

Editorial of the Special Issue “Flood Risk and Resilience in Coastal Zones and Tropical Islands”

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EDITORIAL OPEN ACCESS

Editorial of the Special Issue "Flood Risk and Resilience in Coastal Zones and Tropical Islands"

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One of the characteristics of flooding in coastal areas is that it can be induced by different climatic drivers such as storm surges, wave run-up, rainfall, and/or river flow, each of which can act individually but are also often interconnected. In addition, when flooding is induced by marine drivers impacting sedimentary coastlines, erosion also occurs, which can significantly increase flooding. This is likely to intensify in a climate change scenario in which sea-level rise will directly and indirectly increase flooding in coastal areas. In addition, the concentration of population, infrastructure, and urbanization significantly increases the exposure of these zones. All this results in a very high-risk area, which has been dramatically illustrated during the last decades by the impact of extreme events that have caused great damage in coastal areas around the world either in singular events (e.g., Xynthia in 2010, Sandy in 2012, Gloria in 2020) or by accumulation during a season (winter 2013/2014 in the Atlantic coast of Europe).

Tropical islands are also very high-risk areas. Climate change is impacting these islands severely, with powerful hurricanes observed in the West French Indies over the last decades, for example. And in the long term, sea level rise is/will impact such islands, sometimes erasing them from the world map. At the same time, these high-level risk areas are most often poorly equipped with sensors to predict risks, to alert the population, and to manage adequately the crisis and retrofit phases. Specific tools, toolboxes, and resilience strategies have to be designed for such specific territories, which may be isolated and where several islands at different development levels are part of the same archipelagos. Such specific geographies can be seen as aggravating factors, or on the contrary, as a model to test different resilience strategies because these areas are small and can be modeled and monitored maybe in an easier manner.

With such a broad subject matter, this special issue covers a range of topics from understanding the processes involved to developments in risk analysis methodology, event monitoring, case studies, and advances in knowledge related to these topics.

This special issue is composed of six articles covering six coastal regions of the world and addressing key points aligned with the themes of flood risk and resilience in coastal zones and tropical islands.

The article entitled 'Effect of river cleaning on lowland drainage in South-Eastern Sumatra' (Aprialdi et al., 2023) presents concrete results that address the challenges of coastal and island risks:

In tropical coastal regions, flood risks are exacerbated by the combined effects of climate change (sea level rise, increased rainfall) and local dynamics such as land subsidence. This article examines the case of south-eastern Sumatra (Indonesia), a coastal marshland area heavily affected by tides and logging (eucalyptus plantations), where drainage management is crucial to limiting hydrological risks.

The study conducted along the Lebong Hitam River aimed to assess the impact of riverbed cleaning—defined here as the removal of invasive aquatic vegetation (including *Phragmites karka*, water hyacinth, and pandanus)—on the performance of the drainage network. Five observation stations were used to continuously monitor water levels, flow velocities, flow rates, and bathymetry before and after the intervention, between December 2018 and July 2019.

The results are clear: before cleaning, the dense vegetation slowed the flow to such an extent that the average water

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velocity was well below the critical threshold of 0.75 m/s, promoting stagnation and clogging of the canals. After cleaning a 9 km section (between stations 1 and 2), the hydraulic effects are noticeable:

- At station 2, the flow rate increased from 1.87 to 6.91 m^3/s (a 3.7-fold increase) and the water velocity from 0.01 to 0.06 m/s.
- At station 1, the average water level decreased from 1.2 to 0.7 m, a drop of 42%.
- In the irrigation canals, the drop in water level reached as much as 58% at certain points.
- These improvements were observed without any physical intervention on the depth of the riverbed, demonstrating the effectiveness of simply removing vegetation.

However, the effect of the clean-up is localized: further downstream (stations 3–5), water levels remain strongly influenced by the tides of the Java Sea, limiting the effect of upstream interventions.

The article highlights the importance of integrating tidal dynamics into the design and maintenance of coastal drainage systems. It demonstrates that, in island or deltaic areas, the combination of simple interventions (such as regular river cleaning) and control structures (flap gates, management by 'drainage windows' during low tide) is essential to ensure hydraulic safety and the viability of agricultural and forestry uses.

