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Challenges of Heritage Buildings in Mitigating Mosquito Breeding and Urban Flooding Risks: The Case of George Town, Penang, Malaysia

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Abstract

George Town, the capital of the Malaysian state of Penang, is a city steeped in rich history and diverse cultures, which have influenced its unique architectural styles and tantalising cuisine over the centuries. It is widely recognised as Malaysia's gastronomical capital; its vibrant streets overflowing with an array of delectable street food are destinations for a feast for the senses. The preservation of these cultures has earned the city, along with Malacca, the prestigious designation of a UNESCO World Heritage Site in 2008, making it a must-visit destination for any traveller to immerse themselves in the beauty and diversity of Malaysia's rich heritage. Because of its unique heritage, the site faces new challenges. The article sheds light on potential threats of mosquito breeding in historical structures in urban areas, which could be elevated by occurrences of water-related disasters. This article also discusses the challenges faced by built environment professionals in providing structural mitigations for flood disasters and the inflexibilities in altering the existing infrastructures and heritage buildings to reduce the risk of mosquito breeding and urban flash floods. The current condition could pose a health hazard for local residents as well as visitors from around the globe, as they may be exposed to diseases like dengue. The article underlines the significance of risk communication and delves into the measures taken by municipal authorities for mitigation and disaster risk reduction as well as the prevention of mosquito breeding in the heritage sites.

Keywords: *Disaster Risk Reduction, dengue, post-disaster, UNESCO World Heritage Site.*

Introduction

Heritage buildings are not merely architectural artifacts but repositories of cultural identity, history, and tradition. They stand as living witnesses to the past, offering a tangible link to the customs, crafts, and lifestyles of our forebears. These historical structures, often spanning centuries, hold immense significance for communities, fostering a sense of continuity and pride in their cultural heritage. In George Town, Penang, Malaysia, these heritage buildings have played a pivotal role in earning the city its esteemed status as a UNESCO World Heritage Site in 2008, celebrating its multicultural history and architectural diversity.

However, while these structures stand as testaments to the city's rich past, they also face unique vulnerabilities, one of which is the threat of mosquito-borne diseases. The dense urban fabric of George Town, coupled with its historical architecture, has created conditions conducive to mosquito breeding, particularly within the confined spaces of heritage buildings. These structures, with their intricate wooden structures and open ventilation, often provide ideal breeding grounds for mosquitoes, including the Aedes mosquitoes responsible for transmitting diseases like dengue. This coexistence of heritage preservation and disease vectors poses a significant public health concern for both local residents and tourists, potentially undermining the very cultural heritage these buildings represent. This paper is motivated by the urgent need to address the confluence of heritage preservation and the risks associated with mosquito-borne diseases in heritage building areas. The purpose of this research is to shed light on the complex interplay between cultural preservation, urban flooding, and the associated risk of mosquito breeding in heritage buildings, with a specific focus on George Town, Penang, Malaysia. Through a comprehensive analysis of this multifaceted challenge, we aim to contribute to

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disaster risk management and heritage conservation by offering insights and strategies that can reconcile the dual objectives of cultural preservation and public health in a changing and increasingly urbanised world.

This research is highly relevant in the context of risk communication, as it not only underscores the public health implications of mosquito-borne diseases in heritage building areas but also highlights the significance of conveying these risks to both the local community and visitors. Effective risk communication is an essential component of disaster risk reduction, ensuring that stakeholders are aware of the potential hazards and can take appropriate measures to protect themselves and these invaluable heritage assets. In an era of increasing climate variability and urbanization, understanding how to communicate and mitigate these risks is crucial for the sustainability and resilience of UNESCO World Heritage Sites like George Town.

The primary objectives of this research are threefold: (1) To examine the potential threats of mosquito breeding in historical structures within heritage building areas, (2) To explore the challenges faced by built environment professionals and municipal authorities in mitigating these risks while maintaining the historical and architectural integrity of heritage buildings and (3) To determine the role of risk communication strategies for safety of residents and visitors in George Town, Penang. To achieve these objectives, a qualitative approach was employed. Data was collected through site visits and observations in George Town, as well as interviews with municipal authorities and heritage preservation experts. Qualitative analysis will be conducted to understand the challenges faced by heritage site stakeholders. By addressing these objectives, this research endeavours to provide a comprehensive understanding of the challenges faced by George Town, Penang, and other heritage sites worldwide in their efforts to balance heritage preservation with the management of mosquito-borne disease and urban flooding risks.

