Research Flood Risk and Flood Management Causes and Consequences of Rask and Sarbaz Districts in Balochestan Makoran, 2023 Iran

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ABSTRACT: *This research reveals that for all flood conditions especially on the lower Sarbaz river, have systematically risen for monthly maximum discharge volumes over the period of record. Communities are being menaced by floods since ages [1]. Flood occurrence not only imposes loss to the infrastructure and property but it also claims thousands of lives and leave millions homeless. Floods occur due to hydro-metrological and natural factors. Flooding is one of the most frequent and costliest natural hazards around the world. A holistic perspective on changing rainfall-driven flood risk is provided for the early 21st centuries. Economic losses from floods have greatly increased, principally driven by the expanding exposure of assets at risk [2]. Traditionally, flood risk management has relied on building protective structures such as levees and dams to protect assets based on historical data, which encourages development on floodplains, provides a potentially false sense of security to communities, particularly in the context of climate change, and increases residual flood risk (the risk remaining after implementing risk reduction measures). This article aims to contribute to the management of residual risk by drawing on empirical findings from a survey carried out with flood risk practitioners from the public and private sector in Balochestan Makoran [15]. Findings indicate fundamental concerns relating to how to best manage residual flood risk, despite its long profile and integration in current policy and practice. Other issues revolve around the use of outdated information to guide decisions and the lack of regulatory power to restrict developments in flood-prone areas protected by hard defense structures. Identified barriers to improving current practice include the lack of national guidance and support, financial resources, public awareness, and some technical constraints such as uncertainties in flood modeling, staff expertise, and data availability.*

Keywords: *Flooding, Disaster, Risk, mitigation, Makoran, Disaster Management, planning, management.*

INTRODUCTION

Flood preparedness involves building capacities that enable minimizing losses through effective response and recovery. While there are many preparedness assessments at household and community level, very few have been conducted at institutional level. This study assessed the households' perspectives of the preparedness of civil protection institutions in Balochestan Makoran during the flood of 2023 Rask and Sarbaz districts flood disaster and identified the capacity building needs of the civil protection institutions [2].

The study was conducted at Rask and Sarbaz rivers in Makoran. Thus location up on which this study concentrates is bounded by the coastline of southern Iran and Western Pakistan, approximately, by the line of latitude 25˚ to the South and the line of longitude 60˚ to the west. The area consists of an inland chain of steeply sloping bare rock (mountains) which drain onto a coastal alluvial plain. The analysis is based on a multi-sites analysis approach, since the five rivers locations are not considered sufficiently similar to be pooled together. The Study Area might be classified as “Tropical Triple season Moderate Climate Zone”, which is characterized by single rainfall season from July-September and its moderating influence in temperature. The river flow and rainfall temperature pattern of the area based on the record of data obtained from the Iranian Meteorological and water resources organization department. Iran continues to suffer from natural hazards that threaten to affect the lives and livelihood of its citizens. Due to its unique geo-climatic conditions, Iran is one of the most disaster prone countries in the world and undergoes natural disasters including floods, earthquakes and drought [18]. A location plan is shown in Figure 1.

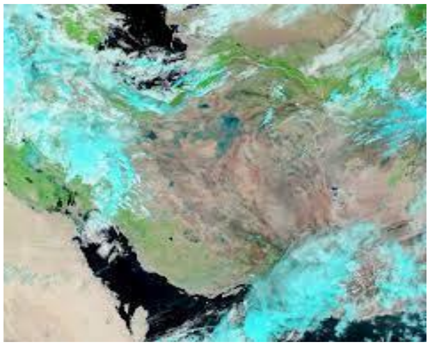

Figure 1: The area of study in Rask , Sarbaz and Pishin Districts in Makoran Region, Sistan and Balochestan Province of Iran

