbia

In the current water legislation, flooding is defined as “a temporary covering of land not normally covered by water” (Official Gazette of RS, No. 30/2010, 93/2012, 101/2016 and 95/2018) [29]. The overbank spilling along with an uncontrolled spread of the waters, i.e., the floods whose varieties depend on the terrain characteristics, bring about consequences for people, the environment and material goods [30].

Floods occur under the influence of several factors. Most often, these are combinations of natural and anthropogenic influences, except when it comes to exclusively meteorological causes. According to the main cause, floods in Serbia can be divided into rain and snowmelt floods, ice floods, floods due to the coincidence of high waters, torrential floods, floods caused by landslides and floods caused by the collapse of dams [31] (pp. 25–26).

Considering the time of the flood wave formation, floods can be plain and calm, which is characteristic for large rivers, where it takes several hours for the formation of a large water wave, or they can be torrential, most often on mountain watercourses, or they can be accidental, sudden floods, caused by the collapse of water or hydropower facilities.

In the territory of Serbia, the largest floodplains are in the valleys of the Tisa, Sava, Velika Morava and Danube Rivers [32]. The Great Morava Basin is particularly threatened by torrential floods that form in a short period of time, and as such are unpredictable and destructive. On the territory observed and analyzed in our research, large rivers include a section of the Danube as well as the South Morava, the Nišava and the Timok Rivers.

Assets of cultural heritage can be jeopardized by any type of flood, depending on their position in relation to the flood-affected area. In addition, the heritage which is not even in a flood area can be endangered by high levels of groundwater and sewage overflows and in periods of heavy rainfall, primarily in urban zones. Stormwater drainage systems cannot receive such a large amount of water in a short period of time, so that spills occur. Contamination after such a spill is especially problematic in cases where fecal and atmospheric sewages are not separated.

History of Floods in the Researched Area

There have been large floods in the observed area since ancient times. Some of the older data on floods are those on the flood in the Timok River Basin in 1915. It was caused by torrential tributaries. It affected the valleys of the Beli, Crni and Veliki Timok Rivers. Numerous villages in the vicinity of Knjaževac, Zaječar and Brestovačka Banja suffered great material damage. In 1938, catastrophic floods occurred in the Djerdap part of the Danube. The cause of these floods was the morphology of the riverbed and the buildup of ice in the narrow part of the river near Kazan. The ice barrier caused the water level to rise upstream, near the town of Gornji Milanovac. The Danube overflowed and flooded this settlement and its surroundings [31] (pp. 42–43).

Back in 1948, the Nišava River overflowed its banks, flooding a large area of the City of Niš. According to the reports, the difference in the water levels between the lowest water level and the water of this flood wave was 5.5 m. In 1948, a great flood also hit the town of Vlasotince. In the same year, the South Morava, following several days of heavy rain, flooded the area of the Grdelica Gorge. The Leskovac Basin was also flooded.

In 1963, due to heavy rainfall, a landslide formed on the Visočica River near the town of Pirot, and as a result, the villages of Zavoj and Velika and Mala Lukanja were permanently submerged. In 1966, an ice flood of the Danube occurred again in Djerdap. On this occasion, floods occurred in the towns of Donji Milanovac and Kladovo. In 1972, the Bor River flooded the pit of the Bor mine. In 1975, floods occurred again in the towns of Aleksinac and Leskovac.

In 1989, in the Vlasina River Basin, near Vlasotinac, a huge flood occurred, with more than 1700 objects flooded. In the same year, as a result of ice accumulation on the South Morava near Stalać and at the confluence of the Jablanica and Veternica Rivers, floods occurred. Therefore, the Leskovac District suffered a great deal of damage. In addition, a large number of households in the Aleksinac Municipality suffered a lot of damage. There were also floods in the Nišava Valley (villages in the vicinity of the towns of Niš, Pirot and Dimitrovgrad) [31] (pp. 54–58).

In May 2005, there was a flood in the South Morava Basin, when the settlements in the Niš District (Aleksinac, Niš, Doljevac, Ražanj and Merošina), the Jablanica District, (Leskovac, Bojnik, Medveđa and Vlasotince), as well as Žitorađa in the Toplica District suffered the greatest damage [33]. In 2006, the water level of the Danube exceeded its historical maximums, so that the floods downstream of HPP Djerdap II threatened the town of Kladovo and Negotin plains. In the same year, as a result of floods, numerous landslides occurred. In the investigated area, landslides are registered in the Morava Basin.

In 2007, Southern Serbia was threatened by floods. Due to melting snow and heavy rainfall, the Vlasina River, as well as the South Morava River, flooded the surrounding settlements. The maximum water levels were recorded in the Vlasina near Vlasotinac, the Jablanica near Pečenjevac, the Toplica near Doljevac and the Južna Morava near Mojsinje. Floods affected the municipalities of Babušnica, Bela Palanka, Dimitrovgrad, Doljevac, Lebane, Leskovac, Pirot and Vlasotince [33]. In 2015, Vladičin Han, Surdulica, Vranjska Banja and lower parts of the town of Vranje were affected by floods [34].

7. Cultural Heritage

According to the Law on Cultural Goods of the RS [35], in Serbia we distinguish four types of immovable cultural assets, namely cultural monuments, spatial cultural and historical entities, archaeological sites and landmarks. In the investigated territory there are 380 declared cultural monuments, 55 archaeological sites, 7 landmarks and 18 spatial cultural and historical entities. Of this number, 51 cultural assets are in the category of “great importance”, while 21 are in the category of “exceptional importance.” One monument is on the UNESCO list of the world cultural heritage.

The vulnerability of every type of immovable cultural asset depends on several factors. One of the primary ones is the topography of the terrain and the position of the immovable property itself in relation to flooding river courses. The key question is whether the object is located in a floodplain. The height at which the object is above the flood risk level is also crucial, as well as whether there is a planned flood defense system in that place.