In a context where climate models predict a sea level rise of 40–120 cm by 2100 in Indonesia, this type of applied research offers concrete levers for local adaptation to coastal risks, while highlighting the need to reconcile technical interventions, regular maintenance, and the involvement of local communities in water management.

The article 'Modelling economic risk to sea-level rise and storms at the coastal margin' (Eaves et al., 2023) focuses on an economic approach to coastal risks in the United Kingdom:

With sea levels rising and storms intensifying, quantifying economic risks in coastal areas is becoming a crucial issue for spatial planning and adaptation management. This article proposes an innovative method for modeling coastal economic risk by combining marine hazards (sea level rise and extreme events) with exposed property values, based on an empirical model tested in Lincolnshire (United Kingdom).

The study uses detailed geographical data (land use maps, socio-economic data, property and land values, flood protection systems) to simulate potential economic losses under different flood scenarios, taking into account climate change, development policies, and investments in coastal protection.

The results show that:

- In a scenario with no infrastructure improvements, average annual flood losses could double by 2080, reaching over £150 million per year in some areas.
- The most exposed areas are those with high building density, low elevation, and coastal defenses that are already under pressure (ageing dykes, insufficient pumps).
- A sea level rise of 1 m would be enough to temporarily submerge the main residential and agricultural areas if no action is taken.

The main interest of the article lies in its combined approach to natural hazards and economic values, which goes beyond simple physical modeling of flooding to incorporate socio-financial issues. In this respect, the proposed model is a tool for prioritizing adaptation investments, highlighting areas where the cost of damage would exceed that of preventive measures.

The study also highlights the importance of taking social and land dynamics into account: areas where land values are low but densely populated are often overlooked in investment plans, even though they are vulnerable. This dimension raises questions of territorial equity and climate justice.

From a broader perspective, this article contributes to the international debate on integrated coastal management: it illustrates how spatial economic analysis tools can strengthen resilience policies, provided they are combined with reliable data, effective local governance, and long-term planning.

For low-income island or coastal territories, this type of methodology can be adapted at low cost, using local economic proxies (agricultural values, critical infrastructure, ecosystem services) to guide development choices toward effective risk reduction.

The article, 'Extreme skew surge estimation combining systematic skew surges and historical record sea levels on the English Channel and North Sea coasts' (Saint Criq et al., 2023), presents advances in modelling extreme coastal events through the introduction of historical data.

In the context of climate change, extreme coastal events, particularly marine submersion, pose a growing threat to coastal and island areas. Saint Criq et al. (2023) propose a major methodological advance to better estimate extreme surges ('skew surges') on the coasts of the English Channel and North Sea. These surges, caused by storms, add to astronomical tides and can lead to devastating floods, as evidenced by numerous historical floods in these regions.

The aim of the study is to rigorously combine recent instrumental data and historical information on extreme sea levels in order to improve the assessment of rare surge quantiles (typically for return periods of 100–1000 years). To this end, the authors have developed an innovative Bayesian approach called HSL (Historical Sea Levels). This approach allows for the integration of historical data that is often incomplete or imprecise (censored values, intervals, qualitative mentions of non-submersion) while taking into account their uncertainty.

The article illustrates the application of this method at nine French and Belgian coastal sites, such as Le Havre, Boulogne-sur-Mer, Saint-Malo, and Ostend. For example, in Boulogne-sur-Mer, an exceptional storm surge was documented on 12 March

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1906, when the sea level reached 3.27 m above hydrographic zero. This level, integrated into the HSL model, makes it possible to better constrain estimates of extreme storm surge quantiles, which would otherwise be extrapolated from modern data covering a period of only 30–70 years.

Another striking example concerns Le Havre, where the period 1882–1953 shows no mention of significant flooding. This information, although indirect, is statistically integrated into the model as an absence of exceedance of a given threshold, helping to reduce uncertainties about extreme quantiles. In this case, the addition of historical data reduces the credibility interval for the 100-year storm surge by more than 30%.

