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Floodplain Preservation as a Nature-Based Strategy for Flood Risk Mitigation: A Global Comparative Analysis

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Abstract

Flooding represents a persistent and intensifying hazard for communities globally, driven by climate change, urbanization, and the degradation of ecosystems that naturally buffer flood impacts. Floodplain preservation is increasingly recognized as a key nature-based solution offering both hydrological and ecological co-benefits. This study presents a comparative analysis of floodplain preservation initiatives in five geographic contexts: the Netherlands, the United States, Germany, Bangladesh, and the United Kingdom. Through a structured literature review and cross-case comparison, the paper assesses the extent to which floodplain preservation reduces flood risk, enhances biodiversity and ecosystem service provision, and contributes to long-term resilience. Results indicate that while flood attenuation is commonly observed at local to regional scales, effectiveness at broader catchment or basin scales depends critically on the spatial extent of interventions, governance and policy integration, and socio-economic contexts. Initiatives anchored in robust institutional frameworks—such as the Netherlands' *Room for the River* programme—tend to deliver superior outcomes. Nevertheless, challenges including land-use conflicts, equity concerns, and financing constraints are nontrivial, especially in lower-income or densely populated settings. We argue that floodplain preservation is most successful when embedded in integrated flood risk management strategies that align environmental, social, and policy goals.

Keywords: Floodplain Preservation; Nature-Based Solutions; Flood Mitigation; Integrated Flood Management; Governance; Cross-Case Analysis

1. Introduction

Floods are among the most frequent and destructive natural disasters, affecting millions globally and exacting substantial social, economic, and ecological costs (UNDRR, 2022). Climate change further exacerbates flood risk through increased precipitation intensity, shifts in storm patterns, and sea-level rise, making extreme flood events more likely to occur in many regions. Meanwhile, human interventions—such as levee construction, river channelization, and urban encroachment—have disconnected rivers from their natural floodplains, reducing the landscape's inherent capacity to buffer flood flows.

Conventional flood risk management has often prioritized structural defenses—such as levees, dams, and hardened channels—to contain water and protect developed lands. While these measures can offer immediate protection, they frequently entail unintended negative consequences, including downstream flood amplification, ecological degradation, and encouragement of settlement in flood-prone zones (Burby, 2006). In recent decades, nature-based solutions (NbS) have gained traction as complementary or alternative strategies. Among these, floodplain preservation and restoration are particularly promising: floodplains can absorb, store, and slowly release floodwaters, reducing peak flows and attenuating flood waves, while simultaneously delivering ecosystem services such as biodiversity support, water quality improvement, and groundwater recharge (Opperman et al., 2009; Tockner & Stanford, 2002).

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Yet globally, many floodplains have been lost, degraded, or disconnected from river systems. It is estimated that more than 70% of major floodplains worldwide no longer function optimally due to human modifications (Wohl, Lane, & Wilcox, 2015). In this context, many governments and organizations are experimenting with floodplain reconnection, setback levees, and restoration within integrated flood risk management frameworks.

The purpose of this paper is to critically assess the role of floodplain preservation in mitigating flood risk by comparing five diverse case studies: the Netherlands, United States (Lower Missouri River), Germany (Elbe River), Bangladesh, and the United Kingdom. Specifically, this work seeks to answer:

- To what extent does floodplain preservation contribute to reducing flood hazards?
- What challenges, trade-offs, and limitations attend its implementation?
- How do institutional, policy, and socio-economic contexts influence outcomes?

By situating empirical evidence and policy analysis in a cross-case framework, this study contributes to the growing literature advocating ecosystem-based adaptation and integration of floodplain strategies into wider flood risk and land use planning.

2. Literature Review

2.1. Floodplains and Hydrological Functions

Floodplains—flat or gently sloped lands adjacent to rivers—function as natural buffers during flood events. By absorbing water, slowing down flow, and providing storage, they moderate flood peaks and reduce downstream impacts (Opperman et al., 2009). Their hydrological contributions include dampening flood waves, retaining sediment, filtering nutrients and pollutants, supporting baseflow, and recharging groundwater (Junk, Bayley, & Sparks, 1989; Tockner & Stanford, 2002).

