

Review

Enhancing the UAE's Disaster Resilience: AI and Flood Risk Assessment for Climate-Driven Challenges

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Abstract: Floods are one of the most serious natural disasters affecting both cities and rural areas. In the UAE, recent heavy rains and floods, especially in Fujairah, have shown the urgent need for better risk management. This study looks at how new technologies such as Artificial Intelligence (AI), Geographic Information Systems (GIS), and remote sensing can help predict and reduce the impact of floods. The paper is based on a qualitative review of recent research and reports between 2015 and 2024, focusing on how these tools improve early warning systems, risk maps, and decision-making and capture social and institutional dimensions of disasters, offering insights into how the community perceives, prepares for, and responds to risk. Results suggest that AI has the potential to make forecasts faster and more accurately than traditional methods, while GIS and remote sensing support better planning and monitoring. At the same time, challenges remain in data availability, coordination between agencies, and public awareness. Drawing from the UAE experience and international examples, the paper suggests four main actions: building a national flood risk database, improving cooperation between institutions, training experts in AI and GIS, and raising community awareness. These steps can help the UAE become stronger and set an example for the region in using technology for disaster resilience.

Keywords: Climate Change; Innovations; Geographic Information System (GIS); Remote Sensing; Risk Assessment

1. Introduction

Urban flooding caused by climate change is presenting itself as one of the most common types of damaging urban climate disasters and subjecting humans and property to harm. Vulnerability associated with rapid urban development, impervious surfaces, and poor drainage systems makes having effective planning, resilient infrastructure, and sophisticated risk management strategies even more critical to reducing risks due to urban flooding, as demonstrated by Wen and Shaw [1]. The Sendai Framework for Disaster Risk Reduction (2015–2030) highlights the importance of resilience through early warning and preparedness, as outlined in the Sendai Framework [2]. While both climate and geography of Dubai follow an arid pattern, several extreme rain periods have identified higher levels of susceptibility within various aspects of the UAE's governance and infrastructures than was previously realised. The Fujairah floods of 2022 exhibited how susceptible the entire country can be to experiencing a sudden flash flood and highlighted the critical need for enhanced disaster management systems, as documented by Terry et al. [3]. According to recent studies, AI (Artificial Intelligence), GIS (Geographic Information Systems), and remote sensing technologies can be used to enhance flood forecast capabilities; develop better hazard maps; and assist with making decisions regarding flood control, as reviewed by Wang et al. [4].

This study utilizes disaster risk reduction (DRR) concepts; it focuses on exploring the applications of artificial intelligence (AI), geographic information system (GIS), and remote sensing technologies as they relate to predicting floods, mapping hazards, and informing institutional decision-making. All available literature indicates that using these technologies improves the efficacy of early warning systems; improves spatial assessments of risk; and improves response coordination. This research will analyse the use of these technologies in the context of the UAE's environment to assess whether technological advancements can help enhance climate resilience from flooding caused by various climatic events and ultimately position the UAE as the regional leader in implementing a climate-adaptive approach to disaster management. This study also examines the institutional, technical, and social challenges related to implementing these new technologies, which include data accessibility, governance cooperation, and local expertise. The goal of this study is to provide practical recommendations for incorporating advanced technologies into a country's national disaster risk management strategies, enhance both prevention and adaptation capabilities, and support evidence-based policies that reduce vulnerability and improve urban and environmental resilience.

2. Methods

This study employs a structured narrative literature review methodology—a rigorous qualitative approach appropriate for synthesising evidence on an emerging, interdisciplinary topic where primary data collection is not feasible within the scope of a review article. The methodology investigates the application of artificial intelligence (AI), geographic information systems (GIS), and remote sensing for flood risk management, with a specific focus on the United Arab Emirates context. Literature was retrieved from Scopus, ScienceDirect, and JSTOR using Boolean search strings: (“flood risk” OR “flash flood”) AND (“UAE” OR “United Arab Emirates”) AND (“artificial intelligence” OR “machine learning” OR “GIS” OR “remote sensing”). Following a PRISMA-aligned four-stage screening process: (1) Identification—312 articles retrieved from Scopus, ScienceDirect, and JSTOR; (2) Screening—147 retained after title and abstract review; (3) Eligibility—68 full texts assessed against inclusion/exclusion criteria; (4) Inclusion—46 peer-reviewed articles were selected as primary sources, supplemented by grey literature (official reports, policy documents) where no peer-reviewed equivalent existed for specific factual claims. Inclusion criteria required: peer-reviewed journal articles; published 2015–2025; English language; empirical or methodological focus on flood risk, AI/ML, GIS, or remote sensing; and relevance to the UAE, Gulf region, or arid-environment applications. Sources lacking methodological credibility or empirical grounding were excluded.

An assessment of data sources was accomplished on a systematic basis using criteria that included methodological clarity, relevance to UAE flood mitigation efforts, and level of understanding achieved regarding using AI, GIS, and remote sensing to mitigate the impact of disasters through integration. By synthesizing regional understanding with global best practices, a collection of innovative solutions and lessons learned existed from other regions that could be tailored to meet the needs of the United Arab Emirates.

This study presents certain limitations. First, there is a reliance on secondary data that means that the originality of this study's results is constrained. No primary validation was completed via field studies or expert interviews. Second, while the use of media-based reports supplies useful contextual information, they may also include some biases. Third, the lack of statistical testing impacts both the validity of the research design as well as the empirical validity of the findings. However, although this limitation exists within both the literature review and the results sections of this article, the literature review did yield sufficient evidence to establish an initial baseline of research gaps that will be useful for guiding policy decisions related to flood risk in the UAE through technology and/or institutional intervention and providing a basis for subsequent studies to help develop resilience against flooding within the UAE.

