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Research Article

Towards Effective Sustainable Disaster Management Approach: How Sustainable Solutions Mitigate Hurricanes and Tropical Cyclones Negative impact

Case Studies from: the USA, China, Oman and the UAE

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ABSTRACT

As communities worldwide confront increasingly severe climate related emergencies, there is an urgent need to move beyond traditional crisis response strategies and adopt sustainable solutions to mitigate the impact of natural disasters. Focusing on hurricanes and tropical cyclones, this study examines their profound effects on the environment, infrastructure, economy, and human lives, utilizing the systematically reviews of 84 articles, reports, and researchers. The study aims to delve in existing evidence regarding the social and economic risks these disasters pose. The research highlighted the critical role of integrating sustainable solutions into disaster management to achieve environmental, economic, and social benefits.

Case studies from the USA, China, Oman, and the UAE demonstrated that adopting green practices such as renewable energy, nature-based solutions, and circular economy principles enhance resilience and recovery. Early warning systems and public education, as implemented in China and the UAE, have significantly reduced disaster fatalities. Also, nature-based strategies like reforestation and wetland restoration mitigate floods and landslides while strengthening ecosystems. The study adds to existing crisis management research by identifying strategies for survival and resilience against climate change impacts. The findings also align with previous studies on climate change effects and offer actionable recommendations for policymakers and governments to enhance disaster mitigation efforts. The proposed strategies provide valuable tools to reduce disaster risks both during and after their occurrence.

Keywords: Climate change, Disaster management, Hurricanes, Sustainable solutions, Tropical cyclones.

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1. INTRODUCTION

Climate change represents a significant global challenge, characterized by rising temperatures, an increased frequency of extreme weather events, sea-level rise, and the loss of biodiversity. Researchers indicate that these changes pose substantial economic and societal challenges (Adger, W. N., Arnell, N. W., Tompkins, E. L., 2005). They also argue that carbon dioxide emissions resulting from human activities is the main cause to this phenomenon (Kabir, M., Habiba, U. E., Khan, W., Shah, A., Rahim, S., De los Rios-Escalante, P. R., Farooqi, Z.-U.-R., Ali, L., Shafiq, M., 2023). To add, they imply that over the past three decades, climate-related disasters have tripled. They claim that; climate hazardous disasters exacerbated by factors such as the accelerated rate of global sea level rise, which has been 2.5 times faster in the period from 2006 to 2016 compared to the 20th century. Besides, anthropogenic climate change has resulted in an increase in the frequency and severity of extreme weather events, global temperature rise, and environmental degradation. All have collectively jeopardized the lives and livelihoods of large numbers of climate-induced migrants and displaced persons (McAllister, S., 2023). Specific examples of the devastating impacts include Cyclone Idai in Southern Africa, which claimed over 1,000 lives and left millions destitute (BBC, 2019).

According to the Intergovernmental Panel on Climate Change (IPCC), the past few decades have seen a significant increase in the number of extreme weather events, including hurricanes, floods, droughts, and wildfires, with devastating impacts on communities across the globe. Among with, between 2000 and 2020, the World Meteorological Organization (WMO) reported 134% increase in disasters compared to the previous two decades. The impacts of climate change have contributed to a sharp rise in the frequency and intensity of natural disasters worldwide (World Meteorological Organization, 2021). This growing trend highlights the limitations of traditional disaster management practices, which are often reactive and focus primarily on immediate relief rather than long-term resilience and recovery. As well as, these crises not only inflict immense human suffering and economic losses, but also have far reaching environmental consequences (Vernick, D., 2024). Hence, the escalating frequency and intensity of climate related hazards worldwide shows the dire consequences of global climate change.

1.1 Hurricanes and Tropical Cyclones Terminology

In 2017, the National Oceanic and Atmospheric Administration (NOAA) identified hurricanes as; intense tropical storms characterized by strong winds (exceeding 74 mph or 119 km/h), heavy rainfall, and low-pressure systems that develop over warm ocean waters. On the other hand, tropical cyclones commonly referred to as; typhoons or hurricanes, as are among the most devastating weather events. These intense circular storms form over warm tropical oceans and feature maximum sustained wind speeds that exceed 119 kilometres per hour, accompanied by heavy rainfall (World Health Organization, 2024). Interestingly, the most significant threats to life and property stem not from the wind itself but from secondary effects such as storm surges, flooding, landslides, and tornadoes. The terminology for these storms varies by region. For example, in the Atlantic and Eastern North Pacific Oceans, they are known as: hurricanes. Differently, in the Western Pacific Ocean, they are called typhoons; and in the South Pacific and Indian Oceans, they are simply referred to as tropical cyclones. Hurricanes exemplify the devastating impacts of climate change, causing extensive physical damage, disrupting infrastructure, and leading to long-term public health issues, including cardiovascular diseases

and post-traumatic stress disorder (Krichene, H., Vogt, T., Piontek, F., Geiger, T., Schötz, C., Otto, C., 2023). Studies highlight a correlation between rising sea temperatures and the increasing intensity of hurricanes, complicating disaster mitigation efforts (Global warming and climate change, 2023).

1.2 Hurricanes and Tropical Cyclones across Countries

In countries such as; the United States, the consequences of tropical cyclones have been catastrophic, with events such as; Hurricane Katrina resulting in damages that exceed billions of dollars (Brown, C. E., Alvarez, S., Eluru, N., Huang, A, 2021; Bakkensen, L., Blair, L., 2022; Young, R., Hsiang, S., 2024). These storms not only inflict physical destruction but also significantly affect mortality rates and public health outcomes (Lau, Y. Y., Yip, T. L., Dulebenets, M. A., Tang, Y. M., & Kawasaki, T., 2022). Also, analyses indicate that vulnerable populations disproportionately bear the brunt of these disasters, under-scoring the intersection of social inequality and disaster impacts (Oliver-Smith, A., 2020). Similarly, in China, the interplay between tropical cyclones and heatwaves has intensified risks, leading to severe health and economic consequences. Researchers suggest that a slowdown in the translation speeds of cyclones can result in increased local rainfall, thereby exacerbating flood risks.

Predictions indicate a growing prevalence of compound hazards as a result of ongoing climate warming. Additionally, Oman has similarly faced significant challenges from tropical cyclones, including Cyclone Gonu and Cyclone Shaheen (Banan-Dallalian, M., Shokatian-Beiragh, M., Golshani, A., Mojtahedi, A., Lotfollahi-Yaghin, M. A., Akib, S., 2021; Terry, J., Al Ruheili, A., Boldi, R., Gienko, G., Stahl, H., 2022). Cyclone Gonu triggered extensive coastal flooding, while Cyclone Shaheen brought unprecedented rainfall, severely damaging infrastructure (Meer, M. S., Mishra, A. K., Nagaraju, V., 2024). Moreover, modelling studies emphasize the necessity of advanced prediction tools to mitigate the risks associated with cyclones in this region (Beraud, C. P. C., Kelly, D. M., 2022; Karami, S., Ghassabi, Z., Khansalari, S., 2024). To add, in the United Arab Emirates, climate change is evidenced by rising temperatures and declining precipitation levels (Paparella, F., Burt, J. A., 2023). Although tropical cyclones are infrequent, their occasional occurrence can result in considerable impacts (Schuenemann, T., 2021).