MATERIALS AND METHODOLOGY

The study was conducted at Pishin and Zirdan Dams in Makoran. The area is located near the borders of Iran and Pakistan. Thus location up on which this study concentrates is bounded by the coastline of southern Iran and Western of Pakistan, approximately, by the line of latitude 25 degree to the South and the line of longitude 60 degree to the west. The area consists of an inland chain of steeply sloping bare rock (mountains) which drain onto a coastal alluvial plain. The analysis is based on a multi-sites analysis approach, since the two rivers locations are not con The study was conducted at Pishin and Zirdan Dams in Makoran. The area is located near the borders of Iran and Pakistan. Thus location up on which this study concentrates is bounded by the coastline of southern Iran and Western of Pakistan, approximately, by the line of latitude 25 degree to the South and the line of longitude 60 degree to the west. The area consists of an inland chain of steeply sloping bare rock (mountains) which drain onto a coastal alluvial plain. The analysis is based on a multi-sites analysis approach, since the two rivers locations are not considered sufficiently similar to be pooled together [1]. Floods are one of the most common hazards in the world also in the some parts of north of Iran. Flood effects can be local, impacting a neighborhood or community, or very large, affecting entire river basins and multiple states [2]. However, all floods are not alike. Floods themselves average four billion dollars annually in property damage alone. Some floods develop slowly, some-times over a period of days. But flash floods can develop quickly, sometimes in just a few minutes and without any visible signs of rain. Flash floods often have a dangerous wall of roaring water that carries rocks, mud, and other debris and can sweep away most things in its path. Overland flooding occurs outside a defined river or stream, such as when a levee is breached, but still can be destructive [29]. Some general reasons of flood include: weather related reasons: heavy rainfall, duration of precipitation, sudden snow melting and physical conditions: soil variety, slop of lands, land degradation and human activities: deforestation, misusing of land and transforming to grasslands or agricultural area, misconstruction of roads, bridges, dams and environmental situations [26]. The flow data was obtained from 12 months from January to December has been tested by computer excel program the peak discharge was ranging from 3580 m^3/sec [18]. This study reviews the existing literature on the flood, flood management, and socioeconomic cost in Iran focusing on riverine and extreme floods (2023). The theoretical framework of the study is shown in Figure 2. Figure 2 Flood hazard map indicates the most vulnerable districts of Iran with a major river system map developed.

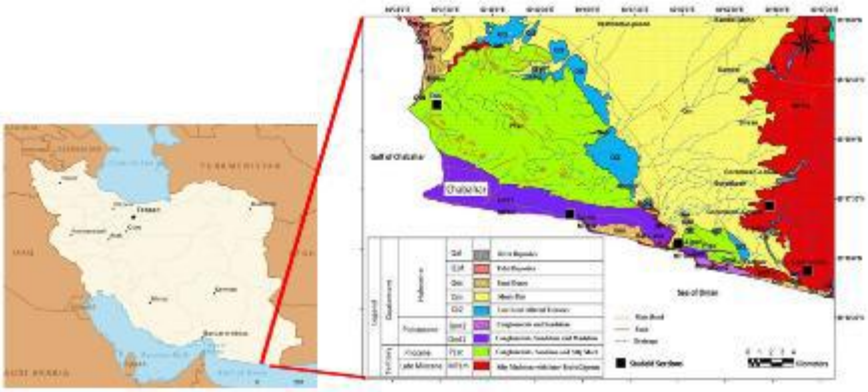

Figure2. The Study area of Makoran (Sistan and Balochestan) region under flash flood 15/4/2023 in Rask and Sarbaz Districts of Southern Iran

CAUSES OF FLOODS IN MAKORAN, RASK AND SARBAZ DISTRICTS, IRAN

The major rivers cause flood losses by inundation of areas along their banks, by damaging irrigation and communication facilities across or adjacent to the rivers, and by erosion of land along the riverbanks. In the upper part of the Makoran Basin System, floodwater spilling over the riverbanks generally returns to the river. However, in the lower part of Makoran, Sarbaz River, which is primarily flowing at a higher elevation than adjoining lands, spills do not return to the river [26]. This phenomenon largely extends the period of inundation resulting in even greater damages. Although flood protection by embankments has been provided along almost the entire length in the Sistan and Balochestan Provinces and at many locations in the upper areas, the bund breaches can still occur. Such breaches often cause greater damage than would have occurred without the bunds because of their unexpected nature and intensification of land use following the provision of flood protection. The inadequate existing discharge capacity of some of the important structures (Road Bridges or Barrages and Rail) on Rivers Sarbaz [2, 4 and 14].