3. Analysis and Discussion

The ability of AI, GIS, and remote sensing technologies to significantly transform the flood hazard assessment process is currently curtailed in the United Arab Emirates by both structural and institutional difficulties. Specifically, low-resolution hydrological and climatic data (due to lack of access) lead to low levels of accuracy in predictive models, fragmented governance structures among municipalities have resulted in inefficient sharing of and coordination of responses to data, reliance on foreign satellite systems has raised questions about data sovereignty and long-term sustainability, and deficiency in the availability of local skills for AI, machine learning, and geospatial

analytics has limited the overall capacity to use these technologies to effectively manage localized flood risks.

Similarly, countries such as Japan and the Netherlands have successfully developed, and utilized, centralized platforms and integrated databases to enable the real-time sharing of information to facilitate the production of more accurate early warning systems while improving the cohesiveness of their responses during disaster situations. By GIS, the UAE can create hazard maps and identify areas at risk for flooding, whereas satellite data from remote sensing allows for the observation of large-scale changes and ongoing monitoring of environmental and hydrological conditions. Additionally, AI-enabled predictive models may combine multiple datasets to forecast flooding events. Limitations in model validation exist because there are not enough local datasets available for creating the predictive models. Before an expanded scale of implementation can be realized into the UAE, sufficient access to data, greater institutional coordination between agencies, development of skills and the availability of sample size for the datasets must be addressed. Developing an effective system of combining technological, institutional, and human capacity-building strategies will be necessary to build greater flood resiliency in the UAE. The key opportunities and challenges are summarised in **Table 1**.

Table 1. Opportunities and Challenges of AI-Driven Flood Risk Assessment in the UAE.

Opportunities	Challenges
AI-driven flood prediction models enhance early warning accuracy. GIS mapping supports precise hazard zoning for urban planning. Remote sensing provides large-scale monitoring with minimal cost. AI can integrate multi-source data for rapid decision-making. Supports the UAE's climate adaptation and resilience strategies.	Limited access to high-resolution hydrological and climatic data. Fragmented governance and lack of centralized data-sharing platforms. Dependence on foreign satellite data and technologies. Insufficient local expertise in AI and geospatial analytics. Limited community awareness and engagement in disaster preparedness.

- Online research publications and platforms such as Science Direct, Google Scholar, Emerald Insight Journals, JSTOR, ResearchGate, and MDPI are accessed in gathering legitimate journals about the UAE's risk assessment innovations for climate-related disasters.
- Online news media outlets such as Khaleej Times, Gulf News, Emirates 24/7, and The National News are also used as reliable sources in getting information about the Fujairah Rains 2022.

3.1. Climate Change and Its Impact on the UAE

Auffhammer [5] focuses on evaluating the economic impacts of climate change in the Asian region by gathering and analysing published literature from different scholars. He stated that there is a greater body of research on the physical effects of climate change than there is on its economic effects. Field journals have a greater body of work that uses diverse techniques for individual industries. Nonetheless, his analysis assesses the conclusions of the body of current research on the general economy in Asia. The research identified that although the effects of climate change may differ based on the region, food production will be impacted. Nevertheless, it appears that many locations will face a drop in productivity brought on by climate change; the most obvious forecast is that rice production will be reduced as growing seasons get shorter and typhoons and extreme hot temperatures directly damages crops. In addition, Burke and Emerick [6] have estimated the economic damage that climate change would inflict on the main international economies by presenting a link between the Gross Domestic Product (GDP) growth rate and a nonlinear measure of temperature variations in their study. Elevated temperatures, increasing sea levels, and severe weather can harm assets and vital infrastructure, affect people's well-being, and thus impede human activities and productivity that are essential for advancing the economy. Salam [7] conducted a secondary analysis of the existing literature to examine the prevalence of climate change and the challenges it imposes on the UAE's environment and society. According to the study, the amount of greenhouse gases building up in the atmosphere is now unparalleled. The carbon dioxide concentration has grown at the fastest yearly pace in the past ten years since continuous direct atmospheric monitoring began. The greenhouse gases in the atmosphere have been striking since the past decades which accelerated climate change.

As illustrated in **Figure 1**, UAE carbon dioxide emissions have increased substantially since 1970, driven primarily by industrial activity and fossil fuel combustion [8]. Furthermore, the article from Fox News [9] reported that the UAE takes the top position on the list of countries with the highest ecological footprints. These factors contributed immensely to the worsening global climate and rapidly intensifying weather. Salam [7] stated that droughts, typhoons, extreme heat waves, and flash floods are examples of severe occurrences that are predicted to

occur more frequently due to climate change. Since 1970, there has been a noticeable rise in the intensity of tropical storm activity in the North Atlantic. Most land regions have experienced a rise in the frequency of heat waves, along with a corresponding increase in the frequency of heavy rains and eventual flooding. Into the bargain, studies have shown that the primary effects of climate change go directly to humanity's health. The frequency and severity of extreme weather events are predicted to grow, which will lead to a rise in fatalities. Natural disasters like extreme rains can cause major flooding that can endanger people's lives as well as their livelihoods, whereas heat waves can lead to rising cases of heat stroke and dehydration. Furthermore, the Gulf nations' biodiversity is already declining, and the severity of climate change will only make matters worse.