The increasing risk of extreme heat, coupled with the potential for cyclonic activity, highlight the urgent need for effective adaptation strategies in response to these evolving environ-mental challenges. Disaster management is at a crossroads as climate change accelerates the frequency and intensity of natural disasters worldwide. As communities worldwide confront the rising tide of these climate-related emergencies, traditional crisis-response strategies often fall short in managing the complex and interconnected challenges posed by hurricanes and tropical cyclones. This reality underscores the pressing need for innovative and sustainable solutions that not only address the immediate consequences of these disasters but also foster long term resilience and reduce environmental impacts.

Understanding the social and economic risks associated with such events are essential for developing effective disaster management strategies and enhancing community preparedness.

This paper examines the multifaceted impacts of hurricanes and tropical cyclones, conducting a thorough review of existing 84 literature reviews to identify gaps in knowledge and challenges in current disaster management practices.

The study offers practical recommendations for implementing sustainable solutions that can mitigate risks and improve responses to catastrophic events by shedding light on these issues.

The study aims to contribute to a more resilient and sustainable future, providing communities with the necessary tools to effectively address the on-going challenges posed by climate change.

2. RESEARCH QUESTIONS

1) What are the key social and economic risks posed by hurricanes and tropical cyclones, and how do these risks vary across different regions and communities?
2) What sustainable strategies and solutions can be implemented to mitigate the environmental, infrastructural, and economic impacts of hurricanes and tropical cyclones, and what are the critical gaps in current research on these approaches?

3. OBJECTIVES OF THE STUDY

The study aims to achieve several key objectives that collectively enhance understanding of climate driven disasters, particularly hurricanes and tropical cyclones. First, it seeks to identify the underlying drivers of climate change. Additionally, the research assesses the multifaceted impacts of hurricanes and tropical cyclones on affected communities, focusing on environmental, infrastructural, economic, and social dimensions presented in three cases: the USA, China, Oman and the UAE. A systematic review of 84 existing literature conducted to elucidate climate change, and the social and economic risks associated with hurricanes and tropical cyclones, thereby identifying critical vulnerabilities within communities. Moreover, the paper addresses significant knowledge gaps in current understanding of hurricanes related risks. Furthermore, the research aims to empower communities by equipping them with tools and strategies designed to enhance preparedness and resilience in the face of such disasters. It will also provide actionable insights to support long-term recovery efforts, ensuring that communities can adapt to the ongoing threats posed by climate change. Ultimately, the study will offer guidance for future research, aiming to deepen general comprehension of climate-driven disasters and refine their management.

4. SIGNIFICANCE OF THE STUDY

This study contributes to the existing literature in crisis management and enhances understanding of climate driven disasters, particularly hurricanes and tropical cyclones. The researcher suggested relevant recommendations for policymakers and other concerned bodies on how to guide future studies and support the development of effective strategies for managing climate-related risks in a rapidly changing world.

5. KEY CONCEPTS AND DEFINITIONS

5.1 Climate change

According to National Aeronautics and Space Administration (2024) climate change is identified as a long-term alteration in temperature, precipitation, wind patterns, and other elements of the Earth's climate system. It is caused by natural factors such as volcanic eruptions, solar cycles or, by human activities, such as the burning of fossil fuels, deforestation, and industrial processes, leading to global warming and extreme weather events (Abbass, K., Qasim, M. Z., Song, H., Murshed, M., Mahmood, H., Younis, I., 2022).

5.2 Sustainable solutions

The International Institute for Sustainable Development (IISD) associates sustainable solutions to the practices or strategies designed to meet current needs without compromising the ability of future generations to meet their own needs (International Institute for Sustainable Development, 2024).

5.3 Disaster management

It is the process of planning, organizing, coordinating, and implementing measures to prepare for, respond to, recover from, and mitigate the impacts of disasters (Tulane University, 2021). Disaster management encompasses the strategic organization and allocation of resources to effectively respond to and mitigate the impacts of a catastrophic event. This involves coordinating the roles, responsibilities, and collaborative efforts of various stakeholders, including emergency responders, private sector entities, public agencies, nonprofit organizations, as well as volunteers and donations. The success of disaster management hinges on the systematic integration of preparedness, response, recovery, and mitigation measures to enhance community resilience and safeguard lives, property, and critical infrastructure in the face of emergencies (University of Central Florida, 2024). Furthermore, the main goal of management function is to avoid hazards and protect people from the effects of hazards when they occur.

5.4 Sustainability

The concept of sustainability is grounded in the fundamental principles that all human need upon the natural environment (U.S. Environmental Protection Agency, 2023). Adopting a sustainable approach entails creating and preserving the conditions that enable productive coexistence and symbiosis between humans and the natural world, thereby supporting the needs of both present and future generations.

5.5 Disaster

The International Federation of Red Cross and Red Crescent Societies (IFRC) define a disaster as; an event that renders a community or society unable to function effectively (IFRC, 2024). Disasters can be either natural or human-made, and may include pandemics, technological catastrophes, or environmental cataclysms. They include earthquakes, tornadoes, hurricanes, pandemics, volcanic eruptions, wildfires, floods, mass shooting, acts of terror, nuclear explosions, and chemical emergencies (International Strategy for Disaster Reduction, 2007).

6. METHODOLOGY

The study is built on analyzing reviews of 84 articles, thus providing a comprehensive analysis of the impacts of climate change on nature, human and economics.

7. REVIEW OF THE LITERATURE

Climate change interacts with various factors impacting global health, including widespread phenomena such as globalization. The impact of climate change is the primary driver to the increase in number of floods globally, as warmer temperatures lead to more intense and frequent rainfall. Earth's average temperature is steadily rising, with atmospheric CO_2 levels now surpassing 400 ppm, primarily due to the intensified greenhouse effect (Mikhaylov, A., Moiseev, N., Aleshin, K., Burkhardt, T., 2020). To add, global climate change represents a significant challenge, contributing to the gradual increase in the planet's average annual temperature. Global warming trend is largely attributed to high levels of industrial production and economic activities, which release substantial amounts of greenhouse gases (Forster, P. M., Smith, C. J., Walsh, T., Lamb, W. F., Lamboll, R., Hauser, M., Zhai, P., 2023).

