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Floods in the Vez River: A Social Analysis through Freytag's Pyramid

Maria da Glória Salgado Gonçalves

Resumo

Este estudo analisa a gestão de cheias na bacia do rio Vez, Portugal, focando na integração entre dados técnicos e narrativas culturais. Através da aplicação da Pirâmide de Freytag e do método K-Means, classificam-se dados de caudal e precipitação, complementados pela análise de relatos jornalísticos e fontes históricas. Destacam-se duas abordagens complementares: a modelação hidrológica para a avaliação de riscos e a relevância dos registos digitais na formulação de políticas públicas sustentáveis. A conjugação de dados quantitativos com narrativas culturais proporciona uma base robusta para estratégias de gestão integrada. Estudos futuros devem aprofundar metodologias interdisciplinares.

Palavras-chave: Floods, Vez River, Freytag's Pyramid, Políticas Públicas.

Abstract

This study examines flood management in the Vez River basin, Portugal, focusing on the integration of technical data and cultural narratives. By applying Freytag's Pyramid and the K-Means method, flow and precipitation data are classified, complemented by an analysis of journalistic reports and historical sources. Two complementary approaches are highlighted: hydrological modelling for risk assessment and the relevance of digital records in the formulation of sustainable public policies. The combination of quantitative data and cultural narratives provides a robust foundation for integrated management strategies. Future research should delve deeper into interdisciplinary methodologies.

Keywords: Floods; Vez River; Freytag's Pyramid; Public Policies.

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Introduction

Flood events, while primarily physical phenomena, carry significant narrative and cultural dimensions, particularly when analysed within social, historical, or environmental contexts. This dual nature of floods highlights their complexity and the need for interdisciplinary approaches to risk management and public engagement. In the Vez River basin, located in northern Portugal, riverine floods represent a growing concern, posing substantial risks to public safety, economic stability, and environmental integrity. These events disrupt daily life, damage critical infrastructure, and challenge local and national authorities' ability to respond effectively.

This study applies Freytag's Pyramid, a classical narrative framework, to the analysis of flood narratives in the Vez River basin. The model's five stages (exposition, rising action, climax, falling action, and resolution) are employed to structure and interpret flood events through historical data, hydrological modelling, and digital flood records. This approach aims to bridge the gap between technical assessments of flood risk and the public's cultural and emotional engagement with these events. By aligning narrative stages with hydrological and meteorological data, such as river discharge and precipitation, the study provides a multidimensional understanding of floods, contextualising both their physical impacts and social ramifications.

The motivation for this research stems from the need to develop innovative communication strategies that resonate with stakeholders, enhancing both public awareness and policy-making. In regions like the Vez River basin, where over 979 flood incidents (between 1900 and 2015) have been recorded alongside significant socio-economic consequences, there is an urgent need for strategies that integrate technical insights with culturally significant narratives. Such an approach not only enriches the academic discourse on flood management but also delivers practical tools for decision-makers, urban

planners, and local communities.

By combining quantitative data clustering (using the KMeans algorithm) with Freytag's narrative structure, this paper aims to reveal how flood narratives evolve and influence public perception, preparedness, and response. This interdisciplinary perspective underscores the potential of integrating hydrological modelling with cultural storytelling to create more effective, inclusive, and sustainable flood management strategies. Ultimately, the study seeks to contribute to a deeper understanding of how technical and cultural dimensions of flood events interact, driving better practices for risk communication and disaster resilience.

Literature Review: Freytag's Pyramid

The work of Gustav Freytag (1816–1895), a German playwright and theorist, has had a significant influence on contemporary literature, particularly through his contribution to the synthesis and analysis of narrative structures (Kelly-Quattrocchi et al., 2024). He is especially recognized for his conception of the "Freytag Pyramid", a model that organizes the narrative into distinct phases (Figure 1), aiding in the analysis of dramatic construction. Furthermore, his work explores the concept of catastrophes within narrative structures, emphasizing how these events can be used to generate tension and development within the plot. "It is the supposition of actualism, the belief that past events are the outcome of processes seen in operation today" (Charlton, 2007, p. 27).