This review follows a process figure (Figure 3) for a scientometric and systematic analysis of the literature that relates to urban flood resilience. In order to clarify the current research status and development trends of urban flood resilience, Cite Space software was used for keyword frequency statistics and high-frequency keyword screening analysis [9 and 11]. VOS Viewer software was used for social network analysis and hierarchical clustering analysis, which finally presents the research changes of urban flooding in a quantitative and dynamic way. Research hotspots in different stages are compared, future trends are predicted according to keywords, and future research directions are explored. Cite Space is an information visualization software that can analyze the characteristics of the literature in various research fields. It includes analysis related to keywords, authors, cited studies, countries, research institutions and journals. It provides visual forms of keyword clustering, cooperative networks, co-cited networks, literature sources, regional distribution and so on [12]. Therefore, flash flood disasters occurred in Rask ,Sarbaz and Pishin districts on cities on 15/4/ 2023 which is illustrated in figure (3).

Figure-3. Illustrates human effects on riverine flood risk disasters Rask, Sarbaz and Pishin Overtopped levee during the flash flood in 15th April 2023

INTEGRATED APPROACH IN FLOOD MANAGEMENT

In the past, floods were considered as a hydrological reality; only structural and non-structural measures were adopted to deal with this phenomenon, but now well-being of the people of the flood prone areas, their economic growth; and social urgency for alleviating poverty prevailing in these floods affected areas, are over riding concerns [7].

Enough hard work is required to address these concerns from both national and regional perspectives. The regional approach is of particular significance as activities undertaken in one country may affect, positively or negatively, the extent of floods in the other regional countries, particularly the downstream ones [27].

To make full use of the experiences gained from flood management activities in the regional countries there is pressing need for exchange of views and experiences, data and information sharing, and working together to develop approaches and methods to address pertinent flood management issues, nationally and regionally, in an open and trusting atmosphere [30].

FLOOD PROTECTION AND SPATIAL PLANNING

A large number of housing estates, infrastructural systems, industrial plants, and enormous farming areas face the danger of being flooded. Therefore, it is essential to create legal, spatial planning and technical documents in order to predict hazards and provide appropriate measures of flood control. In order to reduce the negative effects of river processes (lateral and bottom erosion), as well as the potential flood damage, the structural and non-structural intervention must comprise the whole catchment area at the same time. Effective protection against floods caused by torrential rains requires well-coordinated actions as regards water management, forestry, agriculture, power industry, environment protection, and local economic development [28].

According to flood control and flood management, long-term flood control includes building water reservoirs and limiting erosion. The risk of faster surface runoff may be greatly reduced by altering the land management, e.g. by a forestation, the cultivation of degraded forests, meadows and pastures, delimiting farming areas in order to decrease the formation of erosion material, as well as increasing the infiltration of water to the soil and the land's retentive properties [1-26].

The strategy of "retaining water in the landscape" by decentralized means, such as small reservoirs and micro-ponds, may play an important role in flood management only in meso-scale catchments in the case of small and medium floods, and an insignificant role during the largest floods. This has been confirmed by two projects conducted in the catchment areas of the Sarbaz river. They showed that the water retention measures in the upper course of a river, in the forms of a network of canals and changes in land use, may considerably reduce the occurrence rate of small and medium floods in small basins, or help reduce medium floods in large basins. However, the occurrence rate of large flood events in large basins in the lower course of the river was not particularly affected [25].

However, according to the most effective forms of flood control and flood risk reduction are: officially introducing the rule of no construction in floodplains, moving residential buildings and infrastructure away from the floodplain zones, and controlling the urbanization process [7].

FLOOD CONTROL OBJECTIVES & NEED

Flood management planning and practices in Balochestan (Makoran, Rask) aim at achieving the following objectives [28]:

i. Reduction of flood losses in an economically sound manner;
ii. Prioritizing of areas of greater economic hazards;
iii. Protecting the cities and vital infrastructural installations;
iv. Exploring the possible use of existing flood control facilities;
v. Promoting appropriate land use in flood hazard areas;
vi. Minimizing adverse effects on national ecosystem and environment; and

vii. Creating flood awareness and adaptability in the riverine areas.