Overview of Mosquito-Borne Diseases, Flood Disasters, and Heritage Buildings

A confluence of factors, including urbanisation, climate change, and historic preservation, has created a complex and multifaceted challenge in heritage sites like George Town, Penang. This section provides an overview of the interplay between mosquito-borne diseases, flood disasters, and heritage buildings, highlighting the intricate dynamics that necessitate a holistic approach to risk management.

Mosquito-borne diseases, particularly dengue fever, are a significant public health concern in many tropical and subtropical regions, including Southeast Asia. Dengue, transmitted primarily by Aedes mosquitoes, has been on the rise due to factors such as increased urbanisation, population growth, and climate change (Gubler, 2002). The potential for disease transmission within urban areas is exacerbated by breeding sites for Aedes mosquitoes, often linked to water stagnation and suboptimal waste management (WHO, 2009). Southeast Asia is considered a major hotspot for dengue cases, with 50% of the world's population at risk and 100-400 million annual infections (Samal et al., 2020). Dengue outbreaks in Southeast Asia, such as Indonesia, Phillipines, Malaysia, Singapore and Vietnam pose challenges to healthcare systems and threaten the tourism industry (Miah, 2020).

Heritage buildings, with their unique architectural features and design elements, can inadvertently create suitable breeding grounds for disease-carrying mosquitoes (Kinga et al., 2022). The intricate wooden structures and open ventilation systems in many historical buildings offer dark, sheltered areas conducive to mosquito breeding. According to Lorenz et al. (2020), asbestos roofing and roof slabs in heritage buildings are positively associated with Aedes aegypti adult mosquito infestations. Observations by the authors made in the city of George Town found that local shopkeepers maintained containers filled with rainwater used for watering plants and plates underneath pots to prevent plants from drying in hot weather. Coincidently, large volume containers with water sources from rainwater and well water are suitable breeding places for disease-carrying mosquitoes (Respati et. al, 2020). Furthermore, the historical significance of these structures often limits the ability to modify them, making it challenging to implement effective mosquito control measures (Paskewitz et al., 2013).

Urban flooding is a growing concern globally, often exacerbated by climate change-induced extreme weather events. Urban areas like George Town are especially vulnerable to flooding due to inadequate drainage systems, impervious surfaces, and rising sea levels (Gandini, 2018). Climate change projections indicate an increased frequency and severity of flooding events in many coastal regions, making heritage sites susceptible to inundation. This vulnerability is further exacerbated by the projected increase in the frequency and severity of flooding events due to climate change (Cea, 2022). The unique challenges faced by heritage sites in these areas, such as the potential for significant economic and cultural losses, necessitate a tailored approach to flood vulnerability and risk assessment

(D'Ayala, 2020). A comprehensive methodology that integrates hazard and physical vulnerability information has been proposed for assessing flood risk in historic city centers, which could be applicable to George Town (Ferreira, 2020).

Historic buildings are often located in areas prone to flooding, making them susceptible to significant damage during flood events (Drdácký, 2010). This damage can be severe, causing structural damage, mould growth, and the deterioration of valuable artefacts and documents (Drdácký, 2010). These buildings often lack the flood-resilient features commonly found in modern architecture, which further exacerbates their vulnerability. To evaluate their susceptibility to damage, vulnerability indicators such as building form, structural and fabric integrity, and preservation of architectural and archaeological values can be utilized (Stephenson & D'Ayala, 2014). A multidisciplinary approach that takes into account the future degradation of materials and the impact of climate change is necessary to address these challenges (Cavalagli, 2019). This approach should prioritize the preservation of heritage values while reducing the risks of disasters (El-Ashmawy, 2022).

The interaction between these factors presents a complex nexus in heritage building areas. The inherent vulnerability of heritage buildings to flooding and the suitability of their architecture for mosquito breeding create a dynamic where the preservation of cultural heritage and the health of local residents and visitors are intertwined. These challenges necessitate a comprehensive understanding of the specific risk factors and a strategic approach to disaster risk reduction that safeguards both the architectural legacy and public health. In the following sections, we will explore the challenges faced in mitigating these risks and the strategies employed in George Town, Penang, to address this complex interplay while preserving the city's unique cultural heritage.

Challenges in Preventing Mosquito-Borne Diseases and Urban Flood Disasters in Heritage Buildings

Built-environment professionals play a crucial role in the preservation and adaptation of heritage buildings in the face of urban flood disasters and the threat of mosquito-borne diseases. However, they encounter several significant challenges that hinder their efforts to mitigate these risks while maintaining the historical and architectural integrity of heritage buildings. This section explores the key challenges faced by professionals involved in heritage building preservation in the context of disaster risk reduction.