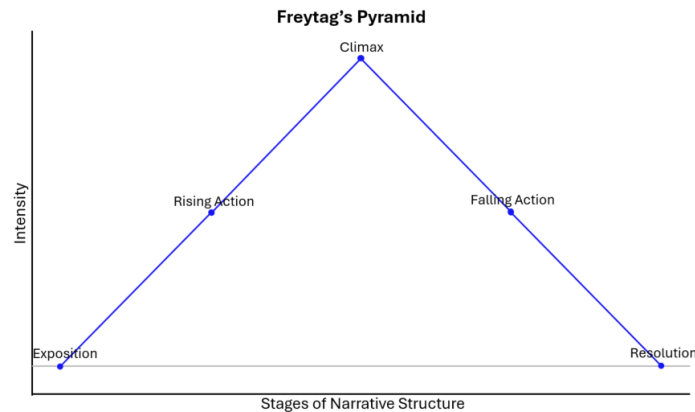


Figure 1. Freytag's Pyramid.
Source: Created by the author in Jupyter Notebook, 2025.

This theoretical framework underscores the dynamic interplay between emotional and social dimensions, offering valuable insights into how floods shape individual and collective experiences, perceptions, and memories. Such an understanding is essential for interpreting immediate responses to these events and for devising long-term resilience strategies.

Climatic and meteorological data, along with their modelling, enable the prediction of in situ tensions (Cortés et al., 2024). Of particular interest is understanding the adaptive variation of biodiversity in response to the impacts of climate change. Climate alterations significantly affect the ecology of mountain pastures at various levels, including shifts in the growing season's dynamics (John et al., 2024). In light of research findings on climate change (Borowiec, 2023; Cortés et al., 2024; Mayer et al., 2023), biodiversity adaptation (De Ron et al., 2022), and humanity's capacity to adapt to increasingly catastrophic floods, it becomes imperative to rethink strategies for ensuring overall safety and survival.

Effective communication of the climate crisis is vital for social acceptance (Borowiec, 2023). Freytag's framework provides a structured approach to analysing the emotional and social impact (Ciğerci & Yıldırım, 2023) of floods, supporting adaptive strategies and resilience to climate challenges.

Materials and Methods Study area

The Vez River Basin is in the northwest of mainland Portugal (Figure 2). This figure, which illustrates the study area, was constructed using data from OpenStreetMap (<https://www.openstreetmap.org>). Geographically, the basin is situated approximately between 41.80° and 41.95° latitude north and 8.30° and 8.12° longitude west. The basin is almost entirely contained within the municipality of Arcos de Valdevez, which gives the river its name. The Vez river discharges into the Lima River, an international basin named after the town of Ponte de Lima.

This is a small basin on a local scale, covering 263 km², with the river stretching 36 km in length (Bellu et al., 2016; Carvalho-Santos, Nunes, et al., 2016; Fonseca et al., 2018). Its geometry is not elongated but rather close to an oval shape. The basin is characterised by a mountainous fluvial geomorphology, reaching an altitude of 1,410 metres, with its highest points situated towards Melgaço.

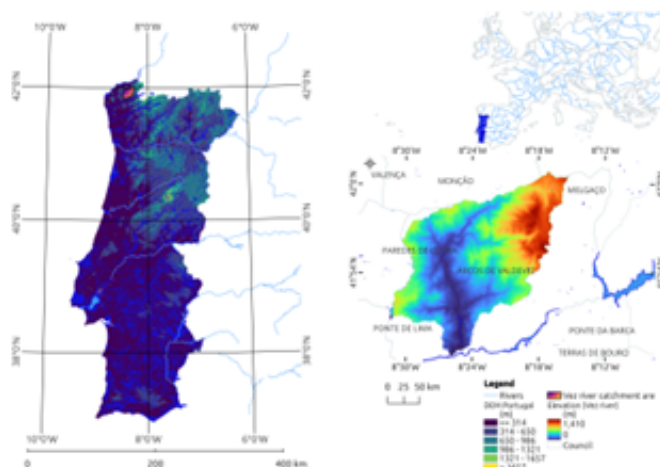


Figure 2. Geographical location and the drainage basin of the Vez River basin.

