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Insights on Enhancing Strategic Value in Disaster Management through IoT technology. A Review Paper from UAE Perspective

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Abstract

Flooding, exacerbated by climate change and rapid urbanization, poses significant challenges worldwide, including in the UAE. Existing research highlights the need for effective disaster management strategies, yet gaps remain in addressing the unique challenges faced by arid regions. This study reviews current disaster management models, focusing on the integration of IoT technologies for enhanced flood resilience. The findings of this study revealed that the integration of Task-Technology Fit (TTF) and the Technology Acceptance Model (TAM) provides a better understanding of how IoT solutions support critical disaster management tasks, such as timely communication, efficient resource allocation, and coordination among stakeholders. Additionally, it offers deeper insights into user acceptance and the strategic value derived from IoT technology. The findings of this study revealed that the integration of Task-Technology Fit (TTF) and the Technology Acceptance Model (TAM) provides a better understanding of the strategic value derived from IoT technology in disaster management. Future research should explore the integration of IoT technologies in managing flooding in arid regions, focusing on developing context-specific frameworks that combine TTF and TAM to enhance the strategic value of IoT in disaster management.

Keywords: Strategic, Value, Disaster, IOT, UAE

Introduction

Flooding is a critical global issue, impacting regions worldwide with varying severity depending on geographic and socio-economic contexts. Its increasing frequency and intensity, driven by climate change, urbanization, and environmental degradation, make it a topic of urgent importance. The catastrophic floods in 2021 in developed nations such as Germany and Belgium revealed vulnerabilities even in advanced urban flood management systems, resulting in significant loss of life, extensive infrastructure damage, and strained recovery efforts (Dharmarathne et al., 2024). These events underscore the limitations of existing risk management frameworks and the need to reassess preparedness and resilience strategies in developed settings. In contrast, developing nations face recurrent monsoon

flooding, which disproportionately affects vulnerable populations. High population densities, poor urban planning, and limited infrastructure exacerbate the impacts, leading to widespread displacement, loss of livelihoods, and prolonged socio-economic stagnation (Rumpa et al., 2023). The absence of early warning systems and inadequate disaster response mechanisms highlights the urgent need for targeted interventions in these regions. This disparity in flood resilience between developed and developing countries underscores the global relevance of studying innovative flood management strategies.

The growing exposure to flooding also presents significant challenges for rapidly urbanizing regions, including those in the Gulf Arab countries, as shown in Figure 1.1, which illustrates trends in natural disasters such as floods, sandstorms, and cyclones from 2000 to 2024. Addressing these challenges is vital to safeguarding infrastructure, public health, and overall resilience. Insights from flood-resilient nations like the Netherlands demonstrate how advanced engineering solutions, such as dikes, flood barriers, and adaptive land-use policies, combined with proactive governance, can effectively mitigate flood risks. The significance of this study lies in its potential to contribute to global disaster management strategies and enhance flood resilience across diverse socio-economic and geographic contexts. The research is particularly important for policymakers, urban planners, and disaster management authorities as it provides insights into effective mitigation strategies that can be adapted to local conditions. For developed nations, the findings can inform the strengthening of existing systems to handle extreme weather events, while for developing countries, the study offers practical guidance on building infrastructure, implementing early warning systems, and improving urban planning to reduce vulnerability. Moreover, this study is beneficial for international organizations and aid agencies working to bridge the gap between resource-rich and resource-limited nations. By highlighting innovative solutions and fostering knowledge sharing, the research can facilitate global cooperation in addressing the shared challenge of flooding. Academically, it contributes to the growing body of knowledge on climate adaptation and disaster resilience, offering a foundation for further research and innovation in sustainable flood management. Ultimately, the study is significant for promoting safer, more resilient communities and ensuring sustainable development in the face of escalating environmental challenges.

