Acadlore Transactions on Geosciences
https://www.acadlore.com/journals/ATG

Identification of Areas with Significant Flood Risks in Counties along the Danube River in Serbia and Their Risk Assessment

Ana Vulevic*

Department of Economy and Technology of Transportation, Institute of Transportation, 11000 Belgrade, Serbia

* Correspondence: Ana Vulevic (anavukvu@gmail.com)

Received: 01-10-2023 **Revised:** 02-10-2023 **Accepted:** 03-03-2023

Citation: A. Vulevic, "Identification of areas with significant flood risks in counties along the Danube River in Serbia and their risk assessment," *Acadlore Trans. Geosci.*, vol. 2, no. 1, pp. 1-13, 2023. https://doi.org/10.56578/atg020101.

Abstract: For countries along the Danube River, their sustainable economic and social development needs the optimum water utilization of both the Danube and its tributaries. In the context of climate change, the risks of floods and natural hazards must be managed, because these risks have caused noticeable damages to the environment, people and their property. The countries along the Danube River have a long tradition of international cooperation in this field. Primarily based on the experience of European countries and literature on flood risk management, this research aimed to acquire up-to-date knowledge, emphasize the importance of integrated and high-quality information, and use the information as flood risk management technology and tool. Some areas in the Danube basin in Serbia have been identified with significant flood risks. Taking these areas as an example, this paper presented flood risks caused by the Danube and a map predicting those risks. In addition, this paper studied relevant information on flood risk management and flood hazards, such as possible scopes and impacts (damages) of floods, as well as their frequency and mechanism in the case study of Serbia. In this context, knowledge and understanding of these natural hazards, as well as geographic information and technology can be used for further planning and control, thus minimizing flood risks.

Keywords: Flood; The Danube River; Geographic information systems; Risk assessment; Land use; Climate change; Spatial planning

1. Introduction

Sustainable development cannot be achieved unless flood risks have been considered by strategic planning in a timely manner. Flood risk mechanism has often been described by the source-path-receptor model [1], where the source can be heavy rain or high sea level, and the path can be watercourses or land routes, through which floodwater makes its way to the receptor, i.e., people and property. Although the sources or root causes of floods (rainfall and sea levels) are natural phenomena and essentially uncontrollable (with the exception of man-made drivers of climate change), the pathways, through which these phenomena are transformed into floods and flood damages, are subject to the influence of local or regional human activities. These activities and their impact can be controlled and can significantly increase or decrease the flood risks to property and infrastructure [2]. Related responsible bodies within the United Nations, led by the Economic Commission for Europe, prepared the document the *Guidelines for Sustainable Flood Prevention* [3], with recommendations and best practices for flood prevention and control areas, which emphasized the adjustment of land use and risk assessments in regions with immediate flood danger.

Uncontrolled development is not desirable, and population growth in urban areas has increased the likelihood of excessive land use in flood-prone areas [4]. Therefore, timely actions must be taken to deal with the constantly developing flood risks in some areas, such as construction of embankments [5] and increasing natural retention.

After huge floods occurred in Europe in 2002, an expert group was established, which produced a document on best practices in flood risk management (EU, 2003). Then the Integrated River Basin Management (IRBM) promoted the sustainable management of watercourses and all environmental segments in the river basin. But it turned out that concrete tools for long-term water management have been missing in most cooperative management agreements, involving 106 of the world's 263 international basins [6]. In addition, the practical value of the 1997 United Nations Convention on the Right to the Non-Navigational Use of International Watercourses has been questioned because of its unclear and sometimes contradictory language and slow progress in ratifying its legal framework [7].

The European Flood Alert System (EFAS), the first international system for forecasting floods of the Danube and providing an early flood warning, was launched in 2008 by the International Commission for the Protection of the Danube River (ICPDR) and the Joint Research Center (JRC) of the European Commission. Several countries, namely, Austria, Bulgaria, Czech Republic, Germany, Hungary, Moldova, Serbia, Slovakia, Slovenia, and Romania, signed the memoranda of understanding for the EFAS development. The SoFPAS 1 project created both vulnerability and flood risk maps for the left and right sides of the Danube River between the Belgrade Municipality of Zemun (1175 km) and the upstream end of the Iron Gate Gorge (1040 km), including parts of Belgrade City along the Danube, i.e., municipalities Zemun, New Belgrade, Stari Grad, Palilula and Grocka areas on larger rivers in the Velika Morava basin. In addition, IPA 2014-2020 flood recovery project in Serbia created both vulnerability and flood risk maps, which identified remaining significant 74 flood areas in Serbia.

Floods and climate change have affected urban and rural areas in Serbian counties along the Danube and have begun to affect their economic, health and social situation, requiring intensive disaster risk management. In 2001, 2002, 2010 and 2013, the regional authorities in Serbia had to protect the population and property from the biggest floods of all time on the Danube. (IPA II indicative strategic document for Serbia, 2014-2020).

The Water Framework Directive as part of EU environmental legislation must be fulfilled by all EU member states in order to protect their resources. The Management Plan for the period 2021-2027 was prepared in Serbia, which achieved a turning point in water protection policies. In addition, climate verification of flood risk measures will be considered by Serbia in the Flood Risk Management Plan that is being prepared.

This paper briefly described the latest situation in the Danube region of Serbia and analyzed some adaptation projects and strategies, which have been implemented. In addition, this paper emphasized the importance of strategic planning in reducing the impact of floods [8] and that of geographic information and technology in flood and coastal risk management [9, 10] as well as the advantages of mapping this natural hazard [11-13]. The paper tried to answer several questions: Do the countries along the Danube have a long tradition in this field? Have EU countries benefited from joint management and responsibility of natural flood hazards? What are the European experience and literature on flood risk management? What is the current state of watercourses, water management and related jurisdiction in Serbia? What are the main critical factors to consider in order to achieve successful flood protection in Serbia and how to consider to make changes? What is the importance of Geographic Information System (GIS)?

2. Methodology

In the process of answering the questions, this paper did qualitative research and analyzed statistical and modeling data, aiming to formulate the theoretical-applicative construction of the research model more precisely, thus achieving the goals and tasks postulated in the framework of the counties along the Danube River and flooding risks. The information is mainly from statistical data, data of competent institutions, European and national documents, reports, communications, legislation and institutions' websites.

3. Result

3.1 Geographic, Economic and Demographic Characteristics

The Danube passes through mountain gateways, agricultural lands, wetlands, and deltaic interlacing's of inland and water near the river's terminus, forming the Danube basin (Figure 1).

The research scope is the Danube area, which consists of Nomenclature of Territorial Units for Statistics (NUTS) 3 districts in Serbia, which are directly connected to the Danube (Figure 2). Each NUTS 3 district is a statistical unit with 150,000 to 800,000 inhabitants. In accordance with the regulation on the nomenclature of statistical territorial units (Official Gazette of the RS, No.109/09 and 46/10, Article 5), each NUTS 3 district is made of local self-government units within administrative districts. Territorial units are part of a certain area. The counties along the Danube River have very favorable geographical and traffic locations and are characterized by cross-border and neighborhood cooperation, developed economy, infrastructure (waterways, ports, piers, roads, railways, energy infrastructure, telecommunications, and urban and communal infrastructure in settlements), and an abundance of natural resources (hydropower potential of the Danube, i.e. Đerdap I, Đerdap II and the planned Đerdap III, coal reserves in the Kostolačko-Kovina basin, agricultural land, natural resources and conditions for tourism, water resources, favorable locations for residential production plants, etc.) [14-17].