The National Oceanic and Atmospheric Administration (NOAA) comprehensive data analysis, on hurricane activity in the North Atlantic Basin, spanning from (1851 to 2023) emphasized the evolving patterns in both the frequency and intensity of storms over the years. One significant finding of the analysis is the increase in the number of hurricanes, particularly major hurricanes classified as category 3 or higher, in recent decades. The report showed a general upward trend, with particularly intense years such as 2005, which recorded 15 hurricanes, including 7 major ones. Also, Accumulated Cyclone Energy (ACE), which quantifies the total energy produced by tropical cyclones in a given season, showed considerable fluctuations but correlate strongly with years of heightened hurricane activity, such as 2005 and 2017, when multiple powerful storms occurred (NOAA's Atlantic Oceanographic and Meteorological Laboratory., 2024). The escalating frequency and severity of flood events globally reflects the pressing need to develop innovative approaches to enhance disaster preparedness (Jain, H., 2024). Also, the report highlighted the frequent above-average hurricane seasons, with 2020 witnessing an unprecedented 30 named storms, potentially driven by climate factors such as rising ocean temperatures. Data revealed variability in hurricane activity across different decades. The dataset highlighted the importance of emphasizing the necessity of analyzing both historical and contemporary hurricane activity to better understand trends, identify their underlying causes, and enhance preparedness for future storms.

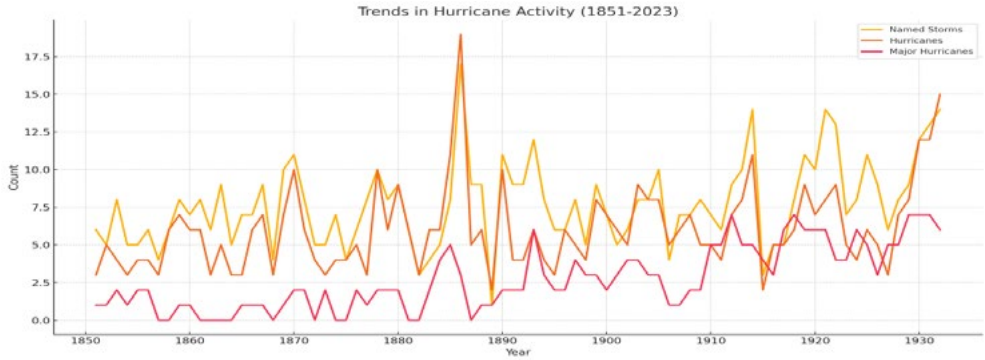

Figure 1. Hurricanes Trend (1851-2023)Source: Self elaboration; based on NOAA's Atlantic Oceanographic and Meteorological Laboratory 2024 data

7.1 How hurricanes develop

Hurricanes develop under specific environmental conditions that involve a delicate interplay of warm ocean waters, low atmospheric pressure, and certain wind patterns. For a hurricane to form, ocean surface temperatures must exceed 27°C (80°F), as this warmth provides the essential heat and moisture needed for the storm's growth. As hot, humid air rises from the ocean; it creates a low-pressure area (Studholme, J., Fedorov, A. V., Gulev, S. K., Emanuel, K., Hodges, K., 2022). The rising air cools and condenses into rain clouds, a process that releases latent heat, further energizing the storm. The upward movement of air draws in surrounding air, while the Earth's rotation causes this incoming air to spin horizontally, giving rise to the hurricane's distinctive rotating structure. Also, this ongoing cycle of rising air, condensation, and heat release propels the storm, enabling it to intensify and expand as long as it remains over warm waters and is supported by favorable atmospheric conditions. This dynamic illustrates the immense energy system that underpins hurricane formation.

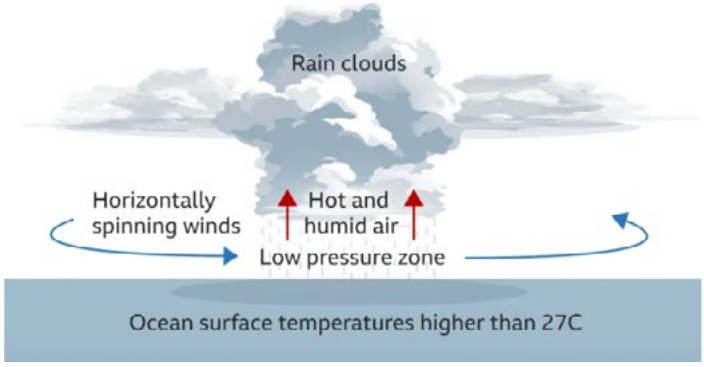

Figure 2. Hurricanes Components. Source: Poynting, M. (2024)

7.2 Hurricanes and cyclones social and economic impacts

Ouyang, Y., Grace, J. M., Parajuli, P. B., Caldwell, P. V. (2022) indicate that hurricanes and cyclones significantly affect the environment, infrastructure, economy, and human lives. Their environmental impacts are severe, starting with storm surges that cause coastal erosion, damage to beaches, and intense rainfall leading to flooding (Sullivan, J., 2023). To add, scientists demonstrated that the increasing intensity and frequency of tropical cyclones have caused considerable damage to marine ecosystems, such as coral reefs, mangroves, and sea grass beds (Feehan, C. J., Filbee-Dexter, K., Thomsen, M. S., Wernberg, T., Miles, T., 2024). On human level, these storms result in loss of life due to high winds, flooding, and storm surges, especially vulnerable societies (Smiley, K. T., Noy, I., Wehner, M. F., Frame, D., Sampson, C. C., Wing, O. E., 2022). Vulnerable communities, particularly those with fewer resources, face even greater challenges (Waddell, S. L., Jayaweera, D. T., Mirsaeidi, M., Beier, J. C., Kumar, N., 2021). For instance, after hurricane Katrina, many repair workers experienced respiratory illnesses such as sinusitis and toxic pneumonitis.

However, it was noted that the respiratory symptoms related to this exposure began to decline within two months after the hurricane (Powell, T. M., Yuma, P. J., Scott, J., Suarez, A., Morales, I., Vinton, M., Li, S. J., 2020). Moreover, studies showed that natural disasters cause psychological repercussions and long term emotional ramifications. Furthermore, studies revealed that each tropical cyclone is linked to an average of 7,000 to 11,000 additional deaths in the 15 years following the event (Young, R., Hsiang, S., 2024). This suggests that the long-term mortality impact of tropical cyclones is significantly greater than what is reflected in official statistics, which generally include only immediate fatalities. Young, R., Hsiang, S. (2024) study estimates that; from 1930 to 2015 tropical cyclones were responsible for approximately 3.6 million to 5.2 million deaths in the United States. Furthermore, disasters have resulted in considerable declines in agricultural output, which in turn has led to economic losses and threatened food security (Food and Agriculture Organization, 2021).

Disasters such as extreme weather and pest outbreaks, including swarms of desert locusts, have caused significant damage to both crops and livestock. This destruction has intensified food insecurity in the regions impacted by these disasters. Moreover, according to the World Meteorological Organization (2024); over the past fifty years, tropical cyclones have inflicted profound human suffering, with more than 779,324 lives lost to these devastating storms. On average, 43 fatalities occur daily as a direct consequence of tropical cyclones and their associated hazards, underscoring the persistent threat they pose to vulnerable communities. The diameter of these formidable weather events typically ranges between 200 to 500 kilometers, though some cyclones expand to a staggering 1,000 kilometers, amplifying their destructive potential. This escalating danger is further compounded by a 200% increase in the population residing in cyclone-prone regions, intensifying exposure to these life-threatening storms.