Structural Challenges

The structural challenges faced by built environment professionals in preventing mosquito-borne diseases and flood disasters in heritage buildings are multifaceted. Many architectural elements of heritage buildings can inadvertently create ideal conditions for mosquito breeding and harbourage. The intricate wooden designs, ornate facades, and open ventilation systems provide dark and sheltered areas where water can accumulate, making them suitable breeding grounds for mosquitoes. The design features that contribute to the historical and aesthetic value of these buildings can also make it challenging to prevent water stagnation, increasing the risk of mosquito-borne diseases. Moreover, the presence of open courtyards and atriums, common in heritage buildings, may provide breeding sites for disease-carrying mosquitoes. Singh (2022) and Harbison (2010) both emphasise the importance of built environment interventions, such as wire mesh policies and stormwater best management practices, in controlling mosquito infestation and reducing mosquito production in urban environments. These studies collectively underscore the need for a holistic approach that addresses the unique structural challenges of heritage buildings while also considering the broader urban context.

Heritage buildings, often located in historical city centers, may be situated in low-lying areas or near rivers and coastlines. These locations enhance their vulnerability to flood disasters. The absence of modern flood-resistant design elements, such as elevated foundations and flood barriers, means that water can easily infiltrate these buildings during floods. D'Ayala (2020) highlights the vulnerability of traditional timber housing in Kuala Lumpur to floods, emphasising the need for tailored mitigation measures. The historical materials used in these structures may not withstand prolonged exposure to water, potentially leading to structural damage, decay, and the erosion of their foundations (Drdácký, 2010). Amaratunga (2014) further underscores the complexity of creating a disaster-resilient built environment, citing challenges such as a lack of regulatory frameworks and inadequate capacities of municipal councils.

Preservation Constraints

Preservation guidelines and regulations are essential for maintaining the historical and architectural integrity of heritage buildings. However, these regulations often impose limitations on implementing mosquito control measures and flood mitigation. Strict conservation guidelines may prohibit structural alterations or the addition of modern materials that are crucial for flood resilience. Jigyasu (2016) further underscores the need for comprehensive legal frameworks and sustainable conservation practices to reduce disaster risks in historic urban areas. This constraint forces built-environment professionals to find innovative and less invasive ways to retrofit buildings, all while preserving their original features. Singh (2022) highlights the role of built environment interventions, such as wire mesh policies, in controlling mosquito infestation. El-Ashmawy (2022) emphasises the need for sustainable preservation strategies to mitigate these risks, while D'Ayala (2020) underscores the importance of localised, tailored mitigation measures for flood vulnerability.

Maintenance and Infrastructure Issues

Maintaining heritage buildings can be challenging, especially when it comes to their drainage systems. Antiquated or inefficient drainage systems require regular maintenance to prevent water stagnation and mosquito breeding. However, the process of maintaining such systems can be complex and costly due to the need for specialised skills, materials and preservation techniques (Abdul-Rashid, 2011; Tan, 2016). Technical information may also be lacking, and there could be defects like settlement and facade cracks that further complicate the maintenance process. These challenges are compounded by the historic nature of these buildings.

Water leaks are a common problem in heritage buildings, which can contribute to mosquito breeding sites and create conditions suitable for mould and structural damage. Repairing such leaks requires identifying the source of the leak without causing damage to historical elements. Despite the importance of maintenance, its implementation is often hindered by organisational and financial factors (Forster, 2009). This can further complicate flood disaster mitigation and mosquito control.

Accessibility and Visitor Management

High-traffic heritage sites in George Town face challenges in managing visitor behaviour to prevent mosquito breeding and damage to the structures. Visitors may unwittingly contribute to mosquito breeding by leaving containers or items that collect water. Effective management and public awareness campaigns are required to educate visitors about the risks and encourage responsible behaviour (See, 2019). Implementing visitor guidelines while preserving the visitor experience is a delicate balance.The preservation of heritage buildings in George Town, Penang is a complex task, with challenges including the unintentional effects of development policies (Lee et al., 2008), the need for adaptive reuse (Wahab, 2018), and human capital issues (Khoo & Lim, 2019). These challenges are further compounded by the need to manage visitor behaviour to prevent mosquito breeding and damage to the structures (Prihatmanti, 2013). Effective management and public awareness campaigns are crucial, but must be balanced with the preservation of the visitor experience. This delicate balance requires careful planning and execution of measures to minimize disruptions (Prihatmanti, 2013).