Geologically, the Vez River Basin is predominantly composed of granite, a substrate characterised by low infiltration capacity (Bellu et al., 2016). The native forest, primarily consisting of oak (*Quercus robur*) and cork oak (*Quercus suber*) trees (Carvalho-Santos, Sousa-Silva, et al., 2016), is largely concentrated in the northwestern part of the basin. Meanwhile, the terraced fields of Sistelo, a distinctive feature of mountain pastures, dominate the north-central region. These ecosystems play a crucial role in sustaining local biodiversity (Carvalho-Santos, Nunes, et al., 2016) while also mitigating seasonal flooding by enhancing water infiltration and reducing surface runoff. As natural buffers, they help regulate hydrological dynamics, contributing to overall watershed stability. By mitigating peak flows, they act as natural buffers against seasonal flooding, contributing to greater hydrological stability. The vegetation cover, combined with biodiversity, provides key advantages for adaptive responses to climate change (Cortés et al., 2024).

Data

The study utilised data from the *Sistema Nacional de Informação de Recursos Hídricos* (SNIRH: <https://snirh.apambiente.pt/>) spanning three decades, from 1 October 1960 to 30 September 1990. The selected variables for analysis included the discharge rate from the Pontilhão de Celeiros (Discharge) station, as well as precipitation data from the Casal Soeiro (raincs) and Cabreiro (rainc) stations. It is worth noting that the discharge variable contains 1951 missing data points, while precipitation has none. The discharge data exhibit gaps throughout the analysed period, with significant missing records in the years 1974, 1975, 1976, and 1977, accounting for 365, 365, 366, and 365 days, respectively. Other years show smaller counts of missing data, such as 1960 (12 days), 1967 (31 days), and 1978 (273 days), highlighting notable inconsistencies in the time series. No treatment was applied to the missing data, as it was determined that the missing values had no significant impact on the adopted model, as described in the Methods section. Additionally, the dataset available on Mendeley (<https://doi.org/10.17632/z5fnkqngdq.2>), covering the period from 1900 to 2015, was used. It includes news articles related to floods in the Vez River basin area.

Methods

For the development of this document, particularly the literature review, a search was conducted using the Dimensions database, and relevant articles were selected and cited throughout the text. Additionally, articles from previous research, stored in Zotero, were considered. These include studies conducted by various researchers focusing on the case of the Vez River Basin.

The KMeans clustering algorithm, implemented in Jupyter Notebook using the Scikit-learn package, was applied with 5 clusters, corresponding to the five stages of Freytag's Pyramid,

to analyse flood narratives. Data from the National Water Resources Information System (SNIRH) were utilised to provide a comprehensive overview of flood-related variables. For days with missing discharge data, precipitation data were also excluded, as it corresponded to the same day. The choice of $K=5$ clusters reflects the complexity of hydrological events in the Vez River basin. Although the elbow method initially suggested $K=2$, the model was trained for $K=5$, allowing for a clearer distinction between critical events (Clusters 2 and 3), transitional states (Clusters 1 and 4), and stable periods (Cluster 0). According to the Silhouette Score criterion, for $k=5$, values of 0.69, close to 1, indicate good separation between clusters (Figure 3). This ensures a comprehensive representation of the data, capturing natural variability and extreme events essential for understanding flood risks and watershed dynamics.

Although the silhouette score for $K = 6$ is slightly higher than for $K = 5$, the choice of $K = 5$ was guided by both methodological and conceptual considerations. The clustering approach was aligned with the five stages of Freytag's Pyramid, ensuring consistency in the narrative analysis of flood events. Furthermore, increasing K beyond 5 did not yield substantially improved interpretability, as the focus remained on distinguishing flood events. A higher silhouette score alone does not necessarily indicate a superior clustering solution, as excessive subdivision may yield statistically well-defined clusters that are less hydrologically meaningful. Thus, the choice of $K = 5$ provides a balanced trade-off between data structure, domain relevance, and interpretability, allowing for a clear distinction between critical flood phases while maintaining coherence with the event classification framework. The selection of the optimal number of clusters was not solely based on the highest Silhouette Score but also on hydrological interpretation and the relevance of the clusters to the study.