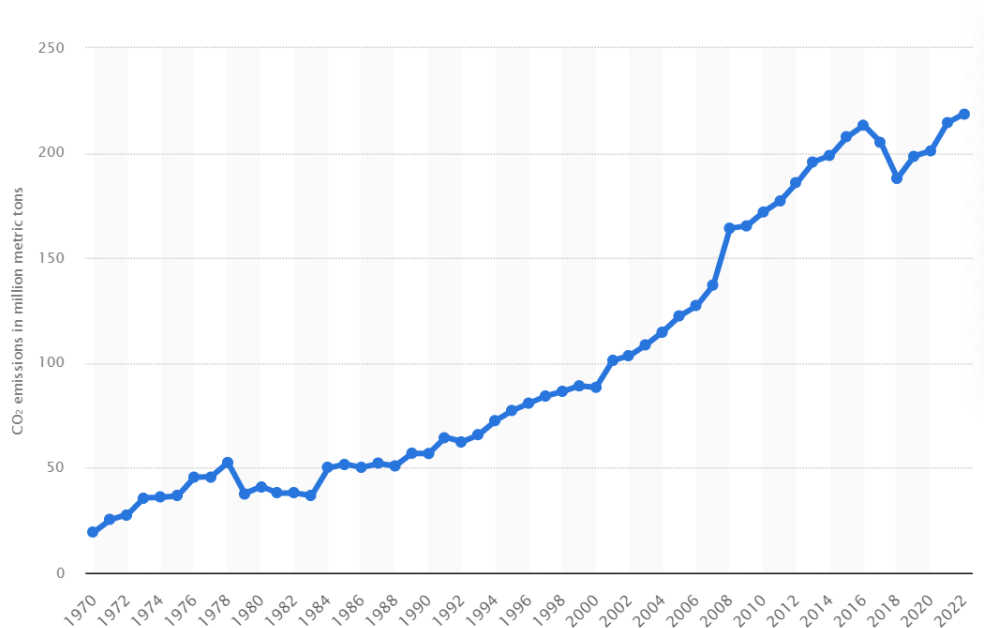


Figure 1. UAE Total Carbon Dioxide Emissions from Fossil Fuels and Industrial Processes, 1970–2022 (million metric tons CO₂).

Source: Statista [8].

The study of Salam [7] overall concluded that there would likely be more dangers to human health because of climate change, especially for people with lower incomes and mostly in tropical and subtropical regions. The largest threat to mankind and the environment in the twenty-first century is climate change.

3.2. Fujairah Flood Event 2022

The most frequent natural disaster that puts infrastructure, the economy, and human lives in jeopardy is a flash flood caused by intensely heavy rainfall. Flash floods are not as common in dry locations like the UAE, but they are becoming more likely in new places where paved towns at the foot of mountains have made surfaces impervious, like in the city of Fujairah. According to the research article of Alhefeiti et al. [10] and reports from Gulf Today [11], in July 2022, Fujairah saw one of the riskiest floods in the city's history since 1995. It is the most rain amount that has fallen on the nation in over 27 years, with 221.8 mm reported at Fujairah Port by the National Centre of Meteorology's ground stations. Moreover, Fujairah rain 2022 has claimed the lives of 7 people and evacuated a total of 4,225 residents, as determined by the UAE Ministry of Interiors. Similarly, the third-largest port in the world, Fujairah, saw significant flooding that hindered petroleum delivery, indicating the disaster's economic effect.

Additionally, the study by Subraelu et al. [12] presented data from the Fujairah Statistics Centre's 2023 demographic data showing that there are a total of 318,325 individuals situated in the emirates of Fujairah, with Fujairah City hosting more than 77% of this population. Due to their location on low coastal plains, most Fujairah City's urban districts are particularly susceptible to flash floods.

On top of that, businesses and infrastructures have also been damaged and affected by the floodwaters that

hit the city of Fujairah. Furthermore, economic repercussions are evident as businesses were forced to halt their operations for at least three consecutive days due to the trail of destruction left by the disaster. Companies had to use their insurance or their personal money to replace any damaged inventory and pay for the necessary repairs [13].

3.3. Innovations for Flood Risk Assessment

A billion tons of ice melt annually, resulting in rising sea levels that threaten to submerge many coastal communities completely by 2030 and 2040. This is one of the main ways that climate change has increased the likelihood of flooding, as inferred in the study of O'Donnell and Thorne [14].

Flash floods impose critical risk on society, environment, and economy. Therefore, to reduce the danger of flooding and its possible destructive impacts, it is crucial to foresee when floods will occur through an accurate and elaborate risk assessment method. Several variables, including real-time precipitation data, the pace at which river levels fluctuate, storm type information such as its length, severity, and most-likely affected area, as well as the familiarity with the features of a river's drainage basin, are necessary to forecast and assess risk of such natural disaster. Throughout the years, innovative advancements have paved the way for utilising the accuracy of risk assessment technologies for flood predictions, incorporating artificial intelligence, machine learning, and deep learning [15]. The most significant technological innovations applied to flood risk assessment in this review include:

3.3.1. Geographic Information System (GIS)

There has been a generous amount of available literature that highlights the application of GIS in risk assessment. The innovations in GIS are particularly widely adopted in flood mapping, flood vulnerability assessment of certain areas, environmental monitoring, disaster management, and identifying flood-prone areas [10,12,16,17].