The authors also show that the method is robust in the face of heterogeneous data quality. In Saint-Malo, several historical observations are known in the form of uncertain intervals (e.g., a storm surge between 2.0 and 2.5 m). Despite these inaccuracies, their integration into the model significantly improves the results.

The main contribution of the study is therefore twofold. Methodologically, it proposes a rigorous and transparent framework for making the best use of often under utilized historical data. Operationally, it provides risk managers with a better estimate of extreme hazards, which is essential for calibrating protective structures, urban planning, and climate change adaptation policies.

In short, this approach helps to strengthen the resilience of coastal and island territories by mobilizing all available sources of knowledge, including those from historical archives. It is a particularly valuable tool in highly vulnerable areas with a rich heritage, such as the coastlines of northwestern Europe.

The article 'Multiobjective programming model for a class of flood disaster emergency material allocation' (Huang et al., 2023) addresses the issue of making resources available to deal with coastal flooding:

In a context of intensifying extreme weather events, flood management, particularly in coastal and island areas, is a strategic issue. The article by Huang et al. (2023) proposes an innovative multi-objective model to optimize the allocation of emergency materials during flood-related disasters, simultaneously integrating multiple rescue centers, multiple disaster sites, and multiple types of supplies.

The major contribution of the article lies in the development of a mathematical programming model that seeks to minimize three objectives:

1. Economic losses during the response phase (before the arrival of relief efforts),
2. Losses during the recovery phase,
3. The total transport time for relief efforts.

A concrete case is analyzed: a flood simulation affecting six cities in the coastal province of Jiangsu (China)—including Nanjing, Zhenjiang, and Wuxi—with five logistics centers. The scenario is based on real data on rainfall, GDP, urban infrastructure, and material needs, including 10 types of essential supplies (rescue clothing, stone blocks, masks, food, etc.). For example, in Nanjing, immediate needs are identified for 7000 masks and 3000 food rations, and an initial stock of 30,000 masks can be mobilized from the Zhenjiang logistics center.

The model takes into account the continuous consumption of resources at the affected sites, modeling the dynamics of shortages with a system based on the 'material gap' theory. It also distinguishes between two types of economic losses:

- Those in the reactive phase, modeled using an exponential function correlated with hourly rainfall (e.g., $Pj = -0.01793 + 0.02554 * e^{(0.00631 * E * t)}$);
- Those in the recovery phase, weighted according to the strategic importance of resources (medicines, food, etc.) and the duration of the deficit.

The model is solved using a hybrid method combining the NSGA-II genetic algorithm and TOPSIS classification. In the simulation, 49 Pareto compromise solutions are obtained, among which the one minimizing overall losses leads to a substantial saving of 1.2 million yuan compared to the minimum transport time scenario. The optimal strategy identified recommends, for example, that Jurong, although peripheral, supply 2100 blocks of stone, while Suzhou focuses on sending masks and food to denser urban areas.

In terms of coastal and island issues, this model is directly transferable. It addresses the critical needs of logistical anticipation, equitable resource allocation, and reduction of economic losses in vulnerable territories, which are often subject to accessibility constraints and increased exposure (port areas, inhabited islands). The integration of local climate variables and socio-economic data allows the model to be customized to specific contexts.

The article 'Spatial Assessment of Territorial Resilience to Floods Using Comprehensive Indicators: Application to Greater Papeete (French Polynesia)' (Bourlier et al., 2025) proposes an approach for assessing Papeete's resilience to coastal and river flooding:

Faced with an increase in hydrometeorological disasters, coastal and island territories must rethink their risk management strategies. The study by Bourlier et al. (2025) proposes an innovative cartographic approach to assessing territorial resilience to flooding, applied to Greater Papeete on the island of Tahiti, French Polynesia. This territory concentrates the vulnerabilities characteristic of tropical islands: disorderly urbanization of coastal plains, exposure to flash floods and marine submersion, and complex governance between the French State and local authorities.

