

## Formulation of Climate Adaptation Plans Using Common Reporting Framework: The Case of Four Malaysian Cities

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### **Abstract**

Enhancing resilience in developing country cities is vital due to their susceptibility to climate change impacts. Therefore, crafting effective climate adaptation plans is essential. However, the lack of attention to the framework and processes for developing such plans persists, as Malaysia is currently formulating a national adaptation policy, resulting in unclear institutional frameworks for its cities. This paper operationalizes the Global Covenant of Mayors for Climate and Energy (GCoM) Common Reporting framework (CRF) as a primary guide for climate adaptation plans in four Malaysian cities—Muar, Penampang, Tawau, and Hang Tuah Jaya. Each city has unique characteristics. The three key phases involve: (i) foundation preparation (i.e., obtaining buy-in and commitment from policymakers; (ii) climate risk and vulnerability assessment (i.e., requiring secondary climatic data and context-specific knowledge from local stakeholders via focused group discussions); and (iii) formulation of adaptation plans (i.e., identifying and prioritizing appropriate adaptation policy options and strategies). The GCOM-CRF is commended for its flexibility and comprehensiveness addressing multidimensional climatic hazards and adaptation actions. The standardized, evidence-based, and collaborative process aligns with the Enhanced Transparency Framework (ETF) under the Paris Agreement. However, achieving a comprehensive climate action plan requires considering the mitigation pillar, detailed implementation roadmap, key implementers, technology partners, project timeframe, financial allocation, and monitoring.

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## 1.0 INTRODUCTION

In this contemporary urban era, cities serve as major hubs for economic, sociocultural, knowledge, and innovation activities. Currently, approximately 55% of the global population resides in cities, a figure expected to rise 68% by 2050 (UN, 2019). The changing climate poses significant challenges to cities, exposing them to the adverse impacts of extreme weather events, both presently and in the future. Climate change effects are anticipated to influence various aspects of urban life, including quality of life, essential services (energy, water, transport, and healthcare), and assets. Despite global efforts to reduce greenhouse gas emissions, these impacts are expected to persist or worsen, even under the most optimistic scenarios aiming to limit global temperature rise to 1.5 °C (IPCC, 2018).

To mitigate the severe economic, social, and environmental consequences of climate change, cities must enhance resilience and adapt to the evolving climate, safeguarding themselves and their communities from inevitable climatic effects. Developing countries undergoing rapid urbanization and industrialization face a critical challenge in this regard. Consequently, local governments in developing countries must formulate effective climate adaptation plans and implement action and strategies to prepare, respond, and adapt to the expected effects of climate change. The cities in Malaysia. However, in contrast to the emphasis on the mitigation pillar, discussions on climate adaptation in cities of developing countries are relatively limited, despite the imperative nature of the topic due to today's catastrophic climatic impacts (see Parry and Terton, 2016; UNCTAD, 2021).

This limitation is likely attributed to the resource constraints faced by some developing countries, encompassing financial limitations, data scarcity, technical expertise gaps, infrastructure and technological options, and human capital deficiencies, hindering the formulation of comprehensive, long-term plans and subsequent implementation (see UNCTAD, 2021; Noble, n.d.). For instance, in the case of Malaysia, a national climate adaptation policy is in progress, despite the country's exposure to various climatic hazards, such as floods and landslides, over the past decades (TheStar, 2019). The absence of a formal national adaptation plan creates challenges in providing a clear institutional framework and direction for non-state parties (e.g., cities), leaving the formulation process of an adaptation plan, particularly at the city level, unaddressed. Cities in Malaysia currently do not have a methodological approach. Therefore, this study guides other cities to develop a plan so they can assess climate risk and climate capacity, also for future planning.

This issue is significant because without a comprehensive, longer-term action plan, as argued by Emeritus Professor Dr. Noble from the Climate Change Institute at the Australian National University, the treatment of adaptation in most developing countries has been "mostly brief, patchy, and very generic, without the context of a national development plan." Consequently, the value and effectiveness of such plans, let alone their implementation, remain uncertain. In light of the aforementioned context, establishing a robust methodological framework for formulating climate adaptation plans becomes crucial. Globally, various methodological frameworks are available for developing city-level climate adaptation plans, such as the Local Governments for Sustainability (ICLEI) Asian Cities Climate Change Resilient Network (ACCCRN) Process (IAP), the Urban Adaptation Support Tool (UAST) provided by the European Climate Adaptation Platform Climate-ADAPT, and the Common Reporting Framework (CRF) of the Global Covenant of Mayors for Climate and Energy (GCOM). Overall, these methodologies, applicable in cities with diverse geographic, climatic, and cultural characteristics, share common traits in providing clear general frameworks and holistic processes to assist cities in crafting effective climate adaptation plans.

Therefore, the objective of this paper is to develop adaptation plans in four selected Malaysian cities using the GCOM-CRF. The GCOM-CRF was chosen for this study because it offers a clear, consistent, and widely used framework for cities. Compared to other approaches like ICLEI's Adaptation Cycle and the ACCRN framework, which can vary by city and may be harder to compare across regions, GCOM-CRF provides a standardized method used by over 13,000 cities worldwide. It also includes practical tools like CIRIS and CRVA to help cities assess risks and plan effectively. These features make it more suitable for this study, especially when aiming for consistent reporting and comparison between cities. Other frameworks are valuable but may be less structured or focused on specific regions or processes. The approach involves adapting the GCOM-CRF as a primary systematic

methodology in the development of climate adaptation plans. The empirical case studies in the cities offer valuable insights for urban policymakers and researchers, enhancing their understanding of the formulation process for climate adaptation plans.

