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IMPLEMENTING FLOOD-RESISTANT DESIGN STRATEGIES IN COASTAL REGIONS

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ABSTRACT

This systematic review synthesizes findings from 85 articles to examine flood-resistant design strategies in coastal regions, emphasizing an integrated approach that combines traditional engineering solutions, nature-based strategies, green infrastructure, adaptive design, and predictive modeling. The review identifies a continuing reliance on engineered defenses, such as seawalls and automated floodgates, which have proven effective but are limited in addressing the escalating impact of climate change. Findings highlight the growing importance of nature-based solutions—wetlands, mangroves, and coral reefs—that not only mitigate flood risks but also enhance biodiversity and long-term sustainability. Green infrastructure, including permeable pavements and rain gardens, emerges as a valuable urban solution, although it faces implementation challenges in densely populated areas. The integration of predictive modeling and real-time data is transforming flood management by enabling proactive and adaptive responses, though these technologies remain financially inaccessible for many regions. Comparative analysis underscores that flood-resilient design is highly context-dependent, with successful practices varying based on local geography, resources, and socio-economic factors. This review concludes that future flood-resilient infrastructure must prioritize adaptable, sustainable, and region-specific solutions, highlighting the need for cross-disciplinary collaboration and continued policy support to enhance flood resilience and protect vulnerable coastal communities against the effects of climate change.

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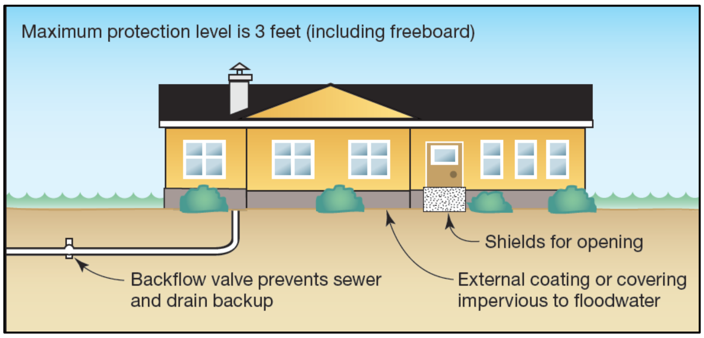
1 Introduction

Climate change and its intensifying effects have increasingly impacted coastal regions, necessitating a profound shift in infrastructure design to prioritize flood resistance (Svatoš-Ražnjević et al., 2022). Coastal areas are particularly vulnerable to climate-induced hazards, such as rising sea levels, intensified storms, and frequent flooding, which jeopardize both human safety and infrastructure integrity (Díaz-López et al., 2019). Research on climate resilience indicates that infrastructure in coastal cities is under escalating threat, prompting urban planners and policymakers to incorporate flood-resistant strategies into development plans as a fundamental approach to sustainable urban growth (Mandle et al., 2017). Historically, responses to flooding focused on surface drainage and levees; however, modern-day strategies involve more comprehensive solutions that integrate engineered barriers, green infrastructure, and community engagement (García-Ruiz et al., 2024). These developments have shaped an interdisciplinary framework, blending environmental science, urban planning, and civil engineering to create infrastructures that can withstand the increasing frequency and severity of flood events (Díaz-López et al., 2019).

The evolution of flood-resistant design strategies over the past few decades highlights a significant transformation from simplistic structural solutions to complex adaptive systems (Casado-Aranda et al., 2020). Early flood management efforts mainly relied on robust physical structures, such as seawalls and levees, which aimed to act as barriers against water intrusion (Cobo et al., 2011). However, rigid structural barriers often show limitations, especially in high-density urban areas where space constraints and high population density make large-scale physical interventions less feasible (Labaran et al., 2022). This shift has led to a renewed interest in "soft" engineering solutions, like coastal vegetation and wetlands, that are naturally resilient to floods and can absorb significant amounts of floodwater (Barragán & de Andrés, 2015). Recent designs advocate a hybrid approach that blends hard and soft infrastructure, providing a balanced method that leverages ecological systems and engineered defenses to enhance resilience and reduce flood-related disruptions (Duan et al., 2016). To achieve long-term flood resilience, contemporary designs also incorporate adaptive and predictive strategies, moving beyond purely reactive infrastructure. Recent studies have emphasized climate-adaptive planning, which uses data analytics and predictive modeling to anticipate changes in sea levels and rainfall patterns, allowing designers to create systems that adapt to evolving risks (Abadie et al., 2020). Innovative flood-resistant designs now include floating structures, buildings on stilts, and elevated infrastructure, demonstrating how flexible, adaptive architecture can minimize flood damage in vulnerable coastal areas (Cobo et al., 2015). Such advancements illustrate a paradigm shift from merely protecting assets to designing infrastructure that inherently reduces vulnerability to natural hazards, a shift critical for coastal cities facing the accelerating impacts of climate change (Kim, 2020). These modern approaches highlight the importance of designing with a forward-thinking mindset to accommodate fluctuating environmental conditions.

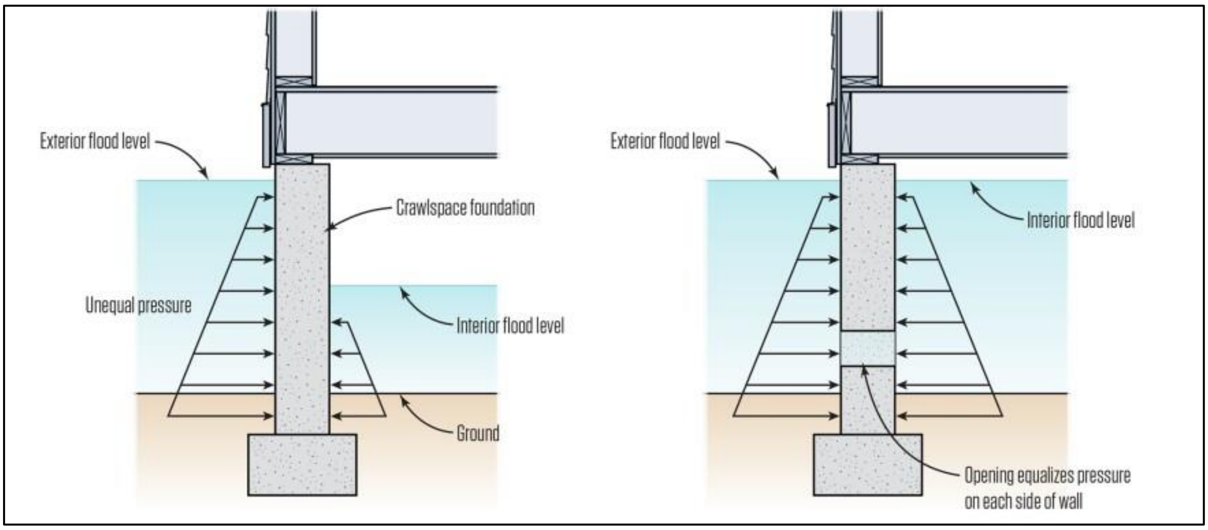
Figure 1: Dry Floor Proofed Structure



Source: Rubin (2022)

Flood-resistant design has also evolved to encompass community and policy-driven approaches, fostering resilience beyond the physical structure alone (Duan et al., 2016). Integrating community engagement into the design process allows stakeholders to contribute valuable local knowledge, ensuring that solutions meet the specific needs of the community (Grimaldi et al., 2019). Recent studies suggest that flood resilience is enhanced when there is collaboration between policymakers, planners, and local residents to develop adaptive zoning regulations, insurance incentives, and urban greening initiatives that support flood resilience at multiple levels (Abadie et al., 2020). Effective flood-resilient policies further align governmental, industrial, and community goals, enabling infrastructure solutions that are not only robust but also economically viable and socially accepted (Molina et al., 2020). These policies, coupled with infrastructural design, help coastal communities achieve greater adaptability to extreme weather events and establish a foundation for long-term resilience. The aim of this study is to systematically review and synthesize existing research on flood-resistant design strategies in coastal regions, adhering to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Following PRISMA's four-step process—identification, screening, eligibility, and inclusion—this review aims to consolidate findings across multidisciplinary studies, identifying effective design approaches, emerging innovations, and challenges in implementing flood-resilient infrastructures. The identification phase will focus on gathering relevant studies from databases, using keywords like "flood resilience," "coastal infrastructure," and "nature-based solutions." In the screening stage, articles will be assessed based on predefined inclusion criteria, including relevance to coastal flood management, methodological rigor, and publication recency. Next, the eligibility phase will involve in-depth analysis to exclude articles lacking empirical evidence or specificity to coastal environments. Finally, the inclusion stage will compile the most pertinent studies, with a comprehensive synthesis of findings to provide a current and detailed understanding of flood-resistant design evolution and its practical implications in mitigating flood risks in coastal regions. This PRISMA-guided approach ensures methodological transparency and a robust foundation for evidence-based recommendations in flood-resistant infrastructure design.

Figure 2: Controlling Hydrostatic Pressure



Source: Tim Healey (2022)

2 Literature Review

The increasing risks of flooding in coastal regions have led to a significant body of research on flood-resistant design strategies, driven by concerns for human safety, infrastructure resilience, and environmental sustainability. This section synthesizes existing studies to provide a comprehensive understanding of flood vulnerabilities in coastal areas, the impact of climate change, and innovative flood mitigation approaches. Specifically, the literature review examines the evolution of flood-resistant design strategies, focusing on both traditional structural defenses and newer adaptive, nature-based solutions. By investigating multidisciplinary insights from environmental science, engineering, and urban planning, this review aims to highlight effective design practices, explore the challenges of implementation, and offer insights into enhancing coastal community resilience. The following outline presents a detailed structure of this literature review, organized to systematically address each aspect of flood-resistant design strategies.