According to Esri [18], GIS are systems capable of generating, mapping, and evaluating any kind of information by connecting data to a map and fusing location data. This creates a basis for mapping and analysis that is now commonly utilized in science and nearly every sector of the economy. GIS aids in understanding patterns, relationships, and geographic context, which benefits users in terms of enhanced management and decision-making.

The study of Subraelu et al. [12] used a GIS tool for risk assessment on floods in certain locations. The innovative technique identifies flash flood-prone locations by analysing satellite pictures from the relevant time frame. Multi-thematic data integration and management are made easier by GIS. Some of the thematic layers created and analysed using weighted overlay analysis for this study's purpose of identifying probable flood-vulnerable locations include drainage density, rainfall, slope, and geology. Maps showing the likelihood of flooding in a certain area are a useful tool for local governments and residents alike. When there is flooding, they can be used efficiently as an evacuation map, hence increasing the efficiency of risk management and response, as well as ensuring the safety of the people in the affected area.

Furthermore, Sefelnasr et al.'s [19] study also uses GIS in flash flood assessment in Dibba Fujairah, UAE. To create a map of flood-prone areas in Fujairah, his study employed GIS model using parameters which are elevation, slope, and the distance to the discharge channels. However, despite the available literature on the application of GIS in the scope of the UAE, there is still an evident gap in the literature as many have not validated their respective study's output models.

3.3.2. Remote Sensing

Another innovation in the field of risk assessment during natural disasters like flash floods is remote sensing. As defined in the US Geological Survey [20], remote sensing pertains to the process of identifying and keeping track of an area's physical features by measuring its emitted radiation usually through the use of advanced satellites that contain special cameras that are able to capture remotely sensed photos.

Rosado and Gagnon [21] detailed that remote sensing is a helpful tool for monitoring flood events and identifying hydrogeological conditions. The possibility of identifying flooded regions has also increased with the spread of satellites. The study utilizes publicly available optical satellite imagery to validate the identified flood risk maps.

The study of Subraelu et al. [12] particularly designed their research to conduct risk assessment of Fujairah City on its flash flood vulnerability using remote sensing. The parameters they have used are rainfall, elevation, drainage density, geology, slope, and land cover.

3.3.3. Support Vector Machine (SVM) and Machine Learning

Maps of flood vulnerability were produced in the study of Liu et al. [22] using an SVM model. An SVM is a machine learning technique that addresses complicated classification problems by utilising supervised learning models.

In addition, Salvati et al. [23] evaluated spatial flood vulnerability in a different study using a combined approach of SVM and frequency ratio. Lastly, they contrasted the ensemble model's performance with another machine-learning benchmark technique called decision tree (DT). In contrast to DT, the combined SVM and frequency ratio approach yields high prediction rates.

3.3.4. Deep Learning Approaches

Deep learning represents an advanced class of machine learning architectures that enables automatic feature extraction from large, complex datasets without manual feature engineering. Unlike conventional machine learning approaches such as SVM, deep learning models learn hierarchical spatial and temporal representations directly from raw input data, making them particularly powerful for flood susceptibility mapping and flood event prediction tasks where the relationships between input variables and flood outcomes are highly non-linear. These architectures, including CNNs and LSTM networks, are discussed in detail in Section 3.3.5.

3.3.5. Flash Flood Prediction Challenges in Arid Environments

Flash floods present fundamentally different prediction challenges compared to riverine or coastal flooding, primarily due to their extremely rapid onset (lead times of 1–6 h), high spatial variability, and dependence on localised, high-intensity convective precipitation. Current AI and remote sensing technologies face significant constraints in real-time flash flood prediction, particularly in data-sparse arid environments like the UAE where historical flood records are extremely limited. The UAE's mean annual precipitation is below 100 mm in most areas, meaning that training datasets for AI models are inherently thin. Standard LSTM or CNN models trained on slowly-evolving flood datasets from temperate regions are often inadequate for capturing the non-linear, rapid-onset dynamics of arid flash floods. Threshold-based Flash Flood Guidance (FFG) systems represent one operational approach, issuing warnings when rainfall thresholds are exceeded, but these rely on adequate rain-gauge density, which remains limited in the UAE. Probabilistic nowcasting approaches and hybrid physics-informed AI models, which embed hydrological process knowledge into the neural network architecture to compensate for data scarcity, represent the most promising emerging directions for UAE flash flood prediction. It is therefore important to acknowledge that while AI and remote sensing tools can substantially improve spatial risk mapping, post-event damage assessment, and longer-term hazard identification for flash flood contexts, the real-time prediction of flash flood onset in arid regions remains an open scientific challenge requiring dedicated research investment. Beyond traditional machine learning, deep learning architectures have demonstrated superior capability in flood prediction tasks due to their ability to extract hierarchical spatial and temporal features from large datasets. Convolutional Neural Networks (CNNs) have been applied to flood susceptibility mapping by learning spatial patterns from satellite imagery and digital elevation models, consistently outperforming conventional statistical approaches. Long Short-Term Memory (LSTM) networks, a variant of recurrent neural networks, are particularly suited to time-series hydrological data, enabling accurate prediction of flood onset and duration by capturing temporal dependencies in rainfall and river flow records. Mosavi et al. [24] conducted a comprehensive review demonstrating that machine learning models, particularly ensemble and deep learning approaches, substantially improve flood prediction accuracy compared to physics-based models, especially in data-scarce environments such as the UAE. Hybrid models combining CNN-based spatial feature extraction with LSTM-based temporal analysis represent an emerging frontier that is especially relevant to arid regions where flash flood dynamics are rapid and non-linear.

