Mitigating Infrastructure Disaster Losses Through Asset Management Practices in the Middle East and North Africa Region

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Abstract

Despite expanding infrastructure investments in developing countries, maintenance of constructed infrastructure is not keeping pace and there is a growing need to focus on the long-term operational demands of new assets to reduce vulnerability. In the Middle East and North Africa (MENA) region, natural hazards and civil conflicts continue to undermine development and disaster risk management. This research sought to examine how infrastructure asset management can reduce the impact of disasters in the MENA region. Twelve interviews were conducted with asset management and disaster risk reduction experts the MENA region and Australia – the latter to identify transferable asset management best practices. Qualitative analysis of interviews identified regional lessons to advance asset management practice as a disaster risk reduction tool. The four main findings were: (1) asset management practice can be a proactive disaster policy; (2) there is need for appropriate levels asset management policy in the MENA region; (3) asset prioritisation improves the effectiveness and decision making in risk management; and (4) whole of life consideration enables effective planning for asset management practices. In alignment with the priorities of the Sendai Framework for Disaster Risk Reduction, this research unpacks geopolitical factors affecting disaster risk and provides knowledge to strengthen governance to manage disaster risk in the MENA region. The research further outlines the barriers and challenges that hinder successful asset management policy implementation, as well as proposes recommendations for disaster mitigation strategies using infrastructure asset management.

Keywords

asset management; Middle East and North Africa; critical infrastructure; risk

1 Introduction

Disasters led to 1.23 million deaths between 2000 and 2019 and affected four billion people [1]. However, these losses are not distributed equally. Low-income countries have on average more than four times as many deaths per disaster as high-income countries. Despite efforts to increase disaster preparedness globally, the number of recognised disasters in the Middle East and North Africa (MENA) region has tripled since the 1980s [2]. In comparison, other regions saw disaster events double in the same time. In this research, we draw on the Centre for Research on the Epidemiology of Disasters (CRED), who define *a disaster as an event in which either 10 or more people die, 100 or more people are affected, there is a declaration of a state of emergency, or there is a call for international assistance.* We will focus on disasters arising from natural hazards in the MENA region, such as earthquakes, droughts, and floods.

Infrastructure such as hospitals, schools, and transport networks play an important role in disaster resilience, ensuring critical services during disasters and supporting recovery of communities in their aftermath. Systems of management and maintenance of infrastructure assets have been implemented successfully in many developed countries to maximise the operational life and efficiency of assets. However, these processes are often not tailored to the challenges that developing countries face, exacerbating vulnerabilities, and resulting in inefficiently utilised assets. As a result of poor maintenance, there is a growing gap in infrastructure resilience [3]. If global disaster risk reduction efforts are to be realised, there is a need to focus not just on new infrastructure investments, but also to consider the robust processes required to maintain these assets as investments [4].

Australia is widely considered a leader in infrastructure asset management. The Institute of Public Works Engineering Australasia [5] defines asset management as the allocation of available resources to match defined objectives with consideration to current and future users. The ISO 55000 standard adds, "asset management translates the organization's objectives into asset-related decisions, plans and activities, using a risk-based approach" [6]. In the face of rapid population growth and climate change, infrastructure assets will become increasingly exposed to hazards and effective asset management processes will be crucial to improving development and planning processes [7]. Given the current global state of neglect for maintenance of infrastructure and the lack of intersecting disaster and asset management knowledge, it is important to understand the current state of asset management and how asset management practices can support disaster risk reduction objectives. We define asset management practices as the processes by which value is added to an asset through maintaining, upgrading, or repurposing an existing asset, as well as the consideration of these processes during design and construction phase.

Poor construction and maintenance of infrastructure are a determinant of economic damage and loss of life during disasters [8]. Despite expanding infrastructure investments, maintenance of constructed infrastructure lags and there is a pressing need to focus on the long-term operational demands of new infrastructure [9]. This lack of infrastructure maintenance often stems from limited resources and inadequate institutional support in developing countries, including within the MENA region [2], which ranked fourth among the six United Nations defined regions in human development in 2018 [10]. In the MENA region, successive natural hazards and civil conflict have undermined development and disaster risk management. There has been limited uptake of asset management in the region to date, in part because of limited consideration of contextual barriers that the region faces, as well as a lack of incentives for better infrastructure maintenance practice. As such, this research aims to answer two main questions:

1. *How can infrastructure asset management reduce the impact of disasters in the Middle East and North Africa region?*
2. *What are the barriers to implementing infrastructure asset management for disaster risk reduction in the MENA region?*

We aim to understand how infrastructure asset management can reduce disaster losses in the MENA region, providing recommendations for asset management policy and contributing knowledge to strengthen disaster risk governance. More broadly, this work seeks to contribute to the Sendai Framework for Disaster Risk Reduction target (c) to "reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030" [11]. A large portion of economic losses due to disasters caused by natural hazards result from damage and loss of existing infrastructure, as well as the economic cost to rebuild, yet maintenance continues to be an unrecognised contributing factor that needs urgent attention.