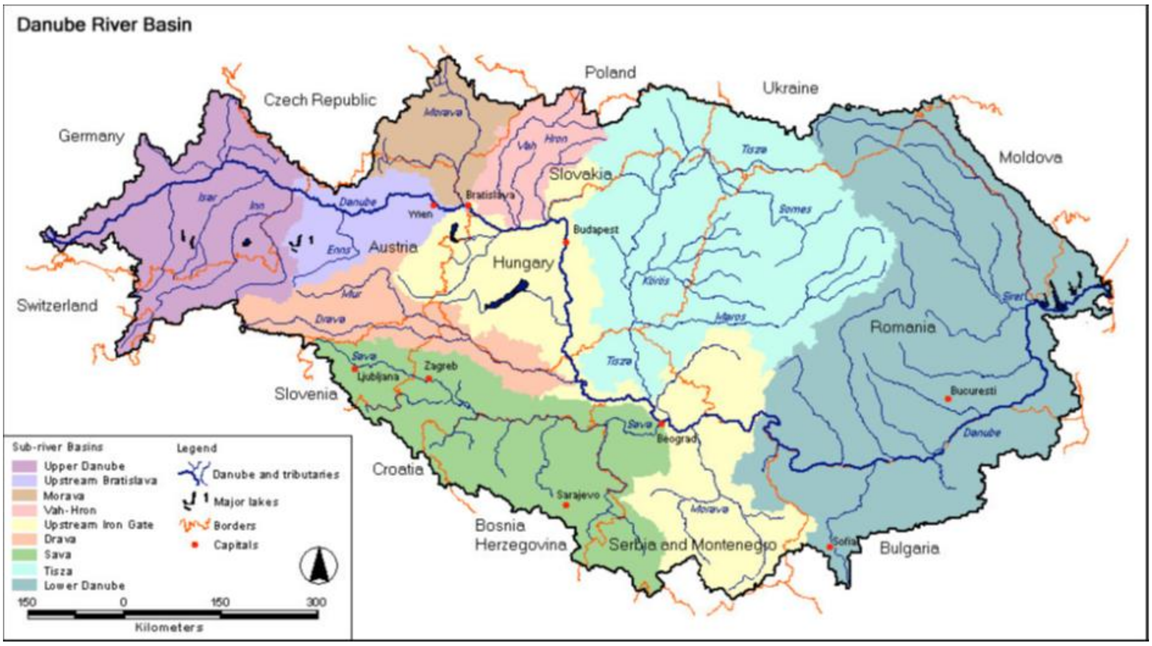

Figure 1. The Danube River Basin

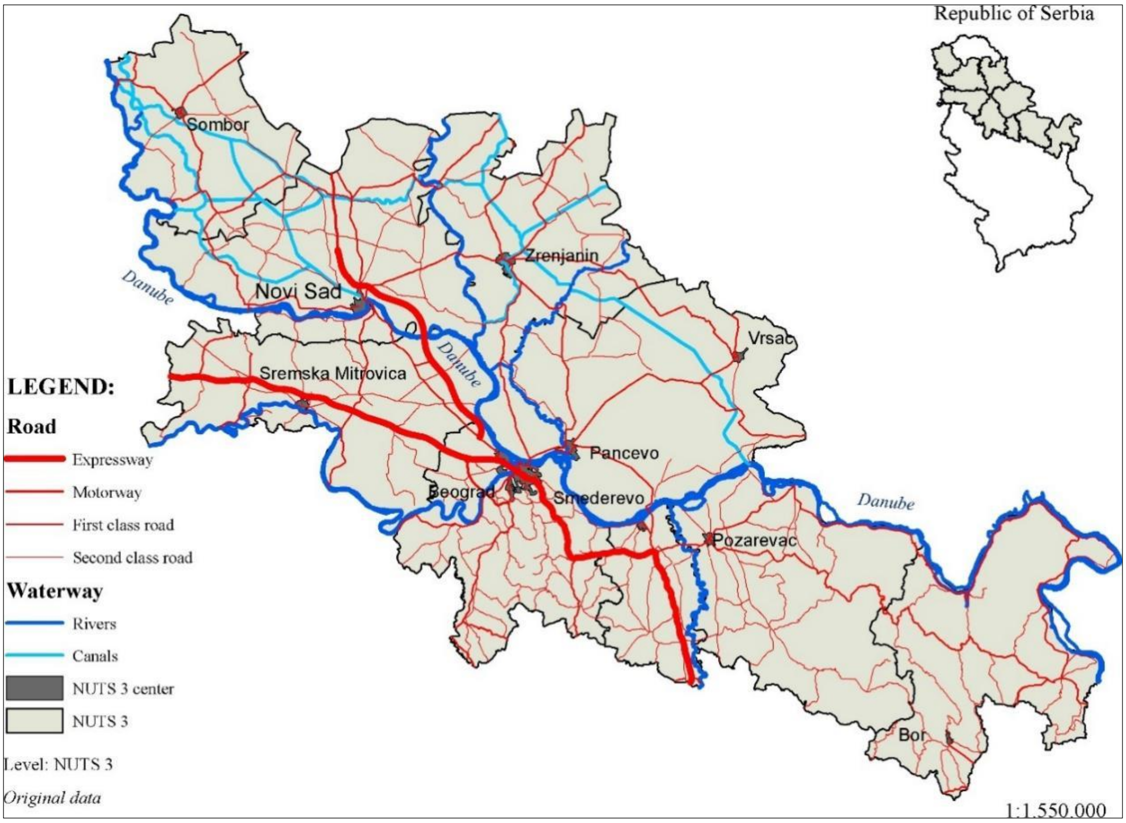

Figure 2. Counties along the Danube River in Serbia
Note: Source: Author

Pollution of water, groundwater and soil, reduced availability of clean drinking water. Insufficient development of regional and housing-communal infrastructure was caused by several factors, such as, high unemployment rate, low level investment, different degrees of development, unfavorable demographic structure, existence of national parks and other protected areas (e.g., IBA, IPA, RAMSAR), improper treatment and disposal of industrial and mining waste, etc. There is an excellent potential for agricultural development, such as fertile soil, favorable climate and geographical location, availability of services, and pastures in protected areas (grade II and III protection). Sustainable land use and agricultural development has many obstacles, such as occupation of land planned for construction of traffic and other infrastructure, industrial pollution (land, water and air), mining near large agrocomplexes, unresolved issues of wastewater treatment, underdeveloped irrigation systems and so on. In addition, forest resources have a significant potential for the sustainable development of counties along the Danube, such as preservation of habitats and biodiversity, possibility of increasing the natural stability and self-renewal of forests and so on.

3.2 Watercourses, Water Management and Flood Risk Prevention

As the main rivers of the Danube in Serbia, Tisa, Sava and Morava (Figure 3) are exposed to a significant increase in water levels during heavy rain period and are also affected by weather conditions in other countries because of their international nature.

In Serbia, counties along the Danube have a big potential for water management development, especially the hydropower potential, which is about 8.35 TWh/year or about 42% in the total 19.7 TWh/year usable potential, greater than all countries along the Danube.

There are favorable factors, such as sources of drinking water (Šalinac, Godomin and Kovin-Dubovac stretch of alluvium intended to supply South Banat, etc.), protection systems against external and internal waters (line systems against large (external) waters of the Danube, and systems against internal waters), possibility of expanding the functions and renewing the HS DTD, regulation of water regimes for larger irrigation systems of high-quality land with the Danube as a water catchment, and possibility of constructing hot water ponds in the depressions near the Danube (spatial plan of the special-purpose area of the international waterway E80 - Danube, Pan-European Corridor VII).