Navigating these challenges requires a comprehensive, multidisciplinary approach that considers the unique characteristics of each heritage building and the broader historical context. Professionals and municipal authorities in George Town have begun to adopt a range of strategies to address these difficulties effectively. These approaches should be implemented with careful planning, community engagement, and a commitment to preserving both architectural heritage and public health, safeguarding the heritage buildings from the risks of mosquito-borne diseases and flood disasters.

The Importance of Risk Communication Strategies for the Safety of Residents and Visitors in George Town, Penang.

Effective risk communication is a crucial component of disaster risk reduction and public health in a city like George Town, Penang, where the preservation of cultural heritage and the safety of residents and visitors are intertwined. The significance of risk communication strategies cannot be overstated and extends to several key aspects as discussed in the following sub-sections.

Raising Awareness of Risks

Risk communication plays a vital role in educating residents and visitors about the potential dangers they may face in George Town. It raises awareness about the risks of mosquito-borne diseases, such as dengue, and the threats of urban flooding. By understanding these risks, individuals can take

proactive measures to protect themselves and others. For example, residents can eliminate potential mosquito breeding sites around their homes, and tourists can be better prepared for potential flood events. Risk communication is a crucial tool in educating individuals about potential dangers and motivating them to take proactive measures (Smillie, 2010; Abunyewah, 2018). It is particularly important in public health, where it can guide responses to infectious disease threats (Dickmann, 2016). The use of maps in risk communication can further enhance public awareness and mitigation efforts (Dransch, 2010). Therefore, in the context of George Town, effective risk communication can play a vital role in raising awareness about mosquito-borne diseases and urban flooding and in motivating residents and visitors to take appropriate actions to protect themselves and others.

Promoting Preventive Actions

Effective risk communication not only informs but also encourages preventive actions. In the context of mosquito-borne diseases, this includes advocating for measures such as using mosquito nets, applying insect repellent, and wearing protective clothing. In the case of urban flooding, risk communication can highlight the importance of staying informed about weather forecasts, relocating to safer areas during flood warnings, and having emergency kits on hand. Encouraging individuals to take these preventive actions can significantly reduce the impact of disasters. Effective risk communication is crucial in promoting preventive actions for disaster preparedness. Abunyewah (2018) emphasises the need to motivate individuals to convert hazard awareness into preparatory behaviour. Tailored, people-centered communication, particularly on protective actions, is found to be more effective than top-down government communication (Haer, 2016). This is especially important in the context of children and adolescents, where strategies such as informational campaigns and parental involvement can promote preparedness (Midtbust, 2018). Boer (2014) further suggests that framing flood risk communication in terms of prevention, focusing on chance and harm, can significantly improve risk communication.

Fostering Community Engagement

Risk communication fosters community engagement by involving residents and visitors in the planning and executing risk reduction strategies. When the local community is informed about the risks and engaged in the decision-making process, they become active participants in safeguarding their own safety and that of the city as a whole. This collaborative approach strengthens community resilience and promotes a shared sense of responsibility for disaster preparedness and response. Risk communication is a crucial tool in disaster risk reduction, as it can motivate communities to take preparatory actions (Abunyewah, 2018). Effective risk communication can be achieved through community engagement, which empowers individuals to make informed decisions and contribute to emergency control (Sjoraida & Anwar, 2018; Maddah, 2022). This approach is particularly important in public health emergencies, where it can ensure accurate information sharing and the adoption of protective behaviours (Gonah, 2020). The success of risk communication and community engagement programs relies on strong partnerships, clear plans and guidelines, well-coordinated structures, and measures for reporting and documentation (Gonah, 2020).

Tailoring Messages to Cultural Context

In a city like George Town, with its rich cultural diversity, risk communication strategies must be sensitive to the local cultural context. Messages and communication channels need to be tailored to the preferences and practices of different communities within the city. This cultural sensitivity fosters greater understanding and compliance with risk reduction measures. Thomalla (2016) and Snel (2019) both emphasise the importance of tailoring risk communication to local cultural contexts. Thomalla suggests a place-based approach to bridge the gap between international organisations and local communities, while Snel highlights the need to address different rationalities in flood risk communication. Sjoraida (2018) and Martinez (2020) further support this, with Sjoraida finding that effective risk communication in disaster-affected communities is crucial and Martinez underscoring the role of cultural aspects in disaster risk reduction measures. These studies collectively underscore the need for culturally sensitive risk communication strategies in diverse urban settings like George Town.