2   Background

In this research, we draw on the World Bank's definition of the MENA region that includes 19 countries, shown in Figure 1. While the MENA region is hazard prone, 80% of recorded disasters between 1980 and 2010 occurred in Djibouti, Egypt, Iran, Algeria, Yemen and Morocco [2]. Flooding accounts for most disasters (53%) in the MENA region, followed by earthquakes (24%) and drought (10%). Drought is perhaps the most damaging hazard globally, resulting in more than half of the 22 million disaster related deaths in the 20th century [12]. Drought is particularly dangerous in the MENA region when combined with flooding, as dried and hardened ground surfaces reduces the infiltration of rainwater. As floods often follow periods of drought, this relationship can compound disaster damages. Inadequate drainage, surfaces that cannot absorb water, non-engineered structures, and the destruction of ecosystems has caused an increase in flood events [2,13]. Although, the occurrence of earthquakes is less frequent than flooding, almost ten times as many people have been killed by earthquakes compared to flooding in the region. Earthquake risk in the MENA region is heightened due to a lack of engineered and earthquake resistant infrastructure [14]. These factors are exacerbated by poor management of infrastructure that often occurs where resources for infrastructure are limited. These hazards – flooding, earthquakes, and drought – often overlap, resulting in a context that is comprised of multi-hazard exposure, and increasingly in urban environments.

Figure 1: Map of the MENA region

2.1   Infrastructure Challenges in the Middle East and North Africa Region

There is a large disparity in income and inequality throughout the MENA region, with oil-rich countries in the Gulf region like Saudi Arabia, the United Arab Emirates, and Qatar recognised as highly developed countries, while developing countries such as Yemen and

Djibouti struggle to maintain infrastructure. Rapid urbanisation has led to 92% of the population living on 3% of the total land area [2]. This has often led to civil infrastructure with low reliability, low technical oversight, and a lack of maintenance [15]. A combination of these challenges has led to high losses during disasters. For example, flooding of low-lying areas of Yemen with inadequate drainage in 2010 led to deaths and hundreds displaced [2]. Poor initial investment in infrastructure has led to greater losses during disasters. A lower percentage of GDP is invested in civil and transport infrastructure in developing countries. With limited funding, countries often prioritise other developmental needs such as health and education, rather than increasing disaster resilience [16].

When critical infrastructure is damaged during a disaster, the economic state and organisation of a city or country is weakened. Critical infrastructure can be defined as infrastructure which is necessary for the functioning of a community and can be both built or natural, such as transport, water, health, energy and telecommunications networks [17]. Damage can leave populations vulnerable to secondary effects of disasters such as inadequate access to water, transport, or health services. Foytik and Robinson [18] argue that the vulnerability of a community to disasters can be observed through the ability of their critical infrastructure to resist, absorb, and recover from hazards and risks. The vulnerability of these critical infrastructure networks can be reduced with strong design codes, management and maintenance programs, and financial resources [19]. However, it can also be argued that highly connected critical networks in cities are left vulnerable due to their interdependence [17]. Therefore, at all levels, investments are needed in maintenance, management, and upgrading of critical infrastructure networks to increase their resilience to natural hazards, particularly in developing countries [20].

Transport infrastructure is essential for economic and social well-being, as well as community cohesion [21]. Transportation infrastructure is especially critical in a disaster event as damages to transport networks can inhibit the capacity for disaster relief and response. Additionally, damaged or reduced capacity transport networks can hinder the economic recovery of an affected region. The transport sector is central to the MENA region's objectives to accelerate economic development through export growth and reducing vulnerability and exclusion [22]. Transport networks are particularly vital for rural communities who rely on these networks to obtain medical treatment, access education, and reach markets. Most countries in the MENA region have transport networks which have high coverage; however, the quality of these networks varies greatly. There are large gaps in these networks rurally and in coping with rapid urbanisation in many areas. Previous efforts have also positioned transportation as central to alleviating the poverty in the region [23].

2.2 Infrastructure Asset Management

For this study we define asset management as the risk-informed management, maintenance, and upgrading of civil infrastructure. Asset management implementation encompasses three critical steps [24]. The first step is the formation of strategic goals aligned with the public interests, including the development of infrastructure accessibility and quality [25]. Second, is the assessment of the current state of infrastructure, such as the age and condition of assets, as well as the asset vulnerability to hazards. This involves assessing the hazards and their likelihoods through a risk assessment. Hazard likelihoods can be monitored over time so intervention measures can be applied when required [26]. The third step is the physical application of asset management practices such as ongoing repairs, upgrades, and replacements based on the current or predicted condition of assets. Asset management processes should be guided by continued assessment and maintenance of successfully operating infrastructure or upgrades for infrastructure that are not meeting current needs. Effective maintenance and upgrades can reduce adverse consequences from the threats identified in step two.

While asset management practices are primarily targeted at preserving or adding value to existing assets, there is an advantage to considering asset management during the design and construction phase [27]. When asset management is incorporated in whole of life design and construction considerations, assets can be designed with robust asset management plans, such that condition is more readily preserved, and maintenance costs are reduced. When these asset management plans are established, consideration for unpredictable and non-linear events are better managed [28]. Even when disaster plans are created, it is not possible to reasonably plan for all scenarios. However, by creating detailed plans targeting disaster risk reduction for the hazards to which an asset would be most exposed, systems and resources are better positioned.