Fortunately, in ancient times, people in settlements were more skillful in positioning significant structures. Thus, churches were most often built on elevations, which turned out to be very favorable regarding, among other things, flood defense. The buildings that were primarily, for functional reasons, positioned next to the rivers, were so structured that occasional floods could not significantly damage them, i.e., they could withstand floods. For example, watermills were positioned next to the rivers, as a specific type of vernacular architecture, which used water as a driving power. Therefore, it was not uncommon for the swollen river waters to sometimes cause damage to such buildings. The stone retaining walls as well as the flood gates upstream of the mills allowed them to get out of such situations with little damage.

Specific situations also happened. Due to the changes in the riverbed, due to its displacement, etc., the buildings which were at the time of their exploitation designed above the flood level could find themselves in the flood zone under new conditions. Likewise, due to poorly maintained drainage systems, or as a result of the flood prevention policies in other parts of the settlement, the surface and underground drainage waters were retained in order to prevent even greater flooding of lower, sometimes more vulnerable areas [36]. For this reason, the objects of cultural heritage, although located at a suitable elevation, were flooded.

Likewise, of great importance is the type of material used for an object as well as the resistance of the given material to staying in water or to cyclic wetting and drying. The material of which heritage assets were built plays a very important role. In most European countries, stone is the most common building material in heritage objects, even for civil architecture. This is not the case in Serbia. The most common building materials are earth-based. Stone was used for monumental assets (churches and more significant residential buildings). The remains of stone structures can be found at archaeological sites, mostly dating from the ancient times. The predominant material used is earthen material (adobe, sun-dried brick, baked brick, roof tile and mud mortar), followed by different types of wood as well as the aforementioned stone (limestone, sandstone and marble) and metal (iron, copper, lead and zinc) [37].

Accordingly, it is easy to conclude that vernacular architecture is the least resistant to floods. The earthen material used for these buildings is very resistant to changes in humidity caused by wetting and subsequent drying. Likewise, adapting these objects to nature, i.e., fitting them into natural environment, although presenting an advantage regarding a comfortable life, becomes disadvantageous in terms of water impact on the objects.

8. Damages to Declared Cultural Monuments

The scope and degree of water damage from flooding depend on the depth of the flood water and the flow rate, the time the object is exposed to the water, the amount of pollutants in the flood water, the material the building is made of and the speed at which the buildings begin to dry out [38] (pp. 32–34).

The total damage can be divided into two groups. The first group consists of damage directly induced by flood impact (disintegration of walls, lifting of flooring, falling off of plaster from walls, etc.). Delayed flood effects are the appearance of moisture in the areas that had no direct contact with the flood water, such as the spread of mold, biodegradation, etc.

Damage to the assets can be caused by the following:

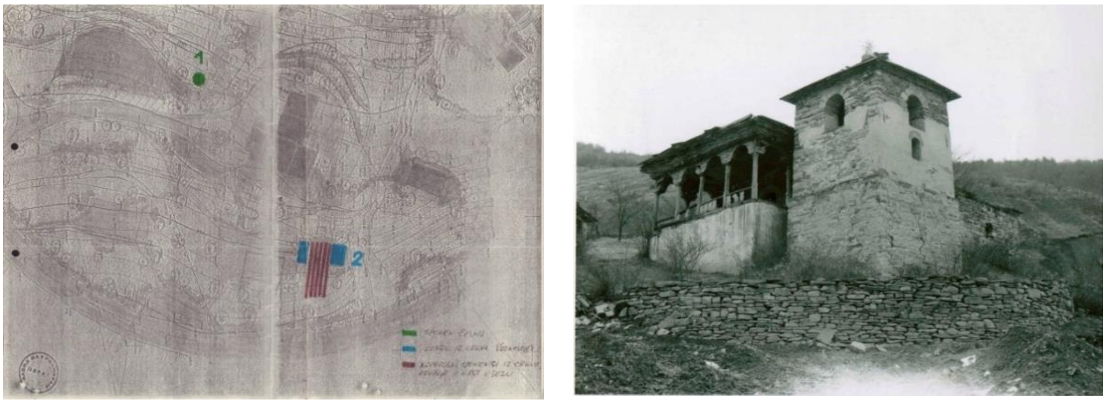
- Horizontal static pressures of the raised water;
- Hydrostatic pressure upwards during immersion;
- Low-speed dynamic flows;
- High-speed dynamic flows;
- Dynamic influence of waves;
- Dynamic influence of floating objects;
- Compacting of the soil or fill;
- Changing the support conditions due to changes in the soil;
- Saturating the material with water;
- Contamination of materials with chemical and biological agents;
- Formation of barriers;
- Ice surfaces [39].

By inspecting the complete documentation available at the Institute for the Protection of Cultural Monuments in Niš as well as by extensive research in the field, we have confirmed our initial observation. There are very few sacral monuments that have been threatened by this type of natural disaster. On the other hand, buildings of residential architecture, especially rural ones, are in a much worse situation.

8.1. Church in the Village of Zavoj

One of the most extreme cases of damage, or, rather, of complete destruction of an object with monumental properties, is that of the sinking of the village of Zavoj near Pirot (Figure 2b). Due to the sudden melting of snow and heavy rainfall in February 1963, colluvial processes were initiated due to the soaking of massive slopes on Mount Stara Planina. The formed landslide created a natural dam to the Visočica River over 40 m high. Rainfall continued, the water level rose, and due to natural circumstances, the newly created lake expanded more and more, soon submerging the village of Zavoj with about 160 houses in it. After Zavoj, the lake also submerged the upstream villages of Mala and Velika Lukanja. The army tried to demolish this natural dam by blasting, which, if it were to give way, could threaten over 70 settlements in the Nišava Valley. Since the mining did not produce the desired result, the army strengthened the natural dam, while at the same time kept digging a channel to empty the lake. After excavating the drainage tunnel, after several months the lake was partially drained. All the previously sunken objects emerged from the water, including the Church of the Ascension of the Lord dating to the 16th century. It was decided to arrange the lake bottom in such a way that the objects, together with the Church, would be demolished and the vegetation cut down, and the dam lake of the current HPP Zavoj formed there. At first, regarding its origin, the lake was classified as a tectonic type, while currently it falls into the category of artificial lakes due to the construction of the artificial dam.