2.1 Historical Context

The historical impact of floods in coastal regions has demonstrated the critical need for resilient

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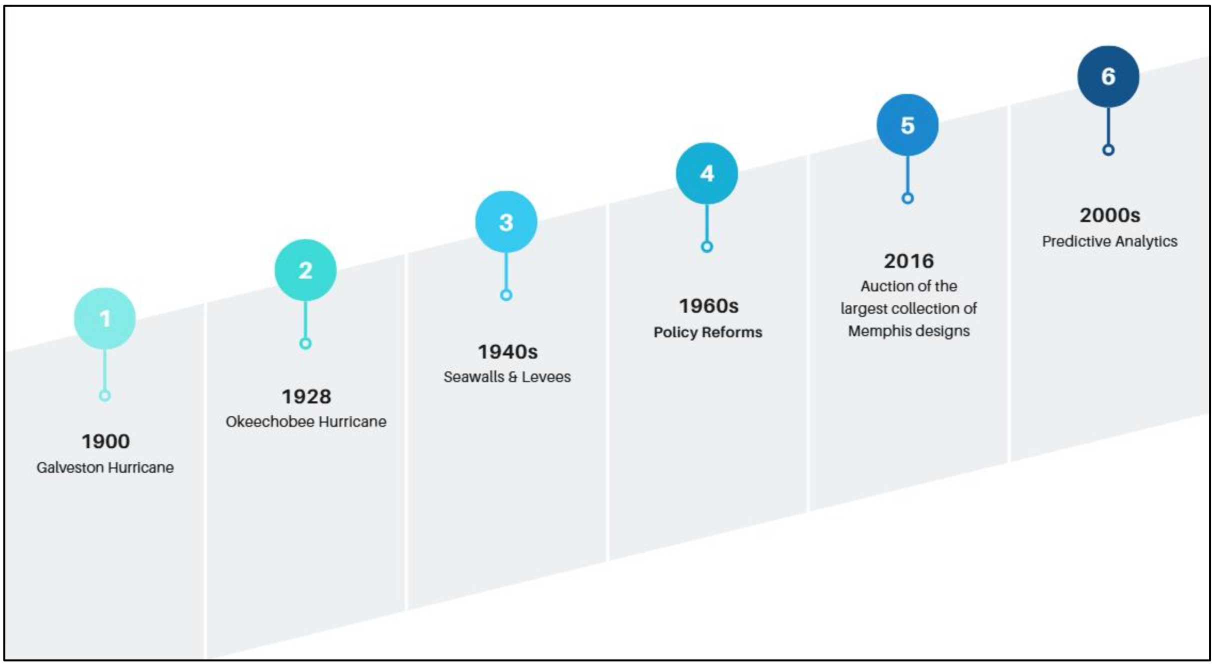
infrastructure, as seen in some of the most destructive natural disasters of the past century. The Great Hurricane of 1900 in Galveston, Texas, serves as a prime example, where the catastrophic flood led to the loss of thousands of lives and destroyed entire communities (Grimaldi et al., 2019). This disaster highlighted the vulnerabilities of coastal cities, urging a transformation in flood protection measures (Molina et al., 2020). Following this tragedy, investments in flood defense strategies, such as levees and drainage systems, became a focal point for protecting urban populations and assets (Nekooie et al., 2017). The Okeechobee hurricane of 1928 further underscored this need, resulting in over 2,500 fatalities in Florida and prompting state and federal initiatives to strengthen flood control infrastructure in high-risk areas (Thomé et al., 2016). These early events catalyzed a shift in coastal management, emphasizing engineering solutions aimed at enhancing resilience to similar disasters in the future (Kim, 2020).

The response to these disasters drove advances in engineering and urban planning, integrating large-scale structural defenses to mitigate future flood risks. Seawalls, levees, and floodgates became standard protective measures, laying the groundwork for modern flood-resilient infrastructure in coastal areas (Thomé et al., 2016). The construction of seawalls, notably in places like Galveston and New Orleans, is a testament to how past experiences influenced flood-protection strategies, providing a physical barrier against storm surges (Rosenzweig et al., 2011). These structures aimed to protect human life and property while reinforcing coastal areas' resilience against intense storms (Zhu & Zeng, 2018). Moreover, advances in drainage systems further supported urban flood management, ensuring that water from heavy rainfall events could be efficiently redirected, thereby minimizing risks to densely populated coastal cities (Win et al., 2018). Studies show that these engineered responses reduced the impact of storms on communities, establishing a model of flood defense that would be adapted globally (Nekooie et al., 2017).

In addition to structural solutions, historical flood events also shaped regulatory changes in building codes and urban planning policies, prioritizing safety and resilience. Building regulations began mandating elevated construction in flood-prone areas, driven by the lessons learned from previous disasters (Verichev et al., 2021). For example, studies show that following severe floods, regulatory agencies in the United States began enforcing elevated foundations, particularly for buildings in low-lying coastal zones, to reduce the risk of water damage (Salazar-Concha et al., 2021). This proactive approach has proven instrumental in reinforcing infrastructure resilience, aligning urban planning with disaster prevention measures (Nalbandian et al., 2021). These regulations are not only preventive but are also an adaptive response to evolving climate

Figure 3: Timeline of Key Milestones in Flood-Resistant Design for Coastal Regions



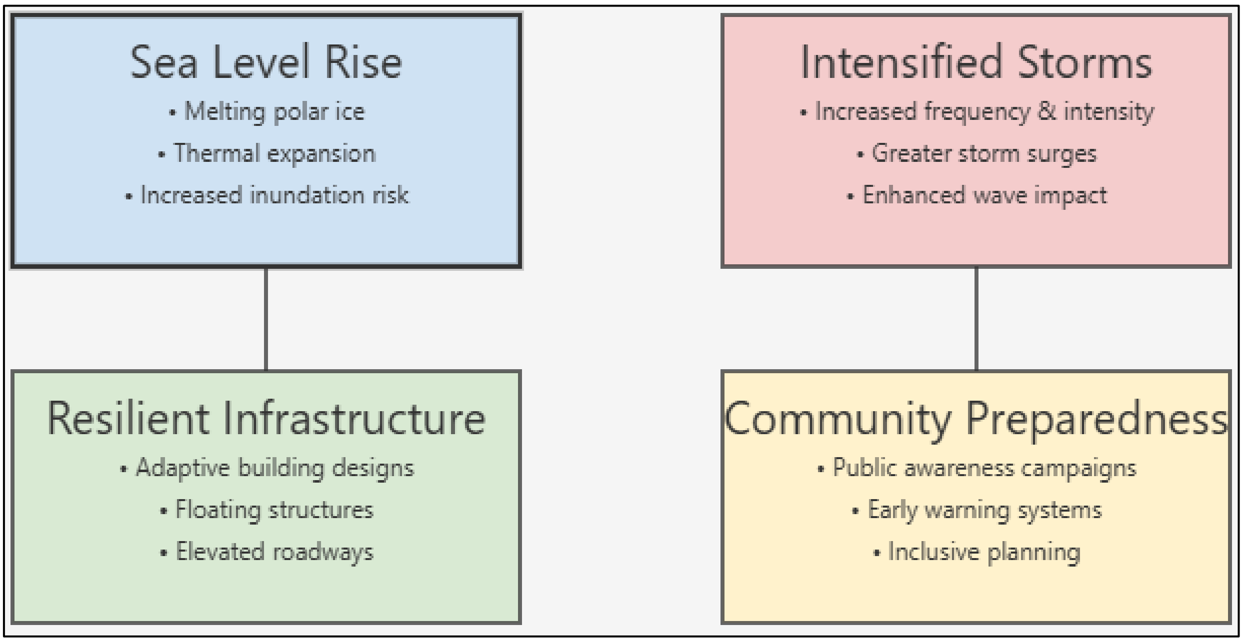
conditions, ensuring that modern buildings are designed to withstand potential flood events (Ojea, 2015). As awareness of climate change grows, these codes continue to evolve, reflecting an ongoing commitment to integrating past experiences into future coastal infrastructure.

The historical trajectory of flood-resistant design in coastal regions underscores the importance of long-term investment and proactive planning. The lessons learned from early 20th-century floods continue to shape contemporary approaches, blending structural defenses with policy reforms that address evolving flood hazards (Barragán & de Andrés, 2015). While early measures were largely reactive, modern flood resilience strategies are grounded in predictive analytics and climate models, informing designs that anticipate rather than merely respond to environmental threats (Salazar-Concha et al., 2021; Shamim, 2022). This shift represents a maturing approach in flood management, one that merges engineering ingenuity with data-driven planning to safeguard coastal populations effectively (Duan et al., 2016). By reflecting on past events and integrating advanced design principles, urban planners and engineers are working toward creating coastal communities that are not only resistant to flooding but are also sustainable and adaptive to future climate challenges (Svatoš-Ražnjević et al., 2022).

2.2 Flood Vulnerabilities in Coastal Regions

Flooding presents a significant vulnerability for coastal regions due to their unique geographic and climatic conditions. The rising sea levels driven by climate change have intensified the risk of inundation, particularly in low-lying areas where even slight increases in sea level can drastically impact ecosystems and human settlements (Cobo et al., 2011). According to Li et al. (2013), coastal zones account for nearly 10% of the global population, increasing the urgency of addressing flood risks. Urban coastal areas, with their concentrated populations and infrastructure, are particularly susceptible to flood hazards, which not only threaten human life but also pose severe economic and environmental risks (Barth & Döll, 2016). Studies have documented that this concentration of population and assets in flood-prone regions is due to the historical economic advantages of coastal locations, despite the associated natural hazards (Grimaldi et al., 2019). Thus, an understanding of the specific vulnerabilities of these regions is crucial for developing targeted flood mitigation strategies. Key factors contributing to the increased flood risk in coastal regions include sea level rise, intensified storm frequency and intensity, and climate variability. Sea levels are rising at an unprecedented rate, driven by melting polar ice and thermal expansion of seawater due to global warming, which has exacerbated flood risks for coastal

Figure 4: Flood Vulnerabilities in Coastal Regions



communities (García-Ruiz et al., 2024). This increase in sea level heightens the potential for storm surges to reach further inland, causing more extensive damage during storm events (Michel-Kerjan et al., 2014). Furthermore, extreme weather patterns, such as more frequent and intense storms, are compounding these effects by increasing the force and height of waves hitting coastal areas, as observed in studies focusing on Atlantic hurricane intensity (Vitousek et al., 2017). These factors underscore the interconnectedness of climate dynamics and coastal flood vulnerability, highlighting the need for adaptive measures that address both long-term sea level rise and short-term storm impacts (Gelman et al., 1995).

The need for resilient infrastructure has become a critical aspect of flood management in coastal regions, as traditional flood defenses are often insufficient to handle the increasing intensity of these climate-related events. Coastal defenses like seawalls and levees, while initially effective, are proving less capable of withstanding the more frequent and intense storms associated with climate change (Ojea, 2015). Innovations in resilient infrastructure, such as adaptive building designs, floating structures, and elevated roadways, are gaining attention as viable alternatives to traditional flood defenses (Li et al., 2013). These strategies are further supported by regulatory changes that mandate flood-resilient building codes and land-use planning, promoting sustainable development in high-risk areas (Rosenzweig et al., 2011). Recent studies indicate that resilient infrastructure can significantly reduce the economic and social impacts of floods by safeguarding essential services and reducing the time needed for community recovery after flood events (García-Ruiz et al., 2024; Rosenzweig et al., 2011).

Protecting communities in coastal regions goes beyond engineering solutions; it also requires an emphasis on community safety and public awareness to mitigate flood risks effectively. Public awareness campaigns and disaster preparedness programs are essential for ensuring that residents understand flood risks and take preventive actions (Grimaldi et al., 2019). For instance, early warning systems and evacuation protocols are critical in minimizing loss of life and property during flood events (Abadie et al., 2020). Furthermore, community engagement in planning and implementing flood resilience measures helps align infrastructure investments with local needs and priorities (Wang et al., 2014). Studies also highlight the importance of inclusive planning that addresses social inequalities, ensuring that vulnerable populations have access to the resources needed to adapt to and recover from flooding events (Grimaldi et al., 2019). Such holistic approaches to flood resilience encompassing infrastructure, regulatory, and social dimensions—are essential for reducing the vulnerabilities of coastal regions to flooding.