## 2.0 METHODS

The GCOM stands as the world's largest coalition of cities and local governments, voluntarily dedicated to actively addressing climate change. This coalition includes thousands of cities from over 140 countries, representing approximately 900 million of the global population. More than 10,000 cities and local governments within GCOM are committed to implementing adaptation plans and taking measures to effectively incorporate the impacts of climate change for a future that is resilient to climatic challenges. In response to the dynamic climate conditions, GCOM has launched the CRF to offer guidance on climate mitigation and adaptation methodologies for cities worldwide.

In the context of this study on climate adaptation, the focus of this paper centers around the methodology for climate adaptation. The Joint Research Centre (JRC), the scientific and knowledge service of the European Commission, has developed the unified GCOM-CRF methodological framework to assist the cities and local governments of the GCOM coalition in formulating climate adaptation plans. Their guidebook, published in various regions and countries—Europe (Bertoldi, 2018), the Middle East and North Africa (Rivas et al., 2018), Sub-Saharan Africa (Palermo et al., 2019), and Southeast Asia - Malaysia (Ho et al., 2020)—is grounded in a similar unified approach and consistent processes, despite regional variations.

The standardized GCOM-CRF methodological framework proposes three essential phases for cities and local governments to follow in the preparation of a climate adaptation plan. The GCOM-CRF methodology framework encompasses: (i) laying the groundwork; (ii) conducting a climate risk and vulnerability assessment; and (iii) formulating a climate adaptation plan (refer to Table 1). The detailed elaboration of each phase and its components is discussed below.

**Table 1.** Steps involved in climate adaptation plan formulation.

<b>1<sup>st</sup> Phase: Preparing the Groundwork</b>
<ul style="list-style-type: none"> <li>• Securing political commitment</li> <li>• Municipal support</li> <li>• Stakeholder engagement</li> </ul>
<b>2<sup>nd</sup> Phase: Climate Risk and Vulnerability Assessment</b>
<ul style="list-style-type: none"> <li>• Identifying climate hazards and their impacts at different intensity and timescales (past, present and future)</li> <li>• Identifying population group vulnerable to climate hazards</li> <li>• Assessing adaptive capacity</li> <li>• Secondary Data Collection (public official documents and reports)</li> <li>• Focus Group Discussions</li> </ul>
<b>3<sup>rd</sup> Phase: Development of Climate Adaptation Plan</b>
<ul style="list-style-type: none"> <li>• Setting adaptation goals</li> <li>• Identifying adaptation options/actions</li> <li>• Selecting adaptation options/actions</li> <li>• Focus Group Discussions</li> </ul>

To initiate the formulation of a climate adaptation plan, any city or municipality must lay the groundwork. In this initial phase, securing commitment from the highest political level of local governance, such as the Mayor, is crucial. Policymakers at this level serve as the driving force responsible for approving and initiating the entire process of developing a climate adaptation plan. This commitment not only provides a mandate but also empowers the local government to mobilize necessary resources, including budget and relevant municipal staff, to support

the plan's development. To ensure political commitment and municipal support, the proposed climate adaptation plan must align with the municipality's vision and contribute to state, regional, and national policies.

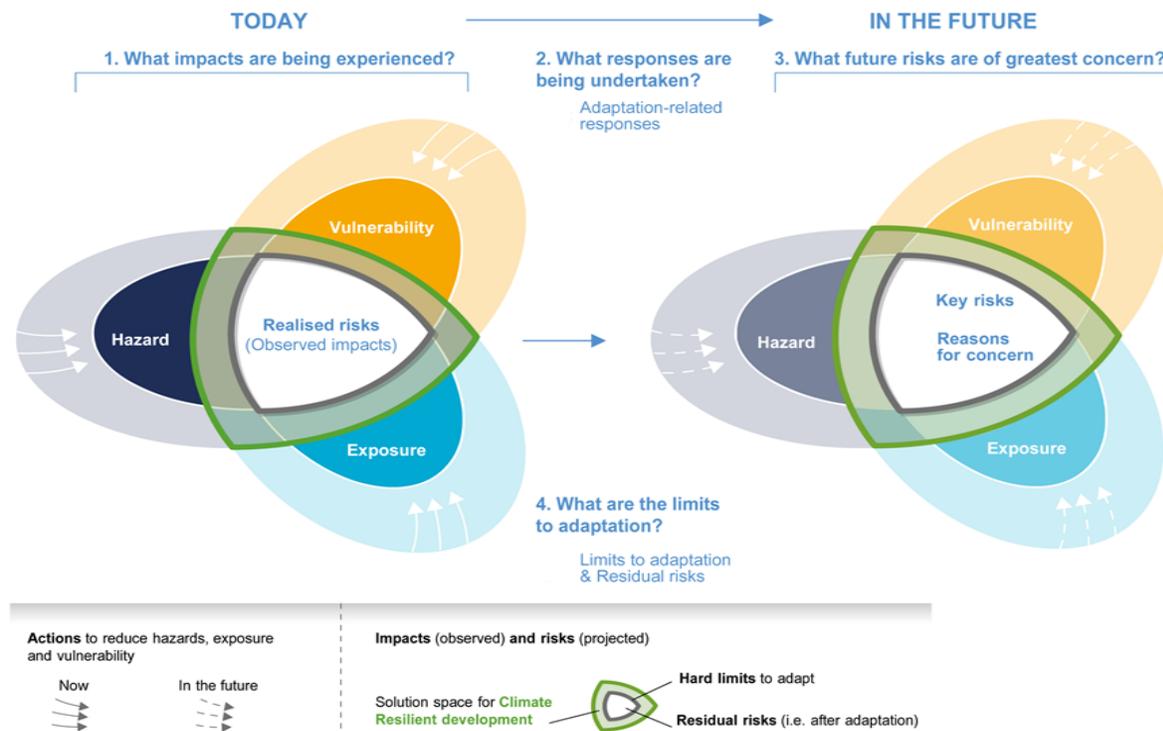
During this stage, the alignment with the municipality's vision promotes buy-in and facilitates approval for resource allocation from local governments, and in some cases, from state and national governments. It establishes broad consensus across all administrative levels on the necessity of a climate adaptation plan, ensuring long-term support and stability for the local government and relevant agencies, regardless of changes in political leadership. Additionally, it encourages the participation of various stakeholders, including industry enterprises, the business community, non-governmental organizations, and citizens. Stakeholder involvement is crucial for the success of climate adaptation plan development, as they can optimize the potential of local resources, including indigenous knowledge, providing a solid basis for decision-making that meets community expectations and assists in developing the adaptation plan.