The entire architectural heritage of the above-mentioned villages, including a few hundred houses, is irretrievably lost (Figure 3a). At the bottom of the current dam lake, which was built from 1982 to 1988, in addition to the remains of the houses, there is also a three-arched stone bridge as well as the former school building. Currently, at low water level, the outlines of the foundations and stone walls of the houses are visible (Figure 4a,b).



(**a**) (**b**)

Figure 3. (**a**) Position of the Church on the plan, during field inspection; (**b**) a rare surviving photo of the Church. Reprinted with permission from [40] 2022, Institute for the Protection of Cultural Monuments Niš.

(**a**) (**b**)

Figure 4. (**a**) Remains of the village cooperative; (**b**) remains of the housing buildings in the flooded village of Velika Lukanja at the time of low water level (photo A. M. Petronijević).

The Church was a protected cultural property. It was a one-nave building, without a dome, with an altar apse and a narthex, to which a prominent belfry was added (Figure 3b). It was arched with a semicircular vault, built with roughly hewn stone, and then plastered and whitewashed on the outside. It was covered with stone slabs. The interior of the nave and altar space were richly painted. As stated in the explanation of the resolution for declaring cultural properties, the Church has a historical, architectural and painting monumental value because it bears witness to the artistic activity of the Serbian people under difficult conditions of slavery under the Ottoman Empire at the end of the 16th century. Its architecture and frescoes make it significant for the study of architecture and painting in Serbia of that time. Some frescoes were removed from the sunken Church. They are at present kept in the Museum of Ponišavlje in Pirot [35]. There was a proposal to relocate the building to the shore of Lake Zavoj after emptying the lake, but this proposal was not realized.

There are still plenty of examples of submersion of cultural heritage in the territory of Serbia, but other submersions were caused by human action, not by nature. In these situations, cultural assets were exposed to danger since the economic aspect of the construction of some buildings overrode the cultural or historical value of the locality. For example, during the construction of HPP Djerdap, many archaeological sites ended up under water, and Lepenski Vir, due to its importance, avoided this fate and was moved to a higher elevation. The example of submergence due to the formation of Lake Zavoj is the only such example in Serbia created by the natural causes.

8.2. Church of St. Archangel in the Village of Boljev Dol

The Church of St. Archangel in the village of Boljev Dol (Figure 5) (Municipality of Dimitrovgrad) was built at the turn of the 17th to 18th centuries. It was declared as a cultural monument. It belongs to the type of smaller sacral objects built of stone and tufa. It is small in size, with a single nave and a semicircular apse in the east. The entrance to the Church is on the west and south side. It is covered with a semicircular vault and covered with stone slabs.

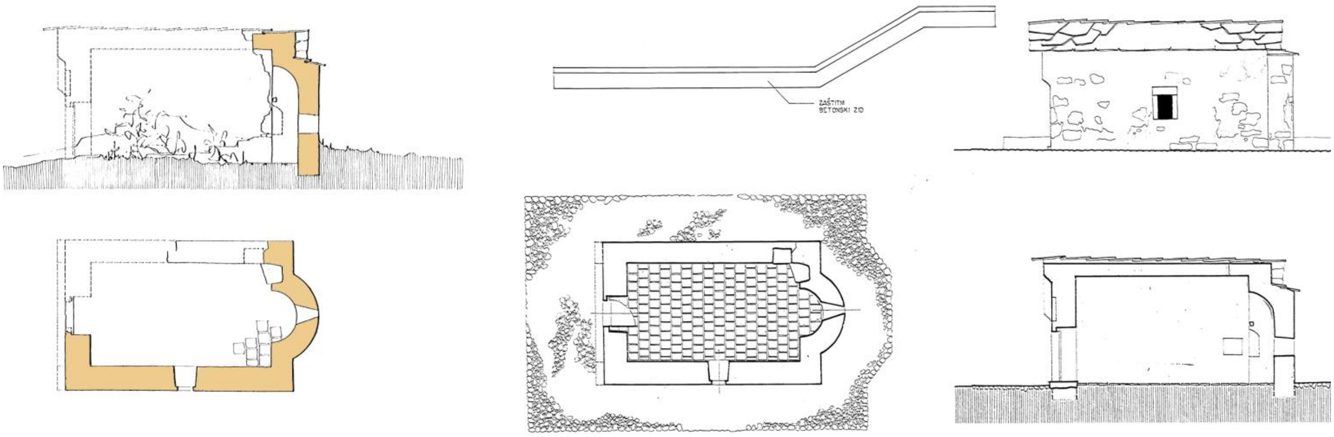


Figure 5. From left to right: the existing state of the Church with the damage shown and the proposal to rehabilitate the building. Drawing A. Radović. Reprinted with permission from [41] 2022, Institute for the Protection of Cultural Monuments Niš.

Because of the proximity of the torrential Dolska River, which flows down from a nearby hill, the Church was damaged and subjected to salvage works even after the occasion of its declaration for a cultural monument. In 1977, regarding the damages done, salvage measures were proposed for the Church. It suffered significant structural damages. The northern and western walls of the Church were demolished. Almost half of the length of the object was demolished (Figure 6). The first temporary protective abutment was set up in 1972. A year later, torrential water broke through the abutment and once again directed its flow straight to the Church. It was then decided to erect a 12 m long protective concrete wall that would permanently solve the problem of the storm surge. In order not to damage the ambient value of the Church, it was planned for the wall faces to be treated with crushed stone (Figure 5).