Table 1. Tropical Cyclones Human and Economic Impact

Category	Data/Details
Number of Tropical Cyclones	1,945 disasters attributed to tropical cyclones in 50 years
Human Impact	Over 779,324 people killed by tropical cyclones
Economic Losses	USD 1.4 trillion in damages over 50 years
Daily Impact	43 deaths and USD 78 million in damages daily since 1970
Typical Diameter	200–500 km; can reach up to 1,000 km
Population Growth in Cyclone Regions	200% increase in population in cyclone-prone regions

Source: Self elaboration based on Young, R., Hsiang, S. (2024).

The economic toll of tropical cyclones is equally alarming, with global losses surpassing USD 1.4 trillion over the past five decades (Table 1). This equates to an average of USD 78 million damages each day, reflecting the severe and recurring financial burdens faced by affected nations. The immense costs stem not only from direct damage to infrastructure, homes, and livelihoods but also from long-term disruptions to economic stability and growth in impacted regions. The scale and frequency of these losses highlight the critical need for enhanced resilience and adaptation strategies to safeguard both human lives and economic resources against the ongoing threat of tropical cyclones.

Economically, hurricanes damage infrastructure like roads and power lines, disrupt agriculture and livelihoods, and halt business operations. The costs of recovery can be staggering, straining local and national economies, while highlighting the urgent need for improved disaster preparedness and climate resilient infrastructure. For example, Molua, E. L., Mendelsohn, R. O., & Akamin, A. (2020) study illustrated that the United States faced more catastrophic tropical cyclones than Europe and Asia. In particular, losses caused by hurricanes Katrina, Harvey, and Maria reached USD 380 billion across the country. The study also pointed out to regional variations in cyclone characteristics, including differences in frequency, intensity, and the financial repercussions associated with them. These results emphasized the importance of developing region-specific strategies to reduce the impacts of these natural disasters.

Natural disasters encompass various extreme weather events which may endanger human health and safety.

Since 1995, more than 4.4 billion individuals have been impacted by such disasters, resulting in economic losses exceeding $2 trillion (Yuhan, J., Wang, D. C., Canada, A., Schwartz, J., 2021). For instance, in June 2008, the Midwest floods affected over 11 million people, while in 2005; Hurricane Katrina incurred damages of more than $125 billion, along with widespread evacuations and property losses. These environmental occurrences are often random and unpredictable. The National Centers for Environmental Information (NCEI) serves as the authoritative source for tracking and evaluating climate events with significant economic and societal impacts, both within the United States and globally. As the nation's primary institution responsible for monitoring and assessing the climate, NCEI provides comprehensive summaries of temperature and precipitation trends,

extremes, and historical comparisons at the global and national levels. The NCEI's role in addressing severe weather and climate events allows it to contextualize these phenomena within a historical perspective. This function is crucial for understanding the scale and magnitude of the economic consequences associated with such events, which have been observed and documented from 1980 to the present day.

The NCEI serves as a vital resource for researchers, policymakers, and the general public in their efforts to understand the evolving trends and impacts of climate change over time by maintaining this comprehensive record of weather and climate-related disasters. In 2024, it anticipated an above average hurricane season in the Atlantic, which runs from June 1 to November 30 (Center for Disaster Philanthropy, 2024). By October 11, there were 13 named storms, comprising four tropical storms and nine hurricanes, with four classified as major hurricanes (Beryl, Helene, Kirk, and Milton). Notably, hurricane Milton intensified from a tropical storm to a Category 5 hurricane within 24 hours, reaching peak winds of 180 mph and exhibiting an exceptionally small eye, referred to as a "pinhole." The aftermath of hurricane Helene highlighted the devastating impact a single storm can have, raising concerns about the capacity of local, state, tribal, and federal resources to respond to the ongoing challenges posed by this active hurricane season.

7.3 Natural disasters cases in the USA, China, Oman and the UAE

7.3.1 The USA

Hurricane Milton made landfall as a powerful Category 3 storm, packing winds that exceeded 120 mph and inflicting substantial damage across Florida (Hill, A. C.,2024). The impact was severe, leading to widespread power outages that affected approximately 3.5 million residents and resulting in at least 24 confirmed fatalities. Additionally, the storm triggered significant tornado outbreaks, and experts suggest that its intensity was likely intensified by climate change, which may have otherwise led to a less severe storm. Economic losses from the disaster were projected to range between $160 billion and $180 billion, with a notable portion of these losses being uninsured, primarily due to the inadequate flood insurance coverage among homeowners. The disarray surrounding disaster response has been further exacerbated by the spread of misinformation, complicating efforts to provide relief to affected communities. Looking ahead, it is crucial for communities to enhance their resilience against such events by implementing stricter building codes, addressing the rising costs of insurance as indicators of risk, and improving land-use practices to better prepare for future climate-related disasters.

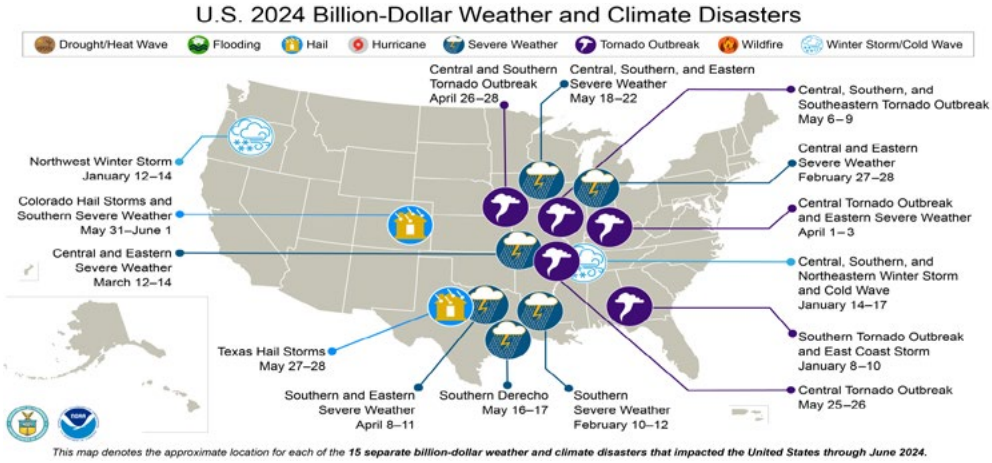

Figure 3. Climate Disasters in the United States in the first half of 2024
Source: NCEI, (2024).

As it can be seen, Figure 3 illustrates the locations of climate disasters that occurred across the United States in the first half of 2024. It highlights 15 separate events, such as hailstorms, severe weather, tornado outbreaks, and winter storms.