The second phase focuses on conducting a comprehensive Climate Risk and Vulnerability Assessment that involves identifying climate hazards and understanding their impacts across different intensities and timescales, which are past, present, and future. It also includes identifying population groups that are particularly vulnerable to these hazards, based on factors such as socio-economic status, age, health, and location. In addition, the assessment evaluates the adaptive capacity of various sectors and communities, which refers to their ability to cope with and respond to the impacts of climate change. This phase incorporates Focus Group Discussions (FGDs) with key stakeholders to gather local insights, perceptions, and experiences related to climate risks. Secondary data from relevant sources, for example, the climate reports, demographic data, and environmental assessments, is also analysed to support and validate the findings.

In the third phase, the focus shifts to the formulation of a Climate Adaptation Plan. This begins with setting clear and achievable adaptation goals that align with local needs and climate priorities. Once the goals are defined, a range of adaptation options or actions is identified based on the findings from the previous assessment phase. Following this, a selection process is undertaken to determine the most feasible and effective adaptation actions. This includes evaluating each option based on criteria such as cost-effectiveness, environmental impact, and social acceptance. Focus Group Discussions are again utilized to ensure that community voices and stakeholder inputs are incorporated into the decision-making process. The resulting Climate Adaptation Plan serves as a strategic roadmap to enhance resilience and reduce climate-related vulnerabilities within the municipality.

Decisions made among various stakeholders are typically based on extensive knowledge, leading to more transparent decision-making. Continuous engagement with stakeholders during later stages of climate adaptation plan formulation, such as setting adaptation goals and prioritizing options, contributes to the co-creation of a future vision, reinforces a sense of ownership, and ensures their long-term acceptance and strong support. In summary, obtaining political commitment, municipal support, and stakeholder engagement at the early stage lay the solid foundation for the preparation of a climate adaptation plan.

Advancing from the initial phase outlined earlier, another prerequisite for local governments to formulate a climate adaptation plan is referred to as a climate risk and vulnerability assessment (CRVA). The concept of CRVA is derived from the latest scoping framework proposed by the United Nations body for scientific assessment on climate change - the Intergovernmental Panel on Climate Change (IPCC). According to the Sixth Assessment Report (AR6) (IPCC, 2022), the illustrative storyline (see Figure 1) highlights the realised risks (observed impacts) and future risks (key risks and reasons for concern), informed by adaptation-related responses and the limits to adaptation. Risk is defined as a function of the expected potential impacts (hazards) of climate extremes, system vulnerability, and exposure. The risk associated with climate-related impacts arises from the interplay of climate-related hazards (including hazardous events and trends) with the vulnerability and exposure of human and natural systems. The arrows illustrate actions to reduce hazard, exposure, and vulnerability, which shape risks over time. Accordingly, the green areas at the centre of the propeller diagrams indicate the ability for such solutions to reduce risk, up to certain adaptation limits, leaving the white residual risk (or observed impacts) in the centre. The shading of the right-hand-side propeller diagram compared with the non-shaded one on the left reflects some degree of uncertainty about future risks (O'Neill et al., 2022).



**Figure 1.** An illustration of the main concepts of climate risk and vulnerability. (Source: O'Neill et al., 2022)

The CRVA assists local governments in examining the configuration of climate risks, encompassing the combination of hazards, exposure, and vulnerability within a specific region. It furnishes essential outcomes and discoveries that enable local governments to substantiate their adaptation plans, aiming to reduce exposure, enhance resilience, and bolster adaptive capacity against climate-induced shocks and stresses. The assessment may manifest as a comprehensive single evaluation or multiple assessments conducted for individual sectors. Various tools and approaches, both qualitative and quantitative, can be employed for this assessment (Mukheibir and Ziervogel, 2007). The choice of method should hinge on the assessment's purpose, geographical scope, and resource availability, including data, tools, finances, and technical expertise. Table 2.2 delineates the strengths and weaknesses of three commonly used methodological approaches for CRVA: the indicator-based approach, model-based approach, and participatory approach. Indicator-based and participatory approaches demand fewer resources and technical skills, making them viable options for small and medium-sized cities. Conversely, the model-based approach typically necessitates advanced technical skills and robust geo-referenced datasets, rendering it more accessible to larger cities endowed with adequate resources and capacities.

Local governments require a comprehensive comprehension of the climate risks and vulnerabilities faced by their cities to inform decision-making and policy formulation. The CRVA aids local governments in recognizing their territory's exposure to climate hazards across different timescales (past, present, and future), assessing intensity, vulnerabilities, risks, and impacts. Hence, local governments must acknowledge the primary climate risks posing current and potential threats to their populace, assets, livelihoods, and the environment. In this regard, the formulation of an effective climate adaptation plan indeed relies on the CRVA (i.e., evidence-based analysis) to serve as essential information or a baseline for identifying current and future climatic scenarios. This information enables local governments to establish adaptation goals and select potential adaptation options and strategies, as elaborated in the following paragraph.