(**a**) (**b**)

Figure 6. Church of St. Archangel in the village of Boljev Dol after the flood: (**a**) exterior, (**b**) interior. Photo Jovan Šurdilović. Reprinted with permission from [41] 2022, Institute for the Protection of Cultural Monuments Niš.

Proposals were also made to first erect some kind of temporary and later a permanent protective structure over the destroyed part of the building, but these proposals were abandoned. It was decided to rebuild the destroyed parts of the building with the original material that was found in the form of drifts in the immediate vicinity of the Church, imitating the original masonry technique [36]. The original covering of stone slabs was restored over the vault, which was rebuilt with tufa. The floor was made of bricks. The preserved fresco paintings on the remaining walls were conserved (Figure 7).

(**a**) (**b**)

Figure 7. Church of St. Archangel in the village of Boljev Dol after conducted rehabilitation and conservation measures: (**a**) exterior, (**b**) interior. Photo Z. Radosavljević. Reprinted with permission from [41] 2022, Institute for the Protection of Cultural Monuments Niš.

9. Damages to Assets of Vernacular Architecture

Upon inspection of the complete documentation of the Institute for the Protection of Cultural Monuments in Niš, it was determined that these are the only recorded cases of damages induced by flood impact upon declared cultural monuments. However, during minor floods that occurred periodically, the reported damages were mainly on the buildings in villages. Some of the damaged buildings have elements of traditional architecture, and although they are not listed in the register of cultural assets, they deserve to be mentioned.

In this section, the observed damages to the assets of material cultural heritage and their general classification are presented (Figure 8). The damages to the assets representing the movable cultural heritage have not been taken into consideration in this research because the risk of their flooding is negligible. The field research was conducted to observe and record the damages done to the buildings both as direct or indirect flood damages.

The assessment of buildings often requires a holistic approach, assuming the buildings as a whole and not just one part of it. The diagnosis of the condition is based on a qualitative and quantitative approach. The qualitative approach is based on direct observation of structural damage and deterioration of materials.

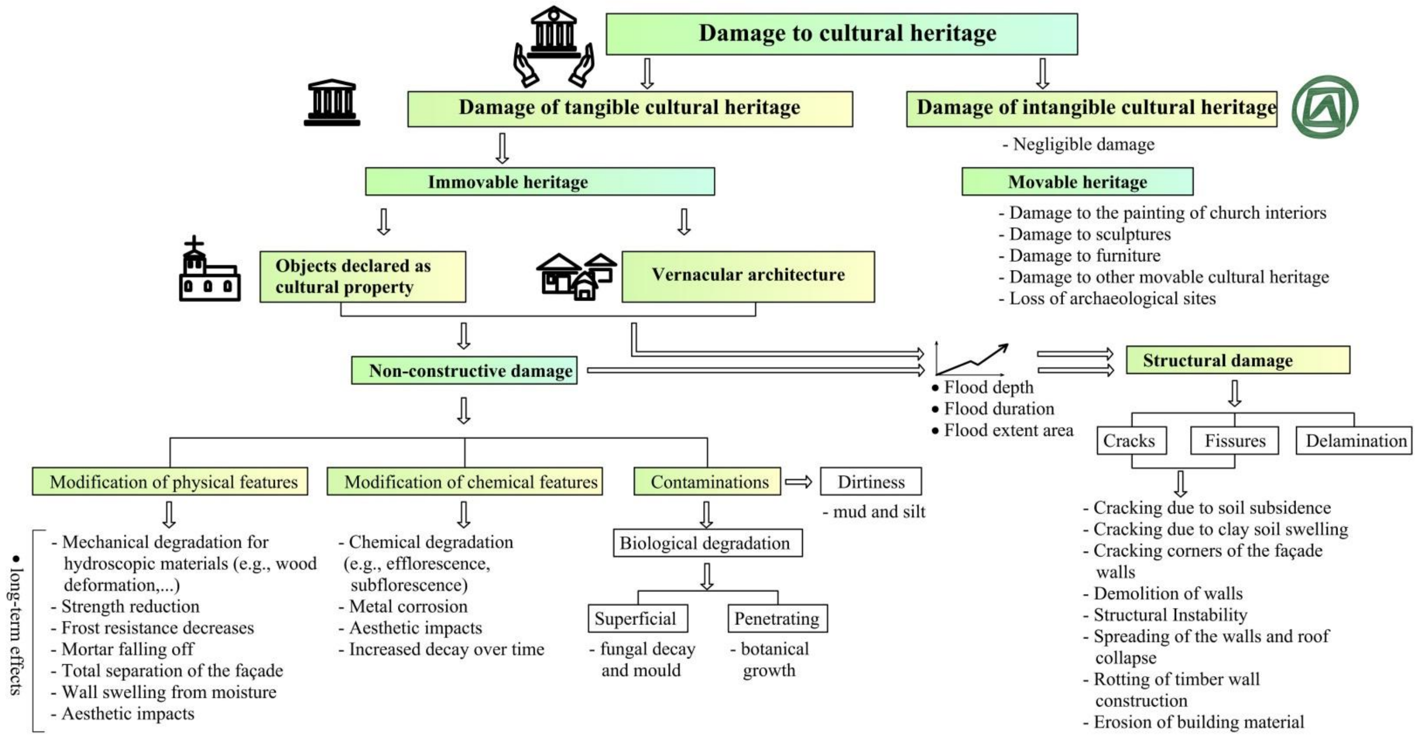


Figure 8. Classification of damages.