2.2. Loss of Floodplains: Causes and Consequences

Floodplains are among the most extensively anthropogenically altered ecosystems. Urban expansion, levee systems, river straightening, sediment trapping, and agricultural conversion have severed river–floodplain connectivity. The consequences include reduced flood storage capacity, accelerated flows, increased flood peaks downstream, degraded water quality, loss of biodiversity, and declining resilience (Wohl, Lane, & Wilcox, 2015). For example, levee construction has been shown in Austria to decrease flood storage potential and heighten downstream flooding velocities (Hauer, Unfer, Schmutz, & Habersack, 2018).

2.3. Nature-Based Solutions (NbS) and Integrated Flood Management

Nature-based solutions seek to work with natural processes rather than solely relying on engineered systems. In flood risk contexts, NbS may include floodplain reconnection, wetland restoration, upstream retention, and managed aquifer recharge. Integrated Flood Management (IFM) frameworks emphasize balancing flood risk reduction with ecosystem integrity and social objectives, advocating for multifunctional approaches and cross-sectoral integration (WMO, 2009; Thieken et al., 2016).

2.4. Global Exemplars of Floodplain Preservation

Empirical and policy literature offers multiple case studies where floodplain strategies have been deployed:

- Netherlands – Room for the River: A large-scale initiative to relocate dikes, lower floodplain surfaces, and create secondary channels, thereby restoring floodplain capacity and reducing peak levels (Rijke, van Herk, Zevenbergen, & Ashley, 2012).
- USA – Lower Missouri River: Restoration of floodplain connectivity and removal of levees aimed at restoring wetland habitat and reducing stages locally (Jacobson et al., 2020).
- Germany – Elbe River Basin Restoration: Dike realignment and reintegration of retention zones to restore floodplain connectivity and ecological function (BMU, 2012).
- Bangladesh – Traditional & Structural Practices: The use of floodplain agriculture, seasonal mobility, and fisheries traditionally coexists with embankment systems that sometimes disrupt natural flood dynamics (Huq & Rahman, 2008).
- United Kingdom – Woodland in Floodplains: Pilot projects in the Midlands involving floodplain afforestation to enhance infiltration and slow runoff (Nisbet & Thomas, 2006).

2.5. Challenges, Trade-Offs, and Emerging Themes

Despite the availability of case examples, implementation faces numerous obstacles: land acquisition and compensation, fragmented governance, competing land uses (e.g. agriculture, urbanization), lack of financial incentives, equity issues, mismatches of intervention scale, and maintenance burdens. The "safe development paradox" (Burby, 2006) shows how structural defenses can inadvertently encourage risky development. Scholars also emphasize that benefits may accrue unevenly across stakeholders (Siders, 2019). Integrating equitable governance, stakeholder participation, and adaptive management is key to overcoming these challenges.

3. Methodology

3.1. Literature Search and Selection

We conducted a structured search across Scopus, Web of Science, and Google Scholar using keywords such as *floodplain preservation*, *flood mitigation*, *floodplain restoration*, *nature-based flood management*, *governance floodplains*, and *policy floodplain connectivity*. Inclusion criteria required (a) empirical or modeled flood mitigation outcomes linked to floodplain strategies, (b) discussion of governance or planning frameworks, and (c) real-world or model-based case studies. The time window considered was 2000–2025. From an initial pool of ~60 sources, we selected ~20 principal studies for in-depth coding and comparative synthesis.

3.2. Case Study Selection

We selected five case studies based on their diversity in geography, scale, governance regimes, and the availability of robust data: Netherlands (Room for the River), USA (Lower Missouri River), Germany (Elbe Basin), Bangladesh, and UK (Midlands woodland). These cases provide a mix of highly engineered and soft/NbS approaches in both developed and developing contexts.

3.3. Comparative Analytical Framework

Each case was evaluated along four interrelated dimensions:

- Hydrological effectiveness — e.g. reductions in flood peaks or stages, storage capacity, flood wave delay.
- Ecological and co-benefit outcomes — e.g. biodiversity improvement, habitat connectivity, water quality, sediment regulation.
- Socio-political feasibility and equity — e.g. stakeholder engagement, land acquisition, compensation, equity effects, public support, cost.
- Policy, governance, and institutional integration — e.g. legal mandates, regulatory alignment, interagency coordination, adaptive capacity.

Cross-case synthesis was then used to identify enabling conditions, constraints, trade-offs, and lessons.

4. Results

4.1. Overview of Cases

Table 1 Overview of Diverse Cases based on Benefits, Hydrological Outcomes and Challenges

Case / Country	Intervention Type	Key Hydrological Outcomes	Major Co-benefits	Principal Challenges
Netherlands (Room for the River)	Dike relocation, floodplain reconnection, channel redesign	Peak reductions up to ~30 cm in key reaches; increased discharge capacity	Ecological restoration, recreation, landscape enhancements	High costs, stakeholder negotiations, coordination across governance levels
USA (Lower Missouri River)	Levee removal, wetland reconnection	Local stage reductions of ~0.12–0.66 m; negligible basin-scale effect (~0.1–0.13 %)	Habitat restoration, connectivity, species benefits	Landowner resistance, funding, scale mismatch

Germany (Elbe Basin)	Dike setbacks, reconnection of retention zones	Slower flood wave velocities, improved sediment distribution, measurable attenuation	Riparian habitat recovery, alignment with EU directives	Regulatory complexity, land use trade-offs, maintenance costs
Bangladesh	Traditional floodplain agriculture vs embankments	Seasonal adaptation yields risk reduction locally; embankments sometimes exacerbate downstream effects	Livelihood support (fisheries, rice), ecosystem functions	Disruption from hard infrastructure, inequity, sediment flow disruption
UK (Midlands woodland floodplains)	Woodland planting, infiltration enhancement	Modest peak flow reductions (~5–10 %) in small catchments	Biodiversity gains, carbon sequestration, aesthetic benefits	Fragmented land ownership, costs, time lag, scale limits

4.2. Hydrological Effectiveness

Every case showed some measure of hydrological benefit when floodplain connectivity was improved. However, the magnitude of benefit scales with the area of intervention and degree of connectivity. In the Netherlands and Germany, large, coordinated projects achieved noticeable peak reductions; in contrast, the Missouri River case showed that local gains may not translate into observable basin-scale reductions.

4.3. Ecological and Co-Benefit Outcomes

Floodplain projects frequently yielded strong co-benefits: increased biodiversity, improved water quality via sediment/nutrient retention, habitat connectivity, recreation, and in some cases carbon storage and groundwater recharge. Such benefits often strengthen the political or social justification for projects, making them more viable.

4.4. Governance, Policy, and Socio-Economic Influence

Governance structures, legal frameworks, funding mechanisms, and stakeholder engagement strongly influence outcomes. The Netherlands' *Room for the River*, with its coordinated multi-layer governance, legal backing, and public engagement, stands out as a model of institutional alignment. By contrast, in Bangladesh, fragmented governance and conflict between traditional practices and structural infrastructures dampen the effectiveness of floodplain strategies. Equity concerns are also paramount: the costs of land conversion, displacement, or lost agricultural income frequently fall on less powerful stakeholders (Siders, 2019).

4.5. Trade-offs, Limitations, and Risks

Key trade-offs and constraints include the competition among land uses (e.g. agriculture, infrastructure), compensation and financing costs, temporal lags before full ecosystem recovery, maintenance demands, and risks of unintended consequences (e.g. sediment starvation, upstream/downstream shifts). Smaller-scale interventions often lack sufficient influence on larger hydrological dynamics, and structural interventions elsewhere may interfere with restored floodplain functions.

5. Discussion

5.1. Interpretation of Contextual Variation

Effectiveness of floodplain preservation depends heavily on geographic, hydrologic, and socio-institutional context. River morphology, rainfall regimes, land cover, baseline river modifications, and economic constraints all mediate outcomes. Projects that operate at sufficient spatial extent and with upstream/downstream coordination perform better.

5.2. Leveraging Co-Benefits for Greater Support

Because hydrological benefits alone often fall short of justifying large investments, co-benefits (ecological, recreational, carbon mitigation, cultural) are critical in creating multi-stakeholder buy-in, diversifying funding sources, and achieving sustainability. Designs that enhance these co-benefits improve the chances of long-term project success.

5.3. Institutional and Policy Design Imperatives

Robust legal and institutional frameworks are essential. These include clear mandates for floodplain management, interagency coordination, alignment with land use and environmental policy, and mechanisms for financing, compensation, and adaptive maintenance. Without such integration, floodplain initiatives may be piecemeal and vulnerable to reversal.

5.4. Equity, Participation, and Justice

Attention to equity is vital. Ensuring that vulnerable populations are not disproportionately burdened, offering fair compensation and livelihood support, and integrating participatory design are essential to socially sustainable outcomes. Recognizing and incorporating traditional knowledge (e.g. in Bangladesh) can strengthen legitimacy and resilience.