Significant hailstorm events are noted in Colorado and Texas, while severe weather incidents are prevalent in the central and eastern U.S. The Central and Southern regions are particularly affected by multiple tornado outbreaks, emphasizing their vulnerability. Winter storms are significant in the Northwest and across the Central, Southern, and Northeastern regions. The increasing frequency and intensity of weather-related disasters in the United States, is potentially linked to the impacts of climate change. Furthermore, Figure (4) shows that year 2024 (marked with a red star) reveals a significant increase in disaster costs, reaching approximately $370 billion by mid-year, making it one of the highest in the observed period. This year surpasses previous costly years like 2017, which saw around $392 billion in disaster costs due to major events such as hurricanes and wildfires. The graph also highlights other notable years: 2012 with $158.9 billion, 2021 with $164.0 billion, 2022 with $182.4 billion, and 2005 with $267.0 billion.

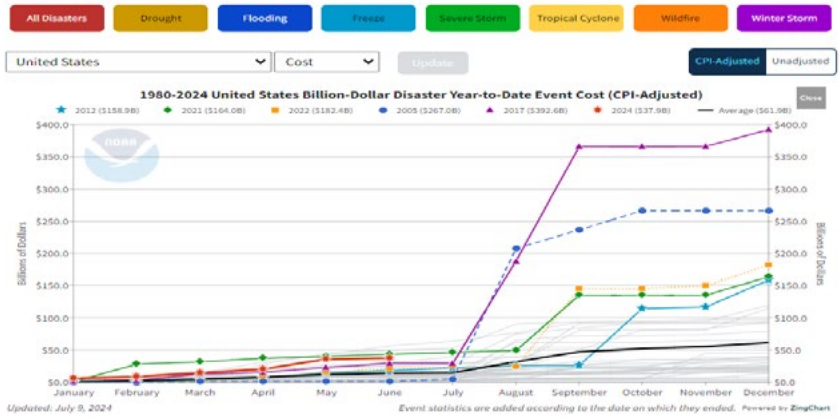

Figure 4. Disasters Loses Costs in the United States (1980 to 2024)
Source: NCEI, (2024)

7.3.2 China

China is a geographically diverse country which exposes it to a susceptible wide range of natural disasters. These hazards affect the nation's provinces, autonomous regions, and municipalities to varying degrees (Wang, P., Yang, Y., Xue, D., Qu, Y., Tang, J., Leung, L. R., Liao, H., 2023). Two thirds of Chinese territory is vulnerable to flooding, while the Eastern and Southern coastal areas, as well as some inland provinces, frequently encounter tropical cyclones. The coastal regions are susceptible to storm surges and red tides, while the country's forests and grasslands face the threat of fires. Notably, half of China's population and more than 70% of its cities are located in areas vulnerable to these various natural disaster types. According to scholars, Southern and Eastern regions of China experienced higher frequencies and greater damage compared to Northern regions (Wang, K., Yang, Y., Reniers, G., Huang, Q., 2021).

Tu, S., Zhang, Y., Liang, M., Wu, D., Xu, J. (2024) research revealed that Southern regions of China experienced a rise in the intensity of tropical cyclones, with more storms reaching higher categories on the Saffir Simpson scale, hurricane wind Scale is a 1 to 5 rating based only on a hurricane's maximum sustained wind speed. Changes in rainfall distribution led to more severe flooding in affected areas. To add, the Pearl River Delta region in South China is at risk as a result of tropical cyclones, which makes it important to carefully study the damage caused by these storms and what leads to it (Sajjad, M., Chan, J. C., 2020).

Sajjad, M., Chan, J. C., (2020) study found that; there is a strong link between the economic damages and the rainfall caused by tropical cyclones, with more rain leading to higher damages. Also, the study indicates that there is a significant connection between economic damages and the wind strength of the storms, indicating that stronger winds result in greater financial losses. The results of the study concluded that; even though rainfall from tropical cyclones has decreased over time, the strength of the storms has increased. Despite the drop in rainfall, economic damages have continued to rise. This suggests that other factors, such as stronger storm winds, growing populations, and urban development, are contributing to the increasing damages in the region. Likewise, China has

experienced a range of natural disasters since 2015, with significant economic and human impacts (Chou, J., Dong, W., Tu, G., Xu, Y., 2020). For example, in 2016, severe flooding affected 32 million people, causing extensive damage to infrastructure and agriculture (Lai, Y., Li, J., Gu, X., Chen, Y. D., Kong, D., Gan, T. Y., Wu, G., 2020). Moreover, in 2020, Yangtze River floods were devastating, displacing millions and causing billions of dollars in damage (Niu, Y., Touma, D., Ting, M., Camargo, S. J., Chen, R., 2022).

7.3.3 Oman and the UAE

The Gulf Council Countries(GCC), including Saudi Arabia, the UAE, Qatar, Oman, Kuwait, and Bahrain, have also faced natural disasters, although their impacts have varied. Oman, for instance, was hit by several severe tropical cyclones. Cyclone Mekunu, in 2018, is one example of them. It caused widespread flooding and significant damage to infrastructure. To add, in early October 2021, Cyclone Shaheen tracked Westward across the far Northern Arabian Sea, penetrated the Gulf of Oman, and made landfall along the Northeast Oman coastline (Terry, J., Al Ruheili, A., Boldi, R., Gienko, G., Stahl, H., 2022). Shaheen was a unique Tropical Cyclone (TC) formed on 30th September 2021, on the Saurashtra coast off Gujrat, from another cyclone Gulab off the Bay of Bengal. Under the influence of warm waters, this one-of-a-kind storm travelled westwards, skirting Pakistan's Makran coast before making landfall on Northern Oman on 4th October 2021 (Mukherjee, P., Ramakrishnan, B., 2023). This storm event represented a unique trajectory, as it was the first of its kind to occur in the region in more than 130 years (Terry, J., Al Ruheili, A., Boldi, R., Gienko, G., & Stahl, H., 2022).

Differently, in the United Arab Emirates (UAE), an unprecedented amount of rainfall was recorded on April 15th, 2024, surpassing all previous daily rainfall records observed over the past 75 years. In a study conducted by Almazroui, M., Khalid, M. S., Islam, M. N., Rehman, S., Sajjad, H. (2020); the researchers argue that the central region of the Arabian Peninsula will experience higher temperatures across all seasons throughout the 21st century, providing valuable information for long-term regional planning. The study investigated the seasonal, inter-seasonal, and regional changes in temperature, as well as the associated uncertainties.

8. RESULTS

This study addressed two critical research questions that arise from the profound effects of hurricanes and tropical cyclones. First, it investigated the key social and economic risks posed by these disasters, exploring how these risks vary across different regions and communities such as the USA, China, Oman and the UAE. It aimed to uncover patterns and disparities in vulnerability and resilience, offering a comprehensive understanding of how such events impact human lives, infrastructure and economics. As a result, the review of the 84 articles provided a comprehensive analysis of the impacts of climate change on nature. The analysis of the studies showed that climate change has intensified tropical cyclones in terms of both intensity and rainfall rates (Walsh, K. J., McBride, J. L., Klotzbach, P. J., Balachandran, S., Camargo, S. J., Holland, G., Sugi, M., 2016). Particularly in the North Atlantic, an increase in Category 3 or higher storms has been observed, with projections suggesting a rise under "+2 ºC" warming scenario (Knutson, T. R., Chung, M. V., Vecchi, G., Sun, J., Hsieh, T. L., Smith, A. J., 2021). Additionally,

studies revealed that the impact of natural disasters varies significantly across different regions, influenced by factors such as geographical location, economic development, and preparedness levels (Padmaja, D. L., Tammali, S., Gajavelly, N., Reddy, K. S., 2022).