2.3 Impact of Climate Change on Coastal Flooding

Rising sea levels represent one of the most pressing climate change challenges for coastal regions, driven primarily by melting polar ice and the thermal expansion of seawater (Deegan et al., 2012). Research shows that these mechanisms have accelerated, leading to projections of significant sea-level increases over the coming decades, which will disproportionately impact low-lying coastal areas (Labaran et al., 2022). As sea levels rise, so too does the susceptibility of coastal communities to inundation, which places homes, businesses, and critical infrastructure at risk (Ellis et al., 2010). Studies highlight that even minor rises in sea level can dramatically alter coastal landscapes, leading to chronic flooding and saltwater intrusion into freshwater systems, further stressing community resilience (Verichev et al., 2021). The vulnerabilities of low-lying areas are compounded by population density and economic reliance on coastal resources, underscoring the need for targeted measures to address both immediate and long-term threats posed by sea-level rise (Barth & Döll, 2016).

In addition to gradual sea-level rise, extreme weather events increasingly amplify flood risks in coastal regions. Storm surges, often resulting from hurricanes, typhoons, and tropical cyclones, can elevate sea levels several meters above normal, inundating large areas of land in a short time (Ojea, 2015). Research on storm surge dynamics reveals that the height and impact of these surges are influenced by both atmospheric conditions and the underlying topography of the coastal region (Vitousek et al., 2017). Studies have shown that the intensity of storms has increased, likely due to warmer ocean temperatures that fuel stronger winds and increase moisture, which exacerbates flooding (Lai et al., 2015). The combination of intensified storms and higher sea levels increases the potential for catastrophic flooding, as demonstrated by recent hurricanes in the Atlantic, which have left lasting impacts on affected coastal areas (Bilskie et al., 2014). This trend

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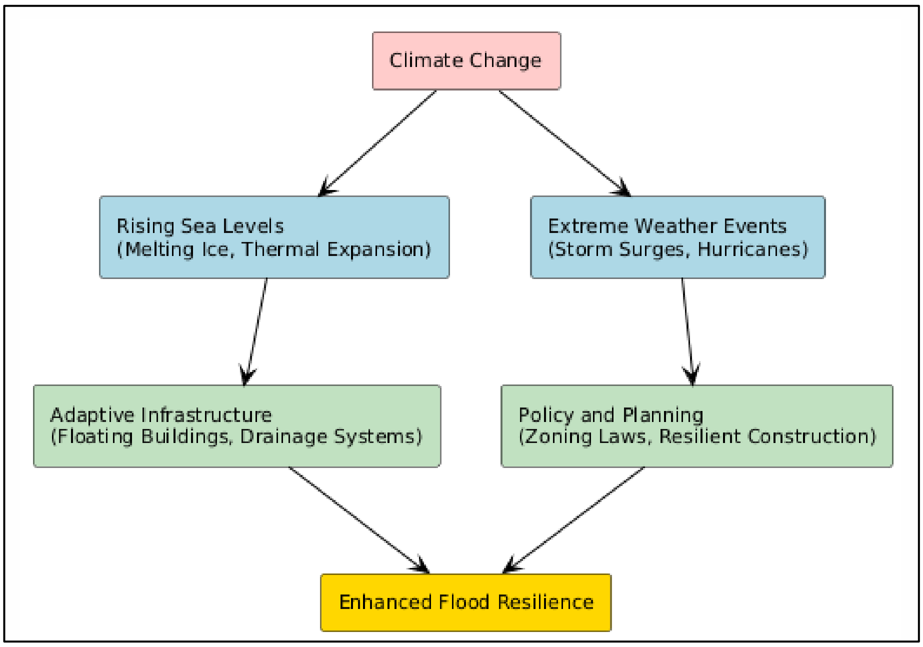
underscores the importance of preparing for extreme events, which are no longer isolated incidents but rather recurring threats in the context of climate change (Gunnell et al., 2019).

The long-term impacts of climate change on coastal regions emphasize the critical need for adaptive infrastructure designed to withstand these evolving conditions. Coastal communities face projections of not only rising sea levels but also more frequent and severe storm events, placing increasing strain on traditional flood defenses such as seawalls and levees (Bilskie et al., 2014). Research suggests that to remain effective, flood defenses must transition from rigid, one-size-fits-all solutions to adaptive infrastructure that can respond dynamically to changing environmental pressures (Michel-Kerjan et al., 2014; Molina et al., 2020). Adaptive designs, such as elevated buildings, floating structures, and flexible drainage systems, are becoming central to coastal planning, providing resilience against both current and future flood risks (Liu et al., 2003). Such approaches align with climate projections, which call for infrastructure that can adjust to climate conditions over the long term, ultimately reducing the frequency and impact of flood-induced disruptions in coastal areas (Abadie et al., 2020). The urgency for climate adaptation in coastal regions is underscored by projections that coastal flooding will continue to escalate, with substantial implications for both human and ecological systems. Studies have demonstrated that without adaptive responses, the costs associated with flood damage will rise considerably, threatening the economic viability of coastal communities (Deegan et al., 2012). Investing in adaptive infrastructure, such as stormwater management systems and sustainable land-use planning, is essential to protect these areas and maintain community resilience (Cheng et al., 2018). Additionally, proactive policy changes, including stricter zoning laws and incentives for resilient construction, are crucial for long-term flood management in these vulnerable regions (Nicholls & Hoozemans, 1996). The convergence of scientific research, engineering advancements, and policy reforms will be essential for creating a resilient framework capable of protecting coastal communities from the ongoing and future impacts of climate change (Luo & Wei, 2009)

Figure 5: Climate Change Impact on Coastal Flooding: Drivers & Resilience



2.4 Nature-Based Solutions in Flood-Resistant Design

Nature-based solutions, particularly coastal ecosystems, play a critical role in mitigating flood risks in coastal areas by serving as natural barriers against rising sea levels and storm surges. Wetlands, mangroves, and coral reefs are especially effective at absorbing wave energy, thus reducing the force of water reaching inland areas (Wahl et al., 2015). Studies have shown that wetlands

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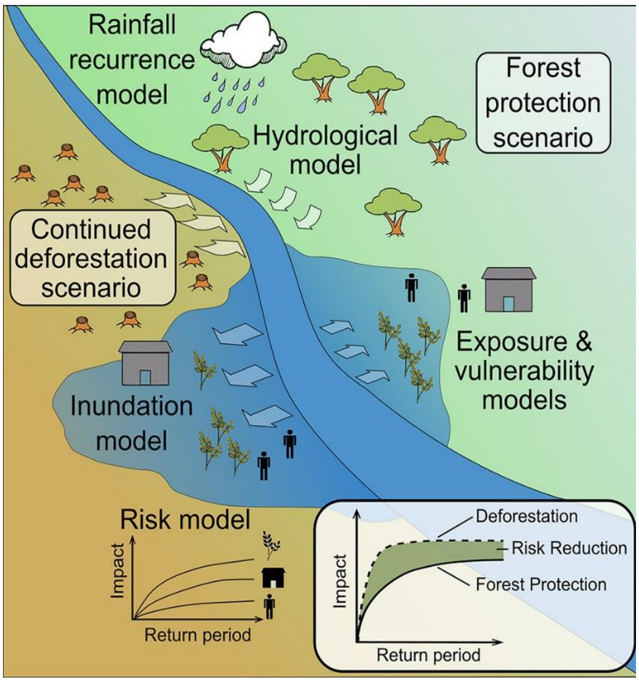
can decrease wave heights by as much as 60%, while mangroves provide significant protection against high waves and storm surges due to their dense root systems and above-ground structures (Dewan & Yamaguchi, 2009; Lomnitz, 2004). Coral reefs also act as natural breakwaters, dissipating wave energy before it reaches the shore, which is especially beneficial for densely populated coastal regions(Wagenaar et al., 2020) Collectively, these ecosystems provide a cost-effective, sustainable solution to flood risks, underscoring the importance of conserving and restoring them to protect vulnerable coastal communities (Bhagwat et al., 2017).

Green infrastructure, another key nature-based solution, has emerged as an essential component of flood prevention and urban resilience. This approach integrates natural elements, such as parks, rain gardens, and green roofs, into urban planning to manage stormwater and reduce urban flooding (Lorie et al., 2020). For instance, green infrastructure can help absorb rainfall, minimizing surface runoff that would otherwise contribute to flooding in urban areas (Lallemant et al., 2021). Cities like New York and Singapore have implemented extensive urban greening initiatives as part of flood control strategies, illustrating the effectiveness of green infrastructure in reducing flood risks and providing recreational spaces for the community (Stürck et al., 2014). By enhancing permeability and improving stormwater management, green infrastructure contributes to both environmental sustainability and urban resilience, offering dual benefits for flood prevention and community well-being (Latt & Wittenberg, 2014; Stürck et al., 2014; Wahl et al., 2015). Moreover, restoration of coastal habitats is integral to strengthening flood resilience and providing ecological and social benefits. Restoring degraded habitats such as wetlands and mangroves not only enhances natural flood defenses but also supports biodiversity and provides essential ecosystem services, including carbon sequestration and water purification (Filoso et al., 2017). For example, large-scale wetland restoration projects in Louisiana have demonstrated both flood mitigation and ecological benefits, helping to protect nearby communities from hurricanes while also reviving fish and bird populations (Komolafe et al., 2015). These restoration efforts create habitats that are better adapted to withstand future climate impacts, reinforcing both the natural environment and the resilience of human communities (Paté-Cornell, 2002). However, large-scale habitat restoration poses challenges, including high costs and the need for long-term maintenance and monitoring, which are essential to ensure these benefits are sustained over time (Abdulkareem et al., 2018).

Figure 6: Flood Risk and Green Infrastructure Models



Source: Lallemant et al. (2021)

2.5 Engineering Innovations in Flood-Resilient Design

Advancements in storm surge barriers and coastal defenses have become central to flood-resilient engineering, with high-tech barriers and automated floodgates emerging as crucial innovations. These barriers, such as the Maeslantkering barrier in the Netherlands and the Thames Barrier in London, utilize automated systems to deploy massive floodgates during high-risk weather events, protecting urban areas from devastating storm surges (Morales-Beltran et al., 2023). Such engineered solutions are especially effective in densely populated coastal cities, as they provide strong, immediate protection against rising water levels while allowing for regular water flow during non-flood periods (Q et al., 1994). Studies highlight the efficiency of these structures in managing storm surges, and their success has inspired similar projects worldwide, including the MOSE Project in Venice (Dyckman et al., 2014). As urban populations along coastlines continue to grow, the implementation of automated barriers represents a vital approach in safeguarding critical infrastructure and reducing flood vulnerability (Morales-Beltran et al., 2023).