Global Effects of Flooding

The Gulf Arab countries, including Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the UAE, are predominantly characterized by arid climates with minimal rainfall (Ahmed et al., 2022). However, in recent years, these nations have witnessed an alarming increase in flooding incidents due to the combined effects of climate change and rapid urbanization. Flooding has caused severe disruptions to infrastructure, economic losses, and loss of life, highlighting the vulnerability of these countries to extreme weather events. The rise in the frequency and intensity of floods is closely tied to global warming, which has significantly altered precipitation patterns in the region (Ahmed et al., 2022). Empirical evidence underscores the role of climate variability and rapid urbanization in exacerbating flood risks. Rising sea surface temperatures in the Arabian Gulf contribute to increased evaporation rates and higher atmospheric moisture, fueling extreme rainfall events (Ali & Thamiry, 2023). However, urbanization in cities such as Dubai and Riyadh has often outpaced the development of adequate drainage and flood management systems, leaving infrastructure highly vulnerable during heavy rainfall events (Terry et al., 2023). Flooding in the UAE in 2022 resulted in

property losses estimated between USD 650 million and USD 850 million, with Dubai being the most affected (Middle East Insurance Review, 2024). Economically, such floods disrupt critical sectors, including tourism and trade, while socially, they disproportionately impact marginalized communities and exacerbate health risks (Arnous et al., 2022).

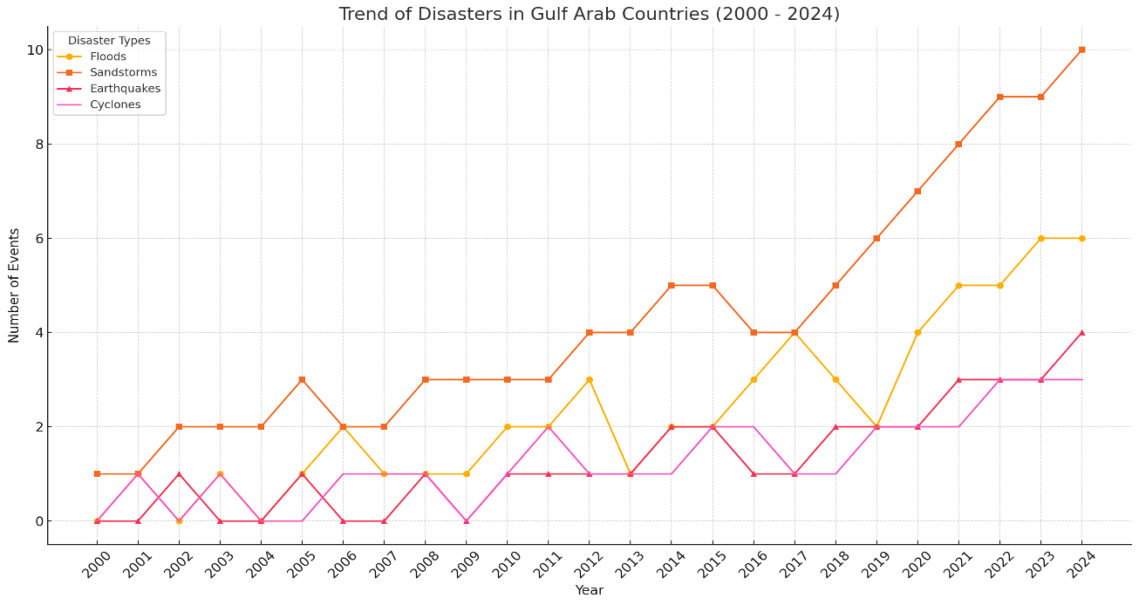

Figure 1.1: Trends and Implications of Natural Disasters in the Gulf Arab Countries (2000–2024)
(Source: National Emergency Crisis and Disaster Management Authority, 2024)

Conversely, in developing nations such as Bangladesh and India, recurrent monsoon flooding is a regular occurrence, disproportionately affecting vulnerable populations. Limited resources and infrastructure exacerbate the severity of flood impacts in these regions. Poor urban planning, combined with high population densities, leaves millions exposed to significant risks annually (Rumpa et al., 2023). The lack of access to early warning systems and inadequate disaster response mechanisms further amplifies the consequences, resulting in widespread displacement, loss of livelihoods, and long-term socio-economic stagnation. These vulnerabilities highlight the urgent need for targeted interventions to enhance flood resilience in resource-limited contexts. Innovative flood management strategies from countries such as the Netherlands offer valuable insights into building resilience. By implementing advanced engineering solutions, including dikes, flood barriers, and adaptive land-use policies, the Netherlands has successfully mitigated flood risks despite being geographically predisposed to flooding. These measures exemplify how technology and proactive governance can reduce the severity of natural disasters. However, the stark contrast in flood resilience between resource-rich and resource-limited nations emphasizes the need for international cooperation and knowledge sharing to address global flooding challenges effectively (El Naggar & Abdelrazik, 2024).