The next section of the paper shows flood damages, both as a direct consequence due to moisture on the assets of sacred and vernacular architecture built of earthen materials, or in post and pan as well as in the masonry structural systems. They are classified, according to type, into non-structural and structural damages, where the degree of the impact depends on the depth of the flood wave, flood duration and surface area of the land affected by the flood.

9.1. Damages on Buildings with Uncompromised Stability

Materials such as adobe and daub are not capable of withstanding a long "stay" in water. If there is a torrential flood, or if a calm flood lasts longer, there is a high probability that such structures will be destabilized. The effect of erosion from fast water is disastrous. The soil material would be completely washed away (Figure 8). If, on the other hand, the effect of floods is short and without dynamic effects, bigger or smaller damages appear on the buildings.

9.1.1. Moisture Effects

Physical degradation and anomalies in the structure occur as an aftermath of the moisture to which the building was exposed during the flood. In the buildings that are predominantly built in the post and pan system, with a wooden frame and infill of some sort, most often earthen material, damages occur due to the differences in the behavior of these two types of materials (Figure 9). Due to the cyclical swelling of wood with increasing humidity and shrinkage due to drying in the walls, expansions occur. They are significantly larger than the limit values that can be sustained by mud mortar. Thus, volume changes in the wooden structural elements due to the changes in humidity percentage result in damages that occur on the plaster of external and internal wall surfaces, such as disintegration (crumbling and turning into dust), blistering, flaking, fragmentation and pealing (Figure 10a,b).

Figure 9. After water receding, a part of mortar is "washed away." On the remaining mortar one may observe straw, which is a form micro reinforcement.

(**a**) (**b**)

Figure 10. Characteristics damages to mud mortar: (**a**) falling of the finish lime mortar; (**b**) total pealing of the mud mortar from the adobe wall (photo A. M. Petronijević).

After wetting, the wooden parts of the building are subject to rotting. In the case of a wooden post and pan, the beams dry out faster than the mortar. Thus, the mortar shrinks and cracks in that place. In this way, the wooden parts of the building (beams, columns, braces, etc.) are additionally exposed to weather effects, which considerably shorten their lifespan (Figure 11). The weak points of post and pan are indentations and cuts, for plugs and other connections, where moisture can retain the longest; therefore, they are most susceptible to rotting [42].

Brick walls that are exposed to flooding can be damaged during drying by the salts that are the aftermath of leaching due to high groundwater levels. The salts reach the surface of the brick and after drying they appear in the form of a white powdery material. On the buildings that are still in use, which are built of brick and plastered, significant leaching on the face of the walls is noted and so is the formation of mineral layers with significant coloring on the wall surfaces (Figure 12a,b). This phenomenon mainly has an aesthetic connotation. The problem arises when this process occurs behind an impermeable outer surface. The salts crystallize and expand, leading to the so-called flaking of brick or stone.

Figure 11. Falling off of mortar due to swelling of timber.

(**a**)

(**b**)

Figure 12. Leaching on the wall face due to floods: (**a**) detail; (**b**) large wall area (photo A. M. Petronijević).

For all types of materials, the degradation is significantly worsened by the frost effect (Figure 13b). Freezing and thawing cycles of wet walls are the second dominant factor of their physical degradation. Freezing after buildings' exposure to floods is very common, considering that after getting wet, the objects do not have time to completely dry before the winter months.

(**a**)

(**b**)

Figure 13. (**a**) Moisture inside the building after water receding; (**b**) separation of mortar from the interior wall after freezing (photo A. M. Petronijević).

The use of stone in the observed buildings of vernacular architecture was reduced exclusively to the pedestal, foundation strips and foundation walls, and, in the case of buildings on sloping ground, to basement walls. Physical damages to the foundation walls are mainly manifested in the joints made in lime or mud mortar. If the walls are made of pebbles from the river drift, and not of larger and better shaped pieces of stone, then these walls must be leveled, i.e., leveling layers of slab stone or brick and most often of wooden beams or wooden beams called "santrač" must be laid along the entire length. They are placed in pairs on the edges of the wall and are tied to each other with a crosstie. This is where the limited durability of wood comes to the fore due to exposure to moisture. Therefore, damages occur on the wooden parts of the walls. In addition, wet wood is susceptible to mold and insect infestation.

"Santrač" beams are exposed to constant alternating wetting and drying, so they rot away over time. After rotting, voids remain, and in those places there is a significant reduction in the cross-section of the wall. With thinner walls the cross-section is reduced by up to 1/3. The inter-space between the wooden beams is filled with smaller pieces of stone, so these are critical places in the static sense as well [42]. Thus, the damage caused in this way can also be classified into another grouping, i.e., damages of structural nature.

An additional problem with the damage of such buildings from moisture is caused by the fact that during the construction period of the observed buildings, no type of prevention of capillary rise of moisture was applied. The capillary rise of water, which is not exclusively related to the flood process itself, causes a significant damage to buildings. The impact is first noticed on the parts of the plinth, where the damages are the greatest (Figure 14). Through capillary rise, the water then migrates to other parts of the structure of the building, which leads to wetting and then to the falling off of the plaster from the walls, and all this is due to long-term exposure and the rotting of the beams and other elements.

(**a**)

(**b**)

Figure 14. (**a**) The capillary rise of water has led to the falling off of the plaster from the lower part of the building due to exposure to the action of water; (**b**) complete falling off of the plaster from the plinth wall (photo A. M. Petronijević).

Metal elements (iron) will corrode unless the aggressive ingredients are washed out from the contaminated water and the element is dried relatively quickly.

9.1.2. Biodegradation

In many cases, biodegradation is a significant factor in the deterioration of assets. These assets are mainly the buildings that are neither permanently inhabited nor provided with regular maintenance. Upon their surfaces exposed to wetting, whether as a result of flooding or not, a layer is formed or even bushy structures up to several centimeters thick. There abound numerous microorganisms such as algae (Figure 15), mold and mildew, and, if the wetting process continues, lichens and mosses as well. A more significant presence of low and high vegetation is characteristic of places with increased humidity in the zone of the contact of the building with the ground. Biodegradation is classified as a contaminating damage.