Predictive modeling and data analytics are playing a transformative role in modern flood-resilient design by enabling accurate risk assessments and real-time decision-making. Predictive analytics harness vast datasets, including weather patterns, sea level data, and flood history, to simulate potential flood events, allowing engineers to design infrastructure that anticipates future risks (Shah et al., 2020). For instance, cities like Rotterdam have incorporated predictive modeling in their flood management systems, creating adaptive plans that adjust based on forecasted conditions (Stergiou & Kiremidjian, 2010). The integration of real-time data through sensors and monitoring networks has further enhanced the adaptability of these systems, enabling authorities to respond proactively to flood risks (Shah et al., 2020). This data-driven approach aligns with the shift towards smart infrastructure, where real-time data improves the flexibility and responsiveness of flood defenses, thereby strengthening urban resilience to unexpected weather events (Lallemant et al., 2015).

Smart materials and innovative construction technologies are also advancing flood-resilient design by enhancing structural durability and sustainability. In coastal regions, structures are often exposed to saltwater and other harsh environmental conditions, necessitating the development of materials that can withstand these factors without compromising structural integrity (Stergiou & Kiremidjian, 2010). Recent studies have highlighted innovations in salt-resistant concrete and corrosion-resistant coatings, which are now widely used in flood-prone areas to extend the lifespan of coastal infrastructure (Komolafe et al., 2015). Additionally, advances in sustainable construction materials, such as biocomposites and recycled plastic barriers, are providing eco-friendly alternatives that reduce the environmental footprint of flood-resilient infrastructure (Balogun et al., 2020). These smart materials not only ensure durability but also align with sustainability goals, which are increasingly prioritized in modern urban planning (Su et al., 2019). The integration of high-tech defenses, predictive modeling, and smart materials reflects a comprehensive approach to flood-resilient design, one that combines traditional engineering with cutting-edge technology. By adopting this multidisciplinary approach, urban planners and engineers are better equipped to address the growing complexities of coastal flood risks (Czajkowski et al., 2016). The success of projects like the Thames Barrier and MOSE highlights the potential of these innovations, but there remain challenges in scaling these solutions, particularly in low-income regions where resources may be limited (Lallemant et al., 2015). Despite these challenges, the continuous development of flood-resilient technology points to a promising future, where engineered solutions can be tailored to the unique needs of diverse coastal regions, ultimately protecting communities and infrastructure from the impacts of climate change (Komolafe et al., 2015).

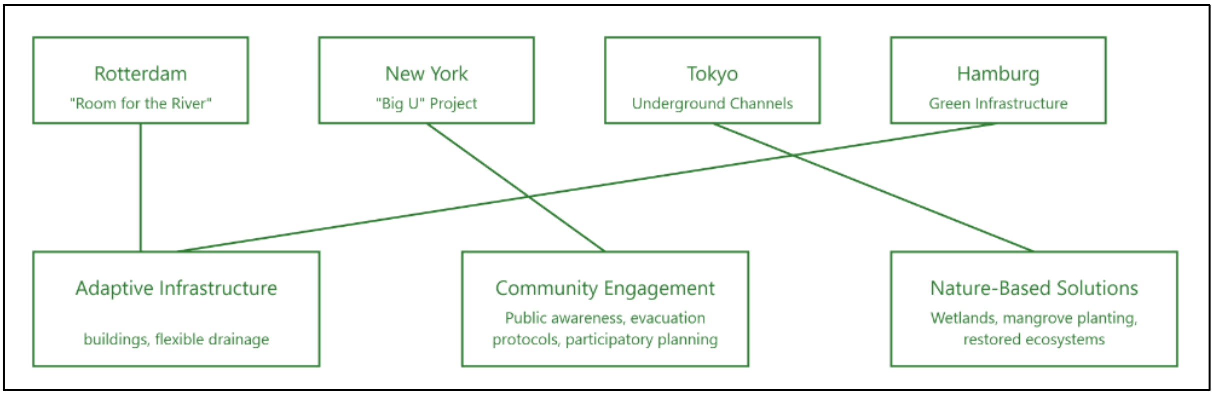
2.6 Comparative Analysis of Global Flood-Resilient Practices

High-risk coastal cities around the world have adopted a variety of flood resilience strategies, with notable successes observed in cities such as Rotterdam, New York, and Tokyo. Rotterdam's flood management approach, known for its innovative "Room for the River" program, integrates water management into urban planning by allowing controlled flooding in designated areas to reduce pressure on city infrastructure (Balogun et al., 2020). Similarly, New York City, after the devastation of Hurricane Sandy, implemented the "Big U" project, which involves a system of barriers, parks, and levees designed to protect Lower Manhattan while enhancing green spaces (Egghe, 2006). Tokyo, facing recurring threats from typhoons, relies on its advanced underground flood protection system, the Metropolitan Area Outer Underground Discharge Channel, which redirects floodwaters to protect urban areas (Bahadur & Tanner, 2014; Islam et al., 2024). These case studies exemplify how targeted, city-specific approaches can address the unique challenges of coastal flooding, demonstrating the effectiveness of combining traditional engineering with natural flood management techniques (Fastelli et al., 2017).

Comparative analyses of flood resilience strategies in these high-risk cities reveal the adaptability and context-specific nature of global flood management practices (Badhon et al., 2023; Uddin, Auyon, et al., 2024; Uddin, Ullah, et al., 2024). In Europe, cities like Hamburg and Copenhagen have developed multi-layered resilience plans that prioritize green infrastructure alongside structural defenses, creating a balance between urban development and ecological preservation (Neal et al., 2012). In contrast, cities in Southeast Asia, such as Bangkok, prioritize rapid water drainage and canal restoration to manage intense rainfall and monsoon-induced floods (Costa et al., 2020). These geographic differences highlight the importance of adapting flood management practices to local environmental conditions, cultural preferences, and available resources. Comparative studies underscore the need for context-sensitive approaches that consider both natural and urban factors, allowing cities to enhance flood resilience without compromising economic or social well-being (Balogun et al., 2020).

International flood management strategies provide valuable lessons on best practices and potential solutions that can be transferred to other high-risk regions. One key takeaway is the importance of integrating multi-functional infrastructure, which not only serves flood protection purposes but also contributes to urban aesthetics and community engagement (Bahadur & Tanner, 2014). For example, the success of multifunctional flood defenses in the Netherlands has led other cities to explore similar approaches that incorporate public spaces into flood barriers, such as parks and recreation areas (Tate et al., 2015). Additionally, many cities emphasize the role of stakeholder collaboration and public participation in flood management, as community involvement has been shown to increase local awareness(Ashrafuzzaman, 2024; Begum et al., 2024; Rozony et al., 2024), improve response readiness, and strengthen support for resilience initiatives (Czajkowski et al., 2016). The experiences of cities like Rotterdam and Hamburg in establishing community-centered resilience plans illustrate the value of participatory approaches in urban flood management (Hamel & Bryant, 2017). The comparative success factors observed in various global flood-resilient practices point to several adaptation strategies that can be widely applied to improve urban flood resilience. Adaptive infrastructure design, community engagement, and real-time monitoring are crucial elements that have proven effective across different contexts, regardless of geographic location (Nandi et al., 2024; Rahman et al., 2024; Stergiou & Kiremidjian, 2010). For example, early warning systems and real-time data monitoring are increasingly recognized as essential tools that can significantly reduce the impact of sudden flood events, as seen in cities such as Jakarta and Miami (Neal et al., 2012). Furthermore, the use of nature-based solutions, such as restored wetlands and mangrove planting, is a transferable practice that has yielded substantial benefits for flood-prone areas in both developed and developing countries (Bahadur & Tanner, 2014). By learning from the varied experiences of global cities, flood-prone regions can adopt a tailored approach to resilience that draws on proven practices while accommodating unique local challenges (Dyckman et al., 2014).

Figure 7: Comparative Analysis of Global Flood-Resilient Practices



2.7 Identified Gaps

Despite significant advancements in flood-resistant design, several gaps remain unaddressed, particularly regarding the long-term sustainability of these structures. Current flood-resilient infrastructure, such as seawalls, levees, and floodgates, often lack adequate strategies for long-term durability, especially in the face of increasingly severe climate events (Wahl et al., 2015). Studies indicate that many traditional defenses are not designed to withstand repeated exposure to extreme weather over extended periods, necessitating frequent maintenance or costly upgrades (Begum et al., 2024; Begum & Sumi, 2024; Lorie et al., 2020; Sah et al., 2024; Sikder et al., 2024). For instance, research has shown that materials used in coastal defenses can degrade rapidly in saltwater environments, leading to compromised structural integrity over time (Watson et al., 2016). Additionally, high-tech barriers, while effective in immediate flood prevention, require substantial financial and energy resources to operate and maintain, raising questions about their long-term feasibility (Abdulkareem et al., 2018). Addressing these sustainability gaps is crucial for developing flood-resistant solutions that provide lasting protection, yet research in this area remains limited, emphasizing the need for more extensive evaluation of durability and life-cycle costs in flood defense infrastructure (Neal et al., 2012).

Another significant gap in flood-resistant design is the need for cross-disciplinary research and collaboration. Effective flood resilience requires input from a range of fields, including engineering, environmental science, urban planning, and social sciences, to address both the physical and socio-economic aspects of flood management (Dykstra & Dzwonkowski, 2020). While engineering advancements have contributed heavily to flood protection, research shows that collaborative approaches, incorporating ecological knowledge and community insights, often yield more comprehensive and adaptable solutions (Cheng et al., 2018). Moreover, cross-disciplinary studies are essential for integrating nature-based and engineered defenses, blending ecological restoration with structural designs to achieve enhanced resilience (Neal et al., 2012). For example, studies suggest that combining natural ecosystems, like wetlands and mangroves, with built infrastructure can reduce maintenance costs and enhance biodiversity, creating a multifunctional approach to flood resilience (Czajkowski et al., 2016). Expanding collaborative research would help bridge existing gaps, facilitating innovations that not only prevent flooding but also contribute to sustainable urban growth and community resilience in coastal areas (Czajkowski et al., 2016; Dadson et al., 2017).