The application of transfer learning further enhances the feasibility of deploying deep learning models in regions like the UAE, where locally labelled training data is limited. By pre-training models on flood datasets from data-rich regions (e.g., Southeast Asia or Europe) and fine-tuning them on UAE-specific inputs, researchers can achieve strong predictive performance without requiring extensive local historical records. Additionally, transformer-based architectures have recently been explored for multi-source data fusion in hydrological modelling, integrating radar precipitation data, soil moisture indices, and land-use classifications into unified predictive frameworks. These

multi-modal deep learning systems show particular promise for early warning applications in urban environments such as Fujairah and Dubai, where the interaction of terrain, infrastructure, and extreme rainfall creates complex flood dynamics that traditional rule-based models struggle to capture.

3.3.6. International Comparative Case Studies

International experience offers critical lessons for the UAE's ambitions to deploy integrated AI-GIS flood risk platforms. Japan's XRAIN (eXtended RADar INformation) system represents one of the most advanced real-time flood monitoring networks globally, combining high-resolution X-band radar precipitation data with AI-driven river level prediction models to generate 30-min flash flood warnings. The system is directly integrated into the national disaster alert infrastructure, enabling automated public notifications and pre-positioned emergency response resources. The UAE can derive valuable lessons from Japan's experience in coupling meteorological data infrastructure with predictive analytics and public communication channels. Similarly, the Netherlands' Delta Programme demonstrates how long-term, data-driven flood risk governance can be institutionalised at a national level. The Dutch model integrates GIS-based flood scenario modelling, sensor networks embedded in dike infrastructure, and machine learning algorithms to continuously assess and update flood risk assessments. Crucially, the programme operates under a legally mandated review cycle, ensuring that risk models are updated as climate conditions evolve. This governance approach addresses precisely the institutional fragmentation that currently limits the UAE's flood management effectiveness. Tehrany et al. [25] have also shown that ensemble machine learning approaches applied in multi-country comparative contexts consistently outperform single-model approaches, suggesting that the UAE could benefit from collaborative regional frameworks involving neighbouring Gulf states to develop shared flood risk datasets and validation benchmarks. Such regional cooperation would simultaneously address data scarcity challenges and strengthen collective disaster resilience across the Arabian Peninsula.

3.4. UAE Efforts in Leveraging Innovations for Disaster Risk Management

The United Arab Emirates Ministry of Climate Change and Environment [26] published a detailed report on the country's advanced innovation and adaptation efforts to address and mitigate the potential impacts of various natural disaster such as heat waves, typhoons, and flash floods. The report highlighted the UAE's risk assessment framework as presented in **Figure 2**.

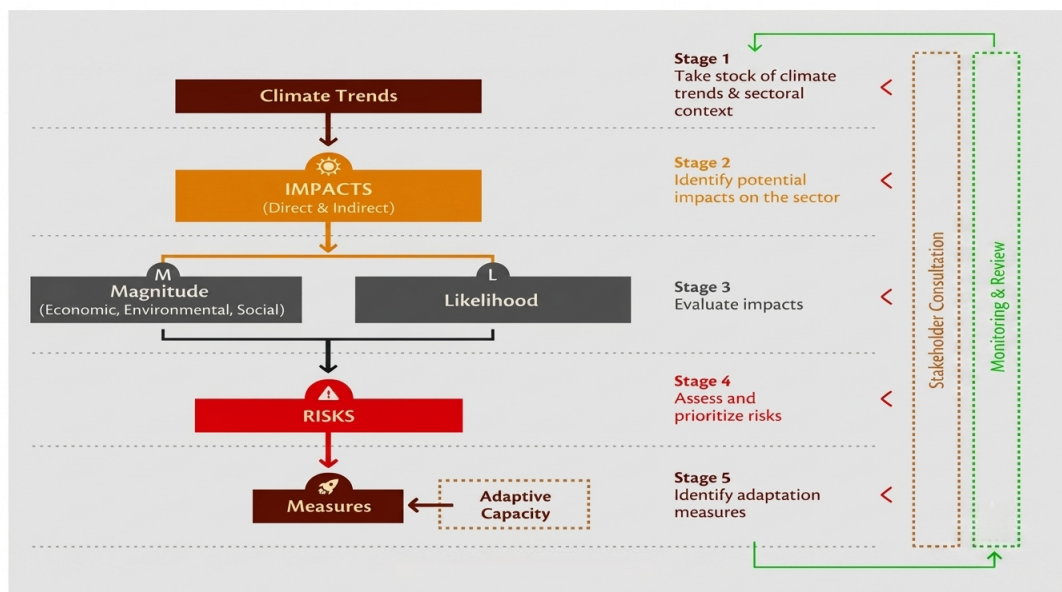


Figure 2. UAE Risk Assessment Framework Process.

Using the framework, the National Crisis Emergency and Disaster Management Authority (NCEMA) assess the

risks according to how likely they are to occur and how much of an impact they will have on the economy, society, and environment. Moreover, the UAE will be able to handle the top threats detected during the risk assessment process thanks to the current climate change adaptation strategies, as shown in the figure below.