Although asset management is a burgeoning field of research, there is rarely an explicit focus on the potential link to reduce disaster risk, despite asset management being suggested as one of the most cost effective components of risk management [29]. Here, we define risk management as the application of policies, procedures, and practices to the tasks of identifying, analysing, assessing, treating, and monitoring risk [30]. Keating et al. [16] reinforces this notion by outlining the there is a clear cycle through which disaster events, disaster management, and disaster recovery spending are linked. Developing countries often lack the resources or finances to implement effective asset management processes and therefore have limited foundation from which to build policy that connects asset management and disaster risk reduction. Increasingly, populations and climate change are accelerating exposure and vulnerability to natural hazards and as such it is crucial that risk-based financing be incorporated into infrastructure development and planning processes [7]. In the MENA region, Meyer et al. [31] and others have pointed out that asset management of transportation infrastructure for climate change, such as retrofitting vulnerable infrastructure and maintaining existing infrastructure, will be important elements in reducing future catastrophic events. Previous research has also highlighted that asset managers in developing countries note that maintenance of infrastructure is imperative for sustainable future growth and resilience, but are inhibited by a lack of systematic maintenance processes [32].

2.3 Challenges Implementing Asset Management

Though the benefits and necessity of asset management practices are evident [33], there are significant barriers preventing its adoption, particularly in developing countries [34]. A principal barrier is the significant investment that is required to set up and carry out maintenance schedules for infrastructure. It can be difficult for governments to allocate and justify spending for long-term maintenance, in part because, if the investment is successful, the benefits will be largely unseen and such long term expenditures often exceed political or commercial agendas [16].

Furthermore, there is also greater ambiguity surrounding possible future development scenarios, forcing governments to make difficult economic trade-offs. This uncertainty is multiplied further in developing countries where data collection can be less reliable and previous research has identified data collection and information sharing as a significant barrier to the implementation of asset management practices [35]. Jansen van Rensburg et al. [36] note these issues often stem from poor standardisation, collaboration, coordination, and communication. The lack of knowledge sharing within government departments and with private entities also further reduces the performance and efficiency of asset management practices [37]. When sufficient and accurate data to implement asset management is available, there is also often a focus on economic criteria, and as a result, environmental or societal consequences of infrastructure asset management have traditionally been overlooked. Tafazzoli [38] suggests that budget constraints in developing countries where growth is a high priority may result in a wholly economic approach to asset management which may conflict with broader development goals.

Another, and perhaps more significant, barrier to effective asset management stems from the lack of political organisation and policy. Beitelmal et al. [37] suggest that "overcoming political and regulatory barriers is essential to the success of any implementation of asset management in infrastructure organisations." In the MENA region, political processes can reduce the impact of disaster risk reduction and development policy, particularly relating to infrastructure [39]. Keating et al. [16] propose that by focusing on the resilience of community well-being instead of resilience to risk, governments could be better persuaded to take action. However, to the contrary, Hamdan [40] identifies that the limited consistent citizen pressure and the lack of disaster impacts on the political elite relative to the general population in the MENA region mean that there is not sufficient incentive for governments to enact meaningful change. In such situations, many individuals and organisations accept the personal cost savings resulting from relaxed policy as property owners and construction companies lack voluntarily adoption of mitigation measures in the face of limited economic incentives [41]. Despite this, the implementation of successful asset management programs in other countries, as well as support from multi-lateral organisations, has caused government focus to gradually shift towards the adoption of asset management programs.

2.4 Can Asset Management Reduce Disaster Losses?

There is general agreement in the development sector that disaster risk reduction programs effectively contribute to reducing the loss of life and infrastructure during disasters but there are gaps in understanding how poorly maintained infrastructure confound these efforts [37,38,42]. Literature and case studies show potential for asset management to reduce disaster losses. Sharifi et al. [43] argue that land degradation, poor maintenance, and overdevelopment of impermeable surfaces with inadequate drainage have exacerbated losses during periods of flooding. It has been similarly argued that earthquakes losses in Algeria would be diminished if design codes been enforced and implemented [14]. These studies suggest that the implementation of infrastructure asset management, such as retrofitting, resilience measures, rehabilitation of structures and maintenance, can increase the capacity of infrastructure to withstand natural hazard events.

There is consensus that maintenance of infrastructure prolongs the service life of an asset, playing an important role in the sustainability of a community [44–46]. Specifically, intelligent transport maintenance systems are recognised as being critical for the MENA region's economic and social prosperity [22] which could be implemented through structured asset management policy. While there is growing knowledge of asset management barriers, study of these processes has largely been examined in developed countries [47,48] and there is a need to better understand opportunities in the socio-political context of the MENA region. Research into the implementation of asset management systems in the MENA region is in its infancy, as is how these systems can be used as part of disaster risk mitigation strategies.

3 Methods

As expertise of asset management in the MENA region is confined to a relatively small number of individuals, we drew from qualitative methods to examine the state of practice of asset management. Below, we outline our data collection, which involved interviews with experts, and then describe our analysis and validation of themes before presenting our results and discussion.

3.1 Data Collection

Interviews were used to unpack the link between asset management and disaster risk reduction in the MENA context, as well as opportunities and barriers. Potential interviewees were selected based on their current experience in the field of asset or disaster

management. Relevant experience was used to screen participants, ensuring that they met at least one of the following criteria: (1) a minimum of 10-years of experience in infrastructure asset management working in Australia; (2) a minimum of 3-years of experience in infrastructure asset management working in the MENA region; or (3) a minimum of 5-years of experience in disaster risk reduction in the MENA region, with a background in infrastructure. Australia was included as a context where asset management systems are relatively advanced in comparison to the MENA region as we wanted to capture lessons from more experienced professionals that may be transferable. Those in Australia were required to have additional years of experience to capture these lessons. Seventy-two potential interviewees were contacted with 53 of them working in the MENA region, with 12 professionals agreeing to participate. Half of the participants worked in the MENA region and the other half in Australia. We sought diversity in backgrounds, including private sector, public sector, and multi-lateral organisations to capture a breadth of perspectives. The number of participants for each location and organisation type can be seen in Table 1.