However, there are limiting factors, such as probability of more uneven water regimes of the Danube upstream of the HPP "Đerdap" dam and its most important tributaries, increase of large water volume due to canalization of the Danube in the upper reaches (excluding inundations), worsening of non-stationary precipitation phenomena due to climate change, increasingly long periods of low water (partly due to climate change and increasing water intake in the upstream countries, particularly in low-water periods), poor sanitation of settlements without WWTP, landfills with hydraulic influence of springs, discharge of industrial waste water without purification, unplanned construction in the zone of springs and even in their narrow protection zone, threats to protective systems from large and internal water lines (e.g. illegal construction), additional slowdown compared with the initial "zero" state caused by backfilling of the HPP "Đerdap 1" reservoir, insufficient maintenance of the coastal protection system, flood control measures affected by water soil threats due to unplanned construction, especially along the defended coast embankment, and division of power in water management area of Serbia, etc. [15-17].

Figure 3. Watercourses in counties along the Danube in Serbia
Note: Source: Author

The Ministry of Agriculture, the Forestry and Water Management (Republican Institute of Water Management), the Public Water Management Company Srbijavode, and local governments (municipalities and cities) are responsible for water management in Serbia, including water management policies and regimes, risk management, water protection, rational use of water, management of river regimes, water supply and other responsibilities prescribed by the Water Law ("Official Gazette of RS", No.30/2010, 93/2012, 101/2016, 95/2018 and 95/2018 and other laws). Duties of other ministries overlap in water resources management, such as the Ministry of Environmental Protection, the Ministry of Health, the Ministry of State Administration, local self-government and the Ministry of Infrastructure. In Vojvodina, related water management activities are entrusted to the Public Water Management Company Vode Vojvodine. The local authorities are responsible for managing local water supply systems, natural lakes, springs, and public wells in municipal areas. Water regimes are maintained and improved according to the *Water Management Strategy of Serbia*.

In the Danube region, the areas with flood risks have the highest proportion in Srednjebanatski County (1,708km^2) and the lowest proportion in Borski County, as presented in Table 1.

Table 1. Area with flood risks in all counties along the Danube (NUTS 3)

NUTS 3	Area of NUTS 3 unit (km^2)	Total area with flood risks (km^2)
City of Belgrade	3,227	665
Srednjebanatski	3,254	1,708
Juzno banatski	4,250	890
Zapadnobacki	2,419	1,042
Juznobacki	4,015	1,042
Sremski	3,485	856
Podunavski	1,251	315
Branicevski	3,865	280
Borski	3,507	187

Source: Republic Agency of Spatial Planning (data calculating in GIS)

In accordance with the ESPON TITAN project, 2013 [18], the flood hazard indicator shows the percentage of flooded land area per NUTS 3 for riverine floods in Danube area in Serbia (Table 2).

Table 2. Area of 100-year river flood (with percentage in NUTS 3 area)

NUTS 3	Area of the 100-year river flood and the percentage in NUTS 3 area
Beograd	20,3452
West Backa	36,493776
South Banat	16,331771
South Backa	27,032085
North Banat	46,80472
North Backa	0,457132
Central Banat	39,740307
Srem	18,009695
Podunavlje	31,928123
Branicevo	8,409605
Bor	3,033713

Source: ESPON TITAN project, 2013 [18]

Multilateral cooperation in the Danube basin takes place within the framework of the *Convention on Cooperation on the Protection and Sustainable Use of the Danube River*, signed by eleven countries along the Danube and the EU in 1994 in Sofia, which was later ratified as the *Convention on the Protection of the Danube River*. The *Decree on Promulgation of the Law on the Convention on Cooperation on the Protection and Sustainable Use of the Danube River* was adopted in 2003. Many transboundary water management international agreements had been signed, namely, the *Agreement on Transboundary Waters* (1955), *Navigation Agreement* (1955) and *Fishing Agreement* (1961) with Romania, the *Convention on Cooperation for the Protection and Sustainable Use of the Danube*, by the ICPDR (1994), and *Tisza River Basin Forum* (2001, Budapest Declaration). For Serbia, climate verification of flood risk measures will be considered in the Flood Risk Management Plan, which is being prepared.

Water protection infrastructure in this Danube area is evident. The Danube-Tisa-Danube canal system was constructed for flood prevention and irrigation, but the efficiency is not good. The priority is being given to the reconstruction of protection structures in cities of Novi Sad, Zemun, Pancevo, Smederevo, Veliko Gradiste and Golubac. Reconstruction has also been planned on the left bank of the River Sava (City of Belgrade and Sremski County). In addition, the same priority has been given to Tisa riverbed [16]. Barrage system, dams, proposed works on dikes, and pier walls are shown in Tables 3 and 4.

Table 3. Barrages and dams in the Danube area

NUTS 3	Actual barrage	Actual dam	Proposed dam
City of Belgrade	In the municipality Pallilula on the river Tamis	-	-
Srednjebanatski	At Tomasevic on the river Tamis	-	-
Juznobanatski	At Opovo on the river Tamis	-	-
Zapadnobacki	At Ruski Krstur on the DTD canal	-	At Stanisic
Juznobacki	At Ruski Krstur on the river Jergicka At Jergicka moore At Novi becej on the river Tisa	-	At Srbobran (on the river Krivaja)
Sremski	-	-	-
Podunavski	-	-	-
Branicevski	-	-	At Kucevo At Vitman At Gradac
Borski	On the river Banjska and the Borsko lake	Djerdap iron gate 1 Djerdap iron gate 2	At Krivelj

Source: Spatial Plan of Republic Serbia

Table 4. Proposed works on dikes and pier walls

River	Reconstruction of dikes and pier walls (km)		Construction of new dikes and pier walls (km)	
Danube	11.5	17.6	6.8	18.8
Tisa	13.8	15.0	0	7.6
Sava	13.3	66.3	22.5	0

Water Management Strategy of Serbia

3.3 How to Consider to Make Changes

3.3.1 Changes in land use

Although spatial planning deals with future spatial arrangement [19-22], its role in flood mitigation was often neglected in practice. Planners are responsible for planning general land use, even in flood areas, and implementing it at all levels, while local risk management agencies have less decision-making power. Development control in flood-prone areas can also be realized through land planning [20, 21]. Although there are three active flood protection measures as follows:

- Reservoirs, which aim to produce electricity and irrigate, apart from retaining the top of the flood wave;
- Retention of less accumulation along watercourses, and prevention of embankment collapse and flooding;
- Relief channels, which are artificial channels that drain excess water from the river;

In Serbia, river valleys are occupied by both legal and illegal construction. In addition, there are problems in retention of reserving areas for flood defense, expropriation, and construction of reservoirs, which takes time to solve.

"*Determining the flood risk, either from a national dataset (once available) or through a specific assessment, is essential to determine the existing and potential future locations and degrees of flood hazard, taking into account the potential impacts of climate change. Based on this information, zones for controlled, and importantly, appropriate development may be set to avoid placing flood-sensitive development in flood-prone areas*" [2].

3.3.2 Flood risk assessment in Serbia

In accordance with the *Law on Water* ("Official Gazette of the RS" No.30/10, 93/12, 101/16, 95/18 and 95/18, etc.), the risk management of harmful effects of water includes preparation of a preliminary flood risk assessment, creation of flood risk maps, as well as creation and implementation of flood risk management plans. Flood hazard is assessed in many countries at national level as part of a flood risk or hazard mapping program. In Serbia, the public water management company prepares both hazard maps and flood risk maps for the territory within its jurisdiction for a six-year period and then review and update them. Maps for areas with significant flood risks are determined by the Preliminary Flood Risk Assessment.

Figures 4-13 (from Danube Atlas - Flood Hazard and Risk Maps 2012) are corresponding flood hazard maps for areas along the Danube in Serbia [23], which show areas exposed to flood hazards and associated potential damages and flood risks, priority measures to be taken within the EU Floods Directive, affected population and possible damages in extreme floods and predicted inundation depth in graded blue colors.