Figure 15. Algal colonization in the areas from which water has not been drained (photo A. M. Petronijević).

9.2. Structural Damage

Structural instabilities in buildings occur very rarely, unless the following take place:

- The object is hit by a strong flood wave, as was the case with the Church in Boljev Dol;
- The flood wave has caused damage with an impact of larger elements it carries with it;
- Some significant changes in the soil have taken place.

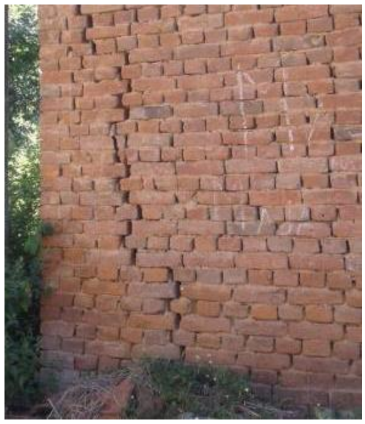
Due to the shock wave of water, materials from some parts of the building (Figure 16) may be carried away, washed away, or even entire walls may collapse.

(**a**) (**b**)

Figure 16. (**a**) Structural damage; (**b**) attempt at rehabilitation of the given damage (photo A. M. Petronijević).

Furthermore, the impact force of water, a high pressure or undermining the soil beneath the building may give rise to cracks in the walls (Figure 17) or tilting and bulging of the walls (Figure 18). Structural damages may even occur later as well, after the building is restored to function, if there are wooden structural elements that continue to rot over time due to the presence of moisture. In this case, cracks would appear later.

(**a**)



(**b**)

Figure 17. (**a**) Adobe wall. After soaking and then after drying, some parts of the walls became separated from each other. (**b**) Structural cracks (photo A. M. Petronijević).

Figure 18. Wall bulging (photo A. M. Petronijević).

Instability problems can be caused by changed support conditions and static destabilization. During floods and land soaking with water, swelling of the clay in the soil can occur. This leads to a change in the conditions for the building support, which is manifested by the appearance of clearly visible cracks. As a consequence, numerous damages occur, such as cracks, deformations and bulging of the walls, from those at the micro level to complete separation of parts of the walls, which leads to distortion of the basic form of the building. In the case of masonry buildings, if the material was adobe, separation of sections of the buildings may occur (Figure 17a).

Wooden structural elements can also be significantly threatened by water, even more so if they are inside the wall mass, which makes the drying process more difficult. In this case, it is necessary to drill small holes at the bottom of the cladding for water drainage. Sometimes it is also necessary to dismantle it for drying, and then return it to the designed position [36]. As a result of exposure to water and moisture, warping may occur (Figure 18), and after a long time, complete rotting.

The phenomenon of delamination is a damage characteristic of multi-layered massive walls of fortification and hydrotechnical buildings on archaeological sites. Delamination is mainly a consequence of the bearing capacity decrease under the impact of moisture and various mechanical characteristics of the layers inside the walls with a complex cross-section. As a rule, the outer "visible" layer of the wall is built with hewn or rounded stone in a relatively regular arrangement, while the interior of the wall is filled with rubble.

10. Preparation of Objects in the Case of Predicted Flood

Flood forecasting and disaster risk assessment [43] is a rather complex and very important procedure for all aspects of human activities in flood-affected areas. A proper and as accurate as possible prediction of upcoming floods can minimize damage to objects [44].

Sustainable flood risk management would be the best solution in the field of cultural heritage protection [45,46]. Currently, flood forecasting is conducted in many ways. By applying the Artificial Neural Network Approach [47], institutional preconfiguration of community participation in flood risk reduction is carried out [48], and the shortcomings in the previous early warning systems are reviewed [49]. Complex mathematical hydraulic and hydrodynamic numerical models for flood modeling have been developed [44], which are being progressively improved. Such systems imply the development of infrastructure, the development of technology-based disaster risk reduction tools and the implementation of a variety of activities. Their realization means acquisition of information and knowledge by the wider population and civil protection commissioners (or experts) [50]. In the case of cultural heritage assets, predicting floods is crucial in gaining time enough to save particular, culturally irreplaceable parts of the asset or equipment. Forecasting floods is crucial for vulnerable assets of cultural heritage to be preserved as much as possible [51].

On the other hand, the risk of high waters and the failure of the protection system cannot be completely avoided, because some of the parameters that influence the occurrence of floods are often random. In addition, it is not possible to fully design the protection system for every big water event. Therefore, in addition to flood risk management and control, an adaptive management approach to protection and salvaging from floods and torrents is also necessary, i.e., adaptation to flood risk [52].

In this regard, it is very important to educate the population about activities and take measures in such situations. In European countries there are manuals for this purpose, in which one can find all the necessary steps to be taken before, during and after the flood [38] (pp. 8–13). For this purpose, the collected, systematized and classified data can represent a very good basis for increasing the level of information of both the population and experts regarding their actions in flood situations [50].

First of all, drains, watercourses and canals should be well maintained because smaller localized floods are most often the consequence of lack of maintenance. Unhindered soil drainage reduces the risk of flash torrential floods. Even if floods do occur, drains and drainage channels play an important role. The first and most important step in preparing cultural assets for a predicted flood is to try to prevent water from entering the building, or at least reduce the amount of water entering the building to the smallest possible extent. Temporary flood barriers are placed around the building or at a designated place in the settlement. They can also be placed next to a single specific building. Sandbags can be very effective as temporary barriers. Their disadvantage is that they are difficult to use.