STRUCTURAL FLOOD MANAGEMENT

It was initially believed that the way to reduce flood damage was to manage the rivers through structural measures and moderate the floods. Structural measures as the name implies involve the construction of structures like dams, embankments, drainage channel etc. However after spending hug amount of money on flood management works, it was realized that this approach was not effective [3]. The reason is not farfetched; as anyone living by the river is at risk of its flooding when flood occurs which the structure cannot contain. Individuals suffer more damage than what they would have suffered had the structure not been built in the first place. Besides, there are various difficulties in the construction of flood management structure (like financial constraints). Due to which it is not possible to protect all flood prone areas from floods of all magnitudes. It was thus, learnt that we should not try to mitigate flood damages by only keeping the water away from the people. This also made the people realized the important of flood plains. Flood plain is the land adjoining the river which it occupies during floods and can be used for dry season farming. The study and use of flood plain in this manner is called “flood plain management” and the reduction of flood damage in this manner is called the “nonstructural” approach [3].

NON-STRUCTURAL

An increasing attention is now being laid on the non-structural measures. The important non structural measures are therefore, described below;

A. Floodplain Management

A flood plain is an area of land that is prone to flooding. People realize it is prone to flooding because it has flooded in the past due to a river or stream overflowing its banks. A flood plain usually is a flat area with areas of higher elevation on both sides. Flood plains can be very small or very large. Small flood plains sometimes are part of a valley. Houses that are built in small flood plains often require more insurance coverage because damage due to flooding is more likely to occur there than in higher elevations. large flood plains can almost take up entire countries [9, 10 and 11]. In Iran River delta, the flood plain of the Sarbaz rivers covers more than 12,000 square kilometers. Flood plains usually are very fertile agricultural areas. Floods carry sediment rich in nutrients and are spread over a wide flood plain area. Flood plains are flat with relatively few rocks to no rocks or other large obstacles that may prevent farming. The flood plains of the Sarbaz River have been Makoran center of agriculture for hundreds of years [3]. Floods are usually seasonal and can be predicted months ahead of time. The ability to develop agriculture, the transportation allowed by rivers, and the normally stable flood season make flood plains ideal locations to develop urban areas. Flood protection infrastructure generally comprises river banks protections, the floodplain zoning, planned urbanization, restoration of abundant channels, dredging of rivers and streams, increased elevations of roads and village platforms, building of efficient storm sewer systems, establishment of buffer zones along rivers, conservation tillage, controlled runoff near construction sites, adjustment of life-style and crop patterns, good governance, and improvement in flood warning/preparedness systems [23].

A floodplain is a low-lying region that borders a river, a creek, a lake, a coast or an alluvial mountain formation. The area generally lies above the high-water mark and is dry except in times of flooding. Floodplains are often described in terms of certain geographical and topographical designations. They can also be categorized by the yearly statistical odds of flood occurrence. i. Riverine Floodplains: Riverine floodplains are usually defined as wide, flat areas that lie adjacent to a river, creek, lake or coastline. Riverine flooding can inundate the plain for days or weeks. The water covering a riverine floodplain is generally shallow, but it can rise if rains continue to fill river channel hundreds of miles upstream [20].

ii. Mountainous Floodplains: Mountainous floodplains are frequently located within ranges characterized by steep river valleys or a peak that has eroded into an alluvial land. Floods in these areas are often of the "flash" variety, occurring with little warning. Mountainous floodplains may be decimated by walls of debris-filled water which possess incredible force but are of short duration [5].

ANALYSES RAINFALL DATA WHICH FLASH FLOOD OCCURRED IN MAKORAN

Recent years have seen an increase in the intensity of extreme rainfalls and the frequency of floods caused by climate change. As a result, South Iran (Sistan and Balochistan province) is facing an ever-increasing risk of flooding due to monsoon and typhoons in the summer season. In South Iran, since the implementation of the Five Major Rivers Restoration, a variety of eco-friendly riverfront facilities, such as ecological parks as well as sports and recreation areas have been constructed on floodplains [18]. These riverfront facilities have a high risk of damage due to inundations during the rainy season. To perform hydraulic analysis and stability assessment of these facilities, accurate numerical modeling is necessary. First and foremost, it is crucial to address the dry/wet (DW) phenomena caused by rising and falling water level [8]. Extreme precipitation events are likely to become more frequent and more extreme under a changing climate. It follows that monetary damages from flooding would also increase relative to baseline, yet this relationship has not been quantified at the scale of the entire Balochistan. In this paper, we quantify how climate change could affect monetary damages from flooding in the coterminous Balochistan. With publicly available historical flooding and river flow data, we estimate region-specific logistic regression models of the probability that severely damaging floods will occur under baseline conditions [13].