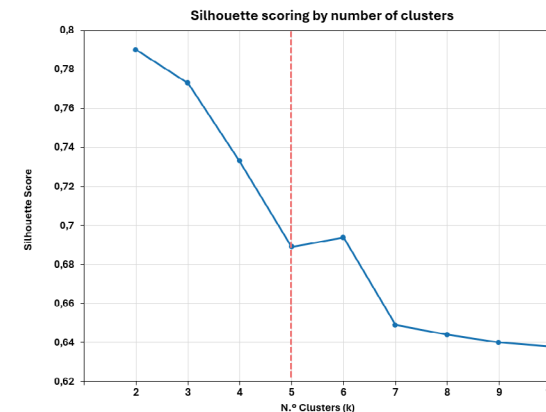


Figure 3. Silhouette score.
Source: Created by the author in Jupyter, based on kmeans with SNIRH data (1960/1990), 2025.

Subsequently, a pyramid was created based on data from the digital flood registry available at <https://doi.org/10.17632/z5fnkgngdq.2>, which includes news reports about floods. This pyramid follows the structure of Freytag's model and has been applied to flood narratives in the context of risk communication and awareness. In point 3, Historical and Cultural Narratives, we recount personal stories from the past shared by residents, specifically focusing on "Linha da Valeta," a prominent figure in Arcos de Valdevez, immortalized in a painting on her house's door, and featured in the 'MurArcos' Festival.

Results

The data analysis was conducted using Freytag's model to structure flood narratives within the Vez River basin. Through the five stages of the model, data from the SNIRH and the digital flood record were examined, focusing on identifying vulnerabilities, understanding the dynamics of action, and assessing the resolution of flood impacts.

Local Impact Narratives

This section applies Freytag's model to analyse the flood narrative within the Vez River basin, focusing on key phases of the event and the associated hydrological data (Figure 4 and Table 1).

The flood cluster analysis (Figure 4) identifies instances where high discharge occurs despite low precipitation, and vice versa. These discrepancies can be attributed to various hydrological factors, particularly the lag effect.

In cases of low precipitation but high discharge, river discharge may be influenced by prior upstream rainfall in mountainous regions, as well as delayed runoff contributions. Additionally, groundwater discharge can sustain river discharge even when surface precipitation is minimal.

Conversely, high precipitation but low discharge can result from soil infiltration and temporary water storage in floodplains and saturated areas. The lag effect in surface runoff also plays a significant role, as rainwater may take time to reach the river. Furthermore, although to a lesser extent, evapotranspiration losses can substantially reduce the immediate contribution of precipitation to river discharge. It is also important to note that K-Means clustering does not consider only discharge but incorporates multiple hydrological variables and identifies outliers, which influence the clustering outcomes (Table 1).

Rising Action Exposition

Introduction to the context of the riverside community, the river's state prior to the event, and the initial conditions. For the variables under study with daily data, the following values were obtained: discharge 4.88 m³/s; rains 0.65 mm; rainc 0.80 mm.

The moment when the river level begins to rise due to heavy rainfall, melting, or other natural factors. Data values obtained were: discharge 19.50 m³/s; rains 13.38 mm; rainc 14.08 mm.

Climax

Tension escalates as the river overflows, causing panic, evacuations, and material and emotional losses. Data values obtained were: discharge 77.92 m³/s; rains 65.08 mm; rainc 66.96 mm.

Falling Action

The most critical point of the event, as the flood peaks, leading to the collapse of barriers or the isolation of populations. Data values obtained were: discharge 370.12 m³/s; rains 41.12 mm; rainc 41.63 mm.

Resolution

The recession of the waters, the response from authorities, recovery efforts, and reflections on the impact and lessons learned. Data values obtained were: discharge 44.84 m³/s; rains 34.16 mm; rainc 31.47 mm.

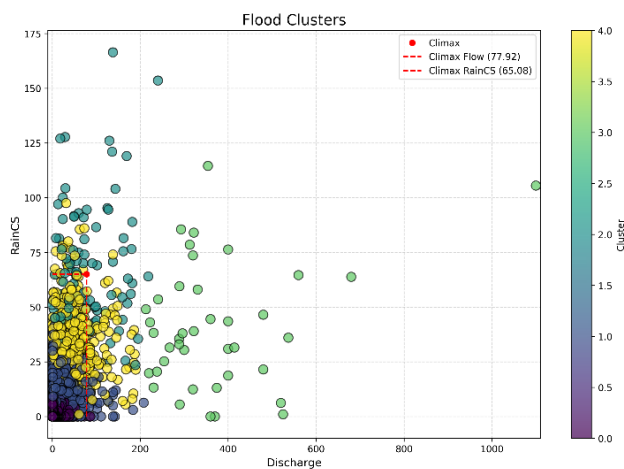


Figure 4. Flood Cluster Analysis: Discharge and Precipitation in the Context of the Flood Climax.