Despite these advances, significant gaps and limitations persist. Data inconsistencies across regions hinder accurate analyses of disaster impacts, particularly in historical records predating satellite technology. Climate models often lack the resolution necessary to simulate the complex dynamics of cyclone formation and behavior, leading to contradictory projections in areas like pole ward expansion. Furthermore, findings from region specific studies are difficult to generalize due to unique local conditions. The lack of longitudinal studies limits understanding of the long-term effects of climate-driven disasters.

The economic and social consequences of tropical cyclones are profound and far-reaching. Coastal economies face significant losses and cyclones also trigger long-term effects, such as population migration, reduced property values, and widening socio-economic disparities. These outcomes pointed to the interplay between economic vulnerabilities and climate-driven disasters, necessitating targeted policy interventions. Additionally, from an environmental perspective, hurricanes have degraded marine ecosystems, including coral reefs and mangroves. These ecosystems, crucial for coastal protection, face heightened risks under increasing cyclone activity. Similarly, the health impacts of hurricanes are both immediate and enduring. The studies highlighted increased risks of infectious diseases, mental health conditions like chronic illnesses such as cardiovascular disease. These findings reveal the multifaceted and long-term nature of disaster-related health challenges.

9. DISASTER MANAGEMENT IMPLEMENTATION

As natural disasters continue to occur, mitigating their impact has become a priority for all nations. Risk management processes typically involve several key steps aiming to mitigate risks in various contexts. These processes include:

9.1 Risk identification

Identifying potential risks is the first step that could impact the holistic processes of Mitigation climate change disasters. It involves understanding both internal and external risks that could arise from implementing disaster management rescue plans. For example, utilizing historical hurricane data and predictive models to identify high risk areas for hurricanes is the first step risk management team can do. Also, monitoring oceanic and atmospheric conditions that could lead to tropical cyclones can be used as well here.

9.2 Risk assessment and analysis

Evaluating the risk to understand its potential impact is the second step in the process. The analysis often includes qualitative and quantitative assessments, prioritizing risks based on factors like probability and severity. Also, various tools

such as risk matrices, fault tree analysis, and analysis SWOT can aid in this step. It aims to decide the sufficient financial and operational resources needed. Using hurricane tracing models, the potential strength, path, and impact of the hurricane can be assessed in this process. This includes simulations of storm surge, high winds, and flooding impacts.

9.3 Risk evaluation

Deciding on what approach suits each type of disaster is an important part in this phase. The evaluation often involves both the government and stakeholders input to ensure alignment with organizational goals. It may vary regarding each country's case and degree of the climate change hazard. Based on the impact projections and the critical nature of affected areas, the government prioritizes risk mitigation efforts in highly populated or economically significant regions. It can also evaluate the costs of implementing protective measures against potential losses if no action is taken.

9.4 Risk treatment (mitigation)

In this stage authorities in charge decide on the actions needed to mitigate the climate changes risk and execute the best strategies of the contingency plans. The goal in this phase is to reduce the risk to an acceptable level that saves life or decrease economic losses. For instance, governments can issue evacuation orders when a high impact hurricane is forecasted. Also, in hurricane prone areas, government initiatives may support building codes that require hurricane-resistant structures, especially for critical infrastructure.

9.5 Implementation of risk controls

Governments and concerned parties in this phase put into place the chosen risk mitigation plan, ensuring that the right resources and responsibilities are allocated policies and procedures when necessary.

9.6 Monitoring and review

In the stage, continuous risk monitoring and regular reviews help in identifying any changes in the risk profile based on the situations that occur on the ground. Government can assign the activation of emergency response teams and other agencies to be on standby in affected regions. Coordination with local authorities also add value at this stage. They can ensure that evacuation plans, shelters, and emergency services are available and equipped.

9.7 Communication and consultation

Effective communication ensures transparency and promotes a risk aware culture within the organization. As the hurricane progresses state agencies can adjust their response strategies based on updated risk assessments. Public alerts and communication such as national weather service and local governments issue real-time alerts to the public via multiple channels, including social media, TV, and radio, to ensure residents stay informed.

9.8 Documentation and reporting

Documenting the process to ensure transparency, track progress, and facilitate reporting is an essential part of mitigation plans and process. Clear documentation

aids in compliance, governance, and future risk assessments, is an added value to future crises. It may also benefit other future research.

These steps create a cyclical process where continuous monitoring feeds back into risk identification. These steps can be amended based on the scenario each country faces.

10. SUSTAINABLE TECHNOLOGIES IN DISASTER MANAGEMENT

Millions of people suffer significantly from the impacts of disasters each year. This represents a major challenge underlying the limited success in disaster management efforts. According to the the World Meteorological Organization, over the past half-century, region has witnessed 3,612 discrete disaster occurrences, resulting in nearly one million fatalities and an estimated $1.4 trillion in economic losses, amounting to almost half of the global total for such catastrophic events (World Meteorological Organization, 2024). Traditional disaster management practices often exacerbate environmental degradation and fail to address the long-term needs of affected communities. The reliance on non-renewable energy sources, such as diesel generators for emergency power, contributes to greenhouse gas emissions and air pollution, further exacerbating climate change (International Renewable Energy Agency, 2023). Efforts to mitigate cyclone impacts rely on both technological and nature-based solutions. For example, mangroves have demonstrated their potential to reduce high-risk flood zones, though they also redistribute risks to lower-risk areas.

Human behaviors also, including risk perception and cognitive biases, significantly affect the success of adapting effective disaster management strategies. There are increasing growing calls for green technologies and innovations in disaster management to mitigate disasters impacts. Addressing hurricanes and climate change' impacts call for more innovative, integrated strategies that combine technological, social, and environmental approaches Greve, A. I. (2016). For example, political attain to this issue can increase positive efforts to share knowledge and methods that accelerate the recovery or the protection process. Also, integrating climate change into hazard mitigation planning by assessing future climate risks, engaging local communities in the planning process and aligning climate adaptation efforts with current hazard mitigation policies are part of the effective strategies to contain climate change hazard (Stults, M., 2017).

Also, developing resilient infrastructure, as well as utilizing nature-based solutions such as mangrove restoration and urban greening protect against storm damage. Bayulken, B., Huisingh, D., Fisher, P. M. J., (2021) conducted a comprehensive literature review to examine methods for transforming cities into more resilient and sustainable regions through the strategic enhancement of blue and green spaces within and surrounding urban areas. Analyzing 298 articles published between 1997 and 2020 across 109 academic journals, the study provided holistic insights into the selection, implementation, monitoring, assessment, and valuation of nature-based solutions in diverse urban contexts. The authors found that cities can expand their green areas by implementing nature-based solutions.