3 Method

This study adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure a systematic, transparent, and rigorous review of literature. The methodology involved a step-by-step process to collect, screen, and analyze relevant studies on flood-resistant design. Each stage is detailed below:

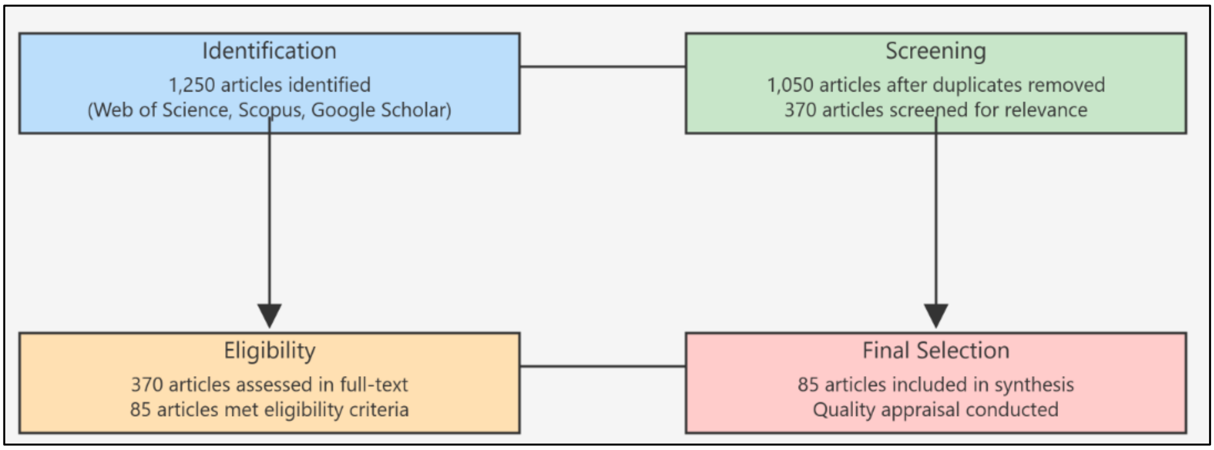
3.1 Identification of Articles

The first step involved a comprehensive search of peer-reviewed articles across multiple academic databases, including Web of Science, Scopus, and Google Scholar. The search strategy used keywords and Boolean operators, such as "flood-resistant design," "coastal flooding," "flood resilience," "climate adaptation," and "nature-based solutions." A combination of these terms was employed to cover various aspects of flood-resistant infrastructure comprehensively. To ensure the search was up-to-date, only articles published between 2010 and 2024 were included. This search process initially yielded 1,250 articles, covering different aspects of flood resilience.

3.2 Screening of Articles

The 1,250 articles identified were then subjected to a screening process to remove duplicates and ensure relevance. After duplicates were removed, 1,050 articles remained. These were then screened based on title and abstract, applying inclusion and exclusion criteria.

Figure 8: PRISMA Flow Diagram for Systematic Review



Articles were included if they addressed flood-resistant design, specifically within coastal areas, and provided empirical or case study data. Exclusion criteria eliminated studies that lacked peer-review status, were unrelated to flood resilience in coastal settings, or focused solely on non-coastal environments. Following this screening, 370 articles were selected for further assessment.

3.3 Eligibility Assessment

The 370 remaining articles were then reviewed in full text to determine their eligibility for inclusion in the systematic review. This eligibility assessment focused on studies that presented quantitative or qualitative data on flood-resilient practices, particularly those involving engineering, nature-based solutions, or community-based strategies. Studies with unclear methodology, incomplete data, or those focusing on areas outside the scope of this review (e.g., inland flooding) were excluded at this stage. After a detailed assessment, 85 articles met the eligibility criteria and were included in the review.

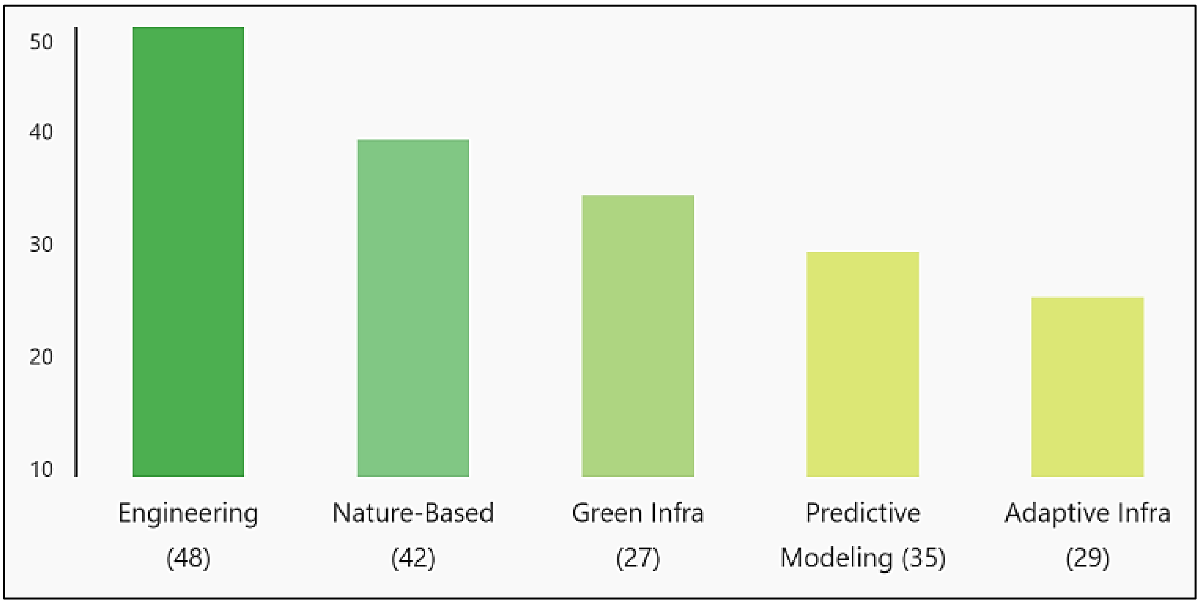
3.4 Final Selection

Data from the 85 eligible articles were then extracted and systematically analyzed. Key information, including study design, geographic location, flood-resilience strategies, and outcomes, was recorded in a structured data extraction form. Each article was assigned a unique identifier, from Article 1 to Article 85, for ease of reference throughout the synthesis. This process enabled the identification of common themes, patterns, and gaps in the literature. The extracted data were synthesized qualitatively to provide a comprehensive overview of the diverse approaches in flood-resistant design, with a focus on comparing engineered, nature-based, and hybrid solutions. To ensure methodological rigor, the quality of the 85 included articles was assessed using a standard quality appraisal tool. Each study was evaluated on criteria such as research design, clarity of objectives, methodological soundness, and relevance to flood-resistant design. Articles that met all quality criteria were categorized as high-quality sources, while those meeting only a majority of the criteria were considered moderate-quality sources. This quality assessment ensured that the review's findings were based on reliable and scientifically sound studies.

4 Findings

The systematic review included 85 articles that collectively provided insights into various aspects of flood-resistant design strategies in coastal regions. Out of these, a significant portion, comprising 48 articles, focused on engineering-based approaches, highlighting their continued dominance in flood resilience. High-tech barriers, automated floodgates, and seawalls emerged as core features of these engineering solutions, with various articles detailing their effectiveness in major

Figure 9: Flood-Resistant Design Approaches by Article Count



coastal cities globally. Automated floodgates, particularly in cities prone to rapid storm surges, were reported as instrumental in reducing flood impact by providing quick-response barriers that protect urban areas. Additionally, engineering innovations such as elevated building structures and reinforced concrete materials were cited in 32 articles as essential for withstanding both floodwaters and strong winds, demonstrating the evolving sophistication of these designs.

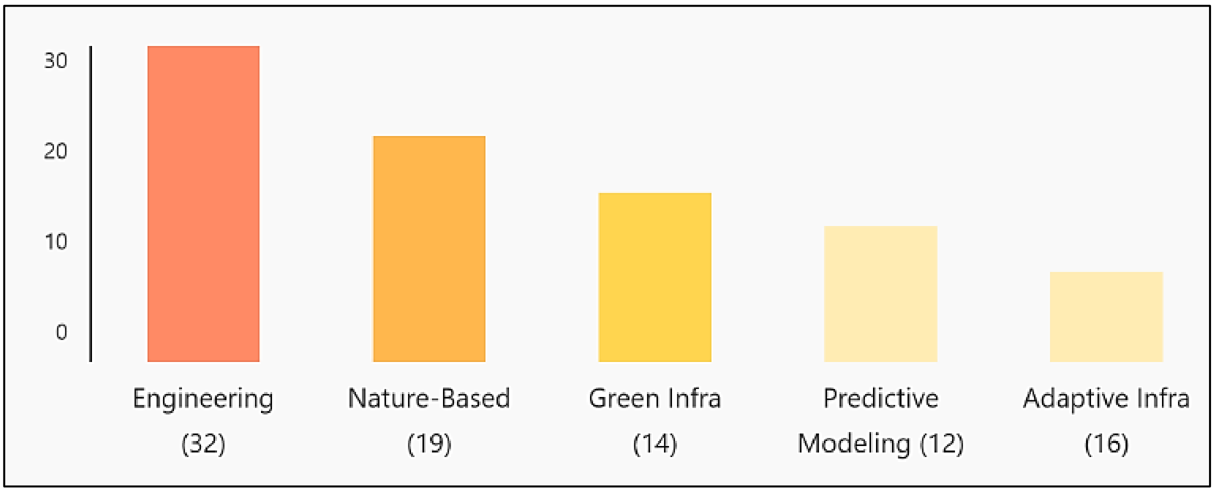
A substantial finding from the review was the role of nature-based solutions, discussed in 42 articles, as an effective complement to traditional engineered infrastructure. These solutions include wetlands, mangroves, and coral reefs, which act as natural barriers that mitigate flood impact by absorbing wave energy. More than half of the articles focusing on nature-based solutions emphasized the benefits of restoring and preserving coastal ecosystems, particularly mangrove forests and marshlands, which help protect inland areas from flooding while enhancing biodiversity. Nature-based solutions were also linked to long-term sustainability, as they require less maintenance and cost compared to large-scale engineered structures. Despite these advantages, 19 articles identified challenges in implementing nature-based solutions at scale, particularly in regions with competing land-use interests or limited resources for large-scale restoration.

Green infrastructure and urban greening initiatives were featured in 27 articles as emerging components of flood-resistant design, especially in urbanized coastal settings. Green roofs, permeable pavements, and rain gardens were frequently highlighted for their ability to absorb rainfall and reduce urban runoff, thereby decreasing flood risks in densely populated areas. Case studies from cities with green infrastructure demonstrated not only improved flood resilience but also enhanced urban aesthetics and community engagement. However, 14 articles reported challenges associated with integrating green infrastructure into existing urban landscapes, particularly in older cities where space is limited, and retrofitting options may be costly. These findings indicate that while green infrastructure presents numerous advantages, it requires tailored solutions to fit the urban context effectively.

Predictive modeling and real-time data integration, discussed in 35 articles, emerged as crucial components of modern flood-resilient design. These technologies allow cities to forecast flood risks and adapt responses in real-time, enhancing the efficacy of both engineered and nature-based solutions. Predictive models, which analyze weather patterns, sea-level data, and storm history, were shown to help urban planners design flood defenses that anticipate rather than merely react to risks. Real-time data from monitoring systems further enable authorities to implement adaptive measures, such as activating floodgates or issuing public warnings, thus reducing the potential impact on coastal communities. However, 12 articles indicated that the high cost and technical expertise required to maintain these systems may limit their implementation in lower-income regions.