**Table 2.** Common approaches in climate risk and vulnerability assessment.

Approaches	Descriptions	Strengths	Weaknesses
Indicator Based	Indicator-based methodologies use a specific set or combination of proxy indicators to produce measurable outputs across various spatial scales. Examples of indicators include the Livelihood Vulnerability Index (LVI) (Hahn et al., 2009), Household Adaptive Capacity Index (HACI), Well-being Index (HWI), Index of Social Vulnerability to Climate Change for Africa (SVA).	Produce measurable outputs across various spatial scales that can be easily used by policy-makers Valuable for monitoring trends and exploring the implementation of adaptation responses.	Limited by lack of reliable data, particularly socioeconomic sources, at the scale required for assessment Challenges associated with testing and validating the metrics used, such as good governance.
Model Based	Model-based methods incorporate climate, biophysical and socioeconomic modelling, and display vulnerability spatially through mapping. These methods commonly focus on a specific driver of change or sector and apply statistical measures and mapping techniques to display vulnerability as well as measures of adaptive capacity and resilience.	Mapping of climate change vulnerability provides an insight into the vulnerability of place and may have some value in identifying vulnerable places and people.	Typically, a snapshot of vulnerability, failing to encapsulate spatial and temporal drivers of structural inequalities.
Participatory Approach	Participatory approach focuses on including stakeholders in the assessment process, and this can be done in a variety of ways and to various extents. A range of tools for participatory vulnerability assessments exist, including cognitive mapping, interviews, surveys, vulnerability matrices, stakeholder engagement workshops and expert-based inputs.	Recognize the local or context-specific knowledge that exists within a system, and the fact that many aspects are best known by those individuals operating within that system.	The perception and understanding shared by participants should ideally be complemented with supporting socio-economic and biophysical data Challenges associated with the identification of the appropriate target group and ensuring that all voices are heard and equally included in the process.

(Source: Davis and Vincent, 2017)

Several studies have explored common approaches to climate risk and vulnerability assessments in Malaysia. One notable initiative is the Penang Nature-Based Climate Adaptation Programme (PNBCAP), led by Think City which utilises a model-based methodology. PNBCAP employs a comprehensive and collaborative framework that addresses both the environmental and social dimensions of climate change within Penang's urban landscape. In addition, a participatory approach was incorporated in the preparation of the Climate Action Plan 2030 for Hang Tuah Jaya, Muar, Penampang, and Tawau. These Climate Action Plans reflect a commitment to decarbonizing local economies while simultaneously promoting equitable growth and ensuring a high quality of life for all citizens.

Derived from the outcomes and insights acquired through the CRVA, cities and local governments are now capable of identifying their specific adaptation requirements and initiating the development of a climate adaptation plan. This plan serves as a pivotal document primarily outlining the actions and strategies that local governments intend to implement in response to current and future climatic risks (including hazards, exposure, and vulnerability) and impacts, with the goal of constructing a resilient city. One of the key aspects in crafting a climate

adaptation plan is for local governments to establish adaptation goals tailored to the potential climate risks and impacts identified. These adaptation goals provide strategic directions, outlining what is intended to be achieved within a specified timeframe. Moreover, the adaptation goals serve as the foundation for local governments to later identify relevant adaptation options. Due to limited resources, it is imperative for local governments to acknowledge that addressing every climatic issue is not feasible (World Bank, 2010). Therefore, it is more effective for them to define adaptation goals by prioritizing and focusing on climate hazards and risks that have more severe impacts, intensity, and frequency. Additionally, adaptation goals should be aligned with higher-level adaptation policies, whether at the regional, state, or national levels. Climate adaptation is inherently a multilevel and multidimensional subject involving all levels of government within a country. This approach ensures that the climate adaptation plan can be positioned and integrated within a larger policy framework, facilitating optimal resource allocation and well-coordinated plan execution.

Following the identification of adaptation goals, local governments should pinpoint potential adaptation options that are directly linked to the previously established goals. Various adaptation options can be considered to address the concerns identified through the CRVA. According to the IPCC (2014), adaptation options can be classified into three main categories: physical options, social options, and institutional options. The literature review can provide insights into adaptation options or best practices successfully implemented by other countries, serving as benchmarks. Once adaptation goals and their potential options are identified, local governments must review and refine them, carefully prioritizing and selecting with input from key stakeholders. Stakeholder participation in the selection of adaptation options is crucial, as it is usually based on their extensive knowledge. This not only promotes transparency in decision-making but also ensures that the selected options are suitable, viable, and acceptable to the community at large, particularly in meeting their welfare. Moreover, stakeholders play an essential role in providing advice and feedback on the details of adaptation options, including costs, timescales, and supporting partners involved in the plan execution, leading to the development of a detailed implementation roadmap.

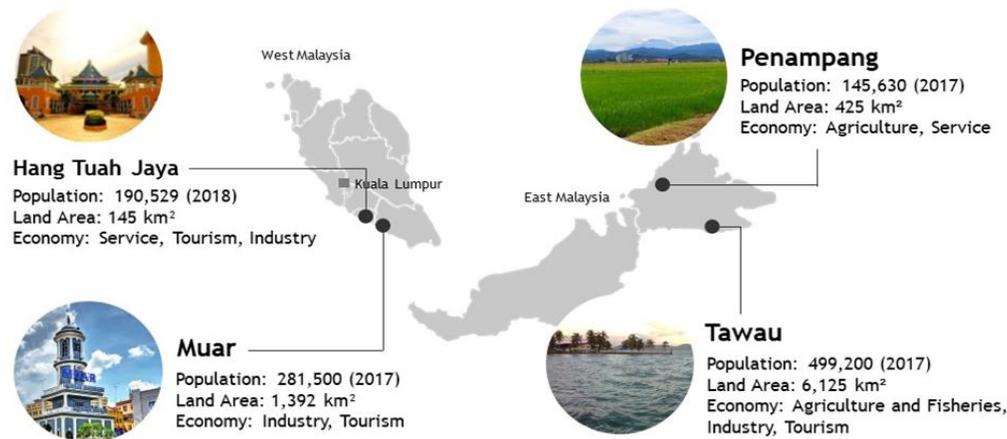
### 3.0 RESULTS AND DISCUSSIONS

This section illustrates the experiences of four pilot cities in Malaysia involved in the formulation of climate adaptation plans using the GCOM-CRF approach. The summarized outcomes of this process are presented in Tables 3, 4, and 5. The selected pilot cities fall within the general category of small and medium-sized urban typology in Malaysia, typically governed by local bodies known as district councils and municipal councils. Currently, Malaysia has a total of 155 local governments, with district councils and municipal councils constituting the vast majority (85%) (refer to the Ministry of Housing and Local Government Malaysia, 2019). Consequently, the lessons learned, and experiences shared from this diverse set of pilot cities can prove beneficial for most cities and local governments in Malaysia.

Malaysia, situated in Southeast Asia within the equatorial zone, experiences a tropical rainforest climate characterized by relatively consistent diurnal temperature variations throughout the year. The daily mean temperature hovers between 26°C and 28°C, accompanied by high humidity and an average annual rainfall ranging from 200cm to 400cm. The country is influenced by the southwest monsoon (May – September) and northeast monsoon (November – March) (MetMalaysia, 2020). Geographically, Malaysia is composed of two non-contiguous regions: West Malaysia (Peninsular Malaysia) on the Malay Peninsula and East Malaysia on the island of Borneo, separated by the South China Sea. While the two regions share a similar landscape, they differ in terms of economy, demography (ethnic groups), and governance. West Malaysia is predominantly home to Malays, Chinese, and Indians, whereas East Malaysia primarily consists of the indigenous communities of Borneo Island (Dayak, Kadazan-Dusun, Bajau, Melanau, and Murut) (Department of Statistics, 2020). The legislative frameworks for local governments in West Malaysia fall under the Local Government Act 1976 (Act 171), while those in East Malaysia operate under the Local Authorities Ordinance 1996 (for Sarawak State) and Local Ordinance 1961 (for Sabah State). These differences in legislative frameworks contribute to distinct operations and administration of local governments, resulting in varied climate issues/hazards and necessitating different adaptation measures and capacities.

The four Malaysian cities involved in the study are Hang Tuah Jaya, Muar, Penampang, and Tawau (see Figure 2). Hang Tuah Jaya, situated in West Malaysia (Melaka State), is a landlocked medium-sized city with a population of 190,529 (2018) and a land area of 145 square kilometers (Rancangan Tempatan : Majlis Perbandaran Hang Tuah Jaya (Pengubahan) 2025, 2019). Its economy primarily focuses on services, tourism, and manufacturing industries, and it is administered by the Hang Tuah Jaya Municipal Council. Muar, a medium-sized riverside and coastal city in West Malaysia (Johor State), has a population of 281,500 (2017) and a land area of 1,392 square kilometers (Draf Rancangan Tempatan Daerah Muar 2030 (Penggantian), 2022). Governed by the Muar Municipal Council, Muar's key economic activities include manufacturing and tourism. Penampang, a small riverside city in East Malaysia (Sabah State), has a population of 145,630 (2017) and a land area of 425 square kilometers. The economy of Penampang is predominantly based on agriculture and services, and it is administered by the Penampang District Council. Lastly, Tawau, a medium-sized coastal city in East Malaysia (Sabah State), governed by the Tawau Municipal Council, engages in economic activities such as agriculture and fisheries, manufacturing, and tourism.

These four cities, Tawau, Penampang, Hang Tuah Jaya, and Muar were selected for several reasons. First, these cities are members of GCoM and have demonstrated interest in aligning with international climate reporting frameworks which expressed their strong political will and commitment to climate action. Secondly, preliminary assessments showed that these cities have relatively better access to local data and institutional support, which is crucial for fulfilling the GCoM's reporting requirements (e.g., GHG inventory, risk and vulnerability assessments, climate action plans). Third, these four cities represent a diverse geographical spread across Malaysia, which allows for more balanced national-level insights into climate actions and vulnerabilities across both East and West Malaysia. Lastly, each city has a distinct urban typology. Including cities at different stages of urban development provides valuable insights for scalable and adaptable climate mitigation and adaptation strategies.



**Figure 2.** Socioeconomic status and land areas of four cities in Malaysia

### 3.1 Preparing the Groundwork

The process of developing climate adaptation plans for the four pilot cities in Malaysia (Hang Tuah Jaya, Muar, Penampang, and Tawau) commences with securing the support and commitment of local governments. This involves engaging mayors, council presidents, council members, and officials from various technical departments such as urban planning, building, engineering, public health, and environment. Motivation is instilled through a series of awareness workshops, wherein the economic and social co-benefits of climate adaptation are thoroughly discussed.

Hang Tuah Jaya, a city well-known for its efforts in climate mitigation and low-carbon development, expresses interest in integrating climate adaptation to address climate change comprehensively. The aim is to

enhance the living environment for the community and garner international recognition, ultimately attracting more investments. Penampang, represented by the Penampang District Council, is particularly focused on addressing recurring flooding issues that annually impact the residents, causing damage to properties and infrastructure.

Upon expressing interest and committing to the development of a climate adaptation plan, each municipality can mobilize human resources, primarily from their technical departments, to establish a climate action committee (CAC) in the cases of Hang Tuah Jaya, Penampang, and Tawau, or a city climate change working group (CCCWG) in the case of Muar. These entities serve as units to lead and coordinate the preparation of the climate adaptation plan. Additionally, by having the municipal CAC or CCCWG, external stakeholders, including other technical agencies, state authorities, local experts, business communities, and the public, can be actively involved in the climate adaptation plan preparation. Table 3 provides details on the ground preparation for each local government, encompassing institutional aspects, stakeholder involvement, motivation strategies, and the establishment of a climate adaptation unit.

**Table 3.** Preparing the groundwork for the four cities.

	<b>Hang Tuah Jaya</b>	<b>Muar</b>	<b>Penampang</b>	<b>Tawau</b>
<b>City Profile</b>	<p><b>Population:</b> 190,529 (2018)</p> <p><b>Land Area:</b> 145 square kilometres</p> <p><b>Economy:</b> Service, Tourism, Manufacturing</p> <p><b>Geography:</b> Landlocked</p>	<p><b>Population:</b> 281,500 (2017)</p> <p><b>Land Area:</b> 1,392 square kilometres</p> <p><b>Economy:</b> Manufacturing, Tourism</p> <p><b>Geography:</b> Riverside and Coastal</p>	<p><b>Population:</b> 145,630 (2017)</p> <p><b>Land Area:</b> 425 square kilometres</p> <p><b>Economy:</b> Agriculture, Service</p> <p><b>Geography:</b> Riverside</p>	<p><b>Population:</b> 499,200 (2017)</p> <p><b>Land Area:</b> 6,125 square kilometres</p> <p><b>Economy:</b> Agriculture and Fisheries, Manufacturing, Tourism</p> <p><b>Geography:</b> Coastal</p>
<b>(I) Preparing the Groundwork</b>	<p><b>Local Government Institution:</b> Municipal Council</p> <p><b>Stakeholders Involved:</b> Internal (Municipal) – Council President, council members and technical departments External – Technical agencies and State authority</p> <p><b>Stakeholders Motivation:</b> International recognition and visibility</p> <p><b>Climate Adaptation Unit:</b> Hang Tuah Jaya Climate Action Committee</p>	<p><b>Local Government Institution:</b> Municipal Council</p> <p><b>Stakeholders Involved:</b> Internal (Municipal) – Council President, council members and technical departments External – Technical agencies</p> <p><b>Stakeholders Motivation:</b> Integration with land use plan</p> <p><b>Climate Adaptation Unit:</b> Muar City Climate Change Working Group</p>	<p><b>Local Government Institution:</b> District Council</p> <p><b>Stakeholders Involved:</b> Internal (Municipal) – Council President, council members and technical departments External – Technical agencies, the business community, and local experts</p> <p><b>Stakeholders Motivation:</b> Addressing flooding issue and international assistance</p> <p><b>Climate Adaptation Unit:</b> Penampang Climate Action Committee</p>	<p><b>Local Government Institution:</b> Municipal Council</p> <p><b>Stakeholders Involved:</b> Internal (Municipal) – Council President, council members and technical departments External – Technical agencies</p> <p><b>Stakeholders Motivation:</b> International recognition and assistance</p> <p><b>Climate Adaptation Unit:</b> Tawau Climate Action Committee</p>

### 3.2 Climate Risk and Vulnerability Assessment (CRVA)

In the initial phase of groundwork preparation, the municipal climate adaptation units of the four Malaysian cities (Hang Tuah Jaya, Muar, Penampang, and Tawau) conducted a comprehensive cross-sectoral assessment of climate risks and vulnerabilities in their respective areas. This assessment aimed to identify climate hazards and their impacts over different time frames, along with recognizing vulnerable populations and the municipal capacity to adapt. Due to limitations in resources, technical capacity, and detailed climatic data, these cities predominantly relied on a participatory approach. This involved conducting focus group discussions and interviews with various stakeholders, including municipal officials from different technical departments, technical agencies, state authorities, business communities, and non-governmental organizations.

The information gathered through this participatory approach, supplemented by relevant incident news from newspapers and weather data from the Malaysian Meteorological Department, helped the municipalities identify past and present climate hazards, their impacts, and the vulnerable populations affected. Future projections of climate hazards were derived from the official national climate projection data presented in the Malaysia Third National Communication and Second Biennial Report to the United Nations Framework Convention on Climate Change (2018). Table 4 summarizes the results of the climate risk and vulnerability assessment for the four Malaysian cities.

Following the assessment, the Hang Tuah Jaya local government identified climate hazards such as monsoons, flash floods, drought, and vector-borne diseases (specifically dengue). These hazards posed a medium-high level of risk, with expectations of increased frequency and intensity in the future. The impacts included heightened demands for public and healthcare services, affecting various sectors such as food and agriculture, water supply, sanitation, tourism, industry, residential areas, and public health. Low-income households were particularly vulnerable in the Hang Tuah Jaya Municipality.

Similarly, the climate risk and vulnerability assessment for Muar city identified hazards like monsoons, forest fires, flash floods, river floods, coastal floods, and saltwater intrusion. These hazards, with anticipated medium-high magnitude increases in the future, led to increased demands for public and healthcare services. The impacts spanned multiple sectors, including food and agriculture, water supply, sanitation, tourism, environment, biodiversity, and forestry. Low-income households were identified as particularly vulnerable in Muar.

In the case of Penampang, a Focus Group Discussion (FGD) involving 8-10 participants has been conducted with representatives from relevant local departments and authorities such as departments of environment, public health and disaster management agencies. The Penampang District Council's assessment highlighted climate hazards in Penampang City, including flash floods, river floods, rainstorms, tropical storms, and landslides. Flash floods posed a high risk, rainstorms a medium-high risk, and tropical storms and landslides had medium and medium-low risks, respectively. Most hazards were expected to increase in frequency and intensity, affecting public services, water supply, sanitation, transportation, food and agriculture, emergency services, land use planning, and residential areas. Vulnerable populations included those living in sub-standard housing, low-income households, and marginalized groups.

Lastly, Tawau municipal council's assessment identified past and current hazards in Tawau City as flash floods, river floods, storm surges, tropical storms, and vector-borne diseases (specifically dengue). These hazards were expected to increase in both frequency and intensity in the future, with implications including increased demands for public and healthcare services. Affected assets and services included emergency services, food and agriculture, transportation, and residential areas. Vulnerable populations were identified as low-income households and those in sub-standard housing in Tawau City.

**Table 4.** Climate risk and vulnerability assessment.

	<b>Hang Tuah Jaya</b>	<b>Muar</b>	<b>Penampang</b>	<b>Tawau</b>
<b>(II) Climate Risk and Vulnerability Assessment</b>	<b>Climate Hazards:</b> Monsoon Drought Flood (Flash) Vector-borne Disease (Dengue) <b>Vulnerable Population:</b> Low-income households; Elderly; Persons with disabilities; Children & youth; Elderly; Persons with chronic diseases <b>Adaptive Capacity:</b> Access to basic services (s) Government capacity (s) Land use planning (s) Budgetary capacity (c) Rapid urbanization (c) Access to quality/relevant data (c)	<b>Climate Hazards:</b> Monsoon Forest Fire Flood (Flash, River, Coastal) Salt Water Intrusion Vector-borne Disease (Dengue) <b>Vulnerable Population:</b> Low-income households; Children & youth; Elderly; Indigenous population; Persons with disabilities; Persons with chronic diseases; <b>Adaptive Capacity:</b> Access to basic services (s) Land use planning (s) Community engagement (s) Budgetary capacity (c) Environmental conditions (c) Infrastructure capacity (c)	<b>Climate Hazards:</b> Rainstorm Tropical Storm Flood (Flash, River) Landslide <b>Vulnerable Population:</b> Marginalised groups; Low-income households; Persons living in sub-standard housing <b>Adaptive Capacity:</b> Access to basic services (s) Environmental conditions (s) Community engagement (s) Housing (c) Migration (c) Infrastructure capacity (c)	<b>Climate Hazards:</b> Tropical Storm Storm Surge Flood (Flash, River) Vector-borne Disease (Dengue) <b>Vulnerable Population:</b> Low-income households; Marginalised group; Persons living in sub-standard housing; Children & youth; Elderly; Persons with chronic diseases; <b>Adaptive Capacity:</b> Access to basic services (s) Environmental conditions (s) Community engagement (s) Government Capacity (c) Migration (c) Infrastructure capacity (c)

Notes: (s) – support; (c) – challenge

### 3.3 Development of Climate Adaptation Plans

Building on the insights derived from the climate risk and vulnerability assessment, the four Malaysian municipalities gain an understanding of their climate hazards and their impacts across different timeframes (past, present, and future), which could adversely affect economic activities, social welfare, and the environment in their cities. These findings serve as a robust foundation, propelling the municipalities towards the preparation of a climate adaptation plan. In the initial phase of developing the climate adaptation plan, the four Malaysian municipalities prioritize based on the urgency and severity of the identified climate hazards from the earlier risk and vulnerability results. Given the constraints of limited financial resources, prioritization enables more efficient allocation of budgets. The municipalities define and establish their adaptation goals, along with potential policy options objectively linked to these goals, to address the major climate threats. These adaptation goals align with key international, national, and subnational policy frameworks on climate adaptation, ensuring coherence with higher-level policy frameworks for effective implementation later. Streamlining with national and international policy frameworks, all four municipalities have selected 2030 as their target year for achieving their adaptation goals.

Aligned with these adaptation goals, the municipalities identify relevant potential adaptation measures and strategies from available best practices (literature review). Subsequently, these measures are reviewed and refined through focus group discussions and workshops with stakeholders to ensure that the proposed adaptation plans,

comprising goals and strategies, are suitable and pragmatic for the benefit of the community. Additionally, the selected adaptation options, including measures, strategies, and programs, are further discussed and guided by stakeholders' inputs, crucial for the execution of adaptation plans. An implementation roadmap is then established, detailing timelines (short term - less than 5 years, medium-term - 5-10 years, or long term - more than 10 years), location, responsible lead department and key agencies, and supporting partners. Table 5 provides a summary of the climate adaptation plan development for the four Malaysian cities.

The outcomes of the climate adaptation plan development for each Malaysian city are elaborated as follows. In response to Hang Tuah Jaya city's significant climate hazards, including monsoons, drought, flash floods, and vector-borne diseases, the Hang Tuah Jaya Municipal Council and stakeholders have established three adaptation goals. These goals aim to reduce property damage due to monsoons and flooding, decrease water rationing days caused by drought, and minimize the number of dengue cases, all by 50% by 2030 compared to specific reference years. Adaptation measures include integrating rainwater harvesting systems and grey-water recycling in new developments to reduce water consumption during droughts.

Recognizing Muar city's exposure to various climate hazards, the Muar municipal council and stakeholders set four adaptation goals to enhance the city's resilience. These goals target reducing property damage from monsoons and flooding, decreasing human-induced forest fires, maintaining the salinity of the Muar River below 0.5ppt to avoid water treatment plant shutdowns, and reducing dengue cases, all by specific percentages by 2030 compared to reference years. To achieve these goals, measures such as providing access to alternative water supplies and constructing new water treatment plants and dams are proposed.

**Table 5.** Climate action plans for the four cities.

	<b>Hang Tuah Jaya</b>	<b>Muar</b>	<b>Penampang</b>	<b>Tawau</b>
<b>(III) Climate Action Plans for the Four Cities</b>	<p><b>Adaptation Goals (selected):</b> Goal 2 Reduce the number of days of water rationing caused by drought by 50% by 2030 compared to 2017.</p> <p><b>Adaptation Measures (selected):</b> Ensure new developments are integrated with rainwater harvesting systems and greywater recycling for non-potable usage. Encourage industry to use greywater for non-potable purposes.</p>	<p><b>Adaptation Goals (selected):</b> Goal 2 To achieve zero shutdown of a water treatment plant by maintaining the salinity of the Muar River below 0.5ppt (part per thousand) at the intake point.</p> <p><b>Adaptation Measures (selected):</b> Build a water treatment plant in Pagoh, upgrade the Panchor water treatment plant, and construct the Meda Dam to ensure sufficient water supply. Provide access to alternative water supplies such as underground water.</p>	<p><b>Adaptation Goals (selected):</b> Goal 1 Reduce property damage due to rainstorm and flooding by 50% by 2030 compared to 2017.</p> <p><b>Adaptation Measures (selected):</b> Protect existing Paddy Conservation Area zones. End all unlicensed hill cutting and deforestation, especially along the Moyog River. Complete a comprehensive hydrology study of the Moyog River area and also develop a drainage plan.</p>	<p><b>Adaptation Goals (selected):</b> Goal 3 Reduce the number of dengue cases by 50% by 2030 compared to the 2017 level.</p> <p><b>Adaptation Measures (selected):</b> To raise community awareness on the prevention of dengue. Promote 'adaptive reuse' of dilapidated buildings in the city centre and other grey field sites</p>

Based on Table 5, nine adaptation measures have been identified that are not only relevant but also designed to be pragmatic and actionable for local governments. To address the common challenge of weak implementation in Malaysia's climate adaptation efforts, these measures are tailored to align with the local authorities' capacity, institutional roles, and policy frameworks. For example, incentives such as tax breaks, grants, or low-interest loans can encourage developers and industries to adopt sustainable practices. Secondly, awareness campaigns can play an important role in educating both the public and local officials about the importance and long-term benefits of climate adaptation. In addition, enforcement measures must be in place to make sure that policies and regulations are followed. Moreover, community cooperation is essential by involving residents in planning and implementation, it helps build trust, ownership, and long-term support. Overall, by combining incentives, awareness, enforcement, and community participation, the chances of successful and sustained implementation can be greatly improved.

#### 4.0 CONCLUSIONS

As cities increasingly face the impacts of climate-related disasters, climate adaptation becomes a crucial process in building resilience. This study serves as a practical guide for other cities seeking to assess their climate risks, understand their adaptive capacity, and plan for future challenges. By demonstrating how climate adaptation plans can be developed at the city level, this research showcases the application of the GCOM-CRF in four Malaysian cities which are Hang Tuah Jaya, Muar, Penampang, and Tawau. The study finds that these urban areas are exposed to extreme weather events such as monsoons, rainstorms, and tropical storms, which contribute to repeated flooding and damage to essential infrastructure. Low-income households were identified as the most vulnerable group, given their heightened exposure to climate risks and limited capacity to adapt.

Based on the above findings, this study offers several key insights and lessons. The GCOM-CRF approach is considered coherent as it follows the science-to-action principle, rooted in scientific research with practical implementation in mind. It is also comprehensive, addressing multidimensional climatic hazards and adaptation actions. Moreover, its flexibility allows all four local authorities in Malaysia to tailor their climate adaptation plans to suit their diverse backgrounds, including city size, geographical locations, and socioeconomic and institutional characteristics. This feature facilitates the prompt identification and selection of appropriate adaptation actions by the cities.

Additionally, the GCOM-CRF methodology is systematic, providing a step-by-step guide. Formulating an adaptation plan involves more than proposing ameliorative actions and strategies; it requires a rigorous process guided by results from evidence-based climate risk and vulnerability assessments. These assessments, grounded in local multi-stakeholder inputs and consensus via a series of Focus Group Discussions (FGDs), serve as a strong foundation and motivation. The framework guides users and local governments in identifying a strategic direction for formulating sustainable climate adaptation policies and programs, optimizing scarce resources in terms of human and financial capacity by prioritizing feasible and impactful actions to meet adaptation goals.

For more effective climate adaptation, the incorporation of climate change mitigation to create a comprehensive climate action plan is deemed necessary. Although this study primarily focuses on adaptation, some mitigation actions can be considered, as they may synergize with existing adaptation measures. For example, reforestation or tree planting serves both mitigation and adaptation purposes, reducing carbon dioxide and alleviating landslide issues in certain cities.

In addition to the strengths of the GCOM-CRF methodology in climate adaptation planning, the study acknowledges challenges due to data limitations, especially in conducting vulnerability assessments. The participatory approach, often qualitative or perception-based, is commonly adopted but should be triangulated or validated by quantitative methods for better assessment results. Implementation of a plan, with its associated significant budget and coordination requirements involving various stakeholders, necessitates a detailed implementation roadmap. Addressing key questions about project prioritization, implementers, start and end dates, specific locations, and budget allocation ensures project implementability and feasibility. Completing the iterative PDCA (Plan, Do, Check, Act) cycle requires monitoring, reporting, and corrective actions. Regular monitoring

contributes to continuous improvement, recognizing and addressing weaknesses, barriers, and gaps to achieve adaptation goals. These processes not only enhance communication between governments and the public but also improve the objectivity and transparency of the adaptation planning process.

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