Flood water can enter the building through windows and door openings, door frames, thresholds, the perimeter of the window openings, cracks on the external walls and the places of the bricks for facade ventilation. Other points of entry can be sanitary devices if there is no return valve on the sewage network; it is through them that water enters basements and manholes [38] (pp. 14–15). That is why these risky places need to be closed, either with the seals designed for this purpose or with improvised ones. Thresholds on doors, firm sealing of facade openings and setting up of non-return valves on sewage installations are all the measures that do not require much effort, and yet they can significantly mitigate the damage. More permanent protection would include fences, walls and additional drainage ditches around the building in question, if there are conditions for them in the surroundings of the building (meaning if there are no archaeological remains, other historical objects, etc.). Such barriers should be carefully designed regarding their dimensions since they significantly affect the appearance of the environment.

Flood damages cannot be altogether eliminated, but the aim is to reduce the deleterious consequences and to adapt to flood risk (Figure 19). However, this implies the implementation of technical, economic, ecological and safety analyses and calculations that will lead to the justification of the adopted protection system. Such a protection system should represent an integral concept of flood protection that fits into the internationally acceptable concept of sustainable development. It should strive to harmonize the human component (protection of property and human lives) and the environmental component (preservation or re-establishment of natural functions and resources of the flooded area). The new concept of sustainable management is being realized by an appropriate ratio of non-investment and investment works and by reduction in the exposure of the population and environmental attributes to the flood risk [52].

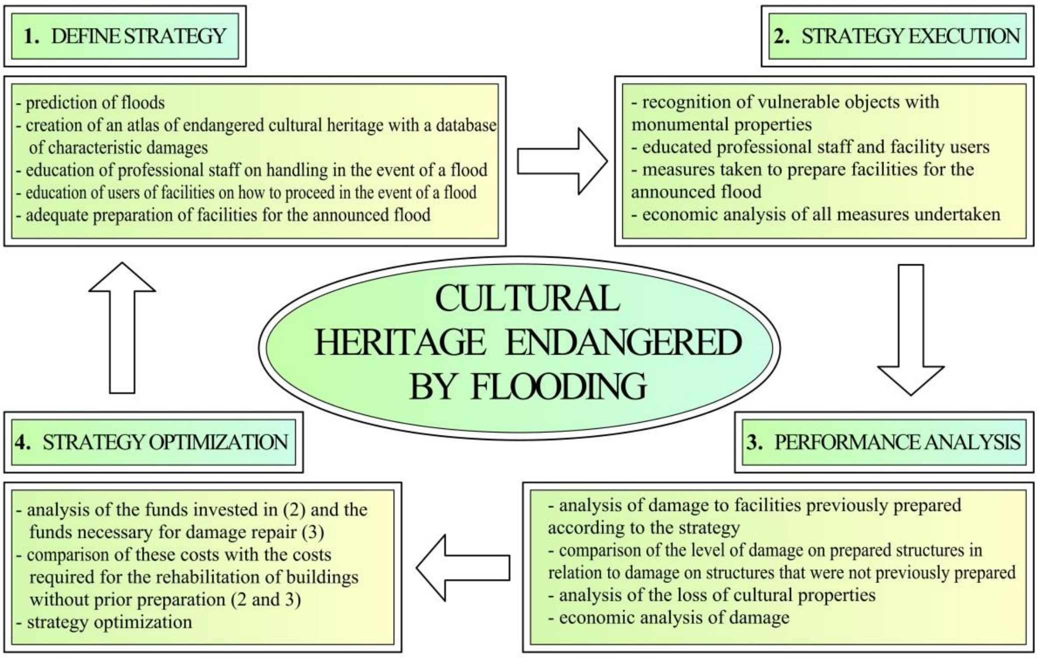


Figure 19. The performance metrics.

11. Rehabilitation

Structural damage must be rehabilitated in consultation with the appropriate profiles of experts. If there is no structural damage to the buildings, the most important task is to remove excess water from the building and its immediate surroundings as soon as possible (Figure 20). First of all, the existing drainage systems must be put back into operation in order to remove water from the foundation structure as quickly as possible. It is desirable to flush all drainage systems with clean water as well as the water and sewage networks of the building itself. Then, potential "water reservoirs" in the structure should be identified, i.e., porous places in the walls, cavities in the walls, etc., in which water could have been retained [36].

It is necessary to remove all wet parts from the structures, whether those are deposits or the existing furniture and flooring. Apart from wooden structural elements, wooden floors are also very vulnerable. As a result of swelling, the entire floor is most often lifted and separated from the base, so that after floods it is necessary to replace the floor coverings. Possibly, if a flood is expected, it is possible to partially pull out the boards from the floor beforehand in order to leave enough space for floor swelling without breaking the pattern.

If there are no wall paintings, or some other historically or culturally significant valuables, it is preferable to remove the water-soaked plaster because drying becomes faster. In the assets categorized as cultural monuments, one should be especially careful, and all rehabilitation measures should be carried out in cooperation with experts in this field.

(**a**) (**b**)

Figure 20. (**a**) Retained water after flood receding; (**b**) silt deposits after flooding (photo A. M. Petronijević).

What follows after the removal of all water-soaked and devastated parts are cleaning and washing of the premises with clean water using chemical agents. Services in charge of biocides and medical ecology carry out final disinfection of all internal and external surfaces, after which they can be used again.