The study's major contribution is methodological. The authors have developed a grid of 22 spatialized indicators, divided into three dimensions of resilience:

1. Socio-economic (e.g., age, employment, access to services),

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2. Infrastructure (e.g., age and materials of buildings, vulnerability of road and electricity networks),
3. Organizational (e.g., presence of risk management plans, accessibility of emergency services).

For example, the 'date of construction of buildings' indicator reveals that the coastal areas of Papeete are mainly composed of buildings constructed before 1997, which are therefore less resistant to flooding than areas located at higher altitudes. Similarly, the analysis of the vulnerability of the electricity network identifies transformers at risk of causing major power cuts, using spatial processing based on Voronoï tessellation.

The originality of the work also lies in the integration of a dual hazard scenario combining marine submersion and torrential flooding, which is highly relevant for islands exposed to cyclones. This approach makes it possible to estimate resilience scores by statistical district, taking into account both the intrinsic potential of the territory and its exposure to hazards.

The results show significant intra-urban heterogeneity: inland neighborhoods, although better equipped, are sometimes isolated in times of crisis, while coastal areas, which are more exposed, lack adequate infrastructure. This detailed analysis makes it possible to target investments (e.g., improving access to refuge areas or modernising critical technical networks).

The proposed approach has strong potential for portability to other tropical island or coastal territories (Caribbean, Indian Ocean, Pacific) facing similar issues. It constitutes a decision-making tool for local authorities, supporting land use planning, prevention, and climate change adaptation policies.

Finally, the article 'Measuring the Degree of "Fit" Within Social-Ecological Systems to Support Local Flood Risk Decision-Making' (Hobbs et al., 2025) proposes an approach to guide local actions to combat coastal flooding:

The article by Hobbs et al. (2025) makes an innovative contribution to local flood risk management by proposing a quantitative method for assessing the fit between institutional actions and socio-ecological dynamics, a concept known as Social-Ecological Fit (SEF). This concept is particularly relevant in coastal and island contexts, where natural hazards (marine submersion, flash floods) interact strongly with social, cultural, and economic issues.

The case study focuses on the North Onslow marshland area in Truro, Nova Scotia (Canada), which is frequently subject to severe flooding due to the combined effect of the world's highest tides (Bay of Fundy), ice jams, river sedimentation, and construction in floodplains. A major event in 2013 caused $3.5 million in damage alone.

To assess the resilience of this system and guide local decisions, the authors implement a Bayesian belief network (BBN). This probabilistic model graphically represents the interactions between social factors (dyke management, decision-makers' knowledge, development projects, budgetary constraints) and ecological factors (frequency of tides, ice jams, extreme weather events, presence of salt marshes).

Three key variables are identified as critical to reducing flood risk in the region:

1. A low frequency of ice jams.
2. A reduction in extreme tides.
3. The removal of dykes (and the restoration of salt marshes).

The authors show that in 100% of the 32 scenarios where the risk of flooding was lowest (out of 256 simulations), these three conditions were met. These results support the controversial strategy of restoring salt marshes to partially replace historic dykes. This measure not only provides natural flood mitigation but also improves biodiversity and carbon storage.

The study also highlights that social factors, such as the level of knowledge of decision-makers or land pressure linked to urban development, have an impact comparable to that of ecological parameters. Thus, more informed, adapted, and concerted governance improves the 'fit' between institutions and natural systems.

This work offers a reproducible method that can be adapted to island or coastal contexts faced with trade-offs between protection against hazards, agricultural or land use, and ecosystem preservation. The BBN used here is a powerful decision-making tool that allows the combined effects of decisions on risk to be visualized and quantified, while integrating uncertainties, expert knowledge, and local data.

In conclusion, this approach equips territories vulnerable to climate change by strengthening their capacity to coordinate social and ecological responses in a coherent, localized, and data-driven manner.

To conclude, these six very interesting articles are proposing great advances and examples in terms of coastal and island resilience to floods. Several dimensions of risks and hazard types are addressed, and of course different methods and approaches are proposed which answer the scope of this special issue. In terms of perspectives, more embedded and systemic approaches may help improve coastal and island resilience and adaptation: maybe a future Special Issue in that direction?

Data Availability Statement

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

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