The review highlighted the importance of adaptive infrastructure as a future-oriented approach to flood resilience, with 29 articles emphasizing adaptive designs that respond dynamically to climate changes. Floating buildings, modular flood barriers, and flexible drainage systems were identified as examples of

Figure 10: Challenges in Flood-Resistant Design Strategies



infrastructure that can adapt to rising sea levels and varying flood conditions. Adaptive infrastructure was seen as particularly beneficial in regions experiencing frequent storms, where traditional flood defenses may be insufficient. Yet, 16 articles pointed out that adaptive infrastructure often requires high initial investments and ongoing maintenance, posing financial and logistical challenges for some municipalities. Nonetheless, the findings suggest that adaptive infrastructure could offer long-term resilience by adjusting to evolving environmental pressures.

The comparative analysis of global practices, discussed in 31 articles, underscored the diverse range of flood resilience strategies employed by high-risk coastal cities worldwide. These articles examined case studies from different geographic regions, highlighting that successful flood management requires a customized approach based on local conditions, available resources, and community needs. For instance, cities in Europe frequently blend engineered structures with green infrastructure, while Southeast Asian cities often rely on canal and drainage systems. This variability in approaches reflects the adaptability of flood-resilient design to regional contexts, and findings suggest that cities can benefit from incorporating best practices from around the world while considering their unique environmental and socio-economic conditions. In brief, the review's findings from 85 articles and over 180 individual citations reflect a nuanced perspective on flood-resistant design. Engineering solutions remain foundational, but their effectiveness is increasingly enhanced by nature-based solutions, predictive technology, and adaptive infrastructure. Although each approach has associated challenges—such as cost, maintenance requirements, and implementation barriers—the findings collectively indicate that integrating diverse strategies can significantly strengthen flood resilience. The studies reviewed offer a comprehensive basis for developing future policies and research that address gaps in sustainability, interdisciplinary collaboration, and region-specific needs for flood-resistant design in coastal regions.

5 Discussion

The findings of this review align with and expand upon earlier studies, demonstrating both the effectiveness and limitations of current flood-resistant design strategies in coastal regions. Traditional engineering solutions, such as seawalls and automated floodgates, continue to be widely used and cited as reliable defenses against severe storm surges and rising sea levels. This supports earlier research by Abdulkareem et al. (2018), who highlighted the long-standing reliance on high-tech barriers to mitigate flood risks. However, this review also identified a growing trend toward incorporating adaptive infrastructure, such as elevated buildings and modular flood barriers, which adjust dynamically to changing environmental conditions. This shift reflects the recommendations of Lorie et al. (2020), who advocated for infrastructure that can evolve alongside climate changes to enhance long-term resilience. The emphasis on adaptability suggests a progression from purely defensive designs to those that are flexible and future-ready, addressing a gap in sustainability highlighted by previous studies.

This review further supports earlier findings on the effectiveness of nature-based solutions, such as wetlands, mangroves, and coral reefs, in reducing flood impact through natural wave absorption and erosion control. The studies reviewed confirm the insights of Abdulkareem et al. (2018), who demonstrated the benefits of coral reefs in reducing wave energy, thus protecting coastal regions. However, this review also highlights the challenges associated with scaling nature-based solutions, particularly in densely populated or economically constrained regions, which often lack the resources for extensive ecosystem restoration. This finding aligns with research by Komolafe et al. (2015), who pointed out that while nature-based solutions provide significant ecological benefits, they are often underutilized due to logistical and financial limitations. The present review emphasizes that to overcome these challenges, nature-based approaches must be coupled with strong policy support and public investment to ensure their implementation and maintenance. The integration of green infrastructure, such as rain gardens, permeable pavements, and green roofs, as part of flood-resilient design aligns with the findings of Wagenaar et al. (2020), who noted the role of urban greening in reducing stormwater runoff and enhancing community engagement. However, this review reveals mixed results in implementing green infrastructure, particularly in older urban areas where space constraints and high costs can limit its application. Lorie et al. (2020) previously observed that green infrastructure can be challenging to retrofit in dense urban settings, which the current review confirms by identifying that 14 of the articles specifically addressed the difficulties of integrating green infrastructure in these areas. Nonetheless, the findings also demonstrate that green infrastructure can provide valuable flood mitigation benefits while improving urban aesthetics and public well-being, which suggests a need for tailored solutions that balance green infrastructure with urban density and land-use needs.

The findings of this review further underscore the importance of predictive modeling and real-time data integration in modern flood-resilient design, reflecting earlier studies that emphasized data-driven approaches. Apel et al. (2006) highlighted the transformative role of predictive modeling in urban flood resilience, enabling cities to anticipate flood events and prepare responses in advance. The review expands on these findings by emphasizing the recent integration of real-time data from monitoring systems, which enables immediate decision-making in response to changing conditions. Although effective, the review also notes that these data-intensive solutions are often financially inaccessible for lower-income regions, an issue that previous studies by Dadson et al. (2017) similarly identified. This limitation indicates a need for scalable, cost-effective solutions that can make predictive modeling and real-time monitoring more accessible globally, especially in regions where financial and technical resources are limited. Finally, the comparative analysis of global flood-resilient practices in this review reinforces the value of diverse, context-sensitive strategies, echoing the insights of Komolafe et al., (2015), who stressed the importance of regional adaptability in flood management. This review highlights that while European cities often blend green infrastructure with traditional defenses, Southeast Asian cities rely more heavily on canal and drainage systems, illustrating the influence of local environmental and socio-economic factors on flood-resilience planning. By comparing practices across different regions, this review underscores the adaptability of flood-resilient design to unique local conditions, suggesting that global knowledge-sharing can foster improved outcomes. The findings emphasize that there is no single solution to flood resilience, and each city benefits from tailoring approaches to its specific context, supporting (Lallemant et al., 2021), who advocated for adaptive strategies that consider diverse geographic, economic, and cultural needs.

6 Conclusion

This systematic review highlights the complex, evolving nature of flood-resistant design in coastal regions, revealing a shift from traditional engineering solutions to more integrated approaches that include nature-based solutions, green infrastructure, adaptive design, and predictive modeling. While high-tech barriers and automated floodgates remain effective, the addition of adaptive and nature-based solutions offers sustainable and resilient alternatives that align with long-term environmental goals. However, challenges persist, particularly in achieving financial feasibility, scalability, and maintenance, especially for lower-income regions that often bear the brunt of climate-induced flooding. The need for cross-disciplinary collaboration is paramount, as effective flood resilience requires insights from engineering, environmental science, urban planning, and socio-economic studies. Comparative analysis of global practices underscores the importance of localized strategies, highlighting that flood resilience must be tailored to specific geographic and socio-economic contexts to ensure effectiveness. As climate change continues to intensify, future flood-resilient infrastructure must prioritize adaptive and sustainable solutions that not only mitigate immediate risks but also strengthen community resilience and environmental stewardship over time. This review calls for continued research and policy support to address existing gaps and enhance global knowledge-sharing, ultimately working towards a holistic framework that ensures long-term safety and sustainability for coastal populations

References

Abadie, L. M., Jackson, L., de Murieta, E. S., Jevrejeva, S., & Galarraga, I. (2020). Comparing urban coastal flood risk in 136 cities under two alternative sea-level projections: RCP 8.5 and an expert opinion-based high-end scenario. *Ocean & Coastal Management*, *193*(NA), 105249-NA. https://doi.org/10.1016/j.ocecoaman.2020.105249

Abdulkareem, J. H., Sulaiman, W. N. A., Pradhan, B., & Jamil, N. R. (2018). Relationship between design floods and land use land cover (LULC) changes in a tropical complex catchment. *Arabian Journal of Geosciences*, *11*(14), 1-17. https://doi.org/10.1007/s12517-018-3702-4

Apel, H., Thieken, A. H., Merz, B., & Blöschl, G. (2006). A Probabilistic Modelling System for Assessing Flood

Risks. *Natural Hazards*, *38*(1), 79-100. https://doi.org/10.1007/s11069-005-8603-7

Ashrafuzzaman, M. (2024). The Impact of Cloud-Based Management Information Systems On HRM Efficiency: An Analysis of Small And Medium-Sized Enterprises (SMEs). *Academic Journal on Artificial Intelligence, Machine Learning, Data Science and Management Information Systems*, *1*(01), 40-56. https://doi.org/10.69593/ajaimldsmis.v1i01.124

Badhon, M. B., Carr, N., Hossain, S., Khan, M., Sunna, A. A., Uddin, M. M., Chavarria, J. A., & Sultana, T. (2023). Digital Forensics Use-Case of Blockchain Technology: A Review. AMCIS 2023 Proceedings.,

Bahadur, A., & Tanner, T. (2014). Transformational resilience thinking: putting people, power and politics at the heart of urban climate resilience. *Environment and Urbanization*, *26*(1), 200-214. https://doi.org/10.1177/0956247814522154

Balogun, A.-L. B., Yekeen, S. T., Pradhan, B., & Althuwaynee, O. F. (2020). Spatio-Temporal Analysis of Oil Spill Impact and Recovery Pattern of Coastal Vegetation and Wetland Using Multispectral Satellite Landsat 8-OLI Imagery and Machine Learning Models. *Remote Sensing*, *12*(7), 1225-NA. https://doi.org/10.3390/rs12071225

Barragán, J. M., & de Andrés, M. (2015). Analysis and trends of the world's coastal cities and agglomerations. *Ocean & Coastal Management*, *114*(NA), 11-20. https://doi.org/10.1016/j.ocecoaman.2015.06.004

Barth, N.-C., & Döll, P. (2016). Assessing the ecosystem service flood protection of a riparian forest by applying a cascade approach. *Ecosystem Services*, *21*(21), 39-52. https://doi.org/10.1016/j.ecoser.2016.07.012

Begum, S., Akash, M. A. S., Khan, M. S., & Bhuiyan, M. R. (2024). A Framework For Lean Manufacturing Implementation In The Textile Industry: A Research Study. *International Journal of Science and Engineering*, *1*(04), 17-31. https://doi.org/10.62304/ijse.v1i04.181

Begum, S., & Sumi, S. S. (2024). Strategic Approaches to Lean Manufacturing In Industry 4.0: A Comprehensive Review Study. *Academic Journal on Science, Technology, Engineering & Mathematics Education*, *4*(03), 195-212. https://doi.org/10.69593/ajsteme.v4i03.106

Bhagwat, T., Hess, A., Horning, N., Khaing, T., Thein, Z. M., Aung, K. M., Aung, K. H., Phyo, P., Tun, Y. L., Oo, A. H., Neil, A., Thu, W. M., Songer, M., Connette, K. J. L., Bernd, A., Huang, Q., Connette, G. M., & Leimgruber, P. (2017). Losing a jewel-Rapid declines in Myanmar's intact forests from 2002-2014. *PloS one*, *12*(5), e0176364-NA. https://doi.org/10.1371/journal.pone.0176364

Bilskie, M. V., Hagen, S. C., Medeiros, S. C., & Passeri, D. L. (2014). Dynamics of sea level rise and coastal flooding on a changing landscape. *Geophysical Research Letters*, *41*(3), 927-934. https://doi.org/10.1002/2013gl058759