Flooding in the Gulf Arab Region

The Gulf Arab countries, including Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the UAE, are predominantly characterized by arid climates with minimal rainfall (Ahmed et al., 2022). However, in recent years, these nations have witnessed an alarming increase in flooding incidents due to the combined effects of climate change and rapid urbanization. Flooding has

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Table 1
Flood in Gulf Arab Countries

Authors	Findings
Ahmed et al., 2022	Flooding incidents in Gulf Arab countries are increasing due to climate change and urbanization, causing disruptions to infrastructure and loss of life.
Terry et al., 2023	Heavy rainfall events linked to climate change significantly disrupt infrastructure and communities, highlighting the need for adaptation measures.
Ali and Thamiry, 2023	Rising sea surface temperatures contribute to extreme rainfall events, exacerbating flood risks in the Gulf region.
Middle East Insurance Review, 2024	Flooding in the UAE caused property losses estimated between USD 650 million and USD 850 million, with Dubai being the most affected.
Fang et al., 2024	Recurrent flooding negatively impacts GDP growth in Gulf countries by increasing infrastructure repair costs and reducing investor confidence.
Arnous et al., 2022	Marginalized communities in Kuwait are disproportionately affected by floods, with limited access to emergency services and increased health risks from waterborne diseases.
Jean Louis et al., 2024	Many Gulf Arab communities have low awareness of flood risks, with cultural factors contributing to higher casualty rates during floods.
Nanjwani, 2024	Flood mitigation efforts in Dubai are undermined by fragmented governance and lack of coordination, despite significant infrastructure investments.
El Naggar and Abdelrazik, 2024	Regional collaboration among GCC countries can enhance flood preparedness through knowledge sharing and joint investments in flood management infrastructure.

Conclusion

Past studies have attempted to address disaster management challenges through various models and strategies. For instance, Duhamel et al. (2016) proposed using operations research and management science heuristics to optimize resource distribution and enhance

resilience during relief operations. Lee et al. (2006) and Lei et al. (2015) emphasized the criticality of coordinating medical teams and dispatching relief supplies promptly to minimize response time. Additionally, Yang et al. (2013) investigated the role of IoT in improving communication and real-time data sharing during disaster scenarios. Despite these advancements, many of these approaches are not tailored to the specific challenges faced by arid regions like the UAE, where urban infrastructure and environmental conditions require customized solutions. Standard flood mitigation techniques, typically designed for temperate regions, may not be applicable in the UAE's environmental and urban context (Al-Dousari, Al-Awadhi, & Misak, 2018). While the potential of IoT technology in disaster management has been explored in studies such as those by Yang et al. (2013) and Simon (1997), there is limited research examining its application in the UAE. Despite previous research focusing on the alignment of technological tasks and fit, there remains a significant gap in understanding how these technologies are perceived and adopted by employees. Furthermore, existing models have yet to be fully applied to disaster management systems tailored to the UAE's distinct environmental, infrastructural, and urban challenges.

In addition, one significant practical challenge in the UAE is the mismatch between urban infrastructure and the increasing intensity of floods. As the frequency and scale of such events rise, the existing drainage systems and flood management infrastructure often prove inadequate. Urban centers like Dubai and Abu Dhabi, which are major economic hubs, are particularly vulnerable. Addressing this challenge requires not only upgrading physical infrastructure but also integrating modern technological solutions to enhance flood mitigation efforts. The adoption of IoT-based disaster management solutions could significantly improve real-time communication, resource distribution, and stakeholder coordination during such events. However, there are still significant barriers in the practical application of such technologies, particularly in terms of integration with existing systems and ensuring their adoption by all stakeholders involved.

Future Research

Future research should focus on adapting existing disaster management models to better fit the unique environmental conditions of the UAE. This includes exploring the role of IoT technology in improving the efficiency of disaster response operations and evaluating the effectiveness of Task-Technology Fit (TTF) and Technology Acceptance Model (TAM) in this context. Additionally, research should focus on overcoming the barriers to the adoption of these technologies, specifically addressing how stakeholders perceive their value and how the integration of IoT can be facilitated within existing infrastructure.

Further studies should also examine how cultural factors, public perception, and government policies influence the acceptance of technological solutions for disaster management in the UAE. Understanding these dynamics is crucial for ensuring that disaster management technologies are not only effective but also widely accepted and utilized by the public and key stakeholders (Imamura, 2022). Finally, research could explore how technological solutions can be scaled across the UAE to create a unified and resilient disaster management system that enhances preparedness and resilience across urban centers, ultimately contributing to the UAE's long-term development goals.

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