Table 1: Participant classification

Number of Participants	Location	Organisation Type
1	Australia	Public Sector
5	Australia	Private Sector
1	MENA Region	Public Sector
2	MENA Region	Private Sector
3	MENA Region	Multi-lateral Organisation

MENA region participants had experience working in Egypt, Lebanon, Jordan, Kuwait, Oman, Yemen, Iraq, Qatar, Djibouti, Saudi Arabia, and the United Arab Emirates (UAE). In Australia, one individual worked in the public sector while five worked for private sector organisations. For those with experience in the MENA region, one had experience in the public sector, two in the private sector, and three with multi-lateral organisations.

Interview questions aimed to understand the challenges facing current asset management policy and practice as well as identify future improvements that could be introduced. The interviews aimed to further understand the implementation of asset management systems, particularly focusing on how these systems interact with disaster management. The interview questions can be found in the supplementary material. Interviews were conducted by a minimum of two individuals from the study team over video conferencing. Notes were also recorded during the interviews and audio was recorded, where permission was granted. Recordings were then transcribed and cleaned by the research team for accuracy. When participants did not wish to be audio recorded, which happened for two of the interviews, one of the research team took notes on the interview which were then typed.

A semi-structured interview format was used, with questions focusing on participant experiences, implementation of asset management, opinions on policy and guidelines, challenges and barriers, and the link between asset management and disaster risk reduction strategies. Example questions included, *"What do you think is needed to increase the implementation of asset management processes?"* and *"What do you see to be the largest barriers or challenges to the implementation of successful asset management?"* An example of a question focused on the intersection of asset management and disaster risk reduction included, *"How do you think asset management policies contribute to mitigating disaster losses?"* For participants based in Australia, questions also sought to understand what lessons could be learned for early adopters of asset management systems.

3.2 Data Analysis

Interview transcripts and field notes were then analysed using qualitative analysis software NVivo to identify themes. A preliminary coding structure was created at the onset of analysis using a deductive coding approach, linked to the primary research questions that sought to understand the state of asset management practice and links between asset management and disaster risk reduction in the MENA region. A total of six overarching categories were identified prior to analysing data, which are defined and shown in Table 2. An inductive coding approach then used to identify emergent themes with each of the six main categories. Quantitative code counts, matrix coding queries by participant attributes (e.g. individual roles, location), and overlapping coding queries were then used to unpack lesson and cross-examine connections between themes.

Table 2: Qualitative coding themes

Theme	Description
Asset Management Practice	The development or implementation of asset management and processes to maintain and manage transportation infrastructure.
Community and Stakeholders	The effect or importance of the local community and other relevant stakeholders in which an asset exists.
Asset Management and Disasters Linkages	Discussion on disaster risk, disaster policy, resilience, and mitigation measures which explains the relationship between asset management and disaster risk reduction.
Policy and Regulation	Asset management policy, guidelines, or regulations including but not limited to government or private guidelines and international or local standards.
Geopolitical Context	Political factors, including but not limited to context, culture, and governance.
Resources	The influence of resources on asset management, such as financial, human, education, or time.

To validate the qualitative analysis, a coding comparison was conducted in NVivo between three independent coders for all 12 interview transcripts and field notes. The comparison sought to determine if emergent themes from the interview transcripts were replicable. Simple agreement represents how much of the same text was the same between two coders. Kappa values are a representation of probability between 0 and 1 that the coding agreement has occurred better than had it been coded randomly. A kappa value of 0 indicates that the coding agreement could have occurred at no better rate than by chance. We followed Bezeley and Jackson's [49] guidance on kappa values, who indicate that between 0.2 to 0.4 is 'fair,' 0.4 to 0.6 is considered 'moderate', and 0.6 to 0.8 is considered 'good.' There was a high level of agreement (>77%) between the three independent coders, with kappa values in the 'fair' to 'moderate' range with a comparison value of 0.38 between the first and third coders and comparison value of 0.51 between the first and second coders. The lower kappa values, when compared to simple agreement, is likely due to the high level of interconnected nodes applied as a result of the inductive approach.

4 Results

Several themes emerged from our analysis of interviews. These sub-themes were categorised under the predefined topics: current implementation of asset management; disasters; policy and regulation; politics and geopolitical context; and resources. A summary of the most common themes is presented in Table 3 where the number of participants who discussed a theme in their response is provided for both the MENA region and Australia.

Table 3: Thematic analysis of interviews classified by location of participant

Theme	Sub-Themes	MENA (n=6)	Australia (n=6)
Current Implementation of Asset Management	Importance of Maintenance	6	5
	Life Cycle Consideration	5	5
	Planning and Decision Making	4	5
	Data Collection	5	5
	Drivers for Asset Management	4	5
	Community and Stakeholders	5	4
Disasters	Communication Infrastructure	1	3
	Disaster Policy	6	5
	Impact of Climate Change	5	2
	Resilience in Infrastructure	6	6
	Transportation Infrastructure	2	3
Policy and Regulation	Challenges in Implementation of Policy	4	6
	Effectiveness of Policy	6	3
Barriers to implementation	Politics and Geopolitical Context	6	6
	Financial resources	4	4
	Human resources	4	5
	Need for Education, Technical Knowledge and Engineered Solutions	6	5

All respondents from the MENA region spoke to the effectiveness of policy in a positive light, in contrast to only three respondents from Australia. Policy and regulation were mentioned repeatedly throughout all the interviews. Participants from both regions discussed the importance of maintenance, data collection, and life cycle considerations. Life-cycle considerations are employed to ensure due consideration is made to the cost, maintenance, and operation of an asset from the design to the eventual disposal of an asset. All respondents also brought up resilience in infrastructure as fundamental to the mitigation of disaster losses and noted the impact of geopolitical climate as a barrier to the successful implementation of asset management. Challenges in resourcing, particularly that there exists a need for education, technical knowledge, and engineered solutions amongst governments and professionals in infrastructure sectors, was widely cited as a pathway to increase the successful implementation of asset management.