Moreover, Abid, S. K., Sulaiman, N., Chan, S. W., Nazir, U., Abid, M., Han, H., Vega-Muñoz, A. (2021) indicate that predictive analytics for forecasting natural

disasters aid policymakers and emergency responders in making informed choices. Similarly, studies revealed that adapting to climate change by focusing on three areas: using predictive analytics, integrating various datasets for better insights into climate patterns, and creating AI tools to support policymakers in developing effective adaptation strategies are effective approaches to mitigate risks (Leal Filho, W., Wall, T., Mucova, S. A. R., Nagy, G. J., Balogun, A. L., Luetz, J. M., Gandhi, O., 2022). On the other hand, Zhang, C., Yin, K., Shi, X., & Yan, X. (2021) suggest utilizing Geographic Information Systems (GIS) for geospatial risk assessment to identify high-risk areas. Additionally, the researchers believe that this method will enhance disaster preparedness in vulnerable coastal regions, will reduce exposure of critical infrastructure, and regulate aquaculture development to limit economic and environmental harm. Fawzy, S., Osman, A. I., Doran, J., Rooney, D. W. (2020) on the other hand, presented several strategies to combat climate change, including conventional mitigation technologies that focus on reducing CO_2 emissions from fossil fuels. The second question the research delved was the sustainable strategies to mitigate the environmental, infrastructural, and economic consequences of hurricanes and tropical cyclones. Cases presented in this study showed various mitigation plans the USA, China, Oman and the UAE used to reduce negative impacts of natural disasters caused by hurricanes and cyclones. Through these inquiries, the study aspired to contribute to the development of effective and sustainable approaches for managing the risks associated with these natural disasters.

10.1 The USA, China, Oman and the UAE Disaster management approach

Addressing climate change and hurricane impacts necessitates comprehensive strategies that include policy initiatives, infrastructure development, and sustainable practices. Countries like China, the United States, Oman, and the UAE have implemented various successful approaches. Sustainable technologies such as renewable energy, green infrastructure and eco-friendly materials play a crucial role in reducing the environmental impact of disaster response (Aguirre-Ayerbe, I., Merino, M., Aye, S. L., Dissanayake, R., Shadiya, F., Lopez, C. M., 2020).

10.1.1 The USA, China, Disaster management approach

The U.S. disaster management approach focuses on climate leadership through initiatives like the Inflation Reduction Act and emphasizes hurricane mitigation through Federal Emergency Management Agency (FEMA) guidance. Also, green infrastructure and eco-friendly materials are equally important in reducing the environmental impact of disaster response. Green infrastructure includes solutions such as green roofs, permeable pavements, and urban forests, which mitigate flooding, reduce heat islands, and improve air quality. For instance, in New York City, the implementation of green infrastructure projects has significantly reduced storm water runoff and improved the city's resilience to extreme weather events (NYC, 2023).

Another example of the mitigation plan is what they implemented after Hurricane Maria. After Hurricane Maria devastated Puerto Rico in 2017, solar energy systems were deployed to provide emergency power to hospitals and other critical facilities. The method significantly reduced the reliance on fossil fuels and ensured a continuous power supply (Aros-Vera, F., Gillian, S., Rehmar, A., Rehmar, L.,2021). In addition to solar power, wind turbines were used to provide essential energy in emergency situations, demonstrating their versatility and resilience in

harsh conditions. The renewable energy sources not only offer immediate relief but also support long-term sustainability by decreasing greenhouse gas emissions and promoting energy independence. On the contrary, China has taken significant steps to mitigate the impacts of natural disasters, through extensive investment in infrastructure and technology.

The government has invested heavily in flood control measures, such as the construction of large dams and reservoirs, to manage the increased risk of flooding from major rivers like the Yangtze (Olson, D. L., Wu, D. D., 2010). Additionally, China has implemented extensive reforestation projects to combat soil erosion and reduce the risk of landslides. Also, it continues to invest heavily in disaster mitigation and recovery, emphasizing rapid response and infrastructure resilience (Cai, J., Zhang, L., Dong, J., Dong, X.,2022). According to Cai, L., Li, Y., Chen, M., Zou, Z. (2020); accurate risk assessment is essential to help allocate resources for disaster relief and make evacuation decisions when hit by a Tropical Cyclone. Nature-based solutions, including reforestation, wetland restoration, and the creation of green spaces, can mitigate the effects of natural disasters by enhancing the resilience of ecosystems.

Reforestation plays a critical role in stabilizing soil, reducing erosion, and enhancing water retention in the landscape. For example, extensive reforestation efforts in the Loess Plateau in China have transformed a previously degraded area into a thriving ecosystem (He, J.-F., Guan, J., & Zhang, W.-H., 2014).

These efforts have not only reduced the risk of floods and landslides but also increased agricultural productivity and improved the livelihoods of local communities. The projects' remarkable outcomes included lifting over 2.5 million people in four of China's poorest provinces out of poverty, doubling farmers' incomes, diversifying employment opportunities, and revitalizing the degraded environment. Sustainable farming practices, natural vegetation regeneration, and improved sediment control led to an increase in agricultural productivity, reduced flood risks, and secured food supplies. The project significantly contributed to the restructuring and market-orientation of the agricultural sector, while also establishing conditions for long-term soil and water conservation in the region (The World Bank Group., 2007).

China also has launched its National Climate Change Adaptation Strategy and invested in renewable energy and afforestation. Moreover, Li, J., Bao, Q., Liu, Y., Wang, L., Yang, J., Wu, G., Shen, Z. (2021) model explores the impact of model resolution on cyclone simulations, accurate high-resolution data, and enhanced predictive capabilities for better forecasting and planning. Furthermore, Shultz, J. M., Russell, J., Espinel, Z. (2005), Lang, C., Ryder, J. D. (2016); and Li, J., Bao, Q., Liu, Y., Wu, G., Wang, L., He, B., Li, J. (2019) studies, examined how cyclones influence public engagement with climate change. They highlighted the need for awareness campaigns to educate the public, as well as policy advocacy to prompt adaptation and mitigation measures, and community involvement to foster local resilience. They recommend improvements in public health preparedness, the establishment of disease surveillance systems for early outbreak detection, and the integration of disaster response with public health initiatives.

10.1.2 Oman and the UAE Disaster management approach

In Oman and the UAE, 80% and 85% of the total populations, respectively, reside in flood-prone and low-lying areas that are highly exposed to heavy rains and cyclones.

Additionally, the prevalence of urban developments with limited permeability and absorptive capacity, inadequate drainage systems, and the hyper-arid soils in some areas exacerbate the risk and severity of flash floods. In response, the UAE and Oman have adopted proactive disaster risk management strategies, including functional early warning, early action, and emergency response systems, as well as long term adaptation planning. As an example; Oman has undertaken several robust measures to mitigate the impacts of severe tropical cyclones, leveraging advanced technology and infrastructure improvements. The country has been significantly affected by cyclones, including notable ones like Cyclone Gonu in 2007, Cyclone Mekunu in 2018, and Cyclone Shaheen in 2021. These events have prompted Oman to enhance its disaster preparedness and response strategies. To add, Oman's National Strategy for Adaptation and Mitigation to Climate Change (2020-2040) outlines comprehensive measures to address environmental challenges and enhance resilience to future cyclones (Green Climate Fund., 2022).

Researcher Alruheili, A. (2017) also, outlined strategies for Oman to improve climate change resilience by creating long term plans that integrate resilience into national development. In his approach he suggests fostering collaboration among different sectors and communities and developing policies that promote adaptive and sustainable practices. Together with, Al-Awadhi, T., Charabi, Y., Choudri, B. S. (2019), the researcher suggests ways to strengthen urban resilience in Oman by upgrading infrastructure to better withstand climate impacts. His solution involves using ecosystem-based adaptation and raising community awareness about climate risks and adaptive practices. Additionally, Mansour, S., Darby, S., Leyland, J., Atkinson, P. M. (2021); Al Habsi, J., al Kalbani, A. (2023) study which employs geospatial modeling to evaluate cyclone risks in Oman, recommends creating risk maps to pinpoint high-risk areas.

Also, the study suggests implementing land-use policies to reduce exposure to marine hazards, and developing tailored emergency response plans for identified risk zones. Moreover, Oman has developed advanced cyclone early warning systems and built cyclone-resistant infrastructure following Cyclone Gonu in 2007 and Cyclone Mekunu in 2018. The concept of early warning systems has gained widespread recognition as a crucial component in mitigating the impacts and consequences of hazardous natural events on societies (Trogrlić, R., van den Homberg, M., Budimir, M., McQuistan, C., Sneddon, A., Golding, B. (2022). Furthermore, Oman has invested heavily in early warning systems and the use of Geographic Information Systems (GIS) and remote sensing technologies. The National Multi-Hazard Early Warning System, established by the Civil Aviation Authority, plays a crucial role in monitoring and forecasting weather events, providing timely alerts to mitigate the impacts of incoming cyclones. This system integrates satellite data, radar, and ground-based observations to deliver precise forecasts and warnings, allowing for timely evacuations and preparations (Times News Service., 2023).

Researchers affirm that community involvement and public education are critical components of Oman's disaster management strategy. The government conducts regular awareness campaigns and drills to educate the public on emergency procedures and safety measures. These initiatives help ensure that communities are better prepared to respond quickly and effectively to warnings, reducing the potential for casualties and property damage (Jones, C., 2024). Oman also collaborates with international organizations and neighboring countries to enhance

its disaster management capabilities. This includes participating in regional initiatives and training programs focused on disaster risk reduction and response. Recognizing the link between climate change and the increasing frequency of severe weather events, Oman has committed to sustainable practices to mitigate long-term risks (Ahmed, M., Choudri, B. S., 2012). Similarly, Oman' neighboring country the UAE have implemented extensive urban planning measures to manage flooding and extreme heat, including the construction of advanced drainage systems and the establishment of cooling centers during heat waves (Almulhim, A. I., Al Kafy, A., Ferdous, M. N., Fattah, M. A., Morshed, S. R., 2024).

11. RECOMMENDATIONS AND CONCLUSION

11.1 Recommendations

Hurricanes and tropical cyclones pose significant threats to coastal populations, primarily through extreme precipitation and strong winds. Thus, accurate risk assessment framework to evaluate the hazard is an essential measure to be taken into consideration (Meng, C., Xu, W., Qiao, Y., Liao, X., Qin, L., 2021). Based on the findings of this research, the following recommendations are proposed to support the further integration of sustainable solutions into disaster management and crisis response.

11.1.1 Enhance policy and regulatory frameworks

Policymakers should develop and implement policies, regulations, and incentive mechanisms that explicitly promote the adoption of sustainable disaster management practices, such as renewable energy, nature-based solutions, and circular economy principles (Wendler-Bosco, V., & Nicholson, C., 2022).

11.1.2 Strengthen institutional capacity

Disaster management agencies and relevant government authorities should invest in building the necessary institutional capacity, technical expertise, and cross sectorial coordination to effectively plan, implement, and monitor sustainable disaster management initiatives.

11.1.3 Increase Funding and financing

Dedicated funding mechanisms, such as green disaster response funds, public-private partnerships, and innovative financing instruments, should be established to support the implementation of sustainable disaster management solutions.

11.1.4 Foster community engagement and ownership

Effective disaster management requires active community involvement and education. Local communities are often the first responders in the aftermath of a disaster. Therefore, educating the public about disaster preparedness and involving them in planning and response efforts can enhance resilience.

11.1.5 Promote knowledge sharing and capacity building

Platforms for knowledge-sharing, best practice exchange, and capacity-building should be established to facilitate the dissemination of sustainable disaster management approaches and support their replication in other disaster-prone regions.

11.2 Conclusions

The research explored the social and economic risks of hurricanes and cyclones and how their impacts differ across regions and communities. It also examined sustainable strategies to minimize environmental, infrastructural, and economic damage while identifying gaps in research on these mitigation approaches. The study examined their effects on the environment, infrastructure, economy, and human lives, systematically reviewing 84 articles, reports, and researchers. The findings of the research demonstrate that the integration of sustainable solutions into disaster management and crisis response can deliver significant environmental, economic, and social benefits. The USA, China, Oman and the UAE case studies provided compelling evidence that the adoption of green practices, such as renewable energy, nature-based solutions, circular economy principles, and decentralized infrastructure, can enhance the resilience and sustainability of disaster response and recovery efforts. One of the key lessons from natural disasters worldwide is the importance of comprehensive preparedness and early warning systems. Countries like China and the Oman and the UAE countries have invested heavily in early warning technologies and public education, which have significantly reduced the death tolls in subsequent disasters.

Early warning systems provide critical lead time for evacuations and other emergency measures, ultimately saving lives and reducing the economic impact of disasters. Sustainable infrastructure not only reduces the immediate damage caused by disasters but also facilitates quicker recovery. Natural disasters have underscored the importance of integrating green solutions into disaster management strategies. Reforestation and wetland restoration, as seen in China and the United States, have proven effective in mitigating the impacts of floods and landslides. These nature-based solutions enhance the resilience of ecosystems, which in turn protects human communities. Green infrastructure, such as permeable pavements and urban green spaces, helps manage storm water, reduce urban heat islands, and improve overall environmental health.

12. IMPLICATIONS OF THE STUDY

The study contributes to the existing literature in crisis management and identifies the survival and resilience strategies to overcome climate change impacts. The findings of this are aligned with those of other scholars investigating climate change affects. The actual results of the paper also provide recommendations for policy makers and governments responsible for mitigating disasters around the world. The presented strategies are an added value in decreasing disaster hazard during and post the occurrence.

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APPENDIX

LIST OF ABBREVIATIONS

GIS	Geographic Information Systems
IPCC	Intergovernmental Panel on Climate Change
GCC	Gulf Cooperation Council
IFRC	International Federation of Red Cross and Red Crescent Societies
IRC	International Rescue Committee
WFP	UN World Food Program
UNDP	United Nations Development Program
WHO	World Health Organization
WMO	World Meteorological Organization