Building Trust and Confidence

Effective risk communication helps build trust and confidence in municipal authorities and professionals responsible for disaster risk reduction. When residents and visitors feel that they are being provided with accurate and timely information, they are more likely to trust in the measures and

recommendations put forth. This trust is essential for successful disaster preparedness and response efforts. Effective risk communication is crucial for building trust and confidence in disaster risk reduction efforts (Fakhruddin, 2020). This is particularly important in the context of medical professionals, who must possess key characteristics such as risk assessment and the ability to frame information based on residents' values (Murakami, 2018). In the context of local communities, efficient risk communication can strengthen their participation in sustainable development goals, leading to improved behaviour patterns and public engagement (Ștefănescu, 2022). Trust in information sources, such as local city authorities and mass media, is also a key factor in enhancing risk awareness and preparedness (Samaddar, 2012).

Proactive and transparent risk communication mitigates panic and the spread of misinformation during disaster events. When people are well-informed and trust the information they receive, they are less likely to react irrationally or fall victim to rumours and false information, which can exacerbate crisis situations.In conclusion, the significance of risk communication strategies in George Town, Penang, cannot be overstated. These strategies are pivotal in protecting the safety of both residents and visitors while preserving the city's cultural heritage. By raising awareness, promoting preventive actions, engaging the community, enhancing early warning systems, tailoring messages to cultural context, building trust, and mitigating panic and misinformation, effective risk communication contributes to a safer and more resilient George Town in the face of potential disasters.

Methodology

The present study was conducted in three stages. The first stage included the review of previous studies and literature as well as the structures of relevant government agencies in the context of this study. The geographical, cultural, social and other aspects of the area were then observed on-site in the second stage, and finally, analysis of the interview data and the observation which leads to the factors affecting the situation were identified. The following subsections describe the methodology and approach in detail.

Location of Research

George Town, located on the northwestern coast of Penang Island in Malaysia, stands as a beacon of cultural heritage and historical significance. Recognized as a UNESCO World Heritage Site since 2008, George Town epitomizes the rich tapestry of diverse cultures, architectural marvels, and vibrant urban life that characterize this enchanting city. This overview provides insights into the geographical features, heritage boundary, and climatic conditions that shape the unique identity of George Town (Plan Malaysia, 2022).

Situated within the state of Penang, George Town occupies a strategic location along the Malacca Strait, a vital maritime artery linking the Indian Ocean to the South China Sea (Plan Malaysia, 2022). The city's geographical coordinates are approximately 5.4164° N latitude and 100.3327° E longitude. Bordered by the sea to the east, George Town boasts a picturesque coastline adorned with sandy beaches and bustling waterfront promenades, offering residents and visitors alike a serene escape and stunning views of the azure waters.

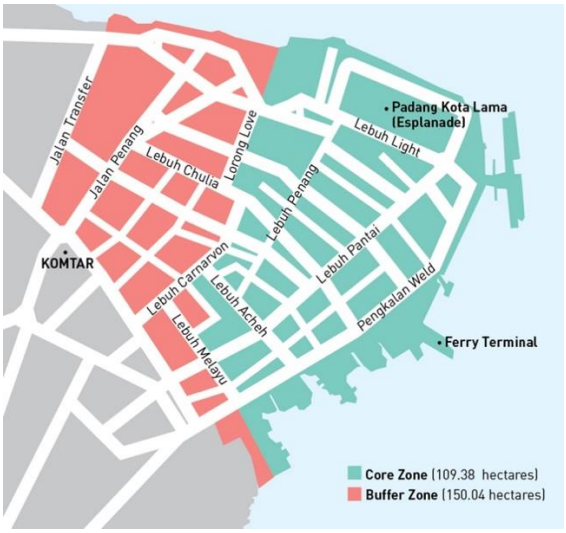

Figure 1: The Boundary of Core and Buffer Zone of George Town World Heritage Site

Refer to Figure 1 above, the UNESCO World Heritage Site designation encompasses both the core zone (109.38 hectares) and buffer zone (150.04 hectares) of George Town, delineating the boundaries within which the city's architectural and cultural treasures are preserved and celebrated (Plan Malaysia, 2022). The core zone encompasses the historic heart of George Town, including its iconic colonial-era buildings, ancient temples, and vibrant street life. Surrounding this core area is the buffer zone, extending the protective umbrella of heritage conservation to the broader urban fabric and safeguarding the city's unique character from encroaching modern development.