Overall, experts noted that asset management could improve the performance of infrastructure, and therefore assist in the mitigation of disaster losses in the MENA region through four key linkages. First, experts emphasised that asset management practice itself

is a proactive disaster management policy, leading to increased resilience of infrastructure. However, those interviewed stressed the importance of appropriate levels of context-specific regulation for asset management, striking a balance between lacking and restrictive policy, to realise its benefits as a stimulus for infrastructure maintenance and reduction of disaster losses. Those interviewed also emphasised that asset management practice should include decision-making processes to prioritise critical infrastructure before, during, and after a disaster which are transferable to many disaster risk reduction frameworks and policies. The central role of life-cycle cost considerations in asset management was furthermore suggested as a mitigation tool. Each of these findings are discussed in more detail below.

4.1 Infrastructure Asset Management and Reducing Disaster Losses

This section highlights the two main findings regarding the role of infrastructure asset management in reducing the impact of disasters.

4.1.1 Asset Management Practice is Proactive Disaster Policy

When asked about disaster policy, both MENA and Australian participants expressed that their country or region did not have proactive disaster policy, instead speaking about the reactive nature of response. There was consensus that most governments have well developed strategies and policies involving emergency management plans and disaster asset recovery schemes. However, when speaking of proactive policy, most participants suggested that risk reduction strategies were more elusive. Reflecting on the links between asset management and disaster risk reduction, there was mention of the need to make this connection more explicit and pronounced. One interviewee from a multi-lateral organisation commented "*we notice that the countries that do their due diligence in asset management and maintenance have far less [disaster] damages than the countries that do not.*" Emerging from these and other comments was a need to better consider the alignment of these often-separate agendas. Experts interviewed drew attention to the different ways in which disaster policies manifest, highlighting the invisible nature of asset management as disaster policy.

4.1.2 Prioritisation of Critical Infrastructure

One area of alignment between asset management and disaster risk reduction programmes that was highlighted by almost all participants was the need to prioritise critical infrastructure. Eleven out of twelve participants spoke about the importance of prioritisation and decision making with limited resources irrespective of the context, including across public, private, and multi-lateral organisations. Experts noted the need for a systematic approach to measure the impact and likelihood of natural hazard risks to allow smarter investment and maintenance decisions to be prioritised. Participants generally expressed that *"there is never enough money so a process to ensure that the biggest bang for the buck is achieved is the best that can be done."* Criticality assessments, which is an approach to measuring risks and level of service of an asset, were spoken about by the majority of participants noting that it is important to identify which part of the infrastructure network will be impacted during disruptions. Participants explained that prioritisation and maintenance of critical infrastructure, and asset network connection points, can avoid 'multiple system failure' during a disaster, being the consecutive failure of interconnected networks.

As pathway to utilise prioritisation, the availability of data emerged as a crucial consideration to enact prioritisation of critical infrastructure during and after disasters. The importance of quality data was mentioned by one participant from the MENA region, *"it's to anticipate, and then prepare and take action. When you are going through your roads and you collect data and see what happens over time, you could predict what's likely to happen."* Another participant summarised the discussions regarding the link between criticality assessments, prioritisation, and data collection, *"Having that basic understanding of your assets and where they are, what they are, the condition and the criticality becomes fairly important. You can't plan to protect or anticipate what the implications are going to be unless you've got that*

information." While asset management was mentioned as a way to improve an asset's resilience, data underpins these efforts.

4.2 Asset Management Barriers

This section focuses on the two main findings relating to the challenges in implementing asset management practices and how they can be used to reduce disaster losses.

4.2.1 Regulation of Asset Management Implementation

There was consensus from all participants working in the MENA region that there exists a need for enforceable regulation surrounding the implementation of asset management for infrastructure, particularly for resilient transportation networks. Participants noted that the field of asset management is "*really new here in the MENA,*" citing we *"don't have general practice guidelines or codes of practice."* All MENA participants expressed a challenge in allocating resources to and incentivising infrastructure maintenance without the backing of legislation and cited that the creation of formal regulation, where it does not currently exist, would advance the implementation of asset management. Another participant commented "*most [MENA] countries have a budget deficit*" and there was a general sentiment across the MENA experts that it is *"very important for these countries to have laws and regulations that require them to optimize their resources, meaning [optimisation of] their budget allocation for investment in new projects, or maintaining the existing ones."* Additionally, one participant working in the public sector in the MENA region expressed that there are unknowns surrounding which department are responsible for planning and implementing asset management and maintenance, suggesting that clear national directives would clarify these roles. They also indicated that regulation would *"resolve the conflict and problems between us and would make the asset management organisation more productive and efficient*" Overall, this is indicative of a growing need for context-specific guidelines and national legislation to support the growth of asset management practice in the region.