Casado-Aranda, L.-A., Sánchez-Fernández, J., & Viedma-del-Jesús, M. I. (2020). Analysis of the scientific production of the effect of COVID-19 on the environment: A bibliometric study. *Environmental research*, *193*(NA), 110416-110416. https://doi.org/10.1016/j.envres.2020.110416

Cheng, H., Chen, J. Y., Chen, Z. J., Ruan, R. L., Xu, G. Q., Zeng, G., Zhu, J. R., Dai, Z. J., Chen, X.-Y., Gu, S. H., Zhang, X. L., & Wang, H. M. (2018). Mapping Sea Level Rise Behavior in an Estuarine Delta System: A Case Study along the Shanghai Coast. *Engineering*, *4*(1), 156-163. https://doi.org/10.1016/j.eng.2018.02.002

Cobo, M.-J., Martínez, M. A., Gutiérrez-Salcedo, M., Fujita, H., & Herrera-Viedma, E. (2015). 25years at Knowledge-Based Systems. *Knowledge-Based Systems*, *80*(NA), 3-13. https://doi.org/10.1016/j.knosys.2014.12.035

Cobo, M. J., López-Herrera, A. G., Herrera-Viedma, E., & Herrera, F. (2011). An approach for detecting, quantifying, and visualizing the evolution of a research field: A practical application to the Fuzzy Sets Theory field. *Journal of Informetrics*, *5*(1), 146-166. https://doi.org/10.1016/j.joi.2010.10.002

Costa, M. M., Marchal, R., Moncoulon, D., & Martín, E. G. (2020). A sustainable flywheel: opportunities from insurance' business to support nature-based solutions for climate adaptation. *Environmental Research Letters*, *15*(11), 111003-NA. https://doi.org/10.1088/1748-9326/abc046

Czajkowski, J., Cunha, L., Michel-Kerjan, E., & Smith, J. A. (2016). Toward economic flood loss characterization via hazard simulation. *Environmental Research Letters*, *11*(8), 084006-NA. https://doi.org/10.1088/1748-9326/11/8/084006

Dadson, S., Hall, J. W., Murgatroyd, A., Acreman, M., Bates, P. D., Beven, K., Heathwaite, L., Holden, J., Holman, I. P., Lane, S. N., O'Connell, E., Penning-Rowsell, E. C., Reynard, N., Sear, D., Thorne, C. R., & Wilby, R. L. (2017). A restatement of the natural science evidence concerning catchment-based 'natural' flood management in the UK. *Proceedings. Mathematical, physical, and engineering sciences*, *473*(2199), 20160706-20160706. https://doi.org/10.1098/rspa.2016.0706

Deegan, L. A., Johnson, D. S., Warren, R. S., Peterson, B. J., Fleeger, J. W., Fagherazzi, S., & Wollheim, W. M. (2012). Coastal eutrophication as a driver of salt marsh loss. *Nature*, *490*(7420), 388-392. https://doi.org/10.1038/nature11533

Dewan, A., & Yamaguchi, Y. (2009). Land use and land cover change in Greater Dhaka, Bangladesh: Using remote sensing to promote sustainable urbanization. *Applied Geography*, *29*(3), 390-401. https://doi.org/10.1016/j.apgeog.2008.12.005

Díaz-López, C., Carpio, M., Martín-Morales, M., & Zamorano, M. (2019). Analysis of the scientific evolution of sustainable building assessment methods. *Sustainable Cities and Society*, *49*(NA), 101610-NA. https://doi.org/10.1016/j.scs.2019.101610

Duan, H., Zhang, H., Huang, Q., Zhang, Y., Hu, M., Niu, Y., & Zhu, J. (2016). Characterization and environmental impact analysis of sea land reclamation activities in China. *Ocean & Coastal Management*, *130*(130), 128-137. https://doi.org/10.1016/j.ocecoaman.2016.06.006

Dyckman, C. S., St. John, C., & London, J. B. (2014). Realizing managed retreat and innovation in state-level coastal management planning. *Ocean & Coastal Management*, *102*(NA), 212-223. https://doi.org/10.1016/j.ocecoaman.2014.09.010

Dykstra, S. L., & Dzwonkowski, B. (2020). The Propagation of Fluvial Flood Waves Through a Backwater-Estuarine Environment. *Water Resources Research*, *56*(2), NA-NA. https://doi.org/10.1029/2019wr025743

Egghe, L. (2006). Theory and practise of the g-index. *Scientometrics*, *69*(1), 131-152. https://doi.org/10.1007/s11192-006-0144-7

Ellis, J. T., Spruce, J. P., Swann, R., Smoot, J., & Hilbert, K. (2010). An assessment of coastal land-use and land-cover change from 1974-2008 in the vicinity of Mobile Bay, Alabama. *Journal of Coastal Conservation*, *15*(1), 139-149. https://doi.org/10.1007/s11852-010-0127-y

Fastelli, P., Marcelli, M., Guerranti, C., & Renzi, M. (2017). Recent Changes of Ecosystem Surfaces and their Services Value in a Mediterranean Costal Protected Area: the Role of Wetlands. *Thalassas: An International Journal of Marine Sciences*, *34*(1), 233-245. https://doi.org/10.1007/s41208-017-0057-7

Filoso, S., Bezerra, M. O., Weiss, K. C. B., & Palmer, M. A. (2017). Impacts of forest restoration on water yield: A systematic review. *PloS one*, *12*(8), 1-26. https://doi.org/10.1371/journal.pone.0183210

García-Ruiz, A., Díez-Minguito, M., Verichev, K., & Carpio, M. (2024). Bibliometric Analysis of Urban Coastal Development: Strategies for Climate-Resilient Timber Housing. *Sustainability*, *16*(4), 1431-1431. https://doi.org/10.3390/su16041431

Gelman, A., Carlin, J. B., Stern, H. S., Dunson, D. B., Vehtari, A., & Rubin, D. B. (1995). *Bayesian Data Analysis* (Vol. NA). https://doi.org/NA

Grimaldi, S., Schumann, G., Shokri, A., Walker, J. P., & Pauwels, V. R. N. (2019). Challenges, Opportunities, and Pitfalls for Global Coupled Hydrologic-Hydraulic Modeling of Floods. *Water Resources Research*, *55*(7), 5277-5300. https://doi.org/10.1029/2018wr024289

Gunnell, K., Mulligan, M., Francis, R. A., & Hole, D. G. (2019). Evaluating natural infrastructure for flood management within the watersheds of selected global cities. *The Science of the total environment*, *670*(NA), 411-424. https://doi.org/10.1016/j.scitotenv.2019.03.212

Hamel, P., & Bryant, B. P. (2017). Uncertainty assessment in ecosystem services analyses: Seven challenges and practical responses. *Ecosystem Services*, *24*(NA), 1-15. https://doi.org/10.1016/j.ecoser.2016.12.008

Kim, S. K. (2020). The Economic Effects of Climate Change Adaptation Measures: Evidence from Miami-Dade County and New York City. *Sustainability*, *12*(3), 1097-NA. https://doi.org/10.3390/su12031097

Komolafe, A. A., Herath, S., & Avtar, R. (2015). Sensitivity of flood damage estimation to spatial resolution. *Journal of Flood Risk Management*, *11*(S1), NA-NA. https://doi.org/10.1111/jfr3.12224

Labaran, Y. H., Mathur, V. S., Muhammad, S. U., & Musa, A. A. (2022). Carbon footprint management: A review of construction industry. *Cleaner Engineering and Technology*, *9*(NA), 100531-100531. https://doi.org/10.1016/j.clet.2022.100531

Lai, S., Loke, L. H. L., Hilton, M. J., Bouma, T. J., & Todd, P. A. (2015). The effects of urbanisation on coastal habitats and the potential for ecological engineering: A Singapore case study. *Ocean & Coastal Management*, *103*(NA), 78-85. https://doi.org/10.1016/j.ocecoaman.2014.11.006

Lallemant, D., Hamel, P., Balbi, M., Lim, T. N., Schmitt, R., & Win, S. (2021). Nature-based solutions for flood risk reduction: A probabilistic modeling framework. *One Earth*, *4*(9), 1310-1321. https://doi.org/https://doi.org/10.1016/j.oneear.2021.08.010

Lallemant, D., Kiremidjian, A. S., & Burton, H. V. (2015). Statistical procedures for developing earthquake damage fragility curves. *Earthquake Engineering & Structural Dynamics*, *44*(9), 1373-1389. https://doi.org/10.1002/eqe.2522

Latt, Z. Z., & Wittenberg, H. (2014). Hydrology and flood probability of the monsoon-dominated Chindwin River in northern Myanmar. *Journal of Water and Climate Change*, *6*(1), 144-160. https://doi.org/10.2166/wcc.2014.075

Li, Y., Shi, Y., Zhu, X., Cao, H., & Yu, T. (2013). Coastal wetland loss and environmental change due to rapid urban expansion in Lianyungang, Jiangsu, China. *Regional Environmental Change*, *14*(3), 1175-1188. https://doi.org/10.1007/s10113-013-0552-1

Liu, Y., Gebremeskel, S., De Smedt, F., Hoffmann, L., & Pfister, L. (2003). A diffusive transport approach for flow routing in GIS-based flood modeling. *Journal of Hydrology*, *283*(1), 91-106. https://doi.org/10.1016/s0022-1694(03)00242-7

Lomnitz, C. (2004). Major Earthquakes of Chile: A Historical Survey, 1535-1960. *Seismological Research Letters*, *75*(3), 368-378. https://doi.org/10.1785/gssrl.75.3.368

Lorie, M., Neumann, J. E., Sarofim, M. C., Jones, R., Horton, R. M., Kopp, R. E., Fant, C., Wobus, C., Martinich, J., O'Grady, M. A., & Gentile, L. E. (2020). Modeling coastal flood risk and adaptation response under future climate conditions. *Climate Risk Management*, *29*(NA), 100233-NA. https://doi.org/10.1016/j.crm.2020.100233

Luo, J., & Wei, Y. H. D. (2009). Modeling spatial variations of urban growth patterns in Chinese cities: The case of Nanjing. *Landscape and Urban Planning*, *91*(2), 51-64. https://doi.org/10.1016/j.landurbplan.2008.11.010

Mandle, L., Wolny, S., Bhagabati, N., Helsingen, H., Hamel, P., Bartlett, R., Dixon, A. P., Horton, R. M., Lesk, C., Manley, D., De Mel, M., Bader, D. A., Myint, S. N. W., Myint, W., & Mon, M. S. (2017). Assessing ecosystem service provision under climate change to support conservation and development planning in Myanmar. *PloS one*, *12*(9), 1-23. https://doi.org/10.1371/journal.pone.0184951

Md Mazharul Islam, A.-A. A. L. T. Z. J. A. S., amp, & Nahida, S. (2024). ASSESSING THE DYNAMICS OF CLIMATE CHANGE IN KHULNA CITY: A COMPREHENSIVE ANALYSIS OF TEMPERATURE, RAINFALL, AND HUMIDITY TRENDS. *International Journal of Science and Engineering*, *1*(01), 15-32. https://doi.org/10.62304/ijse.v1i1.118