George Town experiences a tropical climate characterized by warm temperatures, high humidity, and abundant rainfall throughout the year. The city's proximity to the equator ensures relatively consistent weather patterns, with temperatures ranging from 25°C to 32°C (77°F to 90°F) on average. The rainy season typically occurs from April to October, with peak precipitation in September and October, while the drier months span from November to March. Annual rainfall averages around 2,500 to 3,000 millimeters, nourishing the lush vegetation that adorns the city's streets and parks and contributing to its verdant charm (MMD, 2022 & MMD, 2022).

Selection of the Research Site as the Case Study

The selection of Penang, Malaysia, as a case study in this research is highly justified due to its unique position as a UNESCO World Heritage Site and its susceptibility to both natural disasters, especially water-related disasters, and dengue outbreaks. Penang's historical significance and vibrant tourism industry make it an emblematic representative of heritage areas that face multifaceted challenges. Its dense urban population, coupled with inadequate drainage systems and a reliance on tourism, underscore the potential for increased vulnerability to post-disaster dengue outbreaks. Examination of Penang as a case study can shed light on the intricate dynamics between disaster management, public health, and heritage preservation. Moreover, the findings can offer valuable insights into the strategies necessary to enhance preparedness, mitigate risks, and safeguard the well-being of both residents and visitors in similar disaster-prone heritage locations.

Composition of the Interdisciplinary Research Team

The research team comprises multinational researchers from three universities in various disciplines, namely civil engineering, environmental engineering, public health, medicine, business administration, and political science. Each researcher addressed the research problems making the best use of own expertise and collectively discussed the strategies to overcome the problems identified in the study.

Site Observations and Information Collection through Fieldwork

The fieldwork was conducted over the span of 12 months in Penang, Singapore, and Putrajaya, which locations are shown in Figure 1 below. The aim of the fieldwork in Penang was to investigate the location of the study and observe the physical, cultural, social, and climatic factors that contribute to the vulnerability of the heritage site towards flood disasters, and consequently, mosquito-borne infectious diseases, specifically dengue. Interviews were conducted to gain an in-depth understanding of the issues and challenges faced by the residents, heritage NGOs, local authorities, city council officers and dengue researchers from a local university. Additional three days were allocated to observe and investigate the possible Aedes breeding sites at the tourist hotspot within the George Town World Heritage Site.

Singapore, the neighboring country and another tropical tourist destination, is the secondary location for our fieldwork. Information was collected by observation and interviews. We comparatively explored the current practices, especially the norms that have been adopted by the residents and public authorities in alleviating the risks of dengue as well as drainage systems to overcome the torrential rainfall. The observation was focused on the Singapore Botanic Gardens, a UNESCO World Heritage Site, as well as the Marina Barrage, a place characterized by three functions: a water supply, flood control, and lifestyle attraction. Interviews and discussions were conducted at the National Environment Agency, Singapore, and the Public Utilities Board.

In Putrajaya, Malaysia's administrative centre, we conducted semi-structured interviews with government agencies and experts from 2 local universities. We obtained information regarding the policies and measures taken by the Malaysian authorities to improve disaster preparedness and risk communication strategies for the general public.