In contrast to MENA-based experts, two-thirds of the participants from Australia spoke against more regulation surrounding infrastructure asset management, where significant regulation already exists. One participant's comments reflected this consensus – *"it just adds cost, it adds layers of complexity that don't always help you achieve the outcome."* Clear differentiation between the perspectives of participants from the MENA region to Australia reinforces the importance of context when developing asset management policy, particularly the level of existing maturity of asset management practice within a country. This points to a need for appropriate levels of policy which incentivise asset management without being overly difficult to implement.

Respondents from the MENA region spoke to the effectiveness of policy in a positive light, while respondents from Australia had mixed views on the policy environment. Participants from both regions discussed the importance of maintenance, data collection, and life cycle considerations and the need for these to be addressed in policy. Respondents from both regions also noted that there are challenges in resourcing, particularly that there exists a need for further education to build capacities of infrastructure professionals to advance asset management practices. Similarly, respondents noted the impact of geopolitical climate as a barrier to the successful implementation of asset management – a point which will be discussed further below.

4.2.2 Life-Cycle Considerations

Life cycle considerations was brought up by ten out of the twelve participants involved in the study. They discussed the importance of considering the ongoing costs of asset management, including continuous record keeping of asset performance and criticality, infrastructure maintenance, operational costs, and upgrading when required. MENA participants raised that current models of risk management often miss the cost of maintenance over the asset's service life, particularly in the design phase. As a result,

maintenance is rarely performed, emphasising *"most of the decisions are based on available budget… they don't apply total lifecycle cost analysis based on data, engineering and economics."* MENA participants cited *"none of these countries are maintaining a balanced budget"* and the potential for asset management to operationalize risk-based financing. Life-cycle considerations as part of successful implementation of asset management were a particular point of emphasis where future capacity building is needed. All participants mentioned these processes together provide a platform for managers to systematically address risk reduction.

5 Discussion

This section unpacks the themes identified above and discusses key barriers and challenges facing effective asset management practice and policy implementation that emerged from our analysis.

5.1 Increasing Resilience to Disasters with Proactive Asset Management

Professionals indicated that implementing asset management is a first step toward proactive disaster policy to increase infrastructure resilience to disasters. MENA-based participants expressed that currently *"climate resilient design, implementation, maintenance or rehabilitation is not in place."* Several methods of increasing infrastructure resilience were discussed by all participants in the study, most of which were common across the interviews. The methods discussed during interviews included early warning systems to predict the occurrence of hazard events, maintenance of infrastructure, quality of the original construction with engineered mitigation, and upgrading infrastructure when required. What was unique about these comments is they were not themselves typical for asset management, pointing to potential alignment with more traditional disaster risk reduction programmes.

Early warning systems were noted as vital to ensuring that people within high-risk natural hazard zones were able to safely evacuate and *"to support asset management systems in predicting when disasters may occur…A disaster will impact facilities and infrastructure much more [without warning], than if you can predict and put some mitigation measures in place."* Early warning systems were brought up by five participants in the study, four of which were working in the MENA region, which may indicate one entry point to merging asset management practice and disaster risk reduction objectives in the region. For this link to be made, the availability of data from the MENA region will need to be improved.

Participants expressed that building resilience to disasters from early in the design phase is crucial, such as high structural capacity for storms and earthquakes, sufficient drainage, and elevated structures for flooding. The sentiment across interviews was that "*resilience should not be an afterthought but should be considered from the beginning,"* as this was explained as the most cost-effective way of increasing infrastructure performance and thus reducing the impact of disasters. However, it was noted that it is not always possible to design for extreme events such as high magnitude earthquakes, or severe storms and cyclones, due to technical capabilities as well as limited financial resources, where other methods of increasing resilience become more important. These methods included asset management strategies such as maintaining, upgrading, or renewing assets when required, and was summarised by one participant: *"sometimes you just can't allow for those events, which is why we have so much infrastructure damage when we have a disaster, but we don't have anywhere near as much as we could, so I certainly think that implementing sound asset management gives you the best chance."*

Maintenance of infrastructure was cited by participants as being more important than the quality of original infrastructure when considering long term resilience. This is because the systematic process by which assets are maintained and upgraded helps to overcome any

shortcoming in the design or construction phase. Participants explained that a sustainable way to ensure maintenance is to involve asset management professionals in design phase decisions. One participant expressed, *"At design acquisition, they've already got the people who are going to maintain it helping them decide on the design or choice of equipment, because they understand the implications over the next 20, 30, or 50 years."*

Participants noted that maintenance ensures built-in resilience is retained, as well as reduces degradation over time. They emphasised that *"deferred maintenance results in the asset not living out its design life,"* and *"when we have maintenance, healthy assets reduce the impact of disasters."* This further highlights the significant role that life-cycle cost considerations play in ensuring budgets are allocated for infrastructure to be maintained, and thus that the performance of infrastructure is sustained throughout its service life.

In addition, renewal and upgrading infrastructure was also discussed. When asked about possible pathways to increasing the resilience of infrastructure half of the participants cited upgrading as a critical pathway of doing so. One participant outlined *"if you make a mistake in design and construction, and then find out that you need to increase the resilience, we have to provide [new] mitigation measures, because you have to protect the investment"*. Continuous monitoring of assets is required to ensure that renewals and upgrades are carried out as required to sustain the performance of infrastructure. One participant summarised discussions of resilience *"if you have built your assets out of the right stuff, if you've looked after them, and maintained them, then you're in the best position for that asset to survive."* Therefore, increasing resilience to disasters should include a combination of considerations in the design and construction phases as well as maintenance and renewals.