Therefore, according to the rainfall data that has been obtained gives a realistic description of the flash flood occurred on 15/4/2023 within 24 hours rainfall in Sarbaz 160 mm, Kalat, 168 mm, Komitag 175 mm, Bandan 180 mm, Nasiabad 165 mm, Heet 158 mm, Pirdan 152 mm, Paroud 145 mm, Pirzabad 142 mm, Rask 140 mm, Baftan 162 mm, and Pishin 154. Thus arid climate in Balochistan, and clearly illustrates the times of the year when rainfall is more or less likely [13].

Increasingly focusing in case of rainfall in the Balochistan (Makoran) region it is important during this rainfall flash flood is occurred. The rainfall data that has been determined gives a realistic description and definition of the arid climate in Balochistan and clearly illustrates the times of the year when ever rainfall is more or less likely occurred during certain periods of year. However in this way it is concluded that the lognormal distribution may be used to analyse annual data, because that the Gumbel extreme value distribution is preferable for monthly data from the wet months (Marriott M.J. & Zainudini M.A., 2006). So the dry months are not amenable to this type of analysis eventually for the arid region of Sistan and Balochistan (Makoran) when and where heavy rainfall can be happened; due to the high temperature and humid and cold fronted breeze with the inter-tropical convergence area when penetrates to the coastal surface thus sever and such as heavy precipitation occurred in that particular region of the Balochistan which is analyse and shown in figure 3.

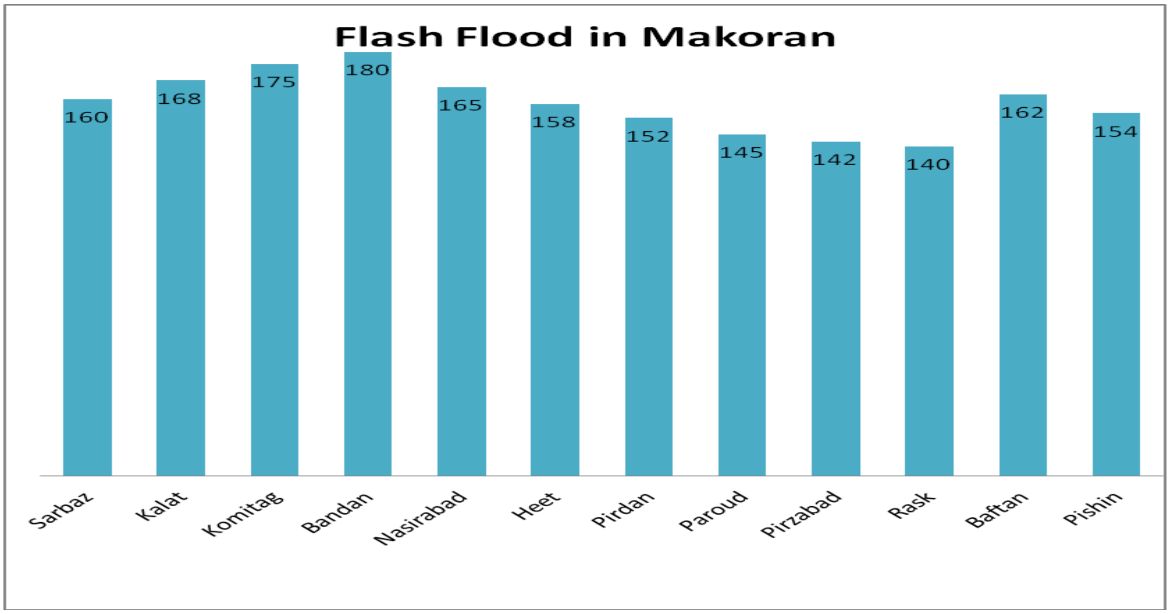

Figure 4: Heavy Rainfall with Flash Flood occurred on 15/4/2023 in the Rask, Sarbz, Pishin Districts in Makoran Region, Iran

CLIMATE CHANGE

A number of participants discussed expected increases in flooding because of climate change, with individuals who discussed coastal flooding being most likely to also mention climate change (specifically sea level rise). For instance, a "high priority" concern for one participant was "how flooding, sea-level rise, climate change and gray infrastructure responses threaten critical coastal habitat." This sentiment that climate impacts on flooding are primarily a coastal issue has also been documented [21].