After cleaning the building, drying is undertaken. Unhindered air circulation should be ensured as a form of natural ventilation. The sooner this is completed, the sooner the process of drying the building begins. It is important that the artificial drying is not too sudden. Exposure to high temperatures can lead to warping of wooden elements, calcification and the emergence of salt on stone or brick surfaces. If there are painted surfaces, they will peel off due to sudden drying. In addition, high temperature combined with moisture favors the growth of mold and fungi on the building [38] (pp. 18–34). In this way, the surface parts of the walls can dry out, which gives the impression that the object is ready for further use. Water may remain trapped inside the walls and later appear in the form of wet stains and mold. Or, after painting supposedly dried walls, the paint may peel off due to water coming out of the core of the wall onto the surface. Therefore, the drying of building should be carried out slowly and gradually. Apart from forced ventilation and heating, it is very important to ensure constant natural ventilation of the building. Sometimes there is a need to open parts of the structure so that the moisture trapped inside evaporates. The duration of drying depends primarily on the duration of the flood and the amount of moisture that needs to be removed. External air humidity and weather conditions also affect it (any structure will dry out faster in the summer than in the winter months). The type of material, i.e., its porosity, is also an important element when we talk about drying the building [53,54].

After complete drying of the building, there follows rehabilitation and restoration of the building to the condition which is as close as possible to the pre-flooding one. For rehabilitation, one should try to use materials that are porous and vapor permeable. If possible, remediation should be carried out by applying the original material mix designs, such as the mortar mix design.

Of course, after the drying process itself, in historic objects, it is necessary to monitor, that is, control, the humidity in the flood-affected asset. The asset is considered dried out if it returns to the pre-flooding state of moisture.

If the asset comprises things of artistic and historical value, they need to be dealt with by conservation and restoration services in order to preserve them as much as possible.

12. Conclusions

Although the researched territory is large in its surface area, there are no significant examples of flood-threatened declared cultural monuments listed. Apart from the Church in Boljev Dol, there are no other examples. The reason for this is the good positioning of the buildings in relation to the river courses. Church buildings are, in most cases, well positioned in this regard. This is also the case with fortifications and other types of heritage. Most often they are not built in the areas that are prone to flooding. In addition, the nature of the materials of which the historical objects are built with greatly influences this finding.

The situation is somewhat different with the objects of vernacular architecture. It is on these objects with elements of traditional architecture in the area of Southern Serbia that considerable damages are observed as a direct or indirect consequence of floods. Streams in villages often overflow, causing minor or major material damages to objects. The situation is like this mostly due to the nature of the materials of which they are built, as well as, to a large extent, due to poor maintenance. The population of rural areas, mostly poverty-stricken and with a lower level of education, is not able to adequately take care of the assets, adequately protect them from floods or repair the damage later. In addition, many of the assets on which damage is detected are not used continuously but only occasionally since their users, i.e., rural population, migrates to the cities. Thus, the dwellers are sometimes not even aware of damage to the assets for a long time. That is why they do not start remediation in a timely manner.

The fact is that floods cause severe damage to the architectural heritage not only while they last but also long after the flood waters subside. If the building neither succumbs to the shock of the flood wave nor its destabilization or collapse occurs immediately, there is still a high probability that damage can occur after the flood. Most of the recorded damages occurred mainly in the post-flooding period. Cracks appear after differential settlement of the soil. Volume changes in the material occur during accelerated drying. Efflorescence occurs during the drying process, as well as various types of biodegradation. With some types of materials, such as adobe, there is a loss of cohesion due to rapid drying.

Despite the aforementioned classification of damages, it is almost impossible to generalize upon all observed types of damage. The database of observed damages illustrated by the above examples remains open for changes and additions. Nevertheless, these classifications can serve as a good basis for the final classification of cultural assets into flood-resistant structures, structures susceptible to partial damage and structures susceptible to complete collapse. In addition, the categorization of conditions that occur during and immediately after floods can help in the design, and later in the implementation of temporary or permanent measures for the protection of cultural heritage.

Cultural heritage is a non-renewable resource that is passed on to future generations; therefore, a good strategy for preserving, managing and using cultural heritage can be of great benefit. Although it is impossible to always predict the coming flood, we must be prepared to minimize its consequences. All types of the damages observed and presented in this paper should be considered in relation to other problems accompanying flood situations. This refers to frequent inability to manage risks, absence of evacuation plans and insufficiently trained staff participating in the salvage process. The protection of immovable cultural assets and the prevention of risks are important because the essence is the preservation of cultural heritage assets in their authentic state rather than their rehabilitation after damage has already been done. State institutions should take all necessary steps to ensure adequate protection of cultural assets. The improvement, strengthening and expansion of the flood defense system along with precautionary measures and the type of preventive activities should reduce the damage to assets to an acceptable level. In addition, the systematic listing, categorization and assessment of the degree of risk of cultural assets should be especially encouraged. With such documentation, the necessary information can be provided to the national authorities responsible for responding to emergency situations such as natural disasters. The next step would be to establish working teams at regional disaster response centers, ensure appropriate staff training, develop response guidelines and establish standards for performing the cultural heritage protection duties during and after floods. The personnel in institutions for the protection of cultural monuments should also undergo the necessary training in order to effectively cooperate in the rescue operations carried out by the competent public services in the event of natural disasters.

If it is impossible to fully protect material cultural assets from flood impact, then damage to them should be reduced to a minimum while protocols for damage repair activities should be provided in advance. Taking steps for rehabilitation and potential restoration of immovable cultural assets should be carried out in accordance with traditional construction techniques that best suit a particular cultural asset. For this purpose, an appropriate system of training and verification of professional qualifications should be established in advance in order to ensure that everyone involved has the required level of competence. These measures should be proportional to the material value of the property, the cultural and historical significance of the assets and the magnitude of the risk to which they are exposed.

Regulations in the domain of cultural heritage, at the level of Serbia, should deal more with the impact of climate change on it. Most countries have created a vulnerability atlas for their heritage as well as accompanying guidelines, i.e., ways of dealing with heritage after a disaster [55,56]. It is important to predict the extent of potential damage to cultural heritage assets and to train experts for prediction and management of the effects that floods can have on cultural heritage. Educating the users of the buildings how to act in such cases is also important.

The improvement, strengthening and expansion of the flood defense system along with precautionary measures and the type of preventive activities should reduce the damage to cultural assets to an acceptable level.

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