5.2 Drivers for Asset Management Implementation

All experts interviewed emphasised that the main driver for asset management implementation was financial benefit, but secondary benefits also emerged that included stronger local institutions and reducing dependence on financing from outside the region. By implementing asset management practices, governments and organisations can save money in the long term which can then be reinvested into the infrastructure or into new projects. One participant summarises the benefit saying:

> *"We can't ignore the financial [benefit], and by financial, I mean you can make an amount of money go further if you're managing your assets better … Asset management can also reduce the cost of owning and operating assets – doesn't matter what sort of asset it is – and that's that financial link. It is good business practice. I know organizations, whereby having implemented asset management, it makes them stronger."*

This indicates that economic concerns, and in particular return on investment, are principle drivers of asset management and allow money to be stretched further. This is especially important as stated by one participant, "*budgets are getting smaller and smaller, and money is getting harder and harder to find.*" Therefore, traditional reactive approaches to asset maintenance will not be sufficient. In the modern global investment landscape, asset management practice shows potential to address instability.

The importance of economics is also a critical element of proactive disaster maintenance. In the United States, a review of 4,000 disaster risk management investments found that there was an average cost-benefit ratio of four to one (FEMA, 2014). If the most important driver of asset management is maximising economic value, proactive disaster asset management should be a primary concern for governments and infrastructure organisations. Indeed, asset management for disasters is a driver itself as noted by one expert, "*if you build the asset, or improve the asset, better than it was before, it has a better chance of surviving the next disaster*" and if infrastructure is not damaged in a disaster event, then less money will need to be invested in to recovery post-disaster.

5.3 Political Willingness

Participants highlighted that political willingness is a significant barrier to preventing asset management policy and processes from being effectively implemented in the MENA region. Without the support from governments in the MENA region, there is unlikely to be implementation of infrastructure asset management policy, regulation, or investment. Eleven out of twelve experts interviewed discussed politics as a barrier to successful implementation of asset management. One expert from the MENA region related to this challenge, "*Politicians are interested in cutting tape where they are commissioning new projects. Politicians are not interested in putting money into maintenance.*" Maintenance of assets generally is not as visible to constituents, where politicians are often motivated by re-election and short-term limits, as has been discussed at length in other literature [50]. This mimics challenges faced globally [51] and by donors who have historically been attracted to new infrastructure investment rather than operation and maintenance costs [16,52]. Political challenges were not restricted to the MENA region however, as Australian-based participants also indicated that short-term election cycles lead to *"little evidence of government at all levels taking long-term infrastructure planning seriously."*

Over-investing in new infrastructure without the consideration of operational and long-term maintenance costs produces a cyclic problem, whereby there is less budget allocated to asset management or infrastructure maintenance, with an increased amount of infrastructure requiring resources to maintain. This was summarised by one participant; *"If we continue to build new infrastructure that carries an ongoing obligation, in addition to maintaining and replacing existing ageing assets, it will only impact on existing finances and increase the renewal burden for future generations."* Thus, the approach of governments has a significant impact on whether a countries' financial resources are sustainably invested with life-cycle cost considerations such that infrastructure can continue to develop while the performance of existing infrastructure is upheld.

Participants also highlighted that countries that do implement basic asset management still struggle with barriers arising from political structures and decision-making. One participant outlined that "*in the MENA region everything is highly centralised, and the maintenance budget is allocated annually at fixed amount, without taking into consideration the road condition or the consequences of not implementing maintenance in a timely manner.*" This creates a system in which assets are not maintained based on their need, but instead by an arbitrary political budgeting decision. This highlights the need for detailed data collection and asset prioritisation processes, such that there is information available to identify minimum maintenance requirements. A participant from the MENA region suggests two changes that need to be made to address this issue. These were to "*move from annual budgeting to long-term planning*" and to *"have more transparency in decision making, allowing stronger governance and accountability."* However, these are deeply entrenched issues in many MENA governments and solutions will take time and significant political restructuring to implement. One method of cultivating such a large-scale change is to focus on the education of politicians and asset managers such that they "*understand the importance of (asset management) for value for money.*"

5.4 Education

A second reoccurring challenge cited was education and local institutional capacity. Participants stated this constraint as a culture of disasters being viewed in a fatalistic sense, framing the consequences of disasters as unavoidable. This paradigm has stifled innovation in connecting what might otherwise be suitable tools for disaster risk reduction, including asset management. Experts noted that this directly contributed to a dangerously casual approach to asset management. On the public end, this has led to relatively little demand for accountability of infrastructure managers, while among infrastructure professionals, it has led to stifled exploration of ulterior benefits of asset management. Further incorporation of

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these themes into higher educational institutions in the region, as well as continuing professional development opportunities are needed to overcome these barriers.

Education is also an issue for the implementation of asset management practices themselves. A MENA participant suggests that there is a "*lack of training of staff about trying to implement good asset management. They don't get it and are concerned that it is going to add to the burden on them rather than provide solutions.*" Without education and training about how asset management should be implemented and its benefits, governments often neglect to regulate it. Without policy and regulation encouraging and enforcing the use of asset management practices, governments and infrastructure organisations will not see a need to train their staff on asset management practice. In this way, there is a cycle in which education is overlooked and asset management is not appreciated. This lack of education impacts the decision-making process, as one participant outlined, "*Poor understanding of the long-term implications of investment decisions made during the planning stage is common observation.*" Therefore, the success of potential policy requirements will continue to depend on the level of knowledge possessed by those undertaking the work.