Corresponding flood hazard maps for areas along the Danube in Serbia by the ICPDR [23] are as follows:

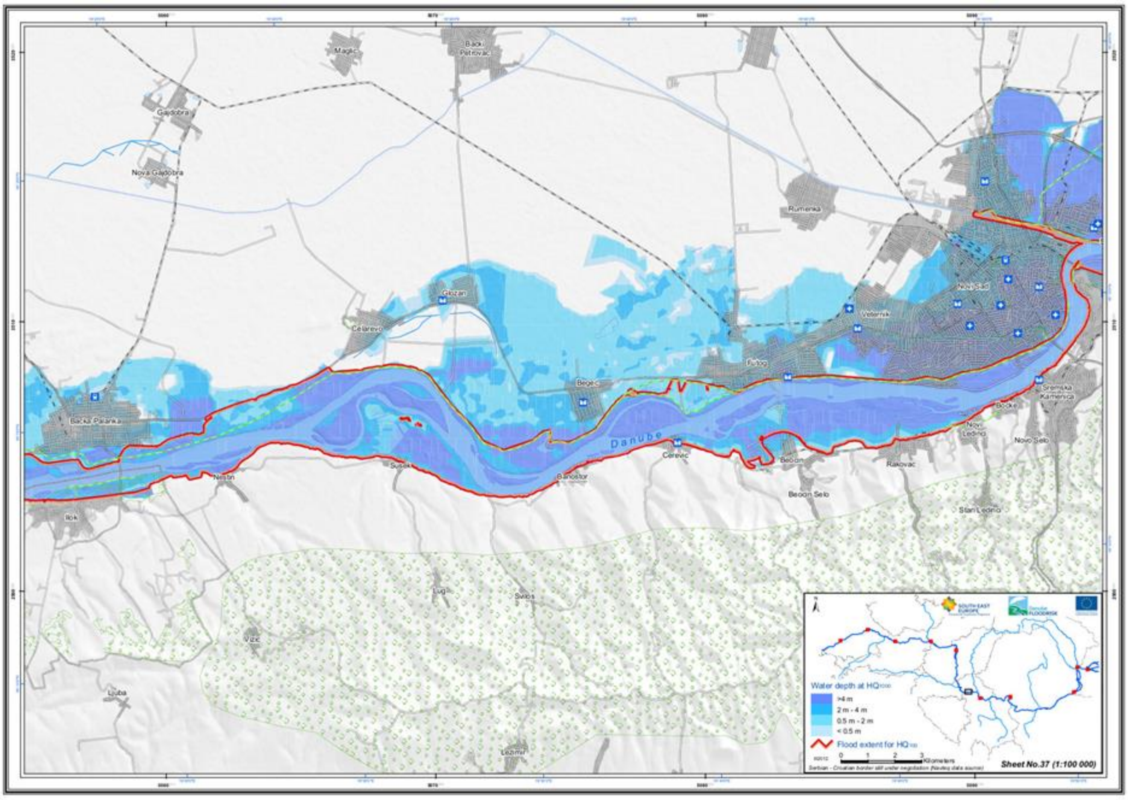

Figure 4. Flood hazard map for areas along the Danube in Serbia/The anticipated inundation depth in graded blue colors. *This product includes data licensed from the ICPDR* [23]

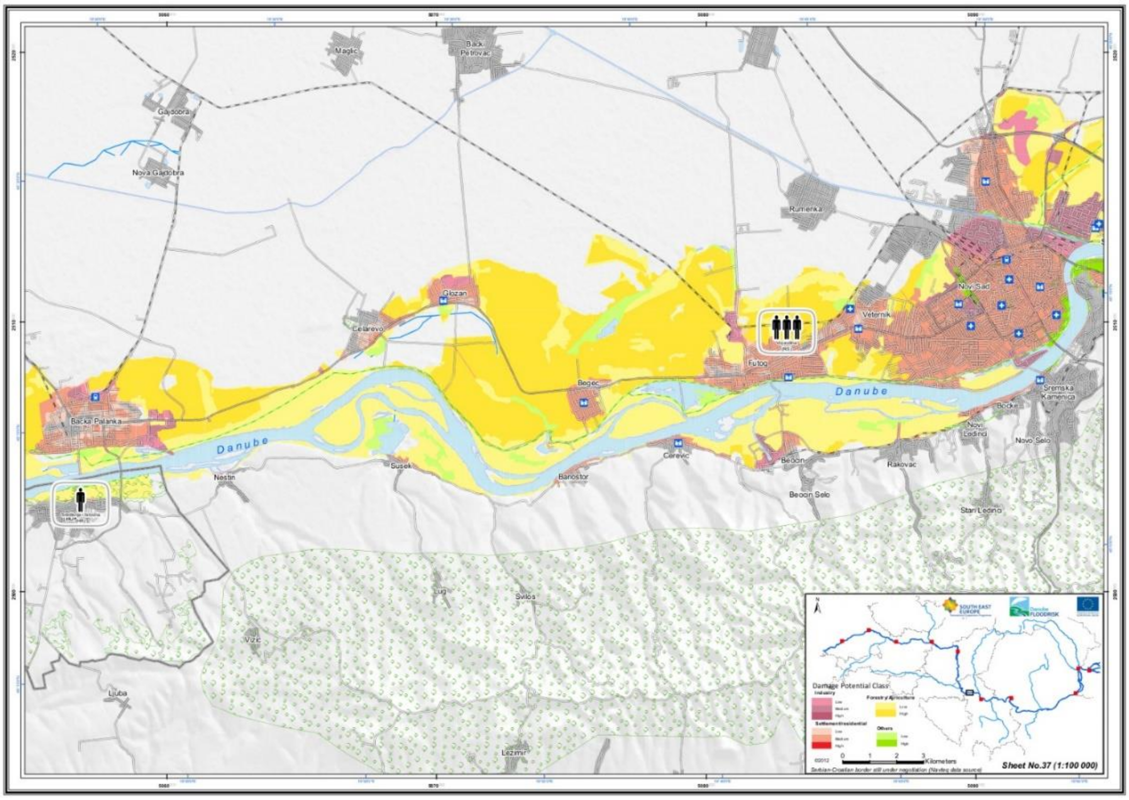

Figure 5. Flood hazard map for areas along the Danube in Serbia/Quantifying the flood risks for people and assets and possible damages in case of extreme floods. *This product includes data licensed from the ICPDR* [23]

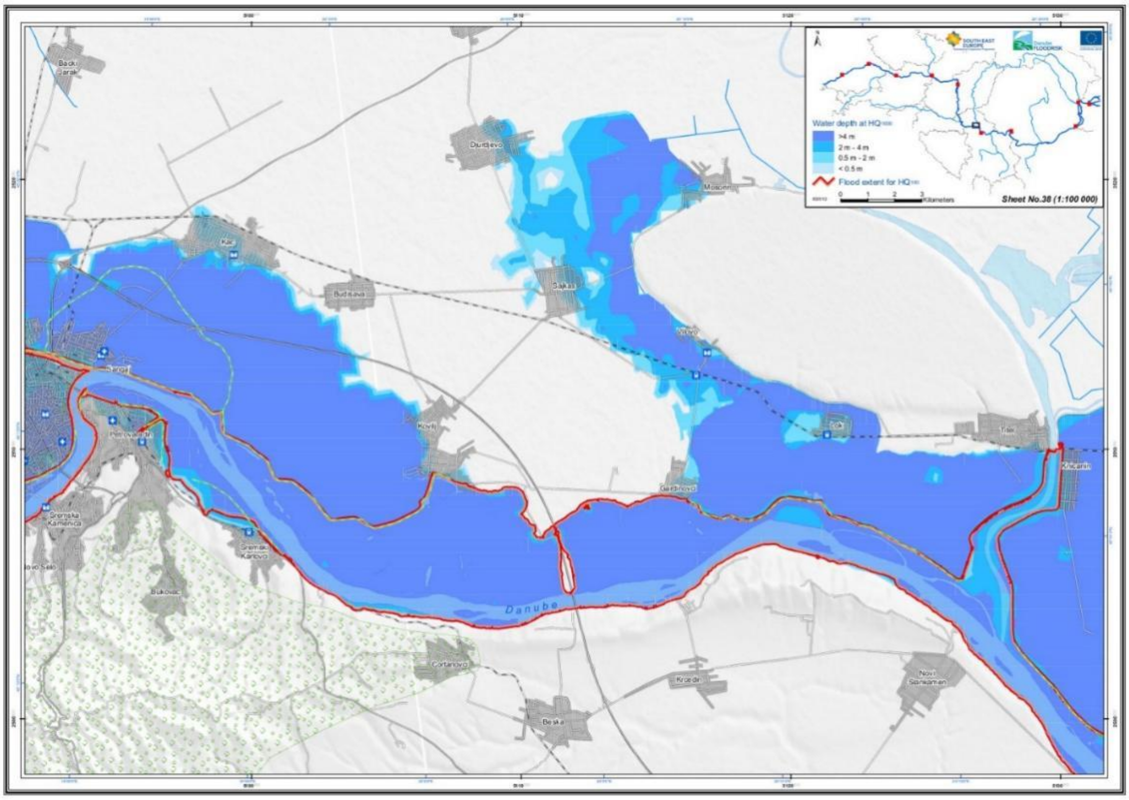

Figure 6. Flood hazard map for areas along the Danube in Serbia/The anticipated inundation depth in graded blue colors. *This product includes data licensed from the ICPDR* [23]

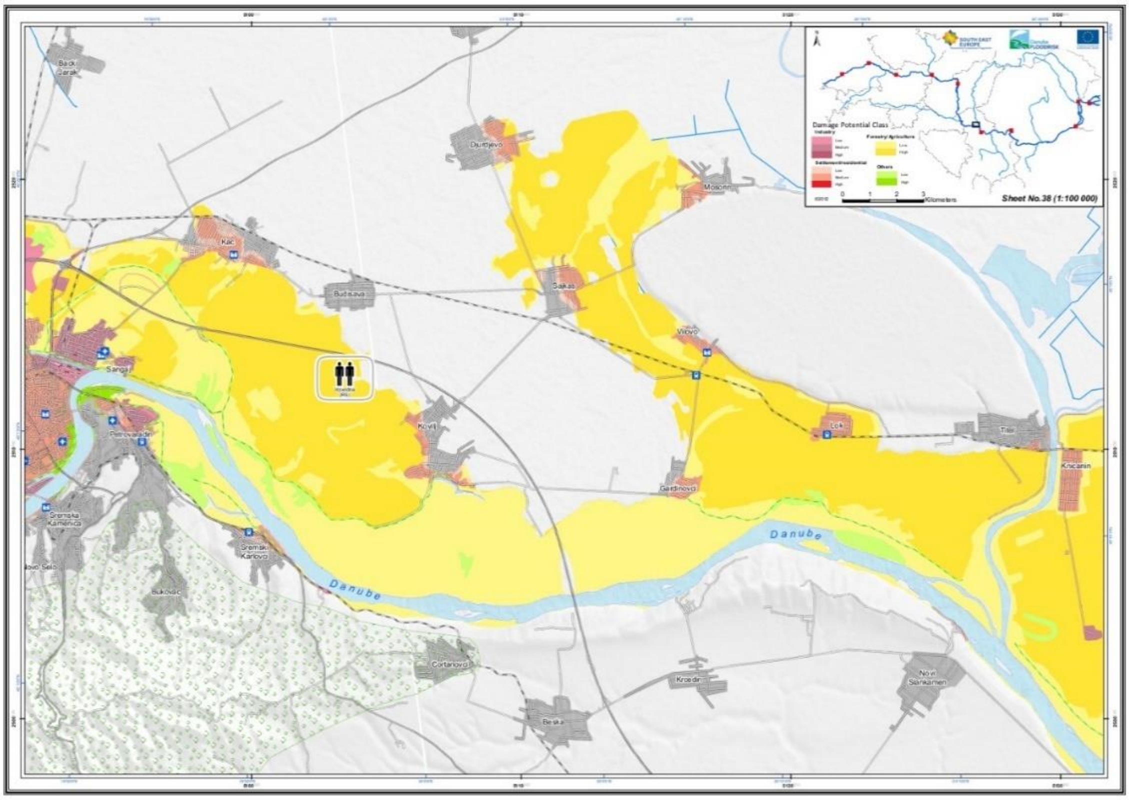

Figure 7. Flood hazard map for areas along the Danube in Serbia/Quantifying the flood risks for people and assets and possible damages in case of extreme floods. *This product includes data licensed from the ICPDR* [23]

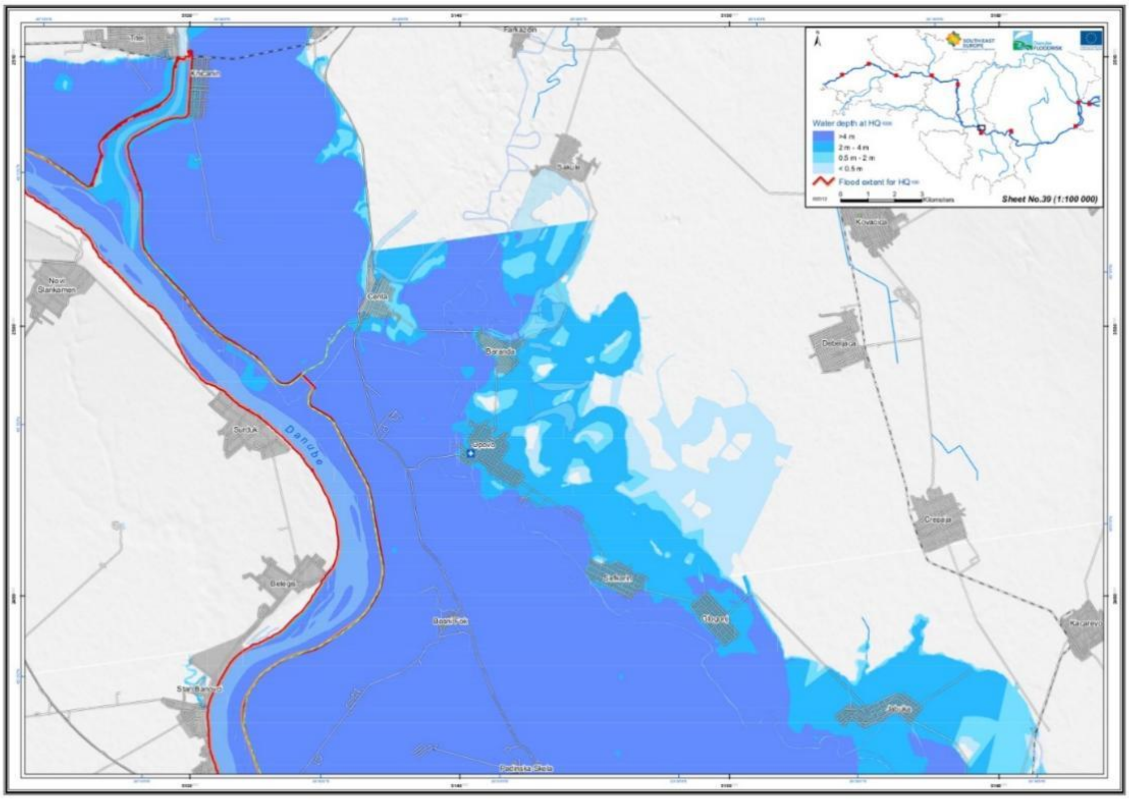

Figure 8. Flood hazard map for areas along the Danube in Serbia/The anticipated inundation depth in graded blue colors. *This product includes data licensed from the ICPDR* [23]

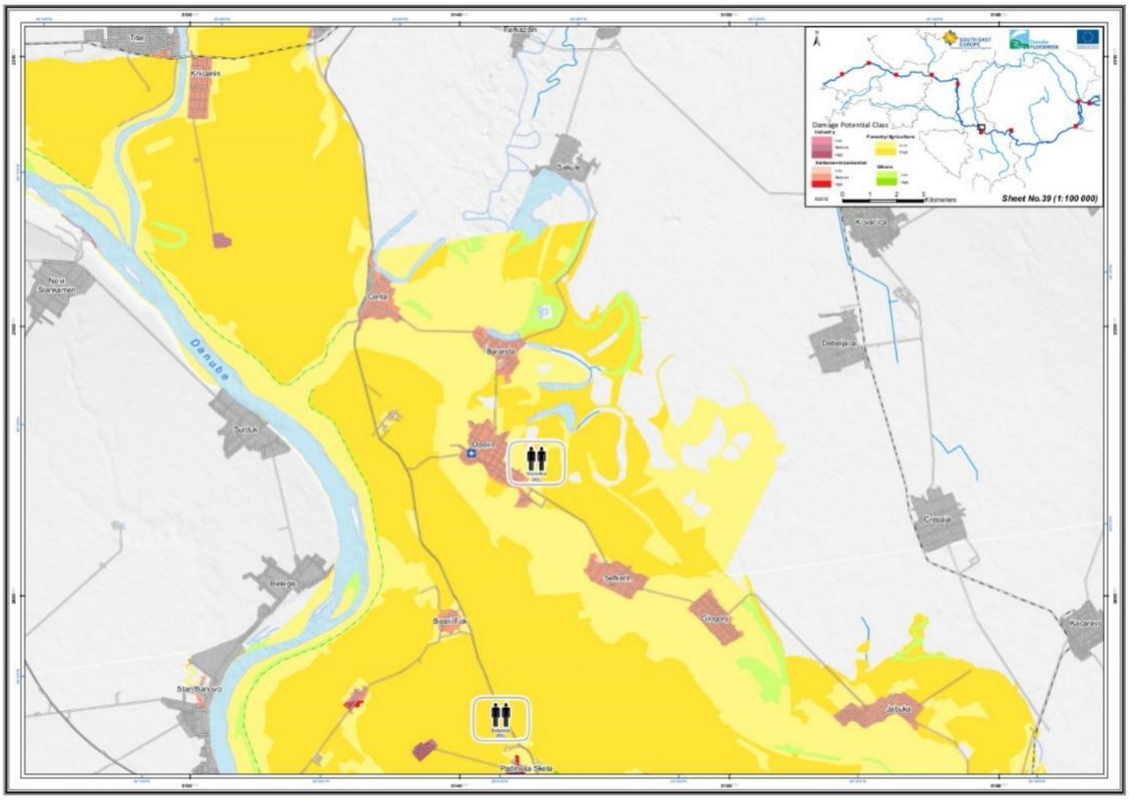

Figure 9. Flood hazard map for areas along the Danube in Serbia/Quantifying the flood risks for people and assets and possible damages in case of extreme floods. *This product includes data licensed from the ICPDR* [23]

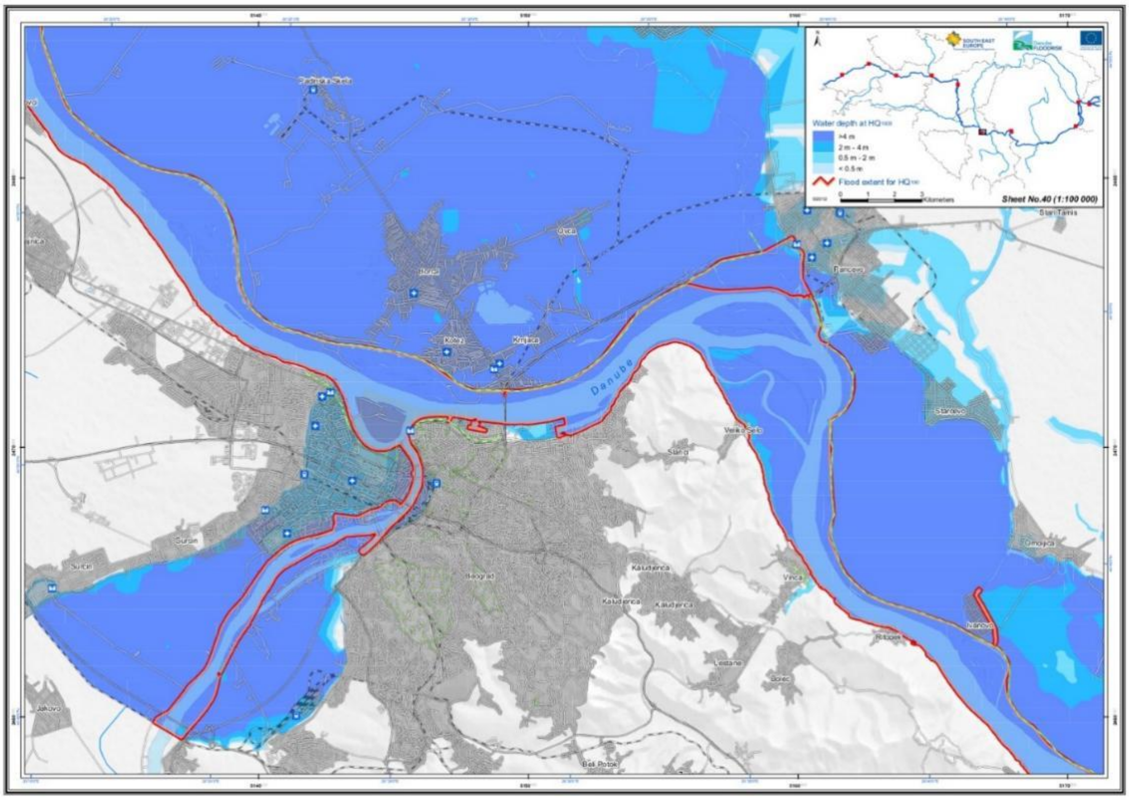

Figure 10. Flood hazard map for areas along the Danube in Serbia/The anticipated inundation depth in graded blue colors. *This product includes data licensed from the ICPDR* [23]

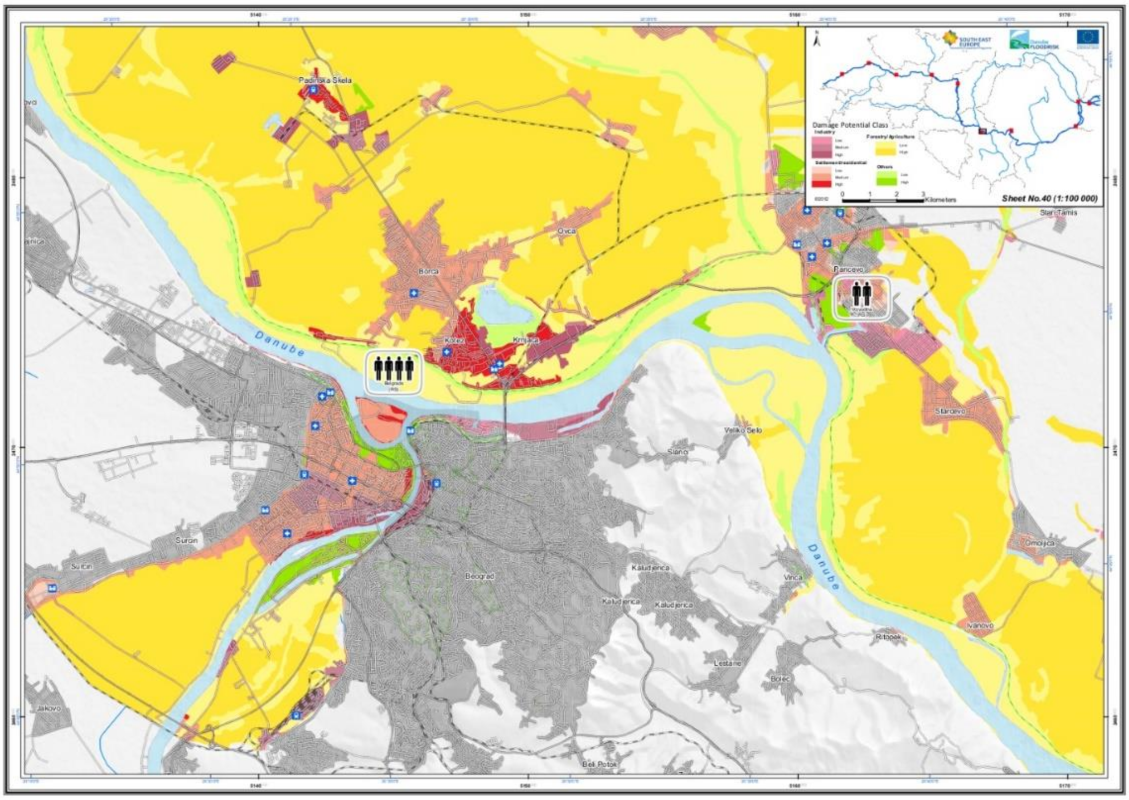

Figure 11. Flood hazard map for areas along the Danube in Serbia/Quantifying the flood risks for people and assets and possible damages in case of extreme floods. *This product includes data licensed from the ICPDR* [23]

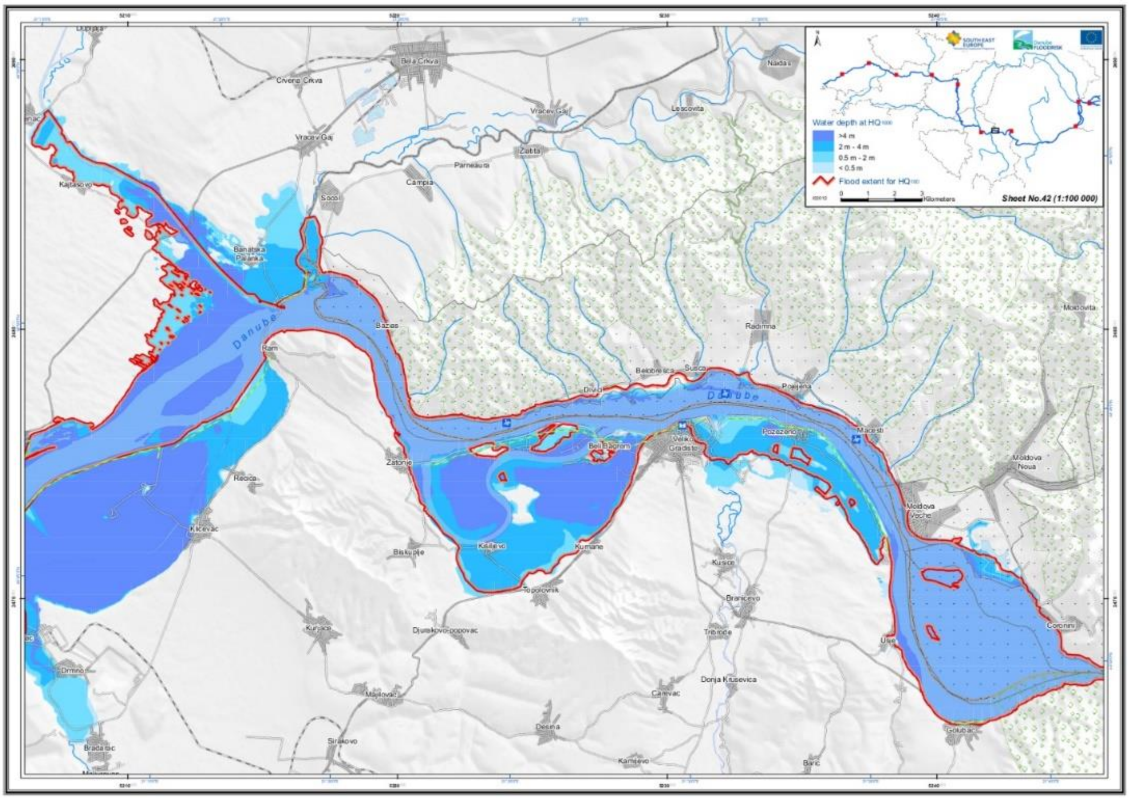

Figure 12. Flood hazard map for areas along the Danube in Serbia/The anticipated inundation depth in graded blue colors. *This product includes data licensed from the ICPDR* [23]

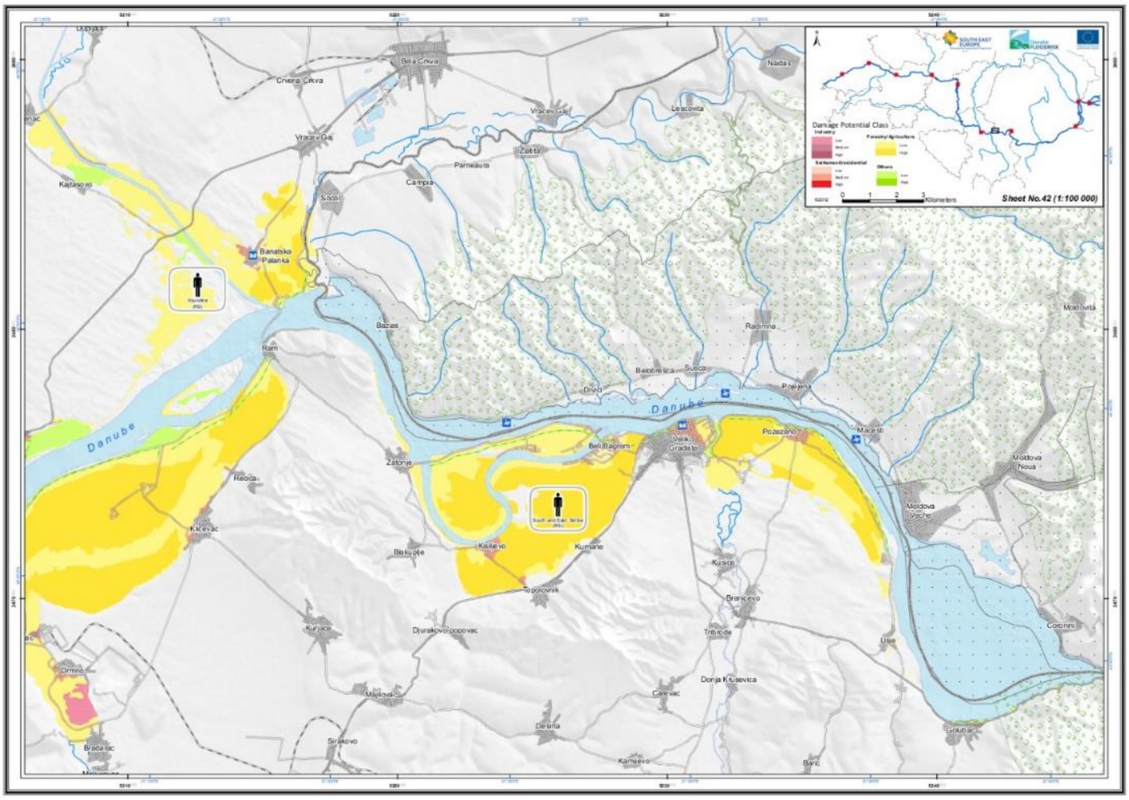

Figure 13. Flood hazard map for areas along the Danube in Serbia/Quantifying the flood risks for people and assets and possible damages in case of extreme floods. *This product includes data licensed from the ICPDR* [23]

4. Conclusion

Effective risk management is not possible unless the risks and the necessary database have been completely understood. Successful flood risk assessment and management include knowledge of locations with problems, natural conditions, climate vulnerability, and changes of land use. Information on the volume of flood waves can be used to reduce risks of those areas by planning construction conditions on time. Planning of certain land uses should be limited by local and regional plans in flooding zones. In addition, larger scale destruction and damage can be prevented by using information on the extent, depth, speed, frequency, mechanism and possible impact of floods. Therefore, there is a need for risk assessment in areas where flooding may be a problem.

When flood risk information is used as part of planning process, timely decisions on future land uses can be made.

GIS tools can be used for visualization, visual inspection and synthesis of different types of data, analysis of flood waves, and determination of flood zones, movement of river sediments and changes in the river bed, as well as for water embankment designers in Serbia to check their solutions even before flood waves. As the analysis shows, though many models and calculations have been made for risk management and mitigation, concrete application of measures are still missing, because the financial resources of water management are often used for other purposes.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares no conflict of interest.

References

[1] G. Fleming, "Learning to live with rivers," *Civil Eng.*, vol. 150, no. 5, pp. 15-21, 2002.

[2] M. Adamson and N. Cussen, "Flood risk and development a sustainable and appropriate approach," In Proceedings of the National Hydrology Seminar, vol. 2003, pp. 44-55, 2003.

[3] "Guidelines for forward-looking flood protection: Floods – causes and consequences," LAWA, 1995, https://www.lawa.de/documents/leitlinien_2902_1552299735.pdf.

[4] "Guidelines on sustainable flood prevention," UNECE, 2000, https://unece.org/environment-policy/publications/guidelines-sustainable-flood-prevention.

[5] J. B. Larsen, "Forestry between land use intensification and sustainable development: Improving landscape functions with forests and trees," *Geogr Tidsskr. Dan J. Geogr.*, vol. 109, no. 2, pp. 191-195, 2009. https://doi.org/10.1080/00167223.2009.10649607.

[6] J. M. M. Neuvel and W. V. Der Knaap, "A spatial planning perspective for measures concerning flood risk management," *Int J. Water Resour. Dev.*, vol. 26, no. 2, pp. 283-296, 2010. http://dx.doi.org/10.1080/07900621003655668.

[7] A. T. Wolf, "Shared waters: Conflict and cooperation," *Annu Rev. Environ. Resour.*, vol. 32, pp. 241-269, 2007. https://doi.org/10.1146/annurev.energy.32.041006.101434.

[8] A. T. Wolf, S. B. Yoffe, and M. Giordano, "International waters: Identifying basins at risk," *Water Policy*, vol. 5, no. 1, pp. 29-60, 2003. https://doi.org/10.2166/wp.2003.0002.

[9] J. M. M. Neuvel and A. van Den Brink, "Flood risk management in Dutch local spatial planning practices," *J. Environ Plann. Manage.*, vol. 52, no. 7, pp. 865-880, 2009. http://dx.doi.org/10.1080/09640560903180909.

[10] M. Jeanson, F. Dolique, and E. Anthony, "A GIS-based coastal monitoring and surveillance observatory on tropical islands exposed to climate change and extreme events: The example of Mayotte Island, Indian Ocean," *J. Coast Conserv.*, vol. 18, pp. 567-580, 2014. https://doi.org/10.1007/s11852-013-0286-8.

[11] B. Zanuttigh, D. Simcic, S. Bagli, F. Bozzeda, L. Pietrantoni, L. F. Zagonari, S. Hoggart, and R. J. Nicholls, "THESEUS decision support system for coastal risk management," *Coast Eng.*, vol. 87, pp. 218-239, 2014. http://dx.doi.org/10.1016/j.coastaleng.2013.11.013.

[12] J. Porter and D. Demeritt, "Flood-risk management, mapping and planning: The institutional politics of decision support in England," *Environ. Plann. A*, vol. 44, no. 10, pp. 2359-2378, 2012. https://doi.org/10.1068/a44660.

[13] C. Macharis and J. Crompvoets, "A stakeholder-based assessment framework applied to evaluate development scenarios for the spatial data infrastructure for Flanders," *Comput. Environ. Urban Syst.*, vol. 46, pp. 45-56, 2014. https://doi.org/10.1016/j.compenvurbsys.2014.04.001.

[14] M. S. Chang, Y. L. Tseng, and J. W. Chen, "A scenario planning approach for the flood emergency logistics

preparation problem under uncertainty," *Transp. Res. Part E: Logist. Transp. Rev.*, vol. 43, no. 6, pp. 737-754, 2007. http://dx.doi.org/10.1016/j.tre.2006.10.013.

[15] A. Vulevic, D. Macura, D. Djordjevic, and R. A. Castanho, "Assessing accessibility and transport infrastructure inequities in administrative units in Serbia's Danube Corridor based on multi-criteria analysis and GIS mapping tools," *Transylv. Rev. Adm Sci*., vol. 53, no. 53, pp. 123-143, 2018. http://dx.doi.org/10.24193/tras.53E.8.

[16] "Spatial plan of the special purpose area of the international waterway E 80 – Danube," Pan-European Corridor VII, 2020, https://www.researchgate.net/figure/The-Spatial-Plan-for-the-Special-Purpose-Area-of-the-International-Waterway-E-80-ie_fig2_346925904#:~:text=The%20Spatial%20Plan%20for%20the%20Special%20Purpose%20Area,from%20the%20Spatial%20Plan%20for%20Special%20Purpose%20Areas.

[17] "Interreg IIIb Project Donauregionen+," EU, 2012, http://www.donauregionen.net/objectives_plus.html.

[18] "ESPON TITAN project," ESPON, 2013, https://www.espon.eu/sites/default/files/attachments/ESPON-TITAN_Main%20Report.pdf.

[19] R. A. Castanho, J. C. Fernández, and J. M. N. Gómez, "Sustainable valuation of land for development. Adding value with urban planning progress. A Spanish case study," *Land Use Policy*, vol. 92, Article ID: 104456, 2020. https://doi.org/10.1016/j.landusepol.2019.104456.

[20] J. M. C. Rodas, J. M. N. Gómez, R. A. Castanho, and J. Cabezas, "Land valuation sustainable model of urban planning development: A case study in Badajoz, Spain," *Sustain.*, vol. 10, no. 5, Article ID: 1450, 2018. https://doi.org/10.3390/su10051450.

[21] M. Baker, S. Hincks, and G. Sherriff, "Getting involved in plan making: Participation and stakeholder involvement in local and regional spatial strategies in England," *Environ. Plann. C: Gov. Policy*, vol. 28, no. 4, pp. 574-594, 2010. http://dx.doi.org/10.1068/C0972.

[22] J. A. Veraart, E. C. van Ierland, S. E. Werners, A. Verhagen, R. S. de Groot, P. J. Kuikman, and P. Kabat, "Climate change impacts on water management and adaptation strategies in The Netherlands: Stakeholder and scientific expert judgements," *J. Environ. Policy Plann.*, vol. 12, no. 2, pp. 179-200, 2010. https://doi.org/10.1080/15239081003722163.

[23] "Danube FloodRisk Project," ICPDR, 2013, http://www.icpdr.org/main/activities-projects/danube-floodrisk-project.