As depicted in **Figure 3**, the UAE emphasized its disaster management innovations through integrating smart technology systems powered by artificial intelligence (AI). To protect people and property, the NCEMA uses AI technology to detect storm motions, analyses meteorological patterns, and offer timely warnings. The integration of AI mainly aims to provide the people with improved access to accurate weather information, including the flood maps for flood-prone areas to ultimately mitigate a more destructive impacts of such natural disasters.

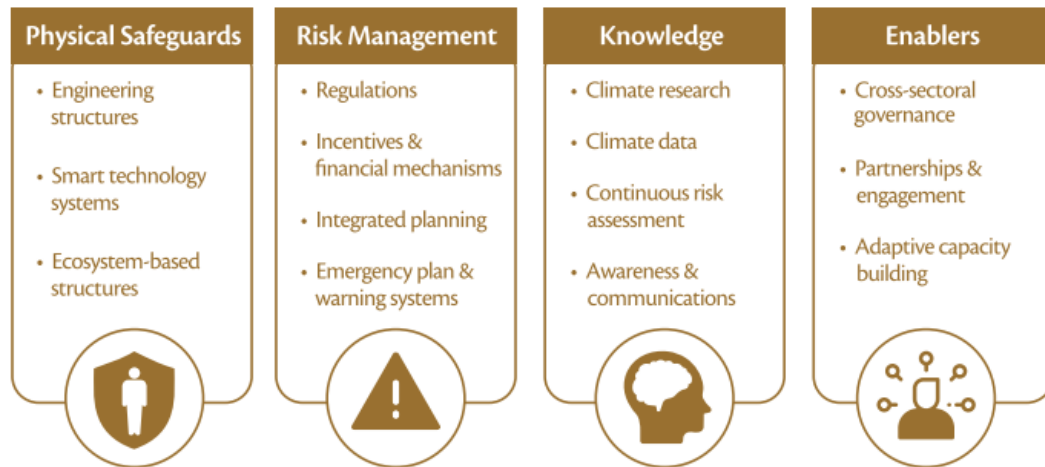


Figure 3. UAE's Focus in Climate Change Adaptation Strategies.

3.5. Risk Assessment Innovations: A Comparative Analysis

Climate change imposes massive environmental, economic, health, and overall social negative impacts. To choose the best course of action and prevent unforeseen repercussions, it is essential to comprehend the cross-sectoral linkages of climate hazards. Hence, national management and response strategies are extremely necessary to effectively assess and mitigate the potential destruction brought by the natural disasters driven by climate change. One of the most commonly present aspects in the current available literature regarding risks assessment and innovations is the integration of AI and machine learning. Ample pieces of research from different scholars worldwide applied mainly GIS and Remote Sensing for flood mapping.

As discussed in the previous sections, AI drives the further innovations of GIS, SVM, and remote sensing technologies to provide a better and more accurate information regarding the areas susceptible to flash floods. Several studies emphasized the utilization of GIS and remote sensing approaches using mainly the parameters for flash floods such as amount of rainfall, the area's slope and land cover, drainage density, and geology [10, 12, 16, 22]. Firstly, a substantial body of earlier research has proven the connection between rainfall and the frequency of floods in an area, as established by Zhao et al. and Tehrany et al. [27, 28]. This is mainly because the volume of rainfall can determine the possible occurrence of flash floods in certain areas. Second, slope suggests that, in hydrological assessment studies, surface discharge management is vital. Numerous studies have recognised the relevance of this topographic feature since the locations with a sharp drop in slope are more likely to flood because of the volume of water that remains stagnant and creates a serious flood consequence [2]. Thirdly, the flood vulnerability in a region can be greatly influenced by the distribution of land cover, the structure of land use, and the history of land cover, hence making this as a vital parameter in innovative flood mapping. Fourthly, water and drainage channels may get clogged by overland flow brought on by insufficient drainage, hence making drainage density another important factor for flood mapping. Lastly, the geology of a place can reveal crucial information about how frequently flood events occur.

Overall, it can be deduced from these studies that these mentioned parameters are highly essential to provide a flood mapping data that can ultimately help the decision-makers and national authorities in developing disaster

management and response strategies.

3.6. Role of AI and Machine Learning in UAE's Disaster Management

The UAE's ability to manage natural catastrophes has greatly increased thanks to AI-driven solutions. These AI-powered solutions have allowed for prior planning and effective response management of the country in the event of natural disasters. To anticipate and lessen the effects of natural disasters like sandstorms and flash floods, sophisticated artificial intelligence algorithms examine a variety of data sources, such as satellite images, weather predictions, and historical records. To protect people and property, the NCEMA of the United Arab Emirates uses AI technology to detect storm motions, analyse meteorological patterns, and offer timely warnings. Predictive models powered by AI improve preparedness for disasters and provide efficient resource allocation for quick reaction and recovery [29].

In line with the Fujairah Rain 2022, massive fatalities and economic losses could have been expected had it not been for the UAE's flood response and recovery plan. The country's predictive models and smart systems have facilitated early warning messages to the public. The article from Gulf News detailed that since 2017, the UAE adopted the National Early Warning System which is a public warning system initiative designed to notify UAE citizens and tourists of impending emergencies [30].