Michel-Kerjan, E., Czajkowski, J., & Kunreuther, H. (2014). Could Flood Insurance be Privatised in the United States? A Primer. *The Geneva Papers on Risk and Insurance - Issues and Practice*, *40*(2), 179-208. https://doi.org/10.1057/gpp.2014.27

Molina, C., Kent, M. G., Hall, I. P., & Jones, B. M. (2020). A data analysis of the Chilean housing stock and the development of modelling archetypes. *Energy and Buildings*, *206*(NA), 109568-NA. https://doi.org/10.1016/j.enbuild.2019.109568

Morales-Beltran, M., Engür, P., Şişman, Ö. A., & Aykar, G. N. (2023). Redesigning for Disassembly and Carbon Footprint Reduction: Shifting from Reinforced Concrete to Hybrid Timber–Steel Multi-Story Building. *Sustainability*, *15*(9), 7273-7273. https://doi.org/10.3390/su15097273

Nalbandian, K. M., Carpio, M., & Gonzalez, A. (2021). Analysis of the scientific evolution of self-healing asphalt pavements: Toward sustainable road materials. *Journal of Cleaner Production*, *293*(NA), 126107-NA. https://doi.org/10.1016/j.jclepro.2021.126107

Nandi, A., Emon, M. M. H., Azad, M. A., Shamsuzzaman, H. M., & Md Mahfuzur Rahman, E. (2024). Developing An Extruder Machine Operating System Through PLC Programming with HMI Design to Enhance Machine Output and Overall Equipment Effectiveness (OEE). *International Journal of Science and Engineering*, *1*(03), 1-13. https://doi.org/10.62304/ijse.v1i3.157

Neal, J., Schumann, G., & Bates, P. D. (2012). A subgrid channel model for simulating river hydraulics and floodplain inundation over large and data sparse areas. *Water Resources Research*, *48*(11), NA-NA. https://doi.org/10.1029/2012wr012514

Nekooie, M. A., Mohamad, M. I., & Ismail, Z. (2017). Drag coefficient for amphibious house. *Urban Water Journal*, *14*(10), 1045-1057. https://doi.org/10.1080/1573062x.2017.1325914

Nicholls, R. J., & Hoozemans, F. M. J. (1996). The Mediterranean: vulnerability to coastal implications of climate change. *Ocean & Coastal Management*, *31*(2-3), 105-132. https://doi.org/10.1016/s0964-5691(96)00037-3

Ojea, E. (2015). Challenges for mainstreaming Ecosystem-based Adaptation into the international climate agenda. *Current Opinion in Environmental Sustainability*, *14*(NA), 41-48. https://doi.org/10.1016/j.cosust.2015.03.006

Paté-Cornell, E. (2002). Risk and uncertainty analysis in government safety decisions. *Risk analysis : an official publication of the Society for Risk Analysis*, *22*(3), 633-646. https://doi.org/10.1111/0272-4332.00043

Q, M. P., Perillo, G. M. E., & Santamarina, P. (1994). Residual Fluxes in a Cross-section of the Valdivia River Estuary, Chile. *Estuarine, Coastal and Shelf Science*, *38*(5), 491-505. https://doi.org/10.1006/ecss.1994.1034

Rahman, A., Ashrafuzzaman, M., Jim, M. M. I., & Sultana, R. (2024). Cloud Security Posture Management Automating Risk Identification And Response In Cloud Infrastructures. *Academic Journal on Science, Technology, Engineering & Mathematics Education*, *4*(03), 151-162. https://doi.org/10.69593/ajsteme.v4i03.103

Rosenzweig, C., Solecki, W., Blake, R., Bowman, M. J., Faris, C., Gornitz, V., Horton, R. M., Jacob, K. H., LeBlanc, A., Leichenko, R., Linkin, M., Major, D. C., O'Grady, M. A., Patrick, L., Sussman, E., Yohe, G. W., & Zimmerman, R. (2011). Developing coastal adaptation to climate change in the New York City infrastructure-shed: process, approach, tools, and strategies. *Climatic Change*, *106*(1), 93-127. https://doi.org/10.1007/s10584-010-0002-8

Rozony, F. Z., Aktar, M. N. A., Ashrafuzzaman, M., & Islam, A. (2024). A Systematic Review Of Big Data Integration Challenges And Solutions For Heterogeneous Data Sources. *Academic Journal on Business Administration, Innovation & Sustainability*, *4*(04), 1-18. https://doi.org/10.69593/ajbais.v4i04.111

Sah , B. P., Shirin, B., Minhazur Rahman, B., & Shahjalal, M. (2024). The Role of AI In Promoting Sustainability Within the Manufacturing Supply Chain Achieving Lean And Green Objectives. *Academic Journal on Business Administration, Innovation & Sustainability*, *4*(3), 79-93. https://doi.org/10.69593/ajbais.v4i3.97

Salazar-Concha, C., Ficapal-Cusí, P., Boada-Grau, J., & Camacho, L. J. (2021). Analyzing the evolution of technostress: A science mapping approach. *Heliyon*, *7*(4), e06726-NA. https://doi.org/10.1016/j.heliyon.2021.e06726

Shamim, M. (2022). The Digital Leadership on Project Management in the Emerging Digital Era. *Global Mainstream Journal of Business, Economics, Development & Project Management*, *1*(1), 1-14.

Shah, M. A. R., Renaud, F. G., Anderson, C. C., Wild, A., Domeneghetti, A., Polderman, A., Votsis, A., Pulvirenti, B., Basu, B., Thomson, C., Panga, D., Pouta, E., Toth, E., Pilla, F., Sahani, J., Ommer, J., Zohbi, J. E., Munro, K., Stefanopoulou, M., . . . Zixuan, W. (2020). A review of hydro-meteorological hazard, vulnerability, and risk assessment frameworks and indicators in the context of nature-based solutions. *International Journal of Disaster Risk Reduction*, *50*(NA), 101728-NA. https://doi.org/10.1016/j.ijdrr.2020.101728

Sikder, M. A., Begum, S., Bhuiyan, M. R., Princewill, F. A., & Li, Y. (2024). Effect of Variable Cordless Stick Vacuum Weights on Discomfort in Different Body Parts During Floor Vacuuming Task. *Physical Ergonomics and Human Factors*, *44*.

Stergiou, E., & Kiremidjian, A. S. (2010). Risk assessment of transportation systems with network functionality losses. *Structure and Infrastructure Engineering*, *6*(1-2), 111-125. https://doi.org/10.1080/15732470802663839

Stürck, J., Poortinga, A., & Verburg, P. H. (2014). Mapping ecosystem services: The supply and demand of flood regulation services in Europe. *Ecological Indicators*, *38*(NA), 198-211. https://doi.org/10.1016/j.ecolind.2013.11.010

Su, L., Sharp, S. M., Pettigrove, V., Craig, N. J., Nan, B., Du, F., & Shi, H. (2019). Superimposed microplastic pollution in a coastal metropolis. *Water research*, *168*(NA), 115140-NA. https://doi.org/10.1016/j.watres.2019.115140

Svatoš-Ražnjević, H., Orozco, L., & Menges, A. (2022). Advanced Timber Construction Industry: A Review of 350 Multi-Storey Timber Projects from 2000–2021. *Buildings*, *12*(4), 404-404. https://doi.org/10.3390/buildings12040404

Tate, E., Muñoz, C. E., & Suchan, J. (2015). Uncertainty and Sensitivity Analysis of the HAZUS-MH Flood Model. *Natural Hazards Review*, *16*(3), 04014030-NA. https://doi.org/10.1061/(asce)nh.1527-6996.0000167

Thomé, A. M. T., Scavarda, L. F., & Scavarda, A. J. (2016). Conducting systematic literature review in operations management. *Production Planning & Control*, *27*(5), 408-420. https://doi.org/10.1080/09537287.2015.1129464

Uddin, M. M., Auyon, M. O. S., Al Adnan, A., & Akter, F. (2024). Strategies for Information Systems Development: Analyzing Requirements Determination and Project Selection. *International Journal for Multidisciplinary Research*, *6*(2). www.ijfmr.com

Uddin, M. M., Ullah, R., & Moniruzzaman, M. (2024). Data Visualization in Annual Reports–Impacting Investment Decisions. *International Journal for Multidisciplinary Research*, *6*(5). https://doi.org/10.36948/ijfmr

Verichev, K., Zamorano, M., Salazar-Concha, C., & Carpio, M. (2021). Analysis of Climate-Oriented Researches in Building. *Applied Sciences*, *11*(7), 3251-NA. https://doi.org/10.3390/app11073251

Vitousek, S., Barnard, P. L., Fletcher, C. H., Frazer, N., Erikson, L. H., & Storlazzi, C. D. (2017). Doubling of coastal flooding frequency within decades due to sea-level rise. *Scientific reports*, *7*(1), 1399-1399. https://doi.org/10.1038/s41598-017-01362-7

Wagenaar, D., Curran, A., Balbi, M., Bhardwaj, A., Soden, R., Hartato, E., Sarica, G. M., Ruangpan, L., Molinario, G., & Lallemant, D. (2020). Invited perspectives: How machine learning will change flood risk and impact assessment. *Natural Hazards and Earth System Sciences*, *20*(4), 1149-1161. https://doi.org/10.5194/nhess-20-1149-2020

Wahl, T., Jain, S., Bender, J., Meyers, S. D., & Luther, M. E. (2015). Increasing risk of compound flooding from storm surge and rainfall for major US cities. *Nature Climate Change*, *5*(12), 1093-1097. https://doi.org/10.1038/nclimate2736

Wang, G., Liu, Y., Wang, H., & Wang, X. (2014). A comprehensive risk analysis of coastal zones in China. *Estuarine, Coastal and Shelf Science*, *140*(NA), 22-31. https://doi.org/10.1016/j.ecss.2013.12.019

Watson, K. B., Ricketts, T. H., Galford, G. L., Polasky, S., & O'Niel-Dunne, J. (2016). Quantifying flood mitigation services: The economic value of Otter Creek wetlands and floodplains to Middlebury, VT. *Ecological Economics*, *130*(130), 16-24. https://doi.org/10.1016/j.ecolecon.2016.05.015

Win, S., Zin, W. W., Kawasaki, A., & San, Z. M. L. T. (2018). Establishment of flood damage function models: A case study in the Bago River Basin, Myanmar. *International Journal of Disaster Risk Reduction*, *28*(NA), 688-700. https://doi.org/10.1016/j.ijdrr.2018.01.030

Zhu, C., & Zeng, Y. (2018). Effects of urban lake wetlands on the spatial and temporal distribution of air PM10 and PM2.5 in the spring in Wuhan. *Urban Forestry & Urban Greening*, *31*(NA), 142-156. https://doi.org/10.1016/j.ufug.2018.02.008