Interestingly, participants who were concerned about rain-driven flooding saw climate change as more of a secondary concern, needed once current flooding problems are addressed:
This quote highlights a concern that a future-oriented focus on climate change will divert resources from communities that already are facing flooding, and which historically have received less attention. Additionally, it highlights the need to ensure that new infrastructure in these communities is adequate for a new climate future [16, 21, 22].

RESULTS AND DISCUSSION

Two key messages can be distilled from the results to better manage residual flood risk in. First, a clearer national directive of how flood risk and residual risk should be managed is urgently needed, particularly for guidance on the regulatory provisions to restrict inappropriate development in flood-prone areas, including those behind protective structures. Second, more dedicated resources and support are necessary to allow local councils to compile more rigorous and consistent (residual) flood risk information and to actively engage with the public for better flood risk awareness and outreach [19].

A lack of a clear national directive on managing flood risk and residual risk is a repeated theme raised by participants in the survey. Local practitioners agree that residual flood risk is increasing, mainly due to climate change and continuing development in the flood-prone areas. As climate change is constantly changing the risk profiles of flood-prone communities, the current practice of flood risk management that relies on lengthy historical observations to predict and design for future extreme events is seen by some as no longer adequate [27]. Although a more adaptive approach is deemed necessary, participants note that such a change is difficult due to the existing institutional context, such as the long-standing defense-oriented risk management paradigm. This supports other research which has similarly identified the strong influence of administrative traditions, disciplinary practices, or outdated standards or codes of practice in continuing more "static" practices [16].

While awareness is high professionally, it is clear that residual risk remains an emerging topic for flood risk management more generally, particularly with regards to effective governance, appetite for more control over private sector development rights, and public awareness of the unseen potential harm [24]. Even though this study provides a useful first step into understanding residual flood risk management, research on this topic, even globally, is still limited particularly in the face of rising climate change influence of flooding and parallel agendas, such as relating to the housing crisis, demanding easier planning or the widening of development rights. Hence, we argue more future research is needed to better address residual risk in two specific contexts: (1) flooding in urban areas that are subject to significant growth pressures, particularly those facing more intense precipitation events or compounding flood hazards including pluvial, fluvial, groundwater rise, coastal storm surge, and sea level rise; (2) flooding in peri-urban and rural areas predicted to experience more intense compounding pluvial and/or fluvial flooding hazards. Additionally, based on this survey, there is still a need for more quality information on the extent to which residual flood risk is actually leading to different planning decisions or influencing wider risk management decision-making processes in practice. Future research can also focus on how residual flood risk is managed in other countries in comparison to with a view to deriving transferrable best practices, or to undertake in-depth case studies of residual flood risk management in specific communities to better understand local barriers and how they can be overcome [27]. Data such as these would also be useful in tracking the extent to which the state of practice has changed or how the forthcoming new resource-management legislation and hazard planning framework proposed for influences effective residual flood risk management. With the rising attention paid to residual flood risk and better understanding of how to manage it (including adaptive approaches), it enables more informed land use planning, policy changes, and risk decision-making to improve the resilience of our cities and rural floodplains in the face of climate change and significant development pressures [23].

CONCLUSION

The research articles in this Special Issue addressed the challenges in flood management and proposed new methods. Flooding is one of the most frequent, harmful, and costliest natural hazards around the world. For many years, structural measures, such as levees and seawalls, have been the principal mitigation actions for flood risk management, focusing primarily on reducing flood exposure to a certain level. While it will always play a role, this conventional engineering-oriented approach to manage flood risk can have more hidden side-effects because development usually increases behind protective structures due to a false sense of security known as the "levee effect," thereby increasing residual flood risk. Adding climate change to the formula, flooding is exacerbating the threat to communities, as evidenced by the increasing frequency and severity of flooding around the world. In this context, it is imperative that we need a more holistic understanding of risk and manage flood risk more effectively by addressing residual flood risk and how it changes over time. We conducted a national survey of practitioners from local councils (i.e., regional and territorial) and consultants who work closely with councils on managing flood risk in, which provides a valuable baseline study to understand how residual flood risk is being managed and to identify the barriers that hinder such endeavors [16]. We find that flood risk professionals are well aware of and concerned with residual flood risk in their communities. All acknowledged that residual risk is increasing in their communities for multiple reasons, including climate change, increasing developments in the floodplains ("levee effect"), inadequate flood mitigation measures, lack of robust (residual) flood risk information, low public (residual) flood risk literacy, and changing topography. The majority reported that residual flood risk had been considered when managing local flood risk, but to varying levels. The most common approach incorporates protective structures into flood hazard/risk assessments and generates specific levee or dam failure scenarios from flood modeling to inform risk decision-making. However, many expressed concerns regarding their existing approach such as using design event that could underestimate flood risk, relying on outdated risk information that fails to consider the changed land use patterns, and adopting unsophisticated (non-hydrodynamic) flood modeling [24].