Source: Created by the author in Jupyter, based on kmeans = KMeans(n_clusters=5) with SNIRH data (1960/1990), 2025.

| STAGE | CLUSTER AND N. ° | DISCHARGE (M³/S) | RAINCS (MM) | RAINC (MM) |
|----------------|------------------|------------------|-------------|------------|
| Exposition | 0; 7150 | 4.88 | 0.65 | 0.80 |
| Rasin action | 1; 1189 | 19.50 | 13.38 | 14.08 |
| Climax | 2; 101 | 77.92 | 65.08 | 66.96 |
| Falling action | 3; 40 | 370.12 | 41.12 | 41.63 |
| Resolution | 4; 525 | 44.84 | 34.16 | 31.47 |

Table 1. Hydrological Data and Clustering Stages for the Vez River Flood Event (including average values with outliers).

Source: Created by the author in Jupyter, based on kmeans = KMeans(n_clusters=5) with SNIRH data (1960/1990), 2025.

As illustrated in Figure 4 and further supported by Table 1, the model identifies that when discharge and precipitation values reach or exceed the climax, the resulting floods are significantly more catastrophic in terms of their impact. These impacts are detailed in the subsequent two models.

Narratives in Risk Communication and Awareness

Communication campaigns through news articles to prevent or mitigate the impacts of riverine flooding were structured according to Freytag’s model to maximise emotional impact and public engagement. The exposure to flood risk in the Vez River basin focuses on critical infrastructure and vulnerable residential areas. Issues related to sewage systems and the Valetas area are highlighted, with impacts recorded in locations such as S. Cosme to Vilela Road, Rio de Moinhos, Trasadário, Prozelo (Ponte Velha), and Rua Nunes de Azevedo. Bridges and footbridges, such as the Ázere Medieval Bridge and Vilela Bridge, experience substantial pressures, exacerbated by inadequate urban drainage, particularly in municipal buildings where drainage systems redirect water into the streets. In total, 79 critical vulnerable locations, 979 recorded incidents, 1449 intervention actions, and 215 consequences were documented.

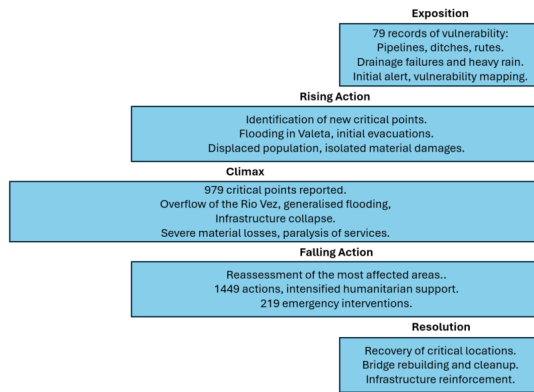


Figure 5. Freytag's Pyramid for the Vez River Basin.
Source: Created by the author in Jupyter Notebook, based on the news (1900/2015), 2025.

In economic terms, losses were recorded in crop fields, uprooted trees, and damage to both public and private infrastructure, with total losses exceeding 1 million escudos (in 1999 and 2000 alone). Substantial expenditures were required for repairs, reconstructions, and clean-ups, including housing, bridges, and drainage systems. Furthermore, economic losses stemmed from the disruption of agricultural and commercial activities, as well as providing support to affected populations. In terms of transportation, road closures, construction delays, and mobility difficulties were reported due to power outages and road blockages. These consequences reflect the scale of material, social, and environmental damage caused by the floods.

Historical and Cultural Narratives

Exposition

The Valeta neighbourhood, celebrated for its historical and cultural significance, has frequently been the focus of media coverage related to flooding from the Vez River and the Vila Fonche stream. An analysis of news articles revealed 69 references to

the term Valeta, underscoring its prominence in discussions about flood-related challenges. The terms Consequences, Actions, and Vulnerability were identified 60, 169, and 26 times, respectively, reflecting the persistent social, economic, and environmental challenges affecting the area.

Rising Action

Over the decades, recurring floods have profoundly impacted the identity and daily life of Valeta's inhabitants. A notable example is the long-term resident of house no. 53, a two-storey property repeatedly inundated by floodwaters. This individual, who resided in the neighbourhood for over a century and passed away at the age of 101, exemplifies the enduring struggles faced by the community. Structural interventions, such as the construction of a retaining wall along the riverside avenue by the former Roads Authority, have often been criticized for exacerbating flood risks rather than mitigating them.

Climax

Flood events in Valeta are cause of severe disruptions and significant hardship. Rising waters impede traffic and parking, while debris accumulation and sewage overflow further deteriorate living conditions. Residents frequently report unpleasant odours and sanitation issues, with floodwaters breaching homes. Although a newly installed sewage pumping station has been promoted as a solution, its proximity to residential areas has raised concerns about potential structural failures and environmental contamination. These apprehensions are further aggravated by delays in implementing comprehensive flood mitigation strategies, leaving many sceptical about the adequacy of existing measures.

Falling Action

The consequences of recurrent flooding impacts of recurrent flooding extend beyond immediate physical damage, with long-term socio-economic implications. Local businesses have experienced declining activity, prompting some proprietors to consider relocating. Efforts to stabilise the area, such as replacing sand with gravel and revitalising the riverbanks, have been implemented, but these initiatives have yet to fully address residents' concerns or restore confidence in the area's resilience.

Resolution

Valeta remains a cultural and historical landmark near sites like Pontilhão da Valeta. Its recovery relies on sustainable, community-focused strategies to protect residents and revitalize the local economy, highlighting the need for integrated urban planning to reduce flood risks and improve quality of life in vulnerable areas.



Figure 6. The face of the floods in Valeta.
Source: Photo by JF S. Salvador, Vila Fonche e Parada, depicting a painting by Daniela Guerreiro, featured in *O Minho*, 2024.

The local narratives of the Valeta neighbourhood paint a compelling picture of resilience intertwined with vulnerability, underscoring the urgent need for sustainable measures that not only reduce flood risks but also safeguard the area's rich historical and cultural heritage for generations to come.

Discussion and Conclusions

Discussion

A simplified model of the Vez River's fluvial landscape was employed to analyse flood events, confirming their recurring nature and partially supporting the principle of actualism (Charlton, 2007). However, this principle is challenged by the differences between past and present fluvial and climatic processes, largely attributed to climate change (Cortés et al., 2024). The long-term evolution of ecosystems, as highlighted in recent studies (Borowiec, 2023; Cortés et al., 2024), reflects the impact of these changes, including human adaptation to extreme events like the recurrent floods in the Vez River basin.

Technical Analysis

Modelling of discharge and precipitation data reveals a consistent pattern of catastrophic flood events, indicating that, on average, one severe event occurs annually. These findings underline the ongoing hydrological risks and provide insights into flood management strategies in the region.

Social and Cultural Reflection

The social response to flooding is also crucial, with human resilience demonstrated through adaptive strategies, such as structural reinforcements in areas like Valeta, often impacted by catastrophic events (Bellu et al., 2016; Fonseca et al., 2018; Gonçalves, 2024). An example of individual resilience is the case of House 53, which illustrates how local communities cope

with these threats. Such adaptations combine both practical and social elements, shaping disaster risk reduction strategies.

Concluding Remarks

The evidence of climate change's localised impacts necessitates a reconsideration of assumptions about Earth's surface processes. Climate change is permanently altering ecosystem dynamics, requiring continuous adaptation from both human and natural systems to manage evolving risks, such as flooding.

Conclusions

The study demonstrated how the application of Freytag's Pyramid can integrate distinct approaches, such as using the KMeans method to classify discharge and precipitation data into five clusters, analysing press narratives, and reviewing historical accounts. This combination provides risk managers with a more comprehensive perspective. We identified 40 catastrophic floods in the Vez River Basin, based on discharge and precipitation data, suggesting that the frequency of severe events may exceed one per year on average.

However, the study has some limitations, including incomplete data and the constraints of the narrative approach, which may not capture all the nuances of historical and social events. Given these limitations, future research should explore the integration of more complete datasets, including meteorological, social, and cultural data, to provide a more holistic and accurate understanding of flood risks. Furthermore, it is crucial to promote public policies that consider both scientific and cultural perspectives, to develop a more adaptive, inclusive, and resilient flood management strategy in the face of climate change.

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