Furthermore, the UAE's target to revolutionize services to the public through a comprehensive AI integration allows for more innovations that could effectively save people's lives and minimize risk in the event of natural disasters. Future national strategies are aimed at further innovating disaster risk management through employing smart systems. Additionally, remote sensing and GIS essentially solidify the country's emergency services as these innovations provide real-time information for responders and citizens about the high-risk areas during a natural catastrophe. Satellite images and emergency mapping services, especially in the case of Fujairah flooding in 2022 offered efficient flood maps and analysis, hence enabling a quicker crisis assessment and management. Lastly, the government continues to work together with international partners to facilitate further innovations. For instance, the UAE's National Centre for Meteorology leveraged its weather forecasting technologies for more climate resilience through integrating innovations from the US and other nations [31].

3.7. UAE Risk Management and Response during the 2022 Fujairah Flood

Although there is no way to prevent natural disasters like flash floods, they may be successfully managed with the use of efficient flood management techniques. Alhefeiti et al. [10] and Alexander et al. [16] provided in their research the map of the high-risk areas for flooding in the city of Fujairah using GIS systems.

Presented in **Figure 4** are the flood-prone areas in the emirates of Fujairah. Flood vulnerable zones have been mapped by several research using a range of techniques. Fujairah City has been recognised as one of the area's most susceptible to floods amongst all UAE cities. As studies show, this is due to the city's rapid urbanization, and the expansion of impermeable infrastructure due to building and road development, hence increasing the risk of flash floods during periods of heavy precipitation in the city.

The UAE government alongside the Ministry of Defence, Joint Operations Command, and other public and private organizations have worked jointly to provide immediate response to the affected areas and help the people in Fujairah, with over 5,000 emergency responders deployed to conduct rescue operations [11]. On top of that, McGinley [32] in Arabian Gulf Business Insight reported that the government further made investments to solidify the country's flood control model.

Consequently, the literature of Subrauelu [12] identified facility maintenance, operational capacity, and infrastructure sizing as essential factors for flood mitigation. While the flood control investment of the UAE government, as reported in the report of McGinley [32], initially targeted drainage system widening; however, channel widening alone has recognised limitations as a long-term structural solution for flash flood management in arid catchment settings. A more effective integrated approach combines: (1) upstream retention basins and check dams in wadi channels to attenuate peak flows; (2) flood diversion channels to redirect excess runoff away from urban zones; and (3) permeable surface treatments and infiltration infrastructure. Watershed management across the full upstream catchment also requires strengthened governance to mitigate flood impacts across agricultural, commercial, and residential areas.

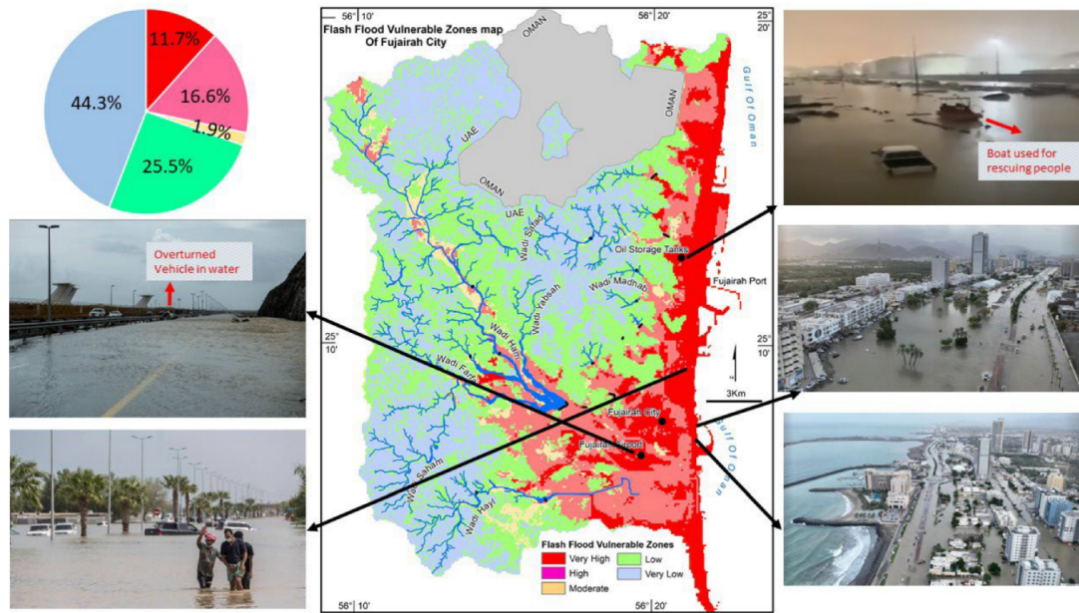


Figure 4. Flood-Prone Areas in Fujairah City, UAE.

Note: Derived from GIS-based multi-thematic analysis integrating Sentinel-1 SAR imagery and Landsat-8 optical satellite data (spatial resolution: 10 m and 30 m respectively; acquisition period: July 2022). As shown, flood-prone zones are concentrated in low-lying areas adjacent to wadi channels draining the Hajar mountain range, confirming the critical role of topography and upstream catchment characteristics in Fujairah's flood risk profile. Source: Alhefeiti et al. [10]; Subraeu et al. [12].