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REFERENCES

[1] Abdi-Dehkordi et al., 2021 M. Abdi-Dehkordi, O. Bozorg-Haddad, A. Salavitabar, S. Mohammad Azari, E. Goharian, Development of flood mitigation strategies toward sustainable development Nat. Hazards, 108 (3) (2021), pp. 2543-2567

[2] Aerts et al., 2018 J. Aerts, W.J. Botzen, K.C. Clarke, S.L. Cutter, J.W. Hall, B. Merz, E. Michel-Kerjan, J. Mysiak, S. Surminski, H. Kunreuther Integrating human behaviour dynamics into flood disaster risk assessment Nat. Clim. Change, 8 (3) (2018), pp. 193-199 View at publisherCrossrefView in ScopusGoogle Scholar

[3] Anita, 2013 J. Anit, Structural and non-structural approaches as flood protection strategy in Muara Angke settlement, North Jakarta, Proceedings of the Second International Conference on Sustainable Infrastructure and Built Environment, FTSL, ITB, Bandung, Indonesia (2013), pp. 19-20

[4] Apel et al., 2008, H. Apel, B. Merz, A.H. Thieken, Quantification of uncertainties in flood risk assessments Int. J. River Basin Manag., 6 (2) (2008), pp. 149-162

[5] Asselman and Klijn, 2016, N.E. Asselman, F. Klijn, Making room for rivers: quantification of benefits from a flood.

*[6] Bin Mokhtar, M.; Ahmed, M.F. Managing a Road as a River to Mitigate the Impact of Urban Flash Floods. J. Flood Risk Manag. **2022**, 15, 1. [Google Scholar] [CrossRef]*

*[7] Rosmadi, H.S.; Ahmed, M.F.; Bin Mokhtar, M.; Lim, C.K. Reviewing Challenges of Flood Risk Management in Malaysia. Water **2023**, 15, 2390. [Google Scholar] [CrossRef]*

*[8] Ahmed, M.F.; Halder, B.; Juneng, L.; Bin Mokhtar, M.; Leeonis, A.N. Flood Potential and near Real-Time Inundation Analysis through Geospatial Approaches in Shah Alam, Malaysia. Geomat. Nat. Hazards Risk **2024**, 15, 2361807. [Google Scholar] [CrossRef]*

*[9] Selamat, S.N.; Abd Majid, N.; Mohd Taib, A.; Taha, M.R.; Osman, A. The Spatial Relationship between Landslide and Land Use Activities in Langat River Basin: A Case Study. Phys. Chem. Earth Parts A/B/C **2023**, 129, 103289. [Google Scholar] [CrossRef]*

*[10] Majid, N.A.; Zulkafli, S.A.; Zakaria, S.Z.S.; Razman, M.R.; Ahmed, M.F. Spatial Pattern Analysis on Landslide Incidents in Kuala Lumpur, Malaysia. Ecol. Environ. Conserv. **2022**, 28, 1624–1627. [Google Scholar] [CrossRef]*

*[11] Zulkafli, S.A.; Abd Majid, N.; Rainis, R. Spatial Analysis on the Variances of Landslide Factors Using Geographically Weighted Logistic Regression in Penang Island, Malaysia. Sustainability **2023**, 15, 852. [Google Scholar] [CrossRef]*

*[12] Norizan, N.Z.A.; Hassan, N.; Yusoff, M.M. Strengthening Flood Resilient Development in Malaysia through Integration of Flood Risk Reduction Measures in Local Plans. Land Use Policy **2021**, 102, 105178. [Google Scholar] [CrossRef]*