5.5. Dynamic Resilience and Adaptive Planning

Given climate change and increasing hydrological variability, static flood control is insufficient. Floodplain preservation must be embedded in adaptive planning cycles, monitoring regimes, and flexible governance to evolve over time. Trade-offs between short-term protection (with structures) and longer-term resilience (via ecosystem restoration) must be openly acknowledged and managed.

6. Conclusion

Floodplain preservation constitutes a promising nature-based approach to enhancing flood resilience, combining hydrological benefits with ecological, social, and planning co-benefits. This cross-case analysis underscores that success depends not only on ecological feasibility but equally on scale, governance, institutional alignment, stakeholder engagement, and equitable resource allocation.

To more fully harness floodplain strategies, practitioners and policymakers should:

- Mainstream floodplain preservation into national or regional flood risk and land use policies.
- Establish legal and institutional frameworks that foster coordination, continuity, and compensation.
- Design funding mechanisms that account for long-term maintenance, stakeholder costs, and co-benefits.
- Prioritize inclusive and participatory approaches to engage affected communities.
- Embrace monitoring, evaluation, and adaptive adjustment in response to climate and hydrologic change.

Future research priorities include deeper hydrologic and economic quantification of basin-scale impacts, valuation of ecosystem co-benefits, longitudinal studies of project performance, and comparative analysis across more diverse socio-ecological settings.

References

[1] Burby, R. J. (2006). Hurricane Katrina and the paradoxes of government disaster policy: Bringing about wise governmental decisions for hazardous areas. The Annals of the American Academy of Political and Social Science, 604(1), 171–191. https://doi.org/10.1177/0002716205284676

[2] Hauer, C., Unfer, G., Schmutz, S., & Habersack, H. (2018). The role of floodplain restoration in flood protection — a case study in Austria. River Research and Applications, 34(5), 421–430. https://doi.org/10.1002/rra.3271

[3] Huq, S., & Rahman, A. (2008). Climate change and Bangladesh: Policy and institutional development to reduce vulnerability. Journal of Bangladesh Studies, 10(1), 1–9.

[4] IPCC. (2021). Climate Change 2021: The Physical Science Basis (Working Group I contribution to the Sixth Assessment Report). Intergovernmental Panel on Climate Change. https://www.ipcc.ch/report/ar6/wg1/

[5] Jacobson, R. B., et al. (2020). The role of floodplain restoration in mitigating flood risk on the Lower Missouri River, USA (U.S. Geological Survey Scientific Investigations Report 2020–5036). U.S. Department of the Interior. https://doi.org/10.3133/sir20205036

[6] Junk, W. J., Bayley, P. B., & Sparks, R. E. (1989). The flood pulse concept in river-floodplain systems. Canadian Special Publication of Fisheries and Aquatic Sciences, 106, 110–127.

[7] Nisbet, T. R., & Thomas, H. (2006). The role of woodland in flood control: A landscape perspective. Scottish Forestry, 60(1), 34–38.

[8] Opperman, J. J., Luster, R. A., McKenney, B. A., Roberts, M., & Meadows, A. W. (2009). Ecologically functional floodplains: Connectivity, flow regime, and scale. Journal of the American Water Resources Association, 46(2), 211–226. https://doi.org/10.1111/j.1752-1688.2009.00326.x

[9] Rijke, J., van Herk, S., Zevenbergen, C., & Ashley, R. (2012). Room for the River: Delivering integrated river basin management in the Netherlands. International Journal of River Basin Management, 10(4), 369–382. https://doi.org/10.1080/15715124.2012.739173

[10] Siders, A. R. (2019). Social justice implications of U.S. managed retreat buyout programs. Climatic Change, 152(2), 239–258. https://doi.org/10.1007/s10584-018-2272-5

[11] Tockner, K., & Stanford, J. A. (2002). Riverine flood plains: Present state and future trends. Environmental Conservation, 29(3), 308–330. https://doi.org/10.1017/S037689290200022X

[12] UNDRR. (2022). Global Assessment Report on Disaster Risk Reduction. United Nations Office for Disaster Risk Reduction. https://www.undrr.org

[13] Wohl, E., Lane, S. N., & Wilcox, A. C. (2015). The science and practice of river restoration. Water Resources Research, 51(8), 5974–5997. https://doi.org/10.1002/2014WR016874

[14] World Meteorological Organization. (2009). Integrated flood management concept paper. Associated Programme on Flood Management. https://www.floodmanagement.info/publications/