4. Results

The study demonstrates that AI-powered flood prediction models combined with GIS-based hazard mapping can significantly enhance the UAE's disaster preparedness. However, the review also identifies critical gaps, including limited public engagement, insufficient cross-agency collaboration, and the need for robust legal frameworks. The findings highlight the necessity of integrating cutting-edge technology with social and institutional strategies to achieve comprehensive disaster resilience. Building on these findings, this study proposes the Integrated AI-GIS Flood Governance Framework for the UAE (IAFGF-UAE) as an original conceptual contribution. The framework organises the UAE's flood resilience architecture into four interconnected layers: (1) Data Infrastructure—a national flood risk database integrating satellite feeds, IoT sensor networks, historical flood records, and real-time meteorological data; (2) AI-GIS Analytical Layer—real-time predictive modelling using CNN-LSTM hybrid architectures, GIS-based hazard mapping, and scenario simulation tools; (3) Institutional Governance Layer—structured coordination protocols connecting NCEMA, the National Centre of Meteorology, municipal authorities, and the Ministry of Interior, underpinned by a legally mandated data-sharing framework; and (4) Community Engagement Layer—early warning dissemination through the National Early Warning System, multilingual public awareness campaigns, and community-based preparedness programmes. The IAFGF-UAE framework provides a structured policy roadmap that connects technological capabilities with governance accountability, addressing the institutional fragmentation identified as the primary barrier to effective flood risk management in the UAE. A future research agenda specifically tailored to Gulf-region climate risk governance should prioritise: (1) flash flood nowcasting methodologies for data-sparse arid environments; (2) transfer learning approaches for AI model adaptation across GCC states; (3) governance frameworks for cross-border climate and hydrological data sharing in the Arabian Peninsula; (4) community-centred flood resilience measurement accounting for the UAE's multicultural population; and (5) integration of UAV/drone-based survey data with GIS platforms for near-real-time post-flood damage assessment and infrastructure monitoring.

Limitations

This study is subject to several important limitations that should be acknowledged. First, the review relies exclusively on secondary peer-reviewed literature and grey literature; no primary field data were collected. Second,

the absence of statistical testing or quantitative meta-analysis means that performance comparisons across technologies are based on reported figures from heterogeneous studies rather than standardised benchmarks. Third, the UAE's arid climate and limited historical flood records constrain the availability of training data for AI models, a challenge acknowledged throughout the review but not empirically resolved herein. Fourth, as a qualitative narrative review rather than a formal systematic review, findings represent evidence-informed insights and conceptual contributions rather than definitive empirical conclusions. These limitations are inherent to the scope and methodology of a literature-based review article and do not diminish the contribution of the synthesis, but they should be considered when interpreting the recommendations.

5. Conclusions

This study examines how artificial intelligence (AI), geographic information systems (GIS), and remote sensing technologies are applied to improve flood risk assessment and disaster preparedness in the UAE, with specific reference to the 2022 Fujairah flood event. Results suggest that the application of AI, GIS, and remote sensing to disaster preparedness has significant potential to provide better quality information to improve early warning systems, more accurately map hazards, and enhance institutional decision-making related to increasing damage caused by extreme weather events resulting from climate change. In addition, previous flooding events in the UAE have shown that the combination of the region's arid climate, rapid urbanization, the use of impermeable building materials, and ongoing climate changes will make flooding more likely and that new strategies for reducing risk due to disaster must be pursued aggressively.

The use of AI-based predictive systems can allow better analysis of complicated datasets sourced from many locations and can also aid with more accurate prediction of floods. This technology combined with GIS and/or remote sensing technologies can help to analyse flood-prone areas more completely and aid better prepare for an emergency response. This type of technological integration is very compatible with the priorities of the Sendai Framework for Disaster Risk Reduction, specifically to improve innovations for increasing the use of early warning systems and preparedness as well as helping to develop resilience against disasters.

Even so, the study has found that several limiting factors exist to enabling full use of AI and geospatial analytics within the UAE, including fragmented governance, lack of access to high-resolution, locally validated hydrological data, and a lack of required technical expertise. There are also sustainability and data sovereignty related issues arising from reliance on international satellite systems for data. In addition to these challenges there is a need for improved institutional coordination, community engagement, consistent communication, and defined legal responsibility as key components of effective implementation if we want to achieve disaster resilience.

The study's findings suggest that a comprehensive strategy integrating technological innovation with institutional capacity-building to manage flood risk and creating an environment where society participates in flood risk management. Practical recommendations emerging from this study include:

1. Establishing a national flood risk database integrating AI, satellite, and field data.
2. Enhancing inter-agency collaboration through centralized platforms.
3. Expanding community-based disaster awareness campaigns.
4. Incorporating AI-driven models into national disaster management frameworks.

Although the UAE has powerful tools for managing flood risk (such as AI, GIS, and remote sensing), all three of these applications can be very effective; however, their effectiveness is contingent on appropriate governance structure, human resources, and community involvement. Future disaster management research should go beyond using secondary data and find primary empirical data for validating predictive models and understanding stakeholder perceptions. In moving forward, these efforts will be necessary in providing an integrative, resilient, and sustainable disaster management system that can address the growing complexity of climate-change-related disaster risk. Recent studies on UAE climate projections [33], convective storm patterns [34], and wadi flood hazard mapping [35] further confirm the urgency of the technological and governance recommendations advanced in this review.

Author Contributions

Conceptualization, F.A. and M.P.; methodology, F.A.; formal analysis, F.A.; investigation, F.A.; resources, F.A.; data curation, F.A.; writing—original draft preparation, F.A.; writing—review and editing, M.P.; visualization, F.A.; supervision, M.P.; project administration, F.A. Both authors have read and agreed to the published version of the manuscript.

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Data Availability Statement

All data supporting the findings of this study are contained within the article. No new data were created.

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Conflicts of Interest

The authors declare no conflict of interest.

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