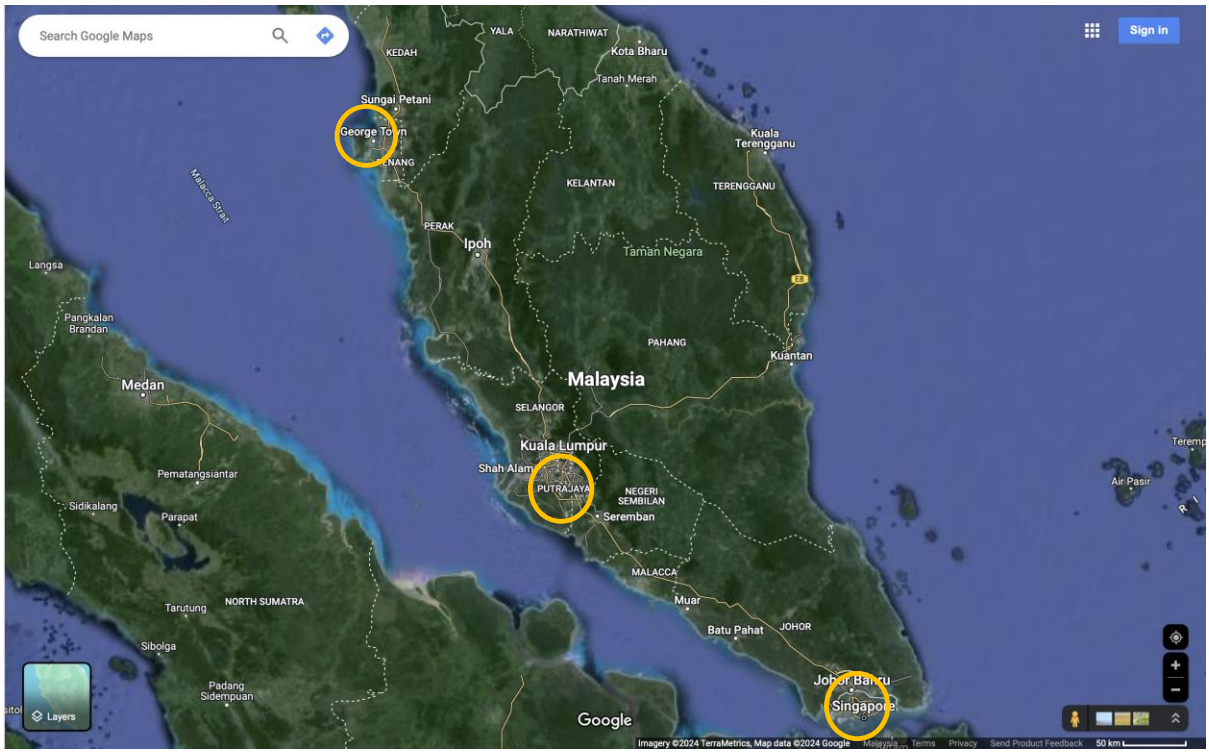

Figure 1: Proximity of fieldwork locations: George Town, Putrajaya and Singapore (source: Google Map)

George Town: A Geographical, Historical, and Environmental Overview

George Town, the capital city of Penang, Malaysia, is renowned for its rich cultural heritage and historical significance. Located on the northeastern tip of Penang Island, it spans a total area of approximately 305 square kilometers. The city's heritage value earned it a UNESCO World Heritage Site designation in 2008, highlighting its well-preserved architectural and cultural heritage influenced by

Malay, Chinese, Indian, and European traditions.The UNESCO site is divided into a **core zone** (109.38 hectares) and a **buffer zone** (150.04 hectares). The core zone encompasses key historical landmarks, colonial-era buildings, and vibrant streetscapes, while the buffer zone protects the surrounding urban fabric from intrusive developments, ensuring the preservation of the city's unique character. Environmental conditions in both zones are managed to balance heritage preservation and urban living.

George Town experiences a tropical climate with high humidity and consistent temperatures. The historical climate trends reveal warming effects attributed to climate change, as evidenced by rising temperatures and increased rainfall variability as shown in Table 1 below:

Table 1: Climate Indicator and Historical Trends in George Town, Penang

Climate Indicator	Current Values	Historical Trends
Annual Daily Average Temperature	Max: 32°C, Min: 24°C	Rising by ~0.3°C per decade since 1980
Daily Average Humidity	70–90%	Increasing during monsoon periods
Annual Rainfall	2,500–3,000 mm	More erratic distribution; peak in Oct.
Monthly Rainfall	Highest in September-October (~400 mm)	Earlier trends show reduced intensity

Flooding is a recurring challenge in George Town, exacerbated by urban development and climate change. Notable floods occurred in **2008, 2017**, and **2018**, causing significant damage to both modern infrastructure and historical landmarks. These events highlighted the city's vulnerability to stormwater drainage issues and rising sea levels.

George Town is home to approximately **700,000 residents**, making it one of Malaysia's most densely populated urban areas. Before the COVID-19 pandemic, in 2019, the city welcomed nearly **4.3 million international tourists**, attracted by its heritage sites, street art, and acclaimed culinary scene. George Town's unique multicultural identity is reflected in its architecture, food, and festivals. This diversity stems from its historical role as a trading hub, which brought together different ethnicities and cultures. The city is dotted with colonial mansions, Chinese clan houses, Indian temples, and Malay kampongs, all contributing to its rich heritage.

Table 2: Key Geographical and Environmental Characteristics of George Town

Parameter	Details
Area (State of Penang)	305 km² (George Town)
Core Zone	109.38 hectares
Buffer Zone	150.04 hectares
Population	~700,000 residents
Tourist Arrivals (2019)	~4.3 million international tourists
Annual Daily Avg. Temp.	Max: 32°C, Min: 24°C
Annual Rainfall	2,500–3,000 mm

Initial Findings from Field Studies

The paper discusses the initial analysis of the data collected during the field studies. The researchers studied the risk communication measures and community awareness program implemented by the authorities to educate the residents about best practices for dengue fever and flood disasters. This study focuses on two challenges faced by Singapore and George Town, specifically

flood disaster and dengue fever. From the data collection, two basic interconnected themes emerged: Mitigation and Risk Communication.

Mitigation Efforts

Initial findings suggest that mitigation measures are crucial in reducing the vulnerability of residents and visitors during potential flood disasters and dengue outbreaks. Comparing the findings obtained from Penang and Singapore, two densely populated urban areas frequently visited by tourists, it is evident that the authorities in both cities adopt different approaches to managing such situations.

Singapore takes a proactive stance in preparing for disasters by managing the climate change factors within the city. All new developments, refurbishments, and retrofitting of old infrastructures in the city are done with meticulous consideration of the environment, embracing sustainable methods and green technology. By managing these factors, flood disaster risk can be mitigated.

On the other hand, George Town in Penang has also started imposing protocols in their new developments, refurbishments, and retrofitting. However, considering that a part of the city has been inscribed as a UNESCO World Heritage Site, modifications or structural mitigations against flood disasters may not be easy and at times may be prohibited due to heritage structures' specifications and regulations.

In terms of mitigation against dengue outbreak, both cities are at risk due to the local hot and humid climate almost year-round. The prevention measures taken by both cities are similar, such as periodic fogging in affected areas, getting rid of stagnant water to reduce mosquito breeding sites, and enforcing penalties for homeowners if mosquito larvae are found on their property. The residents in both cities are accustomed to mitigating against dengue infection through years of conditioning and culturally embedded practices. However, it should be noted that both cities may not share the same approach in disclosing the number of dengue infections among its localities, and the international tourists who come from non-tropical regions where dengue fever is not common may not have the local knowledge of avoiding dengue infections.

Risk Communication

Timely and comprehensive information for the targeted communities is crucial in ensuring safety and preparedness in the event of a disaster. Effective risk communication on the possible occurrence of disasters will increase the probability of human safety and reduce human exposure to hazards for locals and tourists alike. For the city of George Town, disaster risk communication is nation-centric, whereby information is dispersed through the official social media of the National Disaster Management Agency and local news. While the information is easily accessible by the locals, it is not readily accessible to the tourist. The common way of relaying risk communication to tourists is through their accommodation and tourist information center in the city. While information is being passed faster in Singapore, it should be highlighted that Singapore is smaller in size, and the capital is the nation itself, and thus risk communication is much more efficient and faster for both locals and visitors.

Information on dengue outbreaks is an integral component in effective risk communication, as statistical data is crucial in eliciting the appropriate preventive actions by the public. If the local authorities choose not to make the information available, the risk of a dengue outbreak is imminent as the public will continue putting themselves at risk and oblivious to preventive measures that could be taken by themselves. From the field studies, the researchers noted contrasting strategies taken by both cities. Singapore has taken a more inclusive stance in preventing dengue outbreaks by disclosing information to the public and encouraging the public to take proactive measures against dengue outbreaks. On the other hand, the public in Penang may not know about the statistics of dengue outbreaks unless there are fogging activities or site inspections within the area conducted by the authorities. Nevertheless, it is important to note that authorities in both cities have been organising awareness campaigns and knowledge-sharing sessions with the education sector to teach the younger generation to develop good habits and best practices in preventing dengue outbreaks. It is critical that the academic experts and the relevant industry partners to work with the government agencies to provide effective materials and skills that will be beneficial in support of the educational programs.

To address these challenges, cities like George Town employ a combination of risk communication, community engagement, and adaptive measures. By raising awareness about potential risks, engaging the local community, and implementing structural and non-structural risk reduction measures, they seek to protect both the safety of tourists and the preservation of cultural heritage.

Conclusion

It is essential for heritage cities like George Town to find a balance that ensures the safety and satisfaction of tourists while preserving their cultural heritage for future generations. These efforts often require a nuanced and multidisciplinary approach to address the diverse and interconnected challenges of tourist safety and cultural heritage preservation in the context of urban flooding and mosquito-borne diseases. In conclusion, the significance of risk communication strategies in George Town, Penang, cannot be overstated. These strategies are pivotal in protecting the safety of both residents and visitors while preserving the city's cultural heritage. By raising awareness, promoting preventive actions, engaging the community, enhancing early warning systems, tailoring messages to cultural context, building trust, and mitigating panic and misinformation, effective risk communication contributes to a safer and more resilient George Town in the face of potential disasters.

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