[13] Marriott, M. J. and M. A. Zainudini. 2006. A review of rainfall data from the Iranian province of Sistan and Balochistan. Proceedings of the Advances in Computing and Technology Conference, London. ISBN-0-9550008-1-5, pp.113- 118

[14] N. M. Robertson and T. Chan, ―Aerial image segmentation for flood risk analysis,‖ in IEEE International Conference on Image Processing (ICIP '09), pp. 597–600, November 2009

[15] Bin-Ismail, M. Community Response to Flood Disaster: A Case Study of Flooding in Penang, Malaysia. Ph.D. Thesis, Durham University, Durham, UK, 2022. [Google Scholar]

[16] Zulkifli, A.M. Behind the Frequent Floods in Shah Alam; University of Jambi: Jambi, Indonesia, 2021. [Google Scholar]

[17] Oxfam's Policy Paper. Ready or Not: Pakistan's resilience to disasters one year on from the floods. 2011. Available from: http://policy practice.oxfam.org.uk/publications/ready-or-not-pakistans-resilience-to-disasters-one-year-on-from-the-floods-138689

[18] Doswell, C.A., III. Hydrology, Floods and Droughts. Flooding. 2015. Available online: (accessed on 25 November 2024).

*[19] Ahmadun, F.-R.; Wong, M.M.R.; Mat Said, A. Consequences of the 2004 Indian Ocean Tsunami in Malaysia. Saf. Sci. **2020**, 121, 619–631. [Google Scholar] [CrossRef]*

[20] *Ahmed, M.F.; Bin Mokhtar, M.; Alam, L. Factors Influencing People's Willingness to Participate in Sustainable Water Resources Management in Malaysia. J. Hydrol. Reg. Stud.* ***2020****, 31, 100737.*

[21] *Anderson, R. B. (2022). The taboo of retreat: The politics of sea level rise, managed retreat, and coastal property values in California. Economica Anthropology, 9, 284–296.*

[22] *Arnell, N. W., & Gosling, S. N. (2016). The impacts of climate change on river flood risk at the global scale. Climatic Change, 134(3), 387–401. Web of Science®Google Scholar*

[23] *Batica, J., & Gourbesville, P. (2014). Flood resilience index-methodology and application. CUNY Academic Works. Google Scholar*

[24] *Berkhout, F., & Dow, K. (2023). Limits to adaptation: Building an integrated research agenda. WIREs Climate Change, 14, e817. https://doi.org/10.1002/wcc.817 Web of Science®Google Scholar*

[25] *Bidwell, H. (2023). Cyclone Gabrielle: One-in-500-year flood prevention system on its way. New Zealand Herald. Google Scholar*

[26] *Birkland, T. A., Burby, R. J., Conrad, D., Cortner, H., & Michener, W. K. (2003). River ecology and flood hazard mitigation. Natural Hazards Review, 4(1), 46–54.*

[27] *Ahmad, S. and Simonovic, S. (2015). "System dynamics and hydrodynamic modelling approaches for spatial and temporal analysis of flood risk." International Journal of River Basin Management, 10.1080/15715124.2015.1016954, 443-461.*

[28] *Sabzi, H., Humberson, D., Abudu, S., and King, J. (2015). "Optimization of adaptive fuzzy logic controller using novel combined evolutionary algorithms, and its application in Diez Lagos flood controlling system, Southern New Mexico." Expert Systems with Applications, 10.1016/j.eswa.2015.08.043,.*

[29] *Bhadra, A., Bandyopadhyay, A., Singh, R., and Raghuwanshi, N. (2015). "Development and application of a simulation model for reservoir management." Lakes & Reservoirs: Research & Management, 10.1111/lre.12106, 216-228.*

[30] *Nikolic, V. and Simonovic, S. (2015). "Multi-method Modeling Framework for Support of Integrated Water Resources Management." Environmental Processes, 10.1007/s40710-015-0082-6, 461-483.*

[31] *A review of Disaster Management Policies and systems in Pakistan, January, 2005*

[32] *Marriott, M. J. and M. A. Zainudini. 2006. A review of rainfall data from the Iranian province of Sistan and Balochistan. Proceedings of the Advances in Computing and Technology Conference, London. ISBN-0-9550008-1-5, pp.113- 118*