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Navigating the EU Flood Directive Adoption in Montenegro: Challenges, Gaps, and Pathways for Improvement

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ABSTRACT:
Montenegro, as a candidate country for European Union accession, has undertaken the process of aligning its flood risk management framework with the EU Floods Directive (2007/60/EC). This paper examines the challenges and obstacles encountered in different stages of this process, including Preliminary Flood Risk Assessment, Flood Hazard and Fisk Mapping, and the development of Flood Risk Management Plans. It begins with an overview of Montenegro's flood-related legislation before the adoption process, highlighting key shortcomings in regulatory and institutional frameworks. The paper then outlines the steps taken to implement the Directive, identifying difficulties related to data availability, institutional coordination, financial constraints, and technical expertise. Despite efforts to enhance flood risk management, challenges remain in integrating it effectively into national policies and practices. By analyzing these challenges, the paper provides insights into opportunities for improvement and potential lessons for other candidate countries facing similar requirements. The findings contribute to the broader discussion on disaster risk reduction and sustainable flood management in transitioning economies, emphasizing the importance of institutional capacity, long-term planning, and regional cooperation in implementing EU environmental policies.

Keywords: EU Floods Directive, Flood Risk Management, Disaster Risk Reduction, Policy Implementation

1. Introduction

Flooding represents one of the most significant natural hazards worldwide, with the potential to cause extensive damage to human life, infrastructure, and the environment. The severity of flood events has been increasing in recent decades, driven by rising exposure and human-induced changes, while climate change may contribute to more intense local flooding in some regions (Kundzewicz et al., 2014). Projected hydrological changes, including increased peak flows and prolonged low-flow periods, are expected to impact water availability, water quality, and ecosystems, necessitating their explicit consideration in long-term river basin management (Middelkoop et al., 2001). Floods not only result in immediate economic losses but also have long-term consequences for public health, ecosystems, and cultural heritage. The European Union (EU), recognizing the

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importance of comprehensive flood risk management, introduced the EU Floods Directive (2007/60/EC) to reduce flood risks and enhance the resilience of member states (European Commission, 2007).

As a candidate country for European Union accession, Montenegro has recognized the importance of aligning its flood risk management framework with the EU Floods Directive. The directive mandates EU member states to assess and manage flood risks to minimize the adverse impacts on human health, the environment, cultural heritage, and economic activities (European Commission, 2007). While Montenegro has not yet joined the EU, it has proactively pursued alignment with EU standards, understanding that effective flood risk management is essential for the country's environmental sustainability and disaster risk reduction strategies.

This paper focuses on Montenegro's practical experience in implementing the Directive, including the Preliminary Flood Risk Assessment (PFRA), flood hazard and risk mapping, and the development of Flood Risk Management Plans (FRMPs). The analysis will highlight the challenges, gaps, and obstacles encountered throughout the implementation process and will explore opportunities for improvement. Through this examination, the paper seeks to contribute to the broader discourse on sustainable flood management and disaster risk reduction in candidate countries striving to meet EU environmental policy standards.

2. Legislative Context and Institutional Framework

2.1 Legal Framework

Before Montenegro began aligning its legislation with the European Union Flood Directive, several key national legal documents were in place to address water management and flood risk. These documents provided the groundwork for flood risk management in the country and laid the foundation for subsequent legislative reforms. However, when viewed through the lens of the EU Flood Directive, certain shortcomings were evident, and a closer look at the core documents highlights areas where improvement was necessary for full alignment with EU standards.

1. Law on Waters (2007) The Law on Waters served as a fundamental piece of legislation for water management in Montenegro. It provided definitions and principles for managing water resources, flood protection, and environmental conservation. Notably, this law defined terms such as 'flood' and 'flood risk', as well as the national water areas (the Danube and the Adriatic River Basin). The Law on Waters has undergone several amendments over the years, reflecting the evolving needs and requirements of water management and flood risk regulation in Montenegro. This law requires Preliminary flood risk assessments for all river basins and specifies the need for cooperation in cases of international basins. This law was pivotal in the initial steps toward transposing the EU Flood Directive (Government of Montenegro, 2007).

2. Water Management Strategy (2017) The Water Management Strategy provided a more comprehensive approach to water management and flood risk in Montenegro. It focused on four key intervention areas: managing floods caused by surface and groundwater, regulating water flow systems, and controlling erosion and torrential activity. The Strategy also highlighted the need for the protection of waters from harmful

effects, including flood risks, and proposed a set of measures for preventing and mitigating flooding (Ministry of Agriculture and Rural Development, 2017).

While this Strategy expanded the scope of flood risk management, it identified that the national plans for flood protection, particularly the General Plan for Protection Against the Harmful Effects of Water, were not fully aligned with the EU Flood Directive. The Strategy called for better coordination and synchronization of national policy documents and highlighted gaps in long-term flood risk management. Although it proposed significant improvements, the Strategy alone did not provide a direct, detailed framework for complying with EU Flood Directive standards.

3. National Plan of Protection and Rescue from Flooding (2019) The National Plan of Protection and Rescue from Flooding focused on establishing a national framework for managing flood emergencies and rescuing people in flood-prone areas. It included procedures for flood response and coordination between various agencies and stakeholders (Government of Montenegro, 2019). Although this plan addressed flood response and emergency actions, it did not sufficiently address preventive flood risk management, which is a key element of the EU Flood Directive. The Plan's focus on emergency measures left gaps in strategic planning, long-term flood risk reduction, and the management of flood hazards over time.

Summing up the legislative progress, in the process of aligning with the EU Floods Directive, Montenegro has undertaken substantial legislative reforms, particularly through successive amendments to the Law on Waters. These reforms progressively introduced core elements of the Directive, including the integration of climate change adaptation and enhanced stakeholder coordination in water governance. As a result, the current legal framework is fully harmonized with EU requirements.

2.2 Key Documents for Transposition of the EU Flood Directive

While several documents were instrumental in shaping Montenegro's approach to flood risk management, the *Law on Waters* and the *Rulebook on Detailed Content of the Preliminary Flood Risk Assessment and Flood Risk Management Plan* were particularly critical for the transposition process. These documents laid the groundwork for the integration of EU Flood Directive principles into Montenegro's legal framework.

The Law on Waters (Government of Montenegro, 2007) adopts the Directive's definitions of "flood" and "flood risk", ensuring consistency with EU terminology. It mandates the Preliminary Flood Risk Assessment (PFRA) for each river basin district and establishes cross-border cooperation for international basins. Furthermore, the Law aligns with the Directive's requirement to identify Areas of potential significant flood risk and mandates government coordination in cross-border flood risk assessments. The Law requires conducting the flood risk analyses for three scenarios: floods of high, medium and low probability. It establishes a mandatory six-year review cycle for all completed assessments, ensuring they remain up to date, while also incorporating the effects of climate change. The Law also provided regulatory framework to facilitate the issuance of the Rulebook on Detailed Content of the Preliminary Flood Risk Assessment (in further text: The Rulebook).

The Rulebook (Government of Montenegro, 2015) provides further specifications, reflecting Directive guidelines. It specifies the necessary content for flood

risk assessments, and expands on mandatory elements which are to be provided for each of the three analysed flood scenarios. Additionally, it defines the required components of flood hazard maps. Transparency and public participation are reinforced through the Law on Waters, ensuring public involvement in developing and updating flood risk management plans. This structured transposition demonstrates a high level of alignment with EU flood risk management standards, though further harmonization of strategic policy documents is still needed.

2.3 Institutional Framework

Flood risk management in Montenegro is a shared responsibility between *the Government*, *the Ministry of Agriculture, Forestry and Water Management*, and *the Water Administration*. The Ministry oversees policy development and establishes regulations, including the procedures for Flood hazard mapping, Flood risk mapping, and Flood risk management plans. The Water Administration is responsible for conducting Preliminary flood risk assessments and identifying Areas of potential significant flood risk. Based on these assessments, the Government determines priority areas for flood management and officially adopts Flood Risk Management Plans, which must align with River Basin Water Management Plans. These plans are periodically updated to reflect new data and consider climate change impacts. Their implementation follows an Action Program that sets priorities, timelines, and public consultation measures.

3. Key Steps in the Adoption of the EU Floods Directive

Montenegro has structured its River Basin management in line with the EU Water Framework Directive (WFD, 2000/60/EC), establishing two River Basin Districts (RBDs): the Adriatic and Danube RBDs. As required by the EU Floods Directive (European Parliament & Council of the European Union, 2000), the country must develop two Flood Risk Management Plans (FRMPs), ensuring alignment with corresponding River Basin Management Plans (RBMPs).

The EU FD mandates a three-stage approach to flood risk management:

1. Preliminary Flood Risk Assessment (PFRA) – Each River Basin District undergoes an initial assessment to identify Areas of Potential Significant Flood Risk (APSFR). These areas are prioritized for further risk analysis and mitigation planning.
2. Flood Hazard and Risk Mapping – Detailed hazard and risk maps are developed for the APSFRs identified in the first stage.
3. Flood Risk Management Planning – FRMPs must be prepared for each River Basin District, outlining specific measures to mitigate flood risks.

A key initiative that facilitated the mentioned steps was the "Support to Implementation and Monitoring of Water Management in Montenegro" project, funded by the EU under the Annual Action Program 2016 for Montenegro. Implemented between November 2019 and November 2022 (with an additional project extension taking place from 2022 to 2024), this project aimed to enhance the institutional and administrative capacities of Montenegro's water management sector, ensuring compliance with EU directives (IPAFF, 2022). The most significant achievements were the development of

Preliminary Flood Risk Assessments (PFRA) (Government of Montenegro, 2021), Flood Hazard and Flood Risk Maps (FHMs/FRMs), along with Flood Risk Management Plans (FRMPs) for the country's two River Basin Districts (Government of Montenegro, 2023), as well as Directive Specific Implementation Plan for the EU Floods Directive in Montenegro (DSIP) (Government of Montenegro, 2023).

In the following sections, the focus will shift to analyzing the gaps, challenges, and shortcomings in the development of PFRA, FHMs/FRMs and FRMPs, highlighting areas for improvement and future policy recommendations.

4. Challenges and Gaps in Implementing the EU Floods Directiv

4.1 Preliminary Flood Risk Assessment

The Preliminary Flood Risk Assessments (PFRA) for both the Danube and Adriatic River Basin in Montenegro were prepared in 2021. As a result, 19 APSFRs were delineated in the Danube basin (Figure 1), and 6 APSFRs were delineated in the Adriatic basin (Figure 2). The process of conducting the PFRA revealed several challenges, gaps, and uncertainties that hindered the accuracy and comprehensiveness of the assessment. These shortcomings primarily stemmed from data limitations, methodological constraints, and institutional inefficiencies.

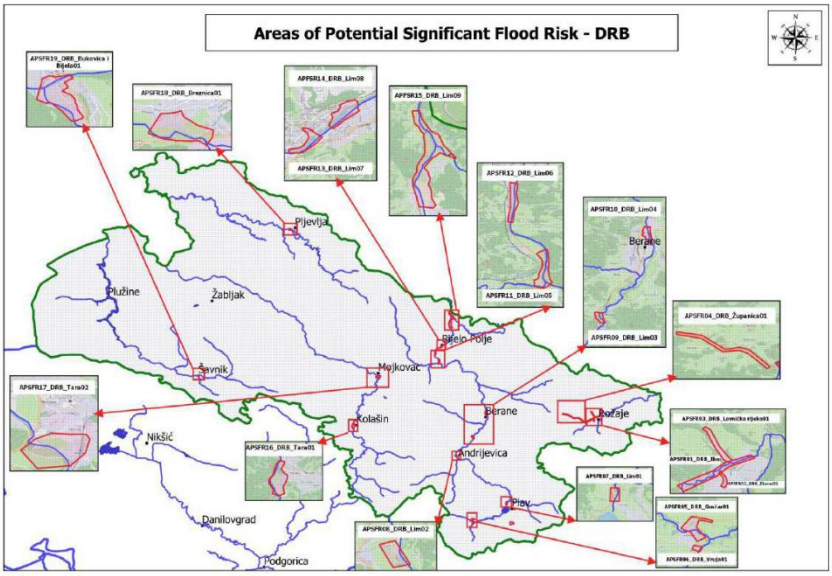

Figure 1. Locations of the APSFRs belonging to Danube Catchment Area (Government of Montenegro, 2021)

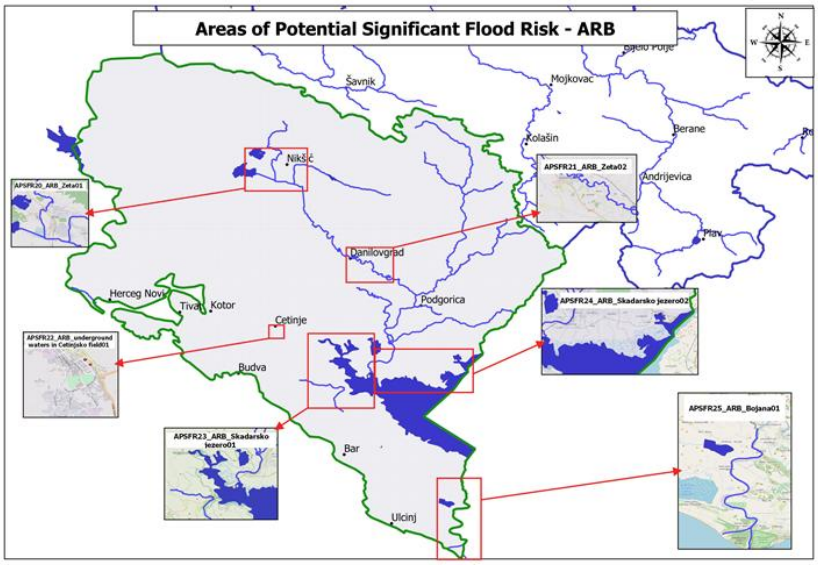

Figure 2. Locations of the APSFRs belonging to Adriatic Catchment Area (Government of Montenegro, 2021)

One of the most significant challenges was the insufficient hydrological data for certain river stretches, particularly transboundary and smaller watercourses. In the Adriatic basin, for example, the Sutorina River could not be designated as an Area of Potential Significant Flood Risk (APSFR) due to the lack of any hydrological data in this area (Government of Montenegro, 2021). Similarly, in the Danube basin, several smaller tributaries were excluded from the assessment due to inadequate monitoring infrastructure and sparse historical flood records (Government of Montenegro, 2021). This issue underscores the need for an expanded hydrological monitoring network to enhance data availability and accuracy. Specifically, small and torrential coastal watercourses and canals are not included in the state-level hydrological monitoring network, leaving gaps in the data needed to assess potential flood risks. Greater focus is needed on managing flood risks in Montenegro's coastal stream systems, and future initiatives should prioritize installing additional hydrological monitoring stations in critical locations to enhance assessment accuracy.

Coastal flooding caused by tidal waves is a common occurrence, often triggered by heavy rainfall and strong southeast winds. Such events often result in short-term water accumulation in communal spaces, including streets and coastal walkways, usually causing limited damage due to their relatively brief duration. However, the negative impact on coastal areas is significant, particularly when the sea is unable to absorb the excess water during heavy rainfall or strong north winds. Several coastal regions are vulnerable to these tidal wave events, which can cause flooding of key areas like promenades and squares. Unfortunately, there are no official data or infrastructure in place to address these phenomena, and the tidal wave events recorded by tide gauges have not been processed (which is why coastal flooding was not included in the PFRA) (Government of

Montenegro, 2021). Given the frequency of these events and their damage potential, this issue requires urgent attention and future mitigation measures.

A challenge in hydrological analysis of high waters is the reliance on limited historical data to estimate the probability of extreme events. In poorly studied basins, high waters are often assessed based on precipitation data rather than flow measurements. Statistical analysis links the size of high waters to their probability, typically using annual maximum flows or water levels. However, the short duration of available data and the difficulty in predicting low-probability high-water events are significant issues, especially when observed values do not cover the full range of potential extremes.

Another critical gap was the inconsistency and incompleteness of historical flood damage records. While some major flood events, such as the 2010/2011 floods, had documented impacts and damages, earlier events lacked systematic reporting. This absence of comprehensive historical data created uncertainties in the identification of APSFRs and limited the ability to establish long-term flood risk trends. Moreover, damage records were often fragmented or unavailable, making it difficult to assess socio-economic impacts effectively (Government of Montenegro, 2021).

Climate change considerations introduced additional uncertainties into the PFRA process. While projections indicate an increase in extreme flood events, the existing flood risk models did not fully integrate future climate scenarios. The inclusion of a 500-year extreme flood scenario in the Adriatic PFRA was a step forward, but there remains a need for more comprehensive climate adaptation measures in both basins. Many local climatic characteristics, heavily influenced by the region's complex topography, land types, vegetation, and their distribution—common features in Montenegro—cannot be accurately captured by global models. This is due to the smaller scale of these local factors compared to the minimum resolution of global models, which limits their representation in flood risk assessments (Government of Montenegro, 2021).

Another gap in the PFRA is the absence of a fixed threshold for determining the risk to agricultural areas. While agricultural assets such as crops, livestock, and machinery are considered at risk in areas where economic damage could be severe, no comprehensive economic data were available, neither for the Danube nor for the Adriatic River Basin. The assessment of agricultural risk is largely based on expert judgment, as the potential damage varies greatly depending on factors like land use (e.g., grasslands, crops, or special cultures), and is not reliably determined solely by measuring the extent of the flooded area. Moreover, as the way land is used for agriculture may vary from year to year, it does not serve as a dependable basis for long-term flood risk management plans. Relying on agricultural land use as a key factor in determining the relevance of APSFRs would lead to the classification of nearly all flood-prone zones as significant, thereby expanding the scope of flood risk maps and management plans beyond practical limits (Government of Montenegro, 2021).

After the initial identification of the APSFRs, the flood extents were obtained through hydraulic modelling in HEC-RAS (U.S. Army Corps of Engineers, 2025). The main limitation of the models is representing the topography with a digital elevation model (DEM) with a 5m resolution (provided by the Montenegrin Real Estate Administration), which does not account for river bathymetry. Calibration of the simulation relied on the data from floods that occured in 2010. While the model provides spatial data for flood

areas and depths, its accuracy is highly dependent on the DEM resolution. Additionally, simulation omitted any potential later modifications to channel management structures that could influence the accuracy of flood predictions (Government of Montenegro, 2021). Institutional and administrative challenges further complicated the PFRA process. Coordination between different agencies responsible for flood risk management was often inefficient, leading to delays and discrepancies in data sharing. Additionally, the transboundary nature of certain rivers, such as the Drin-Buna/Bojana system, required enhanced cooperation with neighboring countries to ensure a harmonized approach to flood risk assessment.

Overall, while the PFRA for the Danube and Adriatic basins successfully identified APSFRs and provided a foundation for further steps in implementing the EU FD, significant gaps and challenges remain. Addressing these issues will require improved hydrological monitoring, standardized methodologies, enhanced historical data collection, and stronger institutional coordination. The installation of new hydrological stations and the development of a centralized flood risk database are among the key recommendations to improve future assessments. Investment in expanding the hydrological monitoring network, especially in areas currently lacking measurement infrastructure and improved monitoring would not only allow for the inclusion of presently overlooked regions in future updates of flood maps, but would also increase model reliability and predictive power. Similarly, the systematic collection and centralization of historical flood damage records would enhance vulnerability assessment and allow the derivation of empirical damage functions. To support this, institutional coordination must be strengthened. This includes better integration among sectors responsible for hydrometeorology, environmental protection, spatial planning, and emergency management. Establishing a shared data platform would facilitate more consistent and efficient exchange of information. At the same time, budgetary allocation mechanisms must prioritize long-term investment in monitoring infrastructure and capacity building. Regular training in GIS applications, hydrological data processing, and risk analysis should also be institutionalized to sustain an informed and technically capable workforce.

4.2 Flood Hazard and Flood Risk Maps

The flood hazard maps (created in 2022) were developed in accordance with the Rulebook, displaying flood extent, water depth, and flow speed for low, medium, and high probability flood events using standardized color coding and graphical representations. However, certain gaps remain in the preparation of flood hazard maps. These deficiencies limit the reliability of flood predictions and consequently, the effectiveness of mitigation strategies (Government of Montenegro, 2024). The key challenges include:

1. *Data Constraints*: The accuracy of Montenegro's flood hazard maps is constrained by limited calibration data, with models primarily calibrated using the 2010/2011 floods, reducing their reliability for other events. Due to insufficient data, key boundary conditions were based on assumptions rather than direct measurements, increasing uncertainty in flood predictions. Only one DEM dataset was available, without additional geodetic or bathymetric surveys, affecting terrain accuracy, especially in floodplains. Incomplete hydrological records and

the lack of real-time monitoring further reduce model precision, while the absence of data on hydraulic structures limits the assessment of flood defenses.

2. *Model complexity/usability*: The lack of measured data for rainfall-runoff, infiltration, and evapotranspiration affects adequate representation of the basin processes. Spatial and temporal resolution is limited by data availability, reducing model precision. Observed data was not available for all APSFRs, impacting model validation. Computational resources were limited, and real-time forecasting was not possible. Shortage of specialized expertise within Institute of Hydrometeorology and Seismology hinders the interpretation and effective use of model outputs.
3. *Climate Change Uncertainty*: Variability among climate models leads to differing flood risk predictions, with no clear consensus on the most accurate scenario. Existing flood hazard maps do not account for biases in climate models, which can affect input data reliability. Limited data on extreme weather events further complicates assessments. Interactions between climate change, land use, and socio-economic factors have not been modeled, leaving gaps in understanding future flood risks.
4. *Human influence representation*: Changes in land use and the extent of impervious surfaces were not accounted for, while available land use data was outdated. Water management infrastructure, including its impact on flood dynamics, was not fully integrated due to data limitations. Socio-economic activities such as industrial development and mining were insufficiently represented, affecting the accuracy of flood risk assessments. Population data was outdated, limiting accurate projections of settlement patterns and their impact on flood exposure.

The flood risk maps (created in 2022), based on the Rulebook, include data on the number of potentially affected people, economic activities, pollution sources, and risks to protected areas. Developed using the risk matrix method, these maps follow guidelines from the Flood Hazard and Risk Mapping for the Drin/Drim-Buna/Bojana River Basin Guidebook (the Guidebook) (GIZ, 2022), prepared within the GIZ project Climate Change Adaptation through Transboundary Flood Risk Management in the Western Balkans (GIZ, 2023). The main shortcomings in flood risk mapping can be identified through the following key aspects (Government of Montenegro, 2024) :

1. *Flood risk assessment methodology*: The risk matrix method was applied, combining hazard and vulnerability data to calculate impact levels (low, medium or high) for different land use classes. While this provides a relative risk indicator, a key gap is the lack of a comprehensive flood damage assessment. The damage prediction, crucial for evaluating the full economic impact of floods, requires detailed vulnerability data and depth-damage functions specific to asset types (e.g., buildings, agricultural land). However, Montenegro lacks location-specific depth-damage curves, and applying global models for this method would require significant time and resources that were unavailable at the time.
2. *Land use data*: The flood risk assessment relied on land use data from municipal planning documents (as the scale of the global land use datasets,

such as CORINE, was inadequate), which was used to assign vulnerability values in the risk matrix. However, this data may not always reflect the current on-site conditions, as areas labeled for industrial use could be vacant land or pastures in reality. This discrepancy may lead to inaccurate risk prioritization, potentially overlooking actual vulnerabilities. Additionally, as urban planning documents are periodically updated, the land use data used in flood risk maps can become outdated, reducing their long-term effectiveness. Regular updates to these maps are essential to ensure they remain relevant and accurately guide flood risk mitigation efforts.

3. *Risk objects data*: Specific risk objects, such as public buildings and important facilities, were identified using Google Maps and cross-checked with the Cadastre Geoportal. However, these data sources were not verified through field surveys, creating the potential for outdated or incomplete information, which could overlook existing risk objects. Regular field validation of this data would ensure more accurate flood risk assessment.
4. *Flood intensity (inundation depth) classification*: The flood risk assessment used four inundation depth classes, as outlined in the Guidebook, while flood hazard maps use three depth classes. This discrepancy can cause confusion, especially when transitioning between maps, and may make it difficult for non-expert users to understand the differences in methodology. To address this, aligning the depth classifications used in both hazard and risk mapping would enhance clarity. Additionally, the lack of a legally binding definition for flood risk depth classes in the Rulebook creates inconsistencies, highlighting the need for a standardized approach in future revisions.

The development of flood hazard maps in Montenegro has been limited by the absence of high-resolution bathymetric data and the lack of comprehensive hydrological calibration. These constraints reduce the precision of flood extent and depth estimations, particularly in areas where riverbed profiles significantly influence hydraulic modeling. While the variability of climate change scenarios adds further complexity to future flood projections, it is important to distinguish that hazard maps are intended to depict the physical characteristics of flooding—such as extent, depth, and velocity—under defined probability scenarios. Socio-economic dynamics, infrastructure developments, and land-use changes primarily affect vulnerability and exposure, and therefore pertain to flood risk rather than flood hazard. That said, both hazard and risk maps are subject to a mandatory four-year revision cycle under Montenegro's regulatory framework, ensuring that evolving receptor dynamics and infrastructural developments are periodically captured. This cyclical updating process allows hazard and risk mapping products to reflect current conditions and remain relevant for long-term flood risk planning, especially in rapidly changing or climate-sensitive areas.

A clear limitation of the current flood risk maps lies in the flood risk assessment methodology, which lacks locally validated depth-damage curves. This restricts accurate cost estimation and prioritization of flood interventions. Additionally, outdated or unverifiable land-use data undermines the identification of vulnerable assets. Addressing this limitation requires a national effort to generate real-time and field-verified vulnerability

datasets. Incorporating these would enhance the accuracy and relevance of risk-based decision-making frameworks in Montenegro.

4.3 Flood Risk Management Plans

Flood Risk Management Plans (FRMPs), created in 2023, outline measures to prevent, reduce, and mitigate flood risks, aiming to protect human health, the economy, the environment, and cultural heritage. These plans, guided by the Flood Directive and other relevant documents, prioritize short and long-term actions for each Area of Potential Significant Flood Risk (APSFR), integrating cost-benefit analysis and stakeholder input for effective implementation (Government of Montenegro, 2023).

One of the shortcomings in the proposed measures within the Flood Risk Management Plans is the tendency to propose interventions that may lead to adverse environmental impacts, particularly through the promotion of traditional structural measures (Ministry of Agriculture, Forestry and Water Management of Montenegro, 2024). These involve physical alterations to riverbeds and banks, which can significantly disrupt aquatic and riparian ecosystems—affecting benthic fauna, fish species, and riparian vegetation. Such interventions often include conventional engineering solutions like concreting or reshaping of channels, which not only degrade natural habitats but also risk long-term ecological imbalance. In contrast, the application alternative measures—based on eco-engineering and the use of green protective zones—offers a more sustainable and less invasive alternative. While slower to implement and dependent on natural processes, such measures would support biodiversity, stabilize banks, and are generally more compatible with conservation goals. The emphasis placed on conventional grey infrastructure suggests a potential overreliance on structural measures, which may overlook the long-term effectiveness and environmental benefits of more sustainable alternatives.

Generally, it may be stated that the Flood Risk Management Plans show a bias towards structural measures, often disregarding ecological consequences. In contrast to current literature promoting nature-based solutions for sustainability, the plans risk ecosystem degradation. This calls for greater alignment with EU best practices emphasizing green infrastructure. Promoting discussion around harmonizing traditional and ecological approaches will enable Montenegro to comply more fully with contemporary flood governance paradigms advocated in academic and policy literature.

The cost-benefit analysis (CBA) methodology used in the Flood Risk Management Plans faces several shortcomings. Firstly, the economic benefits are only assessed for those risk factors for which sufficient data exists, limiting the analysis to human health, the environment, and economic activities. For many factors, such as the value of ecosystem services or human life, there is insufficient data to conduct a thorough evaluation. Additionally, the CBA only incorporates data from three flood periods instead of the recommended five, restricting the accuracy of the damage probability curve. Another major issue is the analysis of only one intervention per Area of Potential Significant Flood Risk (APSFR), meaning the costs and benefits of alternative measures are not considered. Without comparing different interventions, it is difficult to assess the most cost-effective and efficient flood protection solutions. Finally, the CBA assumes that flood interventions will fully protect the affected area, which is often unrealistic. This

overestimation leads to inflated economic benefit calculations, resulting in unusually high Benefit/Cost Ratio (often greater than 10), suggesting the need for caution when interpreting these figures (Government of Montenegro, 2024).

5. Opportunities for Improvement and Pathways Forward

The implementation of the EU Floods Directive in Montenegro has laid important groundwork, but key opportunities remain to strengthen and streamline flood risk management across both technical and policy domains. A priority moving forward is the integration of flood risk considerations into national planning instruments—such as spatial plans, environmental strategies, and infrastructure development programs—ensuring they are not treated in isolation. This requires clear coordination mechanisms between responsible institutions and the mainstreaming of flood-related data and priorities into decision-making processes.

There is also evident need to enhance general public involvement and build professional capacities within institutions. Capacity-building remains an ongoing need, especially in local administrations, where practical tools and guidance are essential to support implementation.

Key opportunities for improving Montenegro's Preliminary Flood Risk Assessment include addressing data gaps in hydrological monitoring by expanding the measuring network, particularly for smaller and coastal watercourses. This would enhance identification of all relevant APSFRs, especially for transboundary rivers and smaller tributaries in the Adriatic and Danube basins. Improved data collection for tidal wave events, which are currently underrepresented, would ensure that coastal flooding is included in future PFRA evaluations.

The accuracy of flood hazard maps can be increased by incorporating more geodetic and bathymetric surveys, especially in floodplains, and integrating data on hydraulic structures. The flood risk maps should include more detailed flood damage assessments. Regular updates of land use data and more precise vulnerability data will ensure more accurate flood risk representation. Additionally, standardizing flood intensity classifications across hazard and risk maps will enhance clarity making it easier for stakeholders to interpret and apply the information in decision-making processes.

Improving the Flood Risk Management Plans could involve prioritizing nature based solutions over traditional structural measures to enhance sustainability and protect biodiversity. Additionally, refining the cost-benefit analysis by considering multiple interventions per APSFR, using more flood periods, and improving economic benefit calculations would lead to more accurate and effective flood risk management.

Generally, a clear pathway forward lies in consolidating experience from the first implementation cycle, drawing lessons from other EU member states, and embedding adaptive, evidence-based approaches into national planning processes. By focusing on these areas, Montenegro can not only fulfill its EU obligations but also lay the groundwork for more resilient and sustainable flood risk governance.

6. Conclusion

The adoption of the EU Floods Directive in Montenegro has represented a significant milestone in the country's efforts to align its flood risk management with EU standards. However, as this paper has demonstrated, key challenges persist in the implementation process, particularly in the areas of data availability, institutional coordination, and the effectiveness of flood risk management tools. While the development of Preliminary Flood Risk Assessments (PFRA), Flood Hazard and Risk Maps, and Flood Risk Management Plans (FRMPs) has advanced flood management efforts, significant gaps remain in hydrological data, the representation of climate change impacts, and the integration of accurate socio-economic data.

The challenges identified in this paper—ranging from insufficient data for smaller watercourses and coastal flooding to the limitations in the flood hazard mapping and risk assessment methodologies—require immediate attention. The lack of comprehensive data for certain basins and the incomplete understanding of flood impacts on vulnerable sectors such as agriculture and infrastructure further complicate the task of designing effective flood management strategies. Additionally, the overreliance on structural measures within FRMPs points to the need for a more balanced approach that emphasizes nature-based solutions to enhance long-term resilience and ecological sustainability. Strengthening institutional coordination and improving cost-benefit analysis methodologies will ensure more effective and sustainable flood risk management. These steps will support informed decision-making and improve the country's resilience to future flood events.

In addition to addressing current institutional and technical gaps, a fruitful area for future research would be evaluating the long-term effectiveness of FRMPs, especially in dynamic coastal and agricultural regions. Exploring how adaptive governance and real-time data could inform flood policies in Montenegro and similar transition economies could provide valuable insights. Comparative studies with early EU member states may also yield transferable practices suitable for Southeast European flood risk contexts.

In light of the points discussed above, refining the mapping methodology by integrating real-time hydrological data and consistent classification schemes will improve the clarity and utility of flood maps for decision-makers. Finally, by replacing structural bias with a balanced nature-based approach in FRMPs would not only enhance environmental compliance but also foster more resilient and sustainable flood protection systems.

In conclusion, while Montenegro has made substantial progress in implementing the EU Floods Directive, significant opportunities for improvement remain. Addressing the identified gaps will not only improve compliance with EU regulations but will also contribute to the resilience of Montenegro's communities and ecosystems in the face of increasing flood risks. By focusing on data enhancement, cross-sectoral integration, and sustainable flood risk management strategies, Montenegro can strengthen its preparedness for future flood events and serve as a model for other countries facing similar challenges.

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