6   Limitations

This study interviewed twelve experts working in the MENA region or Australia. While participants from the MENA region worked over a broad range of countries, not all countries in the MENA region were represented. There are vast differences in the income, development, and geopolitical context between countries in the region which affect the way infrastructure asset management and disaster risk mitigation policy could be implemented. In addition, only one participant working in the MENA region was a government representative. While a diverse range of stakeholders were captured by the twelve interviewees, the public sector was under-represented in comparison to other views. This bias towards private and multi-lateral organisations may limit the generalisability of the findings. While there is relatively lower asset management experience among governments in the MENA region, these perspectives are important in the ultimate adoption of practices. Future research should look to increase the range of participants from all countries within the region and further develop a framework for policy specific to the resource limitations and political context of each country.

7   Conclusion

This study aimed to identify current links between asset management and disaster risk reduction in the MENA region, drawing on expert interviews from practitioners working at the intersection of these fields. Emergent from these perspectives, four main findings surfaced that included a need to better acknowledge that asset management practice is proactive disaster policy, implement appropriate levels of asset management, prioritise assets based on their criticality, and account for life cycle considerations. Our results provide a starting point to understanding practical first steps in advancing asset management as a tool for disaster risk reduction in the context of the MENA region.

Asset management practices are not implemented effectively unless supported by appropriate policy that both enforce good practice and avoid over-specifying requirements to allow for flexibility. To effectively invest limited economic and human resources, assets need to be prioritised such that the most critical assets for disaster response are effectively maintained. Long-term resilience is largely established in the design phase. Hence, asset managers need to be involved in the life cycle considerations at this stage to ensure maintenance and upgrades have been accounted for.

Education, access to financial resources and data, as well as the influence of politics were found to be barriers to the implementation of successful asset management in the MENA region. There was found to be a clear need for regulation in the MENA region, but it is

important that this regulation is not restrictive to organisations implementing their own processes or overly onerous to institutions financially. The first step should be to introduce a principles-based approach rather than detailing prescriptive policy. This could include legislation to:

    i)   Require an asset management plan for asset-rich municipalities, departments, or organisations, particularly transport industries

    ii)   Creation of a professional advisory board to governments in partnership with private sector

    iii)   Require regular collection of data on infrastructure assets, particularly transport networks

    iv)   Require data sharing in open sources both nationally and internationally within the region

    v)   Require long-term budgeting prior to construction of new assets which are to include costs of regular maintenance

    vi)   Multi-year budgeting plans based on the needs of exiting assets and assets currently in the design phase to ensure limited budgets remain optimised

    vii)   Require mandatory training for all asset managers, and certification of high-level asset managers to international standards such as ISO 55001

    viii) Life cycle considerations of assets from the design phase, considering resources required to build, maintain, upgrade the asset

    ix)   Require evidenced-based identification and prioritisation of critical infrastructure assets before, during, and after a disaster

Recommendations (i) and (ii) focus on improving the efficiency and effectiveness of governments and organisations. It was found that many countries did not have policy that required organisations to have an asset management plan. Without an asset management plan, key processes of resource allocation, data collection, and maintenance become difficult. Recommendations (iii) and (iv) focus on ensuring there is sufficient access to data resources. Data collection and sharing was found to be important for the decision-making process such that assets could be effectively prioritised. This research has shown that increased availability and accessibility of data on disaster occurrences and infrastructure performance, along with proactive maintenance and upgrades could allow for improvements in infrastructure performance and thus reduced disaster losses.

Recommendations (v), (vi) and (vii) focus on access to economic and human resources. It was found that many governments currently allocate budgets for asset management on a yearly basis without contingency for unexpected events such as disasters. However, long-term asset management offers a solution through multi-year budgeting and long-term infrastructure strategies. Similarly, long-term investment in education increases the capabilities of human resources to implement asset management strategies with a focus on whole of life considerations.

Finally, recommendations (viii) and (ix) focus specifically on asset management practices that should be implemented to reduce disaster losses. It should be noted that whilst these are the only factors that directly relate to reducing disaster losses, each of the other recommendations aim to provide support and knowledge to maximise the effectiveness of these recommendations. It was found that life cycle considerations are crucial to the asset management process as currently there is a lack of understanding of maintenance costs for the life of an asset. Life cycle considerations will ensure that there is funding such that the asset can retain or improve its quality for its life cycle, hence ensuring that disasters will not affect the asset as significantly. Prioritisation was highlighted as an important process for identifying what assets are most exposed or critical to hazards, and hence require more investment to ensure they maintain their quality.

This research addresses key gaps in literature by connecting asset management with disaster risk reduction in the MENA region through the aforementioned recommendations.

Research has begun to uncover barriers and challenges to successful asset management policy implementation within the MENA region, providing a basis for further cross-national studies to benchmark specific entry points for asset management in individual MENA countries. We view infrastructure asset management policy as a steppingstone to further developing other disaster risk reduction strategies. In alignment with the priorities of the Sendai Framework for Disaster Risk Reduction, this research further advances understanding geopolitical factors affecting disaster risk and provides knowledge to strengthen governance to manage disaster risk in the MENA region.

8   Acknowledgements

9   References

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