PNBCAP
Penang Nature-based Climate Adaptation Programme

SOCIAL RESILIENCE ASSESSMENT AND ACTION PLAN

A Comprehensive Evaluation of Climate Vulnerability in George Town and Bayan Lepas, Penang

Supported By

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Glossary

APM	*Angkatan Pertahanan Awam Malaysia*, Malaysian Defence Force
ATM	*Angkatan Tentera Malaysia*, Malaysian Armed Forces
JPS	*Jabatan Pengairan dan Saliran*, Department of Irrigation and Drainage
KKM	*Kementerian Kesihatan Malaysia*, Ministry of Health
MBPP	*Majlis Bandaraya Pulau Pinang*, City Council of Penang Island
MPKK	*Majlis Pengurusan Komuniti Kampung*, Village Community Management Council
PDRM	*Polis Diraja Malaysia*, Royal Malaysia Police
PKOB	Pusat Kawalan Operasi Bencana
PNBCAP	Penang Nature-based Climate Adaptation Programme
PPR	*Program Perumahan Rakyat,* People's Housing Programme
PWD	Persons With Disabilities
UN-Habitat	United Nations Human Settlements Programme

Executive Summary

This document has been developed under the Penang Nature-based Climate Adaptation Programme (PNBCAP), an initiative aimed at strengthening climate resilience in Penang through nature-based solutions and inclusive, community-driven approaches. The programme responds to increasing climate risks, such as flooding, heat, and environmental degradation, by supporting vulnerable and disadvantaged communities while promoting sustainable, context-specific planning. PNBCAP is funded by the Adaptation Fund and implemented under the overall guidance of UN-Habitat as the Multilateral Implementing Entity. Think City serves as the implementing partner, working in close collaboration with key stakeholders, including the Department of Irrigation and Drainage (JPS), the City Council of Penang Island (MBPP), the Ministry of Health Malaysia (Penang State Health Department), and the *Unit Pengurusan Bencana Negeri Pulau Pinang*.

Under Component 3, the programme focuses on strengthening social resilience by building the capacity of communities and institutions to undertake participatory vulnerability assessments and develop actionable climate adaptation plans. This component emphasises inclusive engagement, environmental awareness, and community empowerment, ensuring that vulnerable groups—including women, youth, the elderly, and other at-risk populations—are actively involved in identifying risks and co-developing solutions to climate-related challenges within their communities. In particular, Output 3.1 provides capacity development support for vulnerability assessments and climate change-related planning at the sub-district level, specifically within the target *mukims* (administrative divisions) of George Town and Bayan Lepas. This supports improved preparedness, planning, and coordination in addressing climate-related risks.

In this context, the document outlines a comprehensive vulnerability and baseline assessment conducted in these areas of George Town and Bayan Lepas, Penang. To support this assessment, a series of community-centred data collection activities were carried out, including Focus Group Discussions (FGDs), with 11 conducted in George Town and 3 in Bayan Lepas, alongside surveys and one-to-one interviews. Training sessions were also held in four targeted locations, with plans for annual implementation through 2027 to ensure continuity and sustained capacity building. In addition to formal data collection, four open days were organised to engage the wider public. These events provided platforms to present preliminary findings, gather community feedback, and foster dialogue between residents, local authorities, and the technical team. They also helped to raise awareness of climate risks and adaptation strategies while strengthening trust and a sense of community ownership.

Looking ahead, the project will continue engagement and training within the same *mukims* through 2027. Local community leaders have been identified as coordinators and champions, while attendance tracking mechanisms are in place to ensure inclusivity and sustained participation over time. To support knowledge-sharing and replication at the national level, the training programme will be integrated into the Malaysian Adaptation Sharing Hub (MASH). This platform will document and disseminate project findings, tools, and methodologies, enabling other *mukims*, districts, and cities across Malaysia to adapt and apply these practices. Integration with MASH supports transparency, scalability, and alignment with national adaptation priorities, with oversight from entities such as the Ministry of Natural Resources and Environmental Sustainability (NRES), National Water Research Institute of Malaysia (NAHRIM), and the Penang Climate Board.

Overall, this effort establishes a strong foundation for community-driven climate adaptation, combining community-local action with structured knowledge management to inform and strengthen resilience-building initiatives across Malaysia.

1. INTRODUCTION

Southeast Asia is among the regions hardest hit by climate change. Malaysia, in particular, faces rising temperatures, more frequent and severe extreme weather events, and sea-level rise. The World Health Organisation projects that by 2050, Malaysia will experience heatwaves 200 days per year, compared to 20 days per year in the 1980s. The urban heat island (UHI) effect exacerbates this impact in cities, raising urban temperatures by up to 8 degrees Celsius compared to rural areas.

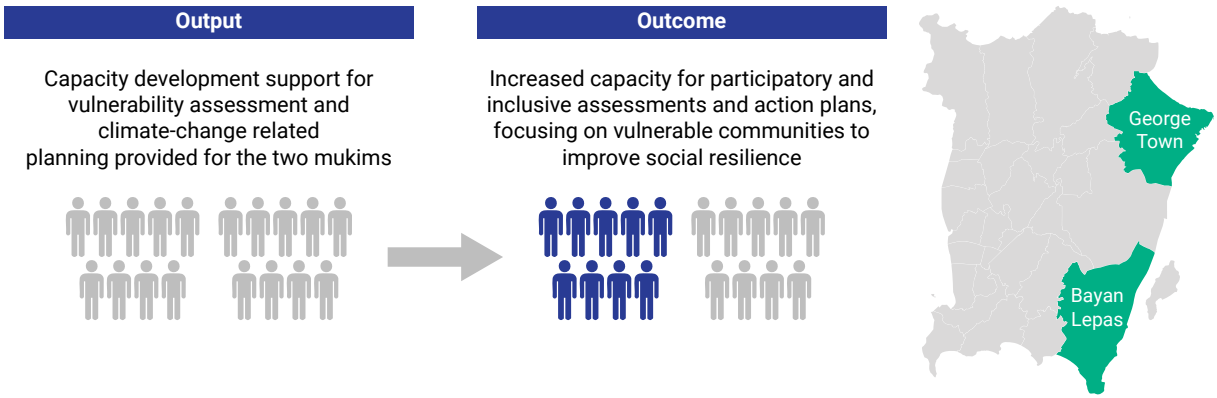
In the urban areas of Penang Island, climate change impacts have been accelerating over the past decades. While sea level rise is less critical, rising temperatures, increased rainfall, and extreme weather events such as flooding threaten the island's safety, development, and prosperity. Adaptation measures are necessary to address these challenges.

According to the United Nations Framework Convention on Climate Change (UNFCCC), climate-vulnerable groups including low-income communities, migrants, the elderly, women, children, and individuals with disabilities are more susceptible to adverse climate effects due to limited resources, social marginalisation, and geographic location. Rising temperatures, extreme weather events, and sea-level rise pose significant threats to their livelihoods, health, and well-being. Addressing these vulnerabilities is crucial for global climate action and requires inclusive and equitable strategies that prioritise protection and empowerment.

In Penang and similar areas, climate change disproportionately affects vulnerable communities, exacerbating existing social and economic disparities. Increased heatwaves pose severe health risks to marginalised populations in urban heat islands, leading to heat-related illnesses and fatalities. Additionally, rising temperatures intensify extreme weather events such as floods, which impact communities in low-lying or poorly constructed areas.

Capacity development support was provided to two *mukims*, George Town and Bayan Lepas, to strengthen their ability to carry out vulnerability assessments and climate-related planning. This initiative aimed to build foundational knowledge and technical skills among local stakeholders to better understand climate risks and integrate them into local decision-making processes. As a result, both *mukims* demonstrated increased capacity to conduct participatory and inclusive assessments, with a particular focus on vulnerable communities. This shift has contributed to better-informed action planning and improved social resilience at the community level.

Figure 1: Enhancing vulnerability assessments and climate-change planning for George Town and Bayan Lepas, aiming to empower communities and bolster social resilience through participatory and inclusive action plans.



The vulnerability assessment baseline is structured around the Planning for Climate Change (P4CC) framework. This involves a non-linear, iterative process that incorporates a values-based, participatory approach alongside strategic planning, drawing on city and local stakeholder capacities (such as human resources, financial resources, political leadership, and governance), local knowledge, and community and stakeholder interests.

2. TARGET AREA AND PROFILES

George Town and Bayan Lepas, two sub-districts (*mukims*) on Penang Island, have been selected as the focus areas for the first phase of the nature-based climate adaptation programme. These locations were chosen based on a combination of their exposure to climate change impacts, existing land use patterns, and community vulnerabilities, with the overarching aim of increasing resilience at the community level.

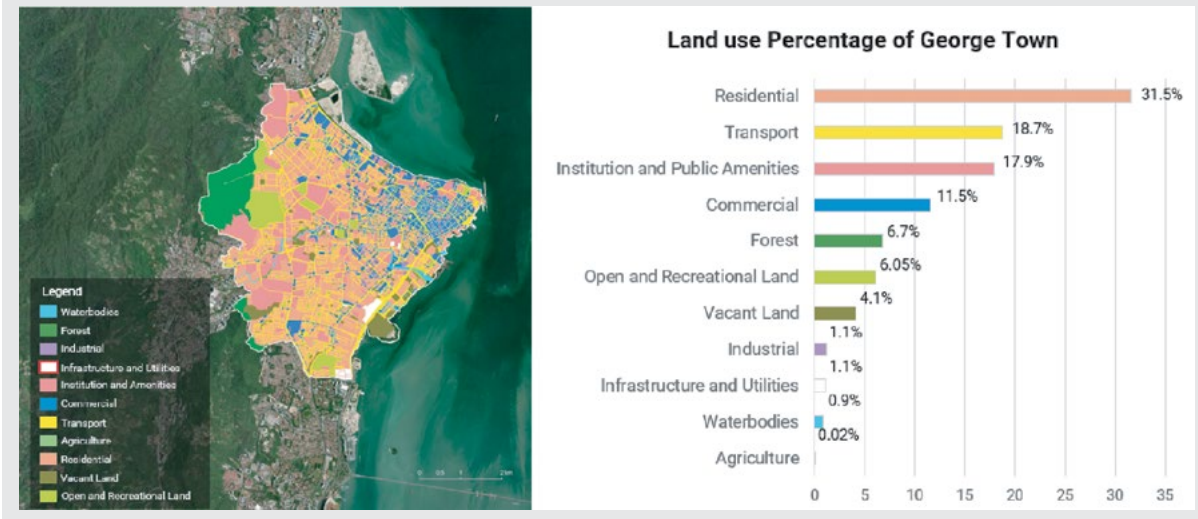
2.1. Land Use Analysis

a. George Town

George Town, the capital of Penang, covers 2,501 hectares and has a population of 158,336 as recorded in the 2020 census, which equals a high population density of 79 people per hectare. The city's land use is diverse and reflects its role as a dense, historic, and economically active urban centre. Residential areas, comprising high-rise apartments, condominiums, and shophouses, make up 31.5 percent of the land. Transport infrastructure accounts for 18.7 percent, highlighting the city's extensive road networks. Institutions and public amenities, including educational institutions, government buildings, and healthcare facilities, occupy 17.9 percent. Commercial areas such as shops, restaurants, hotels, and offices take up 11.5 percent of the land. Forested zones represent 6.7 percent, while recreational spaces account for 6.1 percent, both of which are more common toward the city's periphery. The remaining land consists of vacant plots available for future development (4.1 percent), industrial zones and infrastructure or utilities (1.1 percent each), minimal waterbodies (0.9 percent), and an almost negligible area of agricultural land (0.02 percent).

The historical city centre of George Town was designated a UNESCO World Heritage Site in 2008, reflecting its cultural and architectural value. However, the area is highly vulnerable to climate-related hazards, in particular rising temperatures and flooding. A significant portion of the city lies within a flood-prone zone that also has a high concentration of elderly residents. Approximately 21 percent of George Town's population, or around 41,000 people, are over the age of 60—well above the national average of 14 percent. This overlap between environmental exposure and social vulnerability places George Town at heightened risk and underscores the importance of targeted, inclusive climate adaptation strategies (see Figure 2).

Figure 2: Residential areas dominate at 31.5%, followed by transport (18.7%) and public amenities (17.9%). Other uses include commercial, forests, recreational land, vacant land, industrial, utilities, waterbodies, and agriculture.

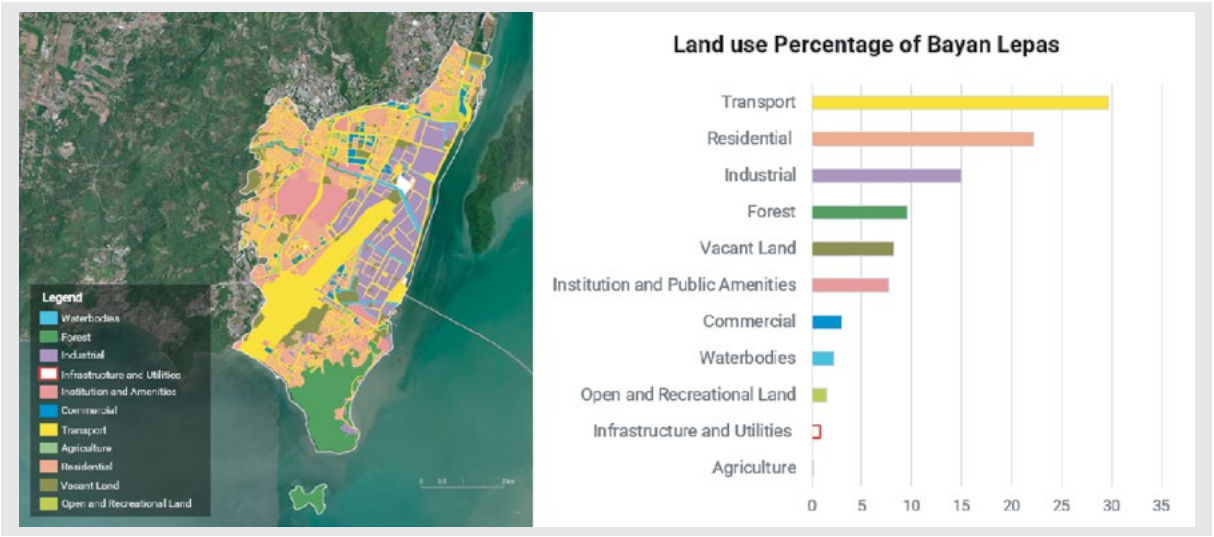


b. Bayan Lepas

Bayan Lepas, a larger *mukim* covering 2,898 hectares, includes Penang's international airport and a major industrial zone. As of the 2020 census, it had a population of 130,455, resulting in a lower density of approximately 42 people per hectare. Over the past decade, Bayan Lepas has undergone rapid urbanisation, reflected in its land use distribution. A significant portion of land is dedicated to transport infrastructure, accounting for 30% of the total area, followed by residential areas at 20% and industrial zones at 15%. In contrast to George Town, Bayan Lepas allocates a smaller percentage of land to commercial areas, forested land, and recreational spaces. George Town also has a notably higher proportion of land dedicated to institutions and public amenities, whereas Bayan Lepas maintains a stronger industrial presence.

Despite these differences, both *mukims* display a diverse mix of land uses that support their urban and economic functions. While Bayan Lepas is less susceptible to severe flooding compared to George Town, it is increasingly affected by the urban heat island effect, as confirmed by remote sensing surface temperature data. The presence of major global electronics firms in the area presents a valuable opportunity for co-investment in greening initiatives within the industrial estate, contributing to both climate adaptation and broader sustainable development goals.

Figure 3: Transport dominates land use at approximately 30%, followed by Residential and Industrial areas. Other uses include forests, vacant land, institution and public amenities, commercial, waterbodies, open and recreational land, infrastructure and utilities, and agriculture.



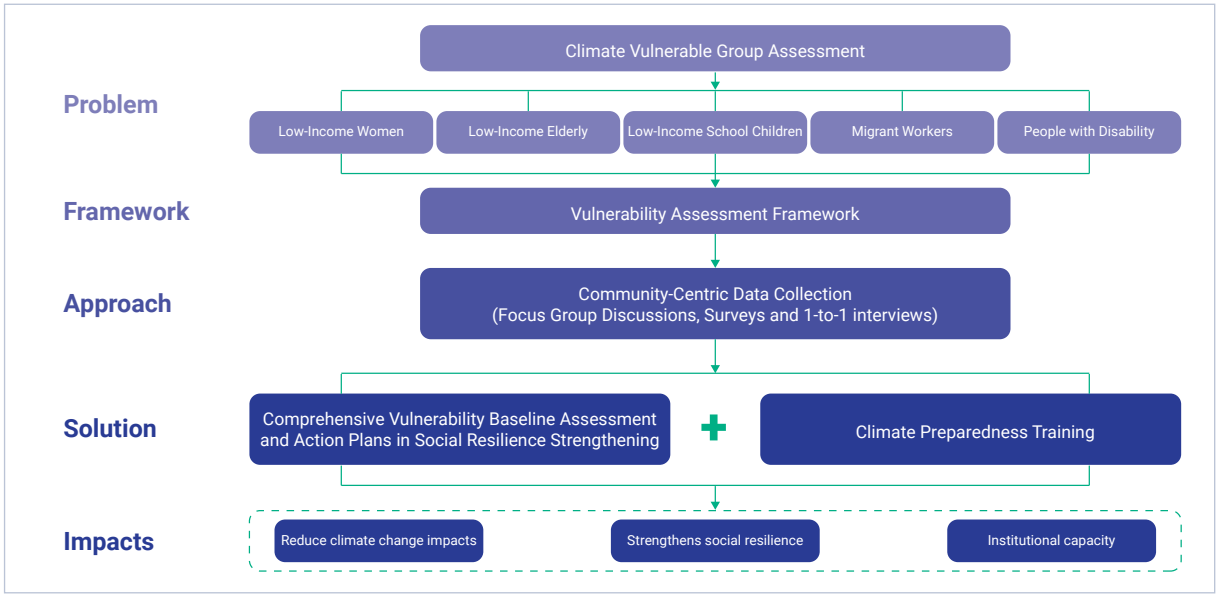
3. PLANNING APPROACH

The planning approach adopted involved identifying key vulnerable populations, including low-income women, senior citizens, school children, migrant workers, and individuals with disabilities. This was followed by the establishment of a vulnerability assessment framework that utilised community-centric data collection methods such as focus group discussions, surveys, and one-to-one interviews to gather detailed and context-specific information.

This process is illustrated in Figure 4, which outlines the overall structure of the assessment.

The first step in the planning process involved identifying key vulnerable populations, which include low-income women, senior citizens, school children, migrant workers, and individuals with disabilities. This was followed by the establishment of a vulnerability assessment framework through community-centric data collection methods such as focus group discussions, surveys, and one-to-one interviews. Based on the insights obtained, a comprehensive vulnerability baseline assessment was conducted, which informed the development of targeted action plans to enhance social resilience. The overarching objectives were to mitigate the impacts of climate change, strengthen community resilience, and improve institutional capacity to support these vulnerable groups.

Figure 4: Planning approach to address the needs of climate-vulnerable groups.



3.1. Focus Group Discussion

In line with SDG 17: Partnerships for the Goals, effective stakeholder engagement is crucial for building robust solutions to climate change. For this project, Focus Group Discussions (FGDs) were conducted as an interfacing method to obtain qualitative information, which complements the quantitative data acquired from surveys. This approach also allowed for deeper probing of stakeholders' views on climate threats and other aspects of the project.

Figure 5: The vulnerable communities identified.

The discussions sought to understand social and environmental issues that might influence the implementation of the project. Essentially, the objectives of the stakeholder engagements are as follows:

1. To inform vulnerable groups in George Town and Bayan Lepas about the Penang Nature-based Climate Adaptability Programme (PNBCAP) and the concerning climate threats, specifically heatwaves and flooding.
2. To obtain feedback from vulnerable groups regarding their level of exposure, sensitivity, and adaptability to climate threats.

3.2. Perception Survey

A short survey was conducted to assess community vulnerability to climate hazards, with focus on exposure, sensitivity, and adaptive capacity. This step is essential for identifying risks and developing targeted adaptation and mitigation strategies. The questionnaire also collected demographic information and insights related to Planning for Climate Change.

Upon survey completion, a comprehensive analysis was conducted to guide local government in formulating climate resilience plans. The assessment identified gaps in climate readiness that may affect the community's ability to adapt. It also identified community leaders and helped develop training and capacity-building initiatives.

Most respondents were from the districts of Timur Laut (where George Town is located) and Barat Daya (which includes Bayan Lepas), with additional participants from the districts of Seberang Perai Utara, Seberang Perai Tengah, and Seberang Perai Selatan. These interviews were conducted during Open Days at the Esplanade and Giant Hypermarket Bayan Baru.

Figure 6: Most respondents were from Timur Laut and Barat Daya.

3.3. One-to-One Interview

A total of 10 one-to-one interviews were conducted to engage with vulnerable communities to verify the information collected during the survey. The interviewees were identified based on the focus group discussions. These sessions allowed for more detailed feedback on initiatives to improve public resilience and adaptability.

4. PLANNING FOR CLIMATE CHANGE (P4CC)

4.1. Planning for Climate Change (P4CC)

The vulnerability assessment baseline is structured around the Planning for Climate Change (P4CC) framework. This involves a non-linear, iterative process that incorporates a values-based, participatory approach alongside strategic planning. It also draws on city and local stakeholder capacities (such as human resources, time, financial resources, political leadership, and governance), local knowledge, as well as community and stakeholder interests.

The primary goal of this vulnerability assessment is to evaluate the area's susceptibility to the effects of climate change. This assessment aims to provide local government with the necessary context to formulate climate change adaptation and mitigation plans.

A **vulnerability assessment** identifies and evaluates the susceptibility of individuals, communities, environments, or systems to harm from external stresses, hazards, or changes. This typically involves examining various factors, such as:

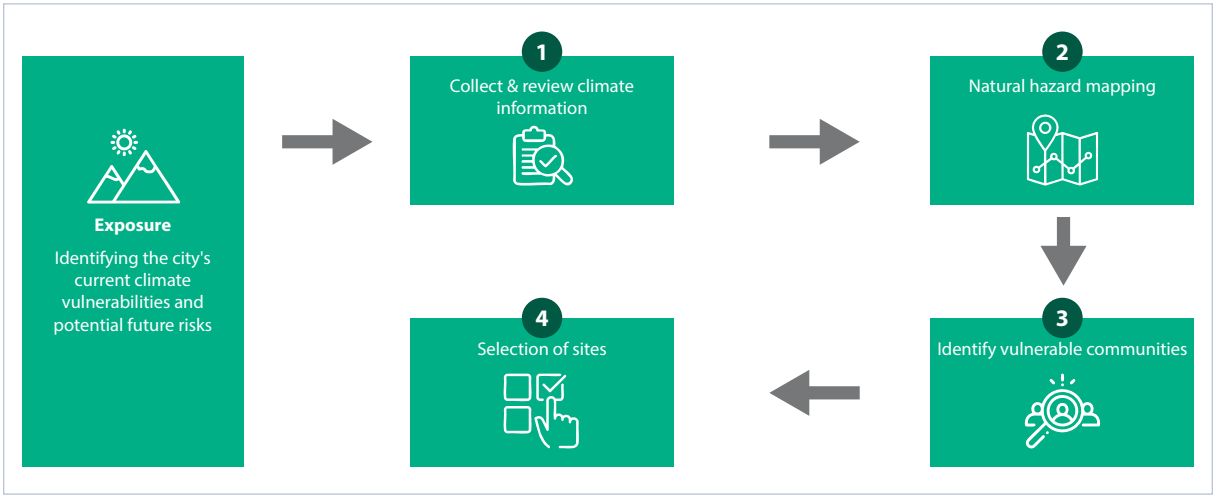
1. A city's **exposure** to climate risks
2. The **sensitivity** of a city's demographics, geographical areas, and institutions to climate-related hazards.
3. Assessment of a city's **adaptive capacity**, indicating the resilience of its people, places, and institutions to cope with current and projected stresses.

4.1.1. Exposure Assessment

The initial steps for the vulnerability assessment involved gathering and reviewing climate and weather data to identify climate hazards. The Exposure Analysis assesses how the city is currently affected by climate change, as well as how it might be impacted in the future based on projected climate data.

This process is illustrated in Figure 7, which outlines a four-step approach to exposure assessment. It begins with the collection and review of climate information, forming the foundation for understanding climate-related trends and risks. The second step involves natural hazard mapping, which identifies areas within the city prone to climate-related threats such as flooding or heatwaves. Next, the assessment identifies vulnerable communities that are most at risk due to their location or socio-economic conditions. Finally, specific sites are selected for targeted action based on the vulnerability analysis, ensuring interventions are appropriately prioritised.

Figure 7: Steps in the Exposure Analysis.



4.1.1.1. Collect and Review Climate Information

The assessment involved the collection and review of historical weather and climate data for George Town and Bayan Lepas. Detailed records on climate projections and the occurrence of extreme weather events over the past decades were collected. Additionally, future climate change projections will be analysed to anticipate changes in temperature, precipitation patterns, sea-level rise, as well as the frequency and intensity of extreme weather events in the region.

Table 1: Exposure Assessment involves Climate Data Collection and Analysis Approach for George Town and Bayan Lepas.

EXPOSURE ASSESSMENT							
Climate Change Hazard	Extreme Event or Change to Average	Historical Trends		Climate Model Projections	Summary Climate Change Projection		Exposure - Preliminary Notes
		Local/Regional Weather Data	Stakeholder Observation		Forecasted future trends and Uncertainty	Probability	
Flooding	Extreme Event and Change to Average	Annual rainfall per hour has increased from an average of 31 mm in the 1990s to 180 mm in 2019.	• The 2017 flood had a significant impact across the island. • Low-lying areas and areas near rivers like Sg. Pinang, Jelutong, and Sg. Ayer Itam are highly susceptible to flooding. • Jalan P. Ramlee and Kg. Dodol face regular flash floods throughout the year. • Kg. Permatang Damar Laut in Bayan Lepas experiences flooding due to its coastal location in the southern part of the island. • Inadequate drainage maintenance, particularly in George Town, is a major factor contributing to previous flash floods. Flash floods have occurred less frequently due to improvements in the drainage system. • Floods occur 2-5 times a year in George Town, with water reaching up to knee or waist level. • Floods also occur 2-5 times annually in Bayan Lepas, typically reaching knee level according to most participants.	**In 2100:** Inundated areas can range from 17.58 km^2 and 26.07 km^2.	Increase in rainfall intensity	High	• Floods in George Town and Bayan Lepas result from heavy rain and are exacerbated by sea level rise. • Despite being able to identify areas with high flood risk, many vulnerable residents lack experience and awareness of flood risks. • Community education on flood preparedness is crucial to improve safety.
Heatwaves	Extreme Event and Change to Average	During the inter-monsoon period from May to July, the lack of rain causes temperatures to rise above 32°C, marking a heatwave. Temperatures sometimes reach 33°C.	• Residents are deeply concerned about recent heatwaves. • Heat exposure primarily occurs when work and daily routines were being carried out. • Activities such as socialising, errands, and community programmes also contribute significantly to heat exposure.	**In 2050:** - 240 days per year where temperature reaches above 35°C. **In 2095:** - Temperature increase of 1.1 - 3.6°C	More frequent and long-lasting heatwaves of higher intensity	High	• Children often underestimate risks, thus neglecting hydration and protection from extreme heat. • In George Town, migrant construction workers are at significant risk due to daily sun exposure of eight to ten hours.
		High heat is concentrated in areas with low vegetation cover such as urban areas, bare land and industrial zones.	• In George Town, nearly all areas within the study zone are perceived to experience heatwaves. Kg. Melayu and Ayer Hitam, which are outside the study area, also experience heatwaves. • In Bayan Lepas, heatwave exposure is identified near the Penang International Airport, Bayan Lepas Free Industrial Zone, Bayan Baru, and parts of Sungai Ara. • Coastal recreational spots like Pantai Esen and Bukit Esen in southern Bayan Lepas are also vulnerable to heatwaves.				
Sea Level Rise	Change to average	Average sea level rise of 3.2 mm/year over the past three decades	• In George Town, vulnerable areas to sea level rise include Gurney Bay, Esplanade, Kg. Makam, and Kg. Kebun Lama. • Bayan Lepas faces the rise of sea levels in southern regions near Kg. Permatang Damar Laut, as well as industrial zones such as the third phase of the Bayan Lepas Free Industrial Zone. • Kg. Dodol experiences flooding attributed to rising sea levels.	**By 2100:** - a projected sea level rise of 0.68m (NAHRIM)	Permanent inundation of large areas of coastlines	Moderate	

4.1.1.2. Natural Hazard Mapping

A significant component of the assessment involves overlaying natural hazard maps with maps illustrating critical exposure variables. These variables include population information such as density and distribution, major infrastructure, as well as land uses. Furthermore, maps were created to show the locations of critical infrastructure (such as hospitals and major government offices) in addition to environmentally sensitive areas (including coastlines, wetlands, water bodies, and conservation areas). This comprehensive mapping helps identify the intersections between natural hazards and vulnerable areas.

The devastating 2017 floods, which displaced thousands and caused widespread infrastructural damage, underscored the urgency of such integrated spatial analysis. During the event, densely populated urban zones, informal settlements, and critical infrastructure in flood-prone areas were disproportionately affected. By examining areas impacted by the 2017 floods, this assessment aims to draw lessons from past vulnerabilities and improve future risk reduction strategies, emergency preparedness, and resilience planning.

a. Land Surface Temperature

Methodology

Land Surface Temperature (LST) is measured by collecting specific data such as thermal, red, and near-infrared bands from a Landsat dataset, which are then input into a Geographic Information System (GIS) model. This model processes and combines the data with key parameters, including top-of-atmosphere reflectance and brightness temperature, thermal emissivity, and vegetation health data to determine the final LST value. As a form of historical climate data, LST offers significant advantages, serving as a key indicator of climate change and influencing many of the Earth's physical, chemical, and biological processes.

Figure 8: Land Surface Temperature Methodology.

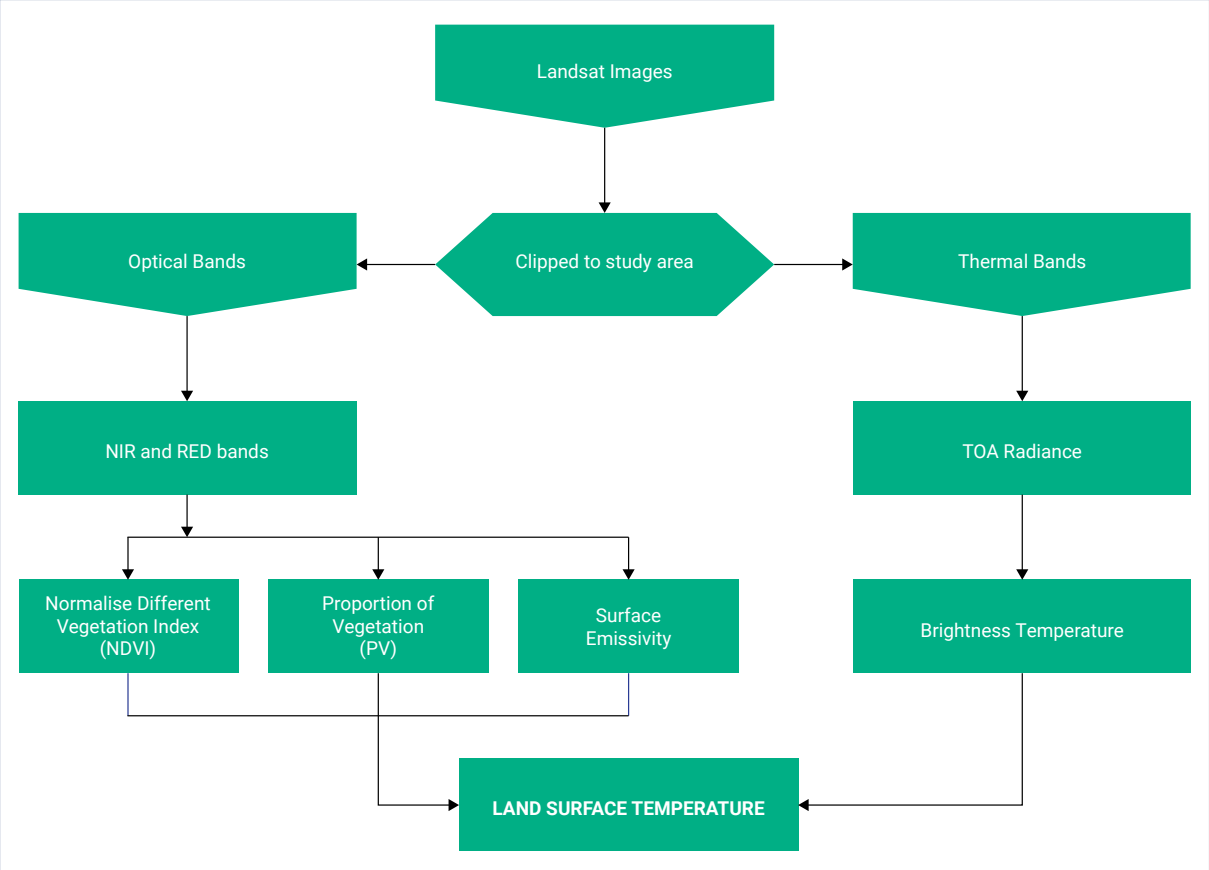
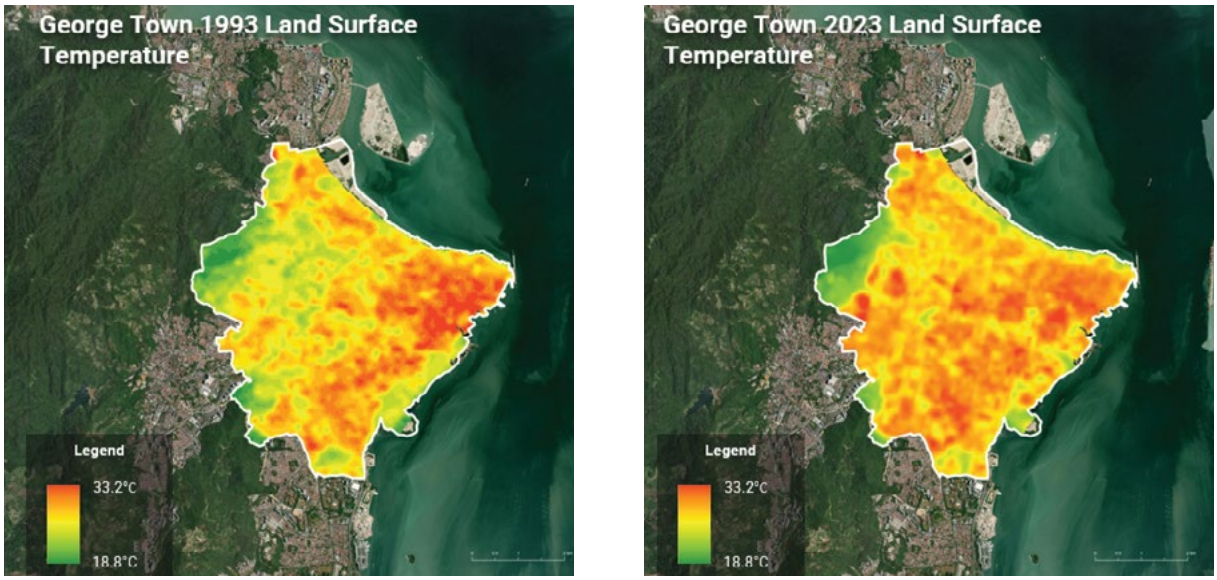


Figure 9: Land surface temperature of George Town in 1993 (left) and 2023 (right). From green to red, the colour gradient indicates increasing temperature, highlighting significant warming over the three-decade period.



The map illustrates a 30-year change in George Town. In 1993, the highest recorded surface temperature was 30°C, while the lowest was 21°C. Land Surface Temperature (LST) was particularly high in Little India and Kampung Jawa Lama, with temperatures reaching 30°C.

In March 2023, the highest and lowest recorded temperatures were 33°C and 23°C, respectively, representing a 3°C increase relative to 1993. The temperature rise occurred across all of George Town. Locations that exceeded 30°C include Little India, Kampung Makam, Taman Hutchings, Taman Koperasi Jelutong, Taman Cheeseman, and Taman Greenview.

Limitations

A key limitation of LST data is that it captures the temperature of the land surfaces, such as rooftops and roads, rather than air temperature.

b. Rainfall Assessment

Penang faces significant flood risk, with an average annual rainfall of 2,434 mm over the past decade. From 2010 to 2018, rainfall increased by 29.6% above NAHRIM's projections. This rise, combined with rapid urbanisation, high tides, and aging drainage infrastructure, has reduced stormwater infiltration and increased surface runoff. This has heightened flood vulnerability, especially on Penang Island.

Table 2: Observed and projected rainfall in Malaysia. Source: Malaysia Third National Communication and Second Biennial Update Report to the UNFCCC (2018).

Parameter	Observed (1970 - 2000)	Projected for 2030	Projected for 2050
Average Annual Rainfall			
Peninsular Malaysia	1891 – 2619 mm	1998 – 2663 mm (1 to 6 % increase)	2068 – 2805 mm (7 to 11 % increase)

Table 3: Average annual rainfall for Penang Island (2010-2018). (Source: JPS, 2018).

Year	Average Annual Rainfall (mm)
2010	2088.65
2011	2260.38
2012	2359.86
2013	2519.10
2014	2389.98
2015	2453.41
2016	2493.41
2017	2642.25
2018	2706.76

In 2016, 47 flood incidents were recorded, primarily in urbanised districts such as Seberang Perai Tengah (19 cases) and Timur Laut (12 cases), indicating insufficient drainage capacity. The 2017 floods were the worst on record, submerging half the urban areas, causing seven fatalities, and involved 159 locations—68 of which had never been flooded before.

Economic losses included RM200–300 million in the manufacturing sector, RM5.7 million in agriculture (affecting 2,626 farmers and 3,464 hectares), and RM57.5 million in fisheries.

c. Flooding assessment

Methodology

Flood maps were derived from a comprehensive 2D hydraulic analysis designed to calculate the extent and depth of potential flooding. The integrated data from hydraulic models, GIS data, and historical data were from *Department of Irrigation and Drainage* (JPS) which recorded 100 years of flood data. By combining these sources, flood maps provide predictions and critical insights for effective planning and mitigation.

Table 4: Colour coding for the flooding assessment in Figure 10.

Colour Code	Degree of Flood Hazard	Flood Depth (m)	Description
	Low	<0.5	**Caution** **Caution**: Flood zone with shallow flowing water or deep standing water. *Note: Walking through water is still possible.*
	Moderate	0.5-1.2	**Dangerous for some** (e.g. children) **Danger**: Flood zone with deep and/or fast-flowing water. *Note: The ground floor of buildings will be flooded, and inhabitants either have to move to the first floor or evacuate.*
	High	>1.2	**Dangerous for all** **Extreme danger**: Flood zone with deep, fast-flowing water *Note: The ground floor and possibly the roof will be covered by water. Evacuation is compulsory.*

Figure 10: Flood map for George Town and Bayan Lepas (Source: JPS).

Limitations

The data is primarily generalised to broad geographic zones rather than hyperlocal areas, which may lead to inaccuracies when interpreting flood risks at the community or household level. This limitation affects the precision of vulnerability assessments and could influence the effectiveness of interventions. Additionally, the maps may not fully capture recent changes in land use, informal settlements, or evolving urban drainage patterns. These factors should be considered when using flood maps for planning and mitigation efforts, and they underscore the importance of complementing technical data with ground-level community insights.

4.1.1.3. Identifying Vulnerable Communities

Think City has conducted preliminary assessments of communities in George Town and Bayan Lepas that are highly vulnerable to climate change. Areas susceptible to extreme heat and flooding were identified and overlaid with indicators of vulnerable communities, as shown in Figures 11 and 12.

Figure 11: Areas in George Town identified as vulnerable to climate change.

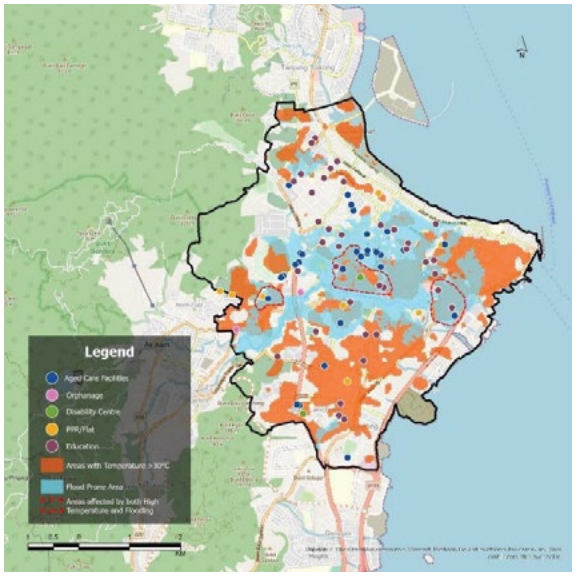
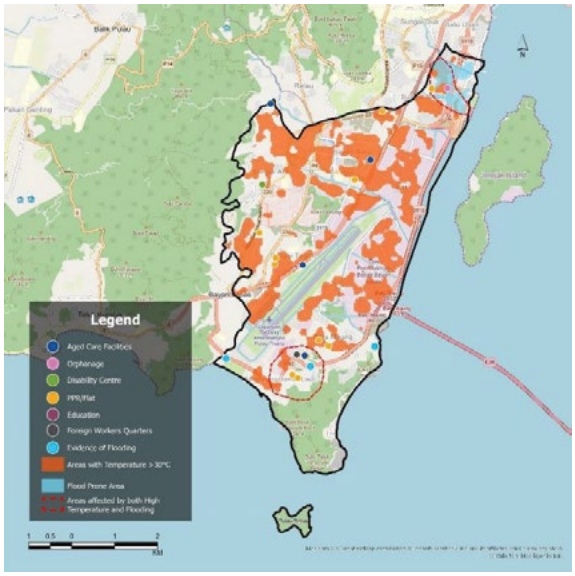


Figure 12: Areas in Bayan Lepas identified as vulnerable to climate change.



Following this, a site survey was conducted in the study area, with 20 residential areas identified as vulnerable based on the following criteria:

- Location marked as vulnerable to high heat and floods during the preliminary assessment
- Observation on the condition of physical infrastructure (i.e., housing type, housing materials, and surrounding infrastructure)

These criteria helped to pinpoint the areas most at risk, providing a foundation for targeted interventions and support for the vulnerable communities. The residential areas are listed in the table below:

Table 5: Vulnerable Residential Areas Identified Based On-Site Survey and Preliminary Assessment.

Residential Type	George Town	Bayan Lepas
High Rise Residential	• PPR Taman Manggis • PPR Jalan Sungai • Flat Taman Sri Pinang • Flat Taman Nusantara • Flat Taman Free School • Flat Lebuh Macallum	• Flat Seri Indah • Flat Taman Bayan Baru • Pangsapuri Bukit Jambul • Flat Taman Muhibbah • Flat Lebuh Mahsuri
Landed/village houses	• Kg. Dodol • Kg. Makam • Kg. Rawa • Solok York	• Kg. Permatang Damar Laut • Kg. Manggis • Kg. Naran • Kg. Baru Sungai Ara • Kg. Masjid

4.1.1.4. Site Selection for Stakeholder Engagement

As part of the planned stakeholder engagement for this project, two meetings were held on 17 April 2024, with the District Officer (DO) for each district, the Land Office of Timur Laut (George Town) and the District and Land Office of Barat Daya (Bayan Lepas). The meetings were also attended by the relevant Penghulu (headman) of the identified areas.

These meetings enabled the team to brief the District Officers and *penghulu* about PNBCAP, and to gather their feedback on the community engagement approach. Following the meetings, the team was able to refine the engagement approach and finalise the list of vulnerable groups requiring engagement.

Figure 13: Briefing with the District Officer of Timur Laut District and Land Office (George Town).

Table 6 shows the residential areas of vulnerable groups as identified during the meeting with the District Officers and Penghulu.

Table 6: Vulnerable Residential Areas Identified Through Engagement with District Officers and Penghulu in George Town and Bayan Lepas.

Residential Type	George Town	Bayan Lepas
High rise residential	• PPR Jalan Sungai • PPR Taman Manggis • Flat Lebuh Macallum • Flat Taman Free School	• Flat Jalan Tengah Selatan
Landed / Village houses	• Kg. Dodol • Kg. Masjid Hashim Yahaya • Kg. Kebun Lama • Kg. Makam	• Kg. Permatang Damar Laut • Kg. Naran • Kg. Seronok

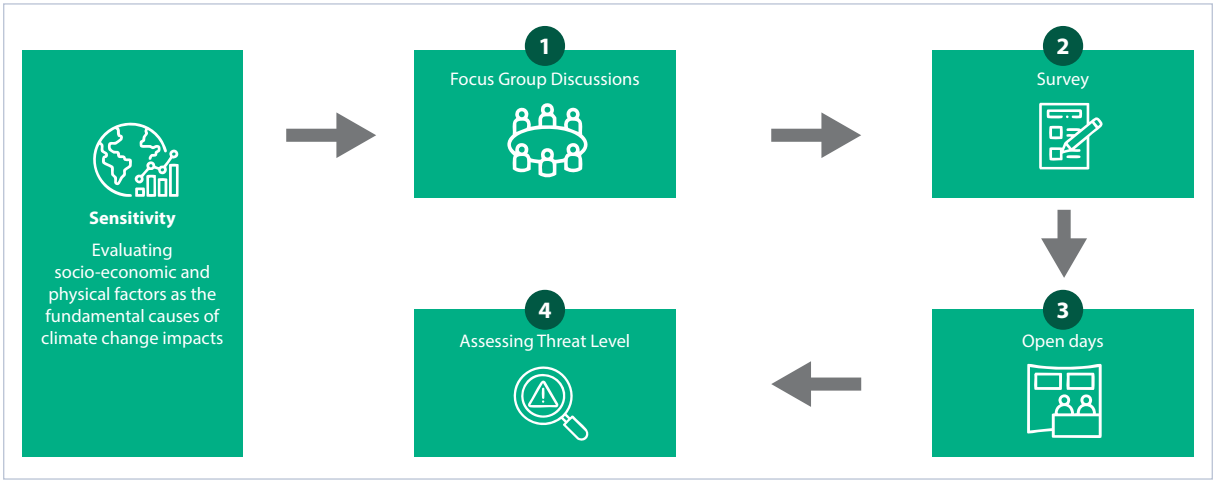
Apart from vulnerable groups from the residential areas, the team also reached out to the Penang Deaf Association and foreign construction workers employed by Think City in George Town to obtain feedback.

4.1.2. Sensitivity Assessment

The sensitivity analysis examines how socio-economic and physical factors influence the impact of climate change. This analysis aims to identify how vulnerable communities are affected by the impact of climate change currently and in the future.

As illustrated in Figure 14, the sensitivity assessment followed a four-step process. It began with focus group discussions to gather insights from community members. This was followed by a survey to collect quantitative data, allowing for broader understanding of household-level vulnerabilities. Following that, open days were held as participatory platforms to validate findings and gather additional input. Finally, all collected data were synthesised to assess the overall threat level faced by the communities. This approach ensured that both lived experiences and measurable indicators were considered.

Figure 14: Sensitivity Assessment Methodology.



4.1.2.1. Focus Group Discussion (FGD)

From 20 April to 14 May 2024, 14 FGD sessions were conducted. A total of 11 sessions took place in George Town, and three were held in Bayan Lepas. These sessions attracted a total of 153 participants across the five identified vulnerable groups. Table 7 provides details of the FGD sessions.

Figure 15: Focus group discussions held with vulnerable groups to identify community needs and climate resilience strategies.



Table 7: Demographic summary of Focus Group Discussions Conducted in George Town and Bayan Lepas (April–May 2024).

	George Town	Bayan Lepas	Total
Total No. of Sessions Conducted	11	3	**14**
Total No. of Participants	95	58	**153**
Total No. of Low-income Women	17	13	**30**
Total No. of Low-income Senior Citizens	20 (9 M; 11 F)	21 (13 M; 8 F)	**47 (22 M; 19 F)**
Total No. of Low-income School Children	17 (10 M; 7 F)	9 (3 M; 6 F)	**26 (13 M; 13 F)**
Total No. of Persons With Disabilities (PWD)	21 (9 M; 12 F)	5 (5 M; 0 F)	**26 (14 M; 12 F)**
Total No. of Migrant Workers	20 (19 M; 1 F)	4 (1 M; 3 F)	**24 (20 M; 4 F)**

Note:
1. *M: Males; F: Females*
2. *Participants from Bayan Lepas also attended the FGD sessions for PWD and migrant workers held in George Town.*

Based on the district officers' suggestions, four residential areas were identified as vulnerable:

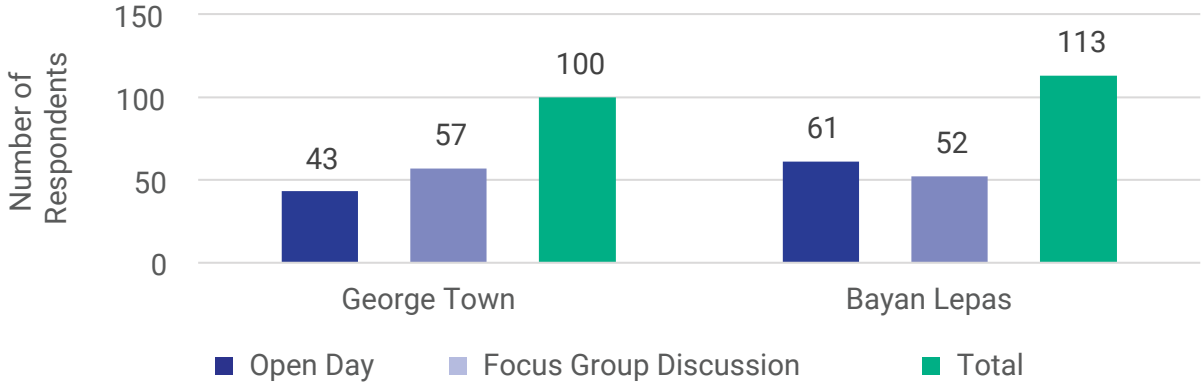
Table 8: Vulnerable Areas Identified Through District Officer Recommendations.

Region	Identified Vulnerable Areas	Type of Residence	Climate Threats
George Town	Flat Lebuh Macallum	Concentrated, high-rise residential buildings	Heat
	Kg. Dodol	Village houses, located near the flood-prone Jalan P. Ramlee	Flood
Bayan Lepas	Flat Jalan Tengah Selatan	High-rise residential buildings	Heat
	Kg. Permatang Damar Laut	Village houses, located near the Penang International Airport and the coast	Heat Flooding

4.1.2.2. Perception Survey

A perception survey was carried out from 20 April – 29 May 2024 to capture responses from the stakeholder engagement sessions, as well as open days conducted on 21 April 2024 (Esplanade, George Town) and 28 April 2024 (Giant Hypermarket Bayan Baru, Bayan Lepas). The responses were collected via an online survey or in-person interviews. A total of 213 responses were collected (100 from George Town and 113 from Bayan Lepas). Of these, the gender breakdown included 95 female and 92 male respondents (26 respondents have left this question blank).

Figure 16: Number of Survey Respondents from Stakeholder Engagement and Open Day.



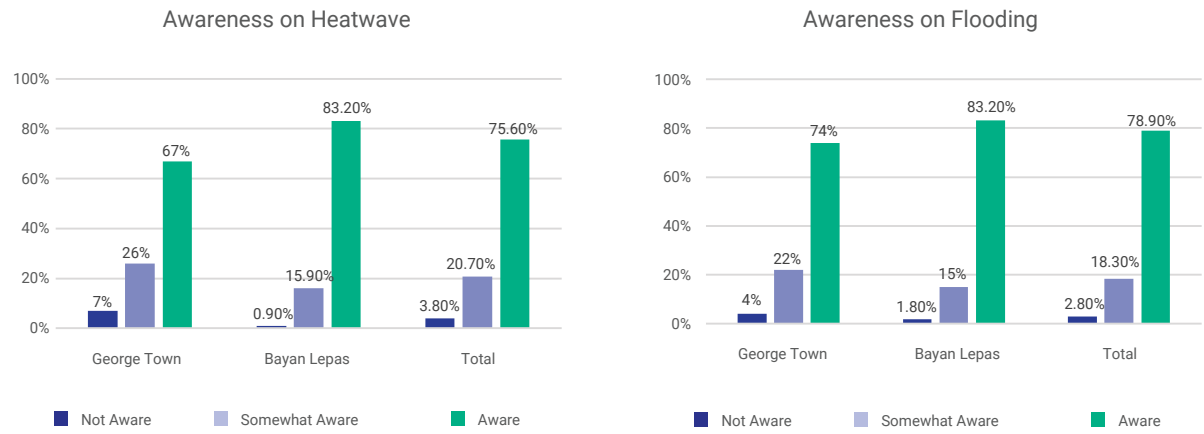
Findings from the FGD and Survey

Level of Awareness

a. Awareness to Heatwaves & Flooding: Survey Findings

The survey analysis reveals varying degrees of awareness to environmental issues among respondents.

Figure 17: Community Perception Snapshot: Heatwave and Flood Awareness by Area.



Overall, 75.6% of the respondents are aware of heatwaves, with Bayan Lepas showing higher awareness (83.2%) than George Town (67.0%). Awareness of flooding is relatively high (78.9%); with respondents in Bayan Lepas (83.2%) showing greater awareness than those in George Town (74.0%).

b. Awareness on Heatwaves & Flooding: FGD Findings

Among the 153 respondents, 149 are aware of climate change and believe it is a real phenomenon (88 from George Town and 61 from Bayan Lepas). However, two school children and one senior citizen from PPR Taman Manggis (George Town) were unsure.

- 77 participants have high awareness of heatwaves (George Town: 38; Bayan Lepas: 39).
- 100 are highly aware of flooding (George Town: 63; Bayan Lepas: 37).

This suggests that heatwaves and flooding are perceived as immediate threats. This might be due to recent temperature increases and recurring flooding in the area, as well as floods in other parts of the nation.

Awareness of heatwaves and flooding is relatively high among vulnerable groups such as low-income women, senior citizens, school children, and people with disabilities (PWD). Women from PPR Jalan Sungai reported higher awareness due to television news programmes; many have also donated clothes to local flood victims.

Despite not having personally experienced floods, school children from Jalan Tengah Selatan are aware of such incidents from news reports. PWD and migrant workers provided mixed response. While most are aware of climate change, many have only moderate or low awareness of heatwaves and flooding. Many of their responses to questions on adaptability, sensitivity, and exposure are concerning. Most participants tend to associate sea level rise with flooding.

Sensitivity to Heatwave Impact

a. Sensitivity to Heatwave Impact: Survey Findings

Effects on physical health such as sickness, heatstroke and dehydration were recorded as the **most severe impact** by respondents.

How severely have these heatwaves or unusually hot days impacted you and/or your family?

Impact	George Town				Bayan Lepas			
	No Impact	Minimal	Moderate	Severe	No Impact	Minimal	Moderate	Severe
Physical health	7.10%	23.20%	37.40%	32.30%	11%	11%	43%	35%
Mental health	35.10%	22.70%	23.70%	18.60%	36%	25%	29%	10%
Income losses	48.40%	23.20%	14.70%	13.70%	58%	19%	16%	7%
Asset losses	71.40%	14.30%	8.20%	6.10%	69%	13%	12%	7%
Interrupted Basic Amenities & Services	59.80%	14.40%	16.50%	9.30%	47%	18%	21%	14%
Life altering events	74.20%	11.30%	7.20%	7.20%	47%	18%	21%	14%
Environmental losses	74.20%	11.30%	7.20%	7.20%	48%	19%	23%	10.0%

Legends

High: 100% – 60% | Moderate–High: 59% – 40% | Moderate: 39% – 20% | Low: 19% – 0%

b. Sensitivity to Heatwave Losses: Survey Findings

Increased energy consumption was noted as the most severe impact from heatwaves, with 24.0% of respondents recording such a response in George Town and 26.9% recorded in Bayan Lepas.

How severely have these heatwaves or unusually hot days impacted you and/or your family?

Losses	George Town				Bayan Lepas			
	No Losses	Minimal	Moderate	Severe	No Losses	Minimal	Moderate	Severe
Health losses	28.40%	30.50%	32.60%	8.40%	35.80%	24.50%	25.50%	14.20%
Monetary losses from reduced productivity	54.70%	16.80%	17.90%	10.50%	54.70%	17.90%	15.10%	12.30%
Monetary losses from increased energy consumption	36.50%	17.70%	21.90%	24.00%	36.10%	10.20%	26.90%	26.90%
Property or material loss / damage	67.70%	13.50%	14.60%	4.20%	65.40%	14.00%	14.00%	6.50%
Environmental loss	55.30%	13.80%	22.30%	8.50%	55.10%	15.90%	15.90%	13.10%

Legends

High: 100% – 60% | Moderate–High: 59% – 40% | Moderate: 39% – 20% | Low: 19% – 0%

c. Sensitivity to Heatwaves: FGD Findings

The most concerning issue related to heat exposure is its impact on **health.** Most participants from both George Town and Bayan Lepas **reported frequent illnesses such as fever, headaches, and sore throats, attributing these conditions to the recent heatwaves, as well as fatigue and exhaustion**. This is particularly alarming for senior citizens, who often have pre-existing health conditions that could be exacerbated by extreme heat. Significant health concerns were also expressed by school children, who spend substantial time outdoors due to school, extracurricular activities, or play. Frequent illness due to heatwaves can hinder their ability to attend school and classes. Nevertheless, children noted that schools would limit sports or extra-curricular outdoor activities during extreme heat, and they are allowed to wear sports attire for better cooling.

Migrant workers face additional challenges in seeking medical treatment, as they must **pay substantial fees which are not reimbursed by their employers**. One participant stated that foreign workers are typically not accepted by government hospitals or clinics. To receive treatment, they are required to pay in advance. One respondent noted that, upon registering at the hospital, she was required to pay approximately RM3,000 for her son who had sustained a broken arm. Many participants expressed that their financial burden is compounded by the need to shower more frequently due to the heat, with some participants taking more than five showers a day. Many have installed additional fans and air conditioning, leading to higher utility bills, which represent a significant burden for low-income families.

The heatwaves also impacted daily lives and businesses. Women and senior citizens report the inconvenience of frequent showers, while businesses such as restaurants, bakeries, and sundry shops **experienced a decline in customers**, which adversely affected their income. In Jalan Tengah Selatan, a business operator disclosed that the night market's business hours have been shortened. Previously, customers would arrive at the night market as early as 4pm; however, due to the weather, many would now only visit after 7pm. Shorter business hours and fewer customers resulted in a decrease in revenue for operators. Migrant workers, who are paid based on work days, face **financial instability when illnesses or business closures prevent them from working**.

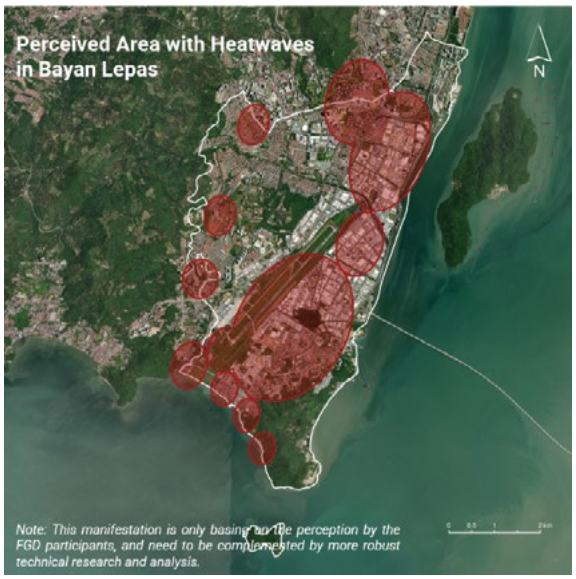
A village representative from Kg. Dodol noted that they had to schedule many community events or activities later in the evening, or move to indoor venues to reduce exposure to heat. Furthermore, certain activities have been shortened to accommodate time constraints.

Table 9: Sensitivity insights for vulnerable populations.

Sensitivity Insights	
Aspects impacted by heatwaves • Health • Utility bills • Daily life and activities • Jobs, businesses, and income	**Vulnerable groups with the highest severity of sensitivity towards heatwaves** (from highest to lowest): • Low-income senior citizens • Low-income children • Migrant workers • PWD • Low-income women

During the FGD session, participants were asked to identify regions in George Town where they sensed excessive heat. It was noted that the entirety of the study area is essentially suffering from heatwaves, along with external areas near Kg. Melayu and Ayer Hitam.

Figure 18: Area perceived to suffer from Heatwaves in Bayan Lepas.



This perception is understandable given George Town's rapid expansion, growing population, and the city's limited green spaces, all of which contribute to the urban heat island (UHI) effect.

The same questions were repeated for respondents from Bayan Lepas. The areas perceived to be exposed to heatwaves are mainly concentrated near the Penang International Airport, Bayan Lepas Free Industrial Zone, Bayan Baru and spots surrounding the Sungai Ara area.

The coastal area south of Bayan Lepas, which comprises of the recreational sites of Pantai Esen and Bukit Esen, are also perceived to be exposed to heatwaves.

Sensitivity on Flooding

a. Sensitivity to Flood Impact: Survey Findings

Respondents in George Town indicated income (17.7%) and asset (17.7%) losses as the most severe effects. Meanwhile, respondents in Bayan Lepas indicated asset losses (12.0%) and physical danger (11.2%) as the most severe effects.

How severely have these floods impacted you and/or your family?

Impact	George Town				Bayan Lepas			
	No Impact	Minimal	Moderate	Severe	No Impact	Minimal	Moderate	Severe
Physical health	76.80%	8.40%	10.50%	4.20%	63.90%	16.70%	11.10%	8.30%
Mental health	72.90%	7.30%	11.50%	8.30%	66.00%	14.20%	11.30%	8.50%
Income losses	72.90%	7.30%	2.10%	17.70%	66.00%	13.20%	11.30%	9.40%
Asset losses	75.80%	8.40%	1.10%	14.70%	63.00%	11.10%	13.90%	12.00%
Interrupted Basic Amenities & Services	70.40%	13.30%	9.20%	7.10%	66.00%	13.20%	10.40%	10.40%
Life altering events	84.50%	8.20%	5.20%	2.10%	76.40%	9.40%	10.40%	3.80%
Physical harm	75.00%	10.40%	8.30%	6.30%	74.80%	10.30%	8.40%	6.50%
School Closures	76.80%	9.50%	6.30%	7.40%	68.90%	13.20%	11.30%	6.60%
Physical Danger	66.30%	12.60%	7.40%	13.70%	63.60%	14.00%	11.20%	11.20%

Legends

High: 100% – 60% | Moderate–High: 59% – 40% | Moderate: 39% – 20% | Low: 19% – 0%

b. Sensitivity to Flooding Losses: Survey Findings

The most severe losses indicated by the respondents from George Town and Bayan Lepas are **monetary losses** from reduced productivity and repairs, as well as property loss or damage. In George Town, property loss or damage was indicated as the most significant loss (14.0%), followed by reduced productivity (12.8%). In Bayan Lepas, monetary losses from reduced productivity (12.5%) were considered most significant, followed by property loss or damage (12.3%).

How severe are the losses (if any) incurred by you and or your family because of flooding?

Losses	George Town				Bayan Lepas			
	No Losses	Minimal	Moderate	Severe	No Losses	Minimal	Moderate	Severe
Health losses	81.40%	7.20%	8.20%	3.10%	71.40%	11.40%	8.60%	8.60%
Monetary losses from reduced productivity	72.30%	10.60%	4.30%	12.80%	66.30%	13.50%	7.70%	12.50%
Monetary losses from repairs and adjustments	75.30%	7.50%	6.50%	10.80%	66.70%	8.60%	13.30%	11.40%
Property or material loss / damage	76.30%	9.70%	0.00%	14.00%	66.00%	11.30%	10.40%	12.30%
Environmental loss	77.70%	6.40%	10.60%	5.30%	70.50%	7.60%	11.40%	10.50%

Legends

High: 100% – 60% | Moderate–High: 59% – 40% | Moderate: 39% – 20% | Low: 19% – 0%

c. Sensitivity to Flooding: FGD Findings

Flooding is known to cause significant **damage to properties and personal belongings**. A significant concern during floods is **insufficient food supplies**. Participants also expressed **concerns about safety,** including the danger of falling trees. Some participants noted that flooding can cause **damage to infrastructures** such as roads, which may affect evacuation.

Persons with disabilities (PWD) who have experienced floods shared concerns about **not receiving early warnings, leaving them with inadequate preparation time**. One participant with a hearing disability noted that he was asleep and left unaware of the increasing water level until it reached his body during the recent flood in Bukit Mertajam. As a result, many of his furniture and household appliances were damaged. A participant from Jalan Tengah described a fatal incident where a disabled person fell from his wheelchair during the rescue effort.

Migrant workers, who are paid based on work days, face financial difficulties when **floods prevent them from going to work**. Flooding also leads to school closure, which affects learning.

In addition, some women and children believe that floods can cause mental and physical **health problems**. A child noted that her sibling was hospitalised due to dengue fever during the floods. Some of the children also claimed that floods cause stress and illnesses such as fever and body aches.

Table 10: Flooding Sensitivity and Affected Aspects of Daily Life Among Vulnerable Populations

Sensitivity Insights	
Impact from Flooding • Damage to property, homes and personal belongings • Safety of family members • Unable to go to work or school • Loss or reduction of income	**Vulnerable groups with the highest severity of sensitivity towards flooding** (from highest to lowest)**:** • PWD • Low-income senior citizens • Low-income school children • Migrant workers • Low-income women

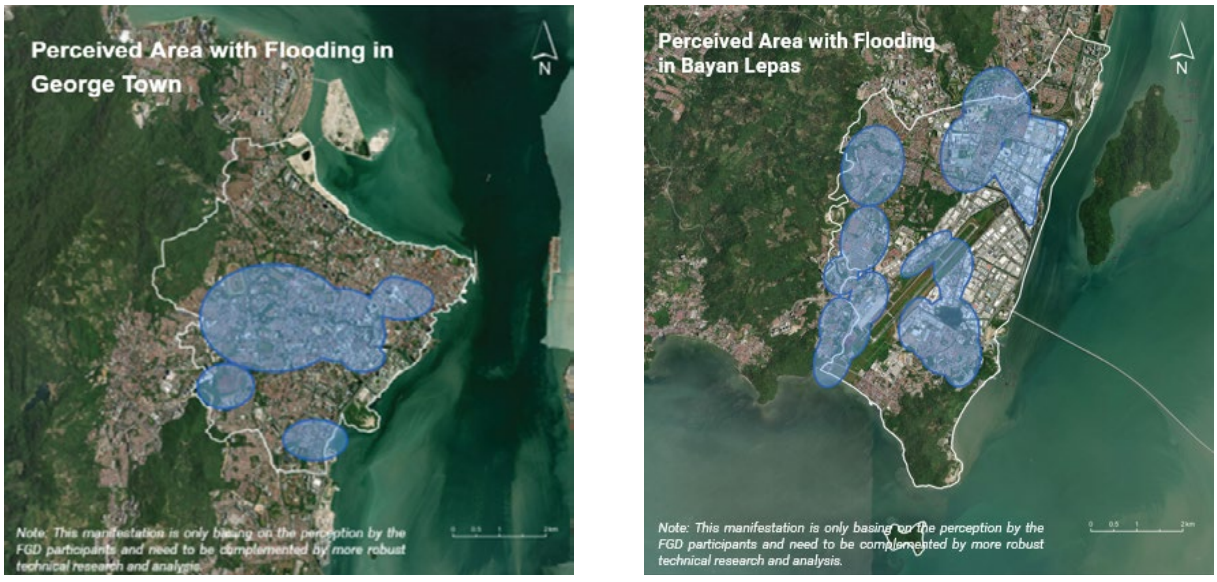
In George Town, residents in low-lying areas or near rivers are particularly prone to floods due to river overflows from Sg. Pinang, Sg. Jelutong, and Sg. Ayer Itam. Jalan P. Ramlee was frequently noted as an area with recurrent flash floods. As Kg. Dodol is located near Jalan P. Ramlee, this village is also often affected by flooding.

The flood-prone areas identified by FGD participants in Bayan Lepas are primarily found in Kg. Permatang Damar Laut, Sungai Ara, Kg. Masjid, Batu Maung, the northern region of the Bayan Lepas Free Industrial Zone, and Bayan Baru.

The frequent occurrence of flash floods in areas such as Jalan Kenari in Sungai Ara, Flat Seri Indah, and Sunshine Square Outlet in Bayan Baru was emphasised by a few of the participants.

Kg. Permatang Damar Laut is considered highly prone to floods due to its proximity to the coast.

Figure 19: Perceived Area with Flooding in George Town and Bayan Lepas.



Sensitivity on Sea Level Rise

a. Sensitivity to rise in Sea Levels: Survey Findings

More than 80.0% of the respondents indicated that they were not affected by the rise in sea levels. In general, respondents in Bayan Lepas perceived the rise of sea levels to have a higher impact on their physical and mental health than those in George Town.

How severely have these Sea Level Rise impacted you and/or your family?

Impact	George Town				Bayan Lepas			
	No Impact	Minimal	Moderate	Severe	No Impact	Minimal	Moderate	Severe
Physical health	85.30%	11.60%	0.00%	3.20%	71.60%	13.70%	10.80%	3.90%
Mental health	82.50%	12.40%	3.10%	2.10%	72.50%	13.70%	10.80%	2.90%
Income losses	81.10%	15.80%	0.00%	3.20%	75.20%	12.90%	7.90%	4.00%
Asset losses	83.50%	10.30%	4.10%	2.10%	76.70%	11.70%	7.80%	3.90%
Interrupted Basic Amenities & Services	84.20%	10.50%	3.20%	2.10%	78.40%	10.80%	6.90%	3.90%
Life altering events	86.60%	10.30%	1.00%	2.10%	80.40%	9.80%	5.90%	3.90%
Physical harm	85.10%	9.60%	3.20%	2.10%	79.40%	10.80%	5.90%	3.90%
School Closures	85.70%	8.20%	5.10%	1.00%	76.20%	10.90%	6.90%	5.90%
Physical Danger	81.40%	9.30%	6.20%	3.10%	76.50%	10.80%	7.80%	4.90%

Legends

High: 100% – 60% | Moderate–High: 59% – 40% | Moderate: 39% – 20% | Low: 19% – 0%

b. Sensitivity to losses from the rise of sea levels: Survey Findings

Similarly, respondents generally indicate limited losses from the rise of sea levels.

How severe are the losses (if any) incurred by you and or your family because of Sea Level Rise?

Losses	George Town				Bayan Lepas			
	No Losses	Minimal	Moderate	Severe	No Losses	Minimal	Moderate	Severe
Health losses	88.80%	9.20%	0.00%	2.00%	72.80%	11.70%	9.70%	5.80%
Monetary losses from reduced productivity	87.40%	11.60%	1.10%	0.00%	75.70%	9.70%	8.70%	5.80%
Monetary losses from repairs and adjustments	88.70%	5.20%	4.10%	2.10%	75.70%	11.70%	8.70%	3.90%
Property or material loss / damage	87.60%	8.20%	4.10%	0.00%	76.90%	10.60%	8.70%	3.80%
Environmental loss	84.40%	7.30%	6.30%	2.10%	75.70%	9.70%	8.70%	5.80%

Legends

High: 100% – 60% | Moderate–High: 59% – 40% | Moderate: 39% – 20% | Low: 19% – 0%

c. Sensitivity to rise in Sea Level: FGD Findings

Respondents who perceive significant impact from sea level rise often associate it with the risk of floods. For example, a senior citizen from Kg. Dodol reported that certain roads in his neighbourhood would become inundated during periods of high tide and heavy rainfall, as a result of overflow from a nearby river.

In George Town, areas that were considered most at risk consist of coastal areas such as Gurney Bay, Esplanade, Pengkalan Raja Tun Uda, Flat Lebuh Macallum, and Bandar Sri Pinang.

The participants also viewed inland locations at Kg. Makam and Kg. Kebun Lama as susceptible to sea level rise. This may be attributed to the association of sea level rise with floods.

Despite associating the rise of sea levels with the risk of flooding, respondents from Kg. Permatang Damar Laut (Bayan Lepas) did not perceive saltwater intrusion into inland areas as a significant issue. Although saltwater intrusion can eventually affect local water sources, soil quality, and the durability of infrastructure, participants believe that it is not an immediate concern as it is an infrequent occurrence.

In Bayan Lepas, areas perceived to be the most susceptible to the effects of rising sea levels are found in the southern region near Kg. Permatang Damar Laut and Pantai Esen. Respondents also identified the third phase of the Bayan Lepas Free Industrial Zone as a high-risk zone. This area is home to industries and numerous tourist attractions, including Pantai Seagate View Pulau Jerejak and Pasar Nelayan Seri Jerejak.

Figure 20: Perceived Area with Sea Level Rise in George Town and Bayan Lepas.

4.1.2.3. Public Engagement

Open days provided a platform for feedback and participation. Display booths were strategically placed in the Esplanade (George Town) on 21 April 2024 and Giant Hypermarket Bayan Baru (Bayan Lepas) on 28 April 2024.

In George Town, the booth attracted a diverse crowd that included residents of Pulau Pinang, as well as visitors from other states and countries. The booth in Bayan Lepas was set up during the Fun Run organised by the National Anti-Drugs Agency (NADA), hence visitors were primarily from Penang Island or Seberang Perai.

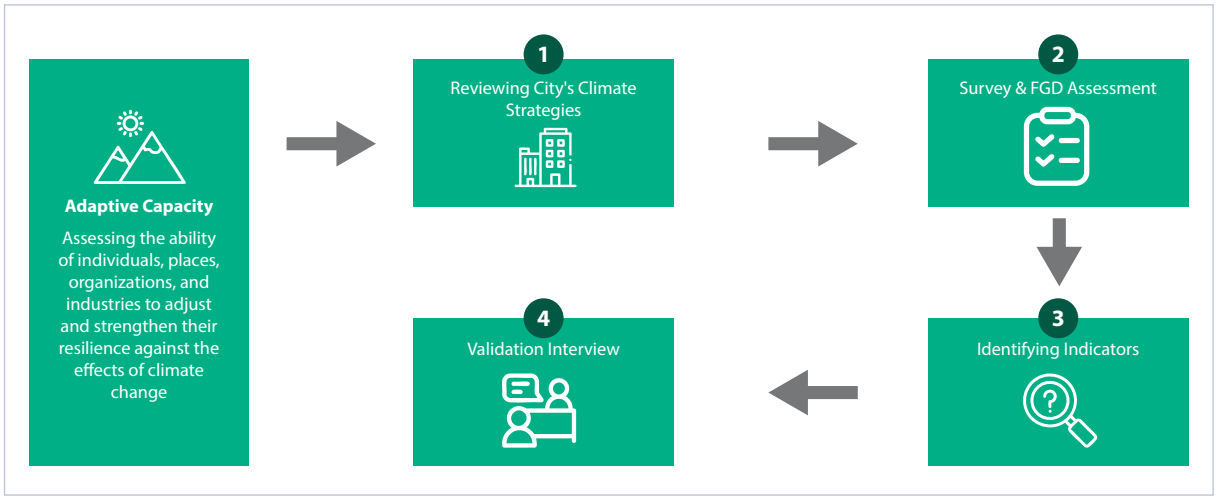
During the Open Day, young adults and parents with young children who are interested in environmental or climate change issues were more likely to participate in the survey.

A small token of appreciation (canned drinks or biscuits) was given out to encourage participation in the survey. Since the attendees are primarily there for the fun run and other leisure activities, the survey was kept brief and concise.

Figure 21: Open Days at Esplanade (21 April) and Giant Bayan Baru (28 April) offered a platform for public feedback on climate issues. Held during public events, the booths attracted families and young adults, with interactive displays and short surveys encouraging participation.

4.1.3. Adaptive Capacity

Figure 22: Adaptive Capacity Assessment approach used to evaluate climate resilience, institutional preparedness, and stakeholder capacity in George Town and Bayan Lepas.



4.1.3.1. Reviewing City Climate Strategies

A review of Penang's climate strategies is a key step in understanding how well its communities are prepared for the impact of climate change. These strategies reveal how the city is allocating resources and supporting vulnerable groups. They also help identify communities that are most at risk, such as those living in flood-prone or low-income areas. With this information, the city can provide targeted support, reduce inequality and strengthen adaptive capacity.

The strategies highlight how Penang is investing in infrastructure such as green spaces and flood protection to better withstand extreme weather. They also show whether communities are included in the planning process. Adaptation efforts become more effective when communities (particularly youth and marginalised groups) are engaged.

Finally, investments in public education and skills training reflect a city's long-term commitment to resilience. These efforts empower individuals to act and adapt.

Table 11: Strategic Focus Areas Supporting Climate Resilience in Penang.

Issue	Local	State	Federal
Heat	Urban greening grants, tree-lining, green rooftops/facades, pocket parks and green parking to reduce UHI	Green Agenda 2030, planning for heat mitigation infrastructure, forest conservation	National climate policy includes UHI mitigation; PNBCAP funded and implemented federally via UNHabitat
Flood	Upgrades by city council, sponge city demonstration projects (e.g., bluegreen corridors, retention ponds, swales)	Sponge city strategy embedded in Penang Structure Plan, peat swamp forest conservation to enhance infiltration	Funds and coordination for basin management and flood victim aid via NADMA and DID

4.1.3.2. Survey & FGD Assessment on Adaptive Capacity

i. Adaptability to Heatwaves

a. Adaptability to Heatwaves: Survey Findings

The majority of respondents from both George Town and Bayan Lepas have adjusted their lifestyle to adapt to heatwaves by **staying hydrated, opting for a healthier diet, and limiting outdoor activities during peak heat hours**.

What measures do you plan to take or have taken to cope with the increasing hot weather?

Adaptability	George Town	Bayan Lepas
Adjusting lifestyle by being more hydrated; healthier diet	60.0%	75.2%
Upgrading home insulation such as installing fans or other cooling devices	50.0%	46.9%
Planting more trees and/or vegetation for shade	27.0%	38.1%
Limiting outdoor activities during peak heat hours	69.0%	67.3%
Search for support and information	14.0%	22.1%
Search for places for relocation	7.0%	5.3%
No actions	6.0%	0.9%

b. Adaptability to Heatwaves: FGD Findings

Heatwaves present challenges for everyone, particularly for vulnerable groups. Many women participants shared that they have adapted their lifestyles to cope with the heat. Across all groups, participants have **increased their water intake**, often supplemented with revitalising drinks or supplements. Children noted that **many schools now provide water dispensers** for easy access to drinking water. Additionally, **some schools allow students to wear sports attire or white shirts instead of standard uniforms**, which they find more comfortable. SK Bayan Baru, for example, has implemented tree-planting as part of their initiative to combat heatwaves. **Outdoor activities and community programs are often shortened or rescheduled** during severe heat.

Many are also **staying informed on the latest news**, particularly regarding heatwaves. Social media platforms such as Facebook, TikTok, and WhatsApp are the preferred sources for updates across vulnerable groups. Most suggested that it is crucial to disseminate information about heatwaves through social media platforms, which are more effective at reaching the younger generations.

The majority of the PWD participants agreed that staying informed about the latest news and information enables them to act with caution during heatwaves. The dissemination of information can be particularly difficult for participants with hearing and speech disabilities, as some of them are illiterate. Many of them use Facebook and TikTok, but crucial information can often be missed. Many have stated that they would explore alternative sources of information, as TikTok and Facebook may experience delays. The most reliable news sources are television programmes that feature sign language interpreters, which are commonly broadcasted by RTM1, Astro Awani, Bernama, and TV Al-Hijrah. Literate individuals often checked the daily temperature on Google. Most of them agreed that WhatsApp is the most efficient method of receiving news.

Participants emphasised the need for **more efficient means to disseminate information** about heatwaves. Many would like to learn more about the issue as well as ways to mitigate and adapt to the impact of heatwaves. Tree-planting and creating green spaces were suggested as effective measures, as they provide shades, reduce surface temperatures, and enhance overall comfort. Some participants are aware of the 1 Million Trees Campaign by the state government and recognised it as a valuable initiative aimed at environmental conservation.

A few participants described house renovation and rearranging furniture as a way to reduce the temperature and increase ventilation.

ii. Adaptability to Flooding

a. Adaptability to Flooding: Survey Findings

When asked about measures to cope with floods, most respondents focused on securing important documents and items, followed by identifying evacuation routes.

What measures do you plan to take or have taken to cope with floods if they occur?

Adaptability	George Town	Bayan Lepas
Improving building and Infrastructure-related	25.0%	48.7%
Identifying evacuation routes	38.0%	47.8%
Securing important documents and items	57.0%	70.8%
Search for support and information	36.0%	49.6%
Search for places for relocation	29.0%	32.7%
No actions	23.0%	4.4%

b. Adaptability to Flooding: FGD Findings

Most participants agreed on the importance of **keeping their homes and surroundings clean from trash**. They understand that trash tends to be washed into drains during heavy rains, clogging drains and leading to floods. Many participants also emphasised the need to **prepare sufficient food and water supplies**, in case of delays in evacuation and rescue efforts. However, few participants were aware of the locations of nearby flood shelters and the importance of preparing emergency kits. The most requested assistance includes **financial aid and help with cleaning up after a flood**. Such support would alleviate the victims' burdens and help them rebuild their lives after a disaster. Persons with disabilities (PWD) highlighted their specific needs, noting that those who are unable to read or hear may require **special assistance from sign language interpreters** to receive crucial information. A proactive approach is essential in assisting PWD during emergencies, and climate emergency training tailored specifically for PWD should be introduced.

4.1.3.3. One-to-One Interviews

The 10 interview sessions were conducted between 26 June and 17 July 2024. Interviewees include stakeholders from government agencies, government-related council, research institution, NGOs, community leaders, and members of community affected by floods (Table 13).

Table 12: Stakeholders Involved in One-to-One Interview Sessions (26 June – 17 July 2024).

Stakeholder Type	Stakeholder	Date of Interview	Focus of Interview
Government Agencies	Occupational Health and Environment Unit, Public Health Division, Penang State Health Department	12/7/2024	Public Health
	Disaster Management Unit, Penang	15/7/2024	Disaster Management
Council / Research Institution / NGO	Penang Green Council	4/7/2024	Climate Action
	River Engineering and Urban Drainage Research Centre (REDAC), Universiti Sains Malaysia	12/7/2024	Research in Climate Mitigation
	Persatuan Aktivis Sahabat Alam (KUASA)	15/7/2024	Grassroot Movement on Climate Action
Community Leaders	Community Leader of Kg. Dodol, George Town	27/6/2024	Community Management
	Community Leader of Kg. Permatang Laut, Bayan Lepas	17/7/2024	Community Management
	Community Leader of Flat Jalan Tengah, Bayan Lepas	10/7/2024	Community Management
Affected Community	Encik Meerasa Mastan from Kg. Dodol, George Town	27/6/2024	Senior Citizen affected by flood in 2017
	Puan Faridah Mohamad Jalil from Bayan Lepas	26/6/2024	Migrant worker residing in Penang

The table below summarises the current climate change initiatives and preparedness by the stakeholders.

Table 13: Summary of Current Climate Change Initiatives and Preparedness Efforts by Key Stakeholders.

Stakeholder	Climate Change Initiative and Preparedness
Occupational Health and Environment Unit, Public Health Division, Penang State Health Department	Ministry of Health (MOH) Penang is preparing and equipping its system to face the impacts of climate change. The initiatives include: • Participating in inter-agencies responses towards climate disasters such as floods and landslides according to the guidelines stipulated by National Disaster Management Agency (NADMA). This includes table-top exercise and disaster simulations to enhance coordination and communication during disasters. • Implements "No Wrong Door" policy to facilitate seamless access to healthcare services. • **Updates to the Disaster Risk Preparedness (DRP) annually on weather-related natural disaster risks** such as floods, landslides, storms and tsunamis. • Participating in the Penang State Disaster Management Committee Meeting • Ensuring the availability of radiology equipment (e.g., CT scans), laboratories, ICU, and CCU facilities in all hospitals. In addition to these, a number of new technologies were adapted: • Utilisation of telemedicine and virtual healthcare to bridge gaps in accessibility. • Air quality monitoring systems. • Climate-resilient healthcare infrastructure. • Early warning systems using weather forecasts, satellite imaging, and AI-powered tools. • Community-based health monitoring systems for disease surveillance. • Renewable energy-powered healthcare facilities. • Mobile health units to reach affected areas. • Geospatial analysis to identify high-risk areas. • Climate-resilient water treatment systems to ensure clean drinking water
Penang Disaster Management Unit (DMU)	DMU is conducting series of community outreach and capacity-building programs in collaboration with government agencies such as the Civil Defence Agency and the Village Community Management Council (MPKK). These initiatives include: • **Community-Based Disaster Risk Management (CBDRM):** This programme trains local communities in disaster risk management techniques, focusing on empowering agencies and local government members to take proactive steps in disaster preparedness, response, and recovery. The training covers first aid, evacuation procedures, and emergency response planning; it is conducted twice annually to accommodate the turnover of officers. • **Raising awareness about disaster risks and preparedness:** The DMU conducts awareness campaigns to educate the public on the risks associated with climate change and natural disasters. • **Simulation drills and real-time exercises:** Puan Ambika Devi, Head of Penang Disaster Management Unit highlighted the importance of conducting regular simulation drills and real-time exercises that involve multiple stakeholders, including government agencies, NGOs, and community members. These drills help identify gaps in preparedness and response, ensuring better coordination during disasters. • **Enhancing the capacity of the MPKK to serve as first responders:** The DMU focuses on building the capacity of the MPKK to act as first responders during disasters. This involves specialised training and resources to equip them with the skills and knowledge to handle emergency situations effectively. • **Developing and implementing local disaster action plans:** The DMU collaborates with local communities to develop and implement disaster action plans. These plans are tailored to the specific needs and vulnerabilities of each community, ensuring coordinated and effective responses during disasters. In 2023, the DMU organised a significant disaster simulation drill in Penang, specifically targeting industrial disasters in response to the state's robust industrial sector. The drill, held on 21 May 2023 at the Perai Bulk Cargo Terminal, was marked by its scale and complexity, and notably involved the participation of the Chief Minister. It involved over 500 individuals from various agencies, including district offices and NADMA. Notably, heavy rain that occurred during the drill added to the challenge. Following the simulation, a thorough postmortem report was compiled and submitted to NADMA. This exercise highlighted Penang's proactive approach to disaster management, focusing not only on floods but also on addressing various industrial disaster scenarios outlined in Arahan MK20. It exemplifies ongoing efforts to enhance readiness and response capabilities beyond conventional flood scenarios.

Stakeholder	Climate Change Initiative and Preparedness
Penang Green Council (PGC)	At policy level, the PGC's role involves assisting state leaders in decision-making through research and advice on policy. PGC works on various initiatives, including waste segregation at source, climate change policies, and public awareness campaigns. PGC also works with various government agencies, private sectors, NGOs, and community groups to enhance the impact of their initiatives. In response to climate change and the evolving paradigm of sustainable development, PGC, together with Penang State Economic Planning Unit and Penang Institute developed the Penang Green Agenda. The Penang Green Agenda commissioned technical experts and scientists to look into sustainability aspects of the Penang State, including developing sustainability indicators. PGC will be conducting a scenario analysis to assess the impacts of environmental issues. The agenda will also engage all stakeholders and people of Penang to identify and combat the current and future environmental challenges, and to propose feasible solutions. The Penang Green Agenda includes a comprehensive study with reports from ten working groups. These groups were formed through stakeholder engagement using a bottom-up approach. The feedback from stakeholders helped prioritise the top ten environmental issues to be addressed in Penang. One of the significant outcomes of the Penang Green Agenda was the establishment of a disaster management unit at the state level. This unit was created based on the urgency highlighted in the working group reports. PGC has launched a flagship initiative known as the Green School Programme, designed for primary and secondary schools across Penang. This programme focuses on fostering environmental awareness and education among students. Participating schools are eligible for incentives in recognition of their efforts to implement sustainable practices. In tandem with this, PGC has also introduced the Green Office Programme, tailored for the private corporate sector. Mirroring the Green School Programme, this initiative encourages and supports businesses in adopting eco-friendly practices. Participating businesses may qualify for incentives such as rebates or tax benefits. Furthermore, PGC administers various awards and incentives to promote and celebrate sustainable initiatives. Notable among these is the Green Journalism Awards, which aims to encourage media professionals to report on environmental news. Additionally, PGC offers incentives related to food waste reduction and efficient water management, providing opportunities for recognition, as well as monetary rewards and tax rebates.
River Engineering and Urban Drainage Research Centre (REDAC), USM	A green sustainable urban stormwater management system known as Bio-Ecological Drainage Systems (BIOECODS) was designed by REDAC and subsequently constructed at the USM Engineering Campus in 2002 BIOECODS aims to solve three problems commonly encountered in Malaysia, namely flash floods, river pollution, and water scarcity. BIOECODS will help preserve the natural characteristics of the river ecosystems. The BIOECODS system is built around key hydrological principles, focusing on the natural water cycle: • Rainfall is captured and directed into the system. • Runoff is managed through swales and ponds to control flow and quality. • Natural vegetation and soil act as water filters. • Groundwater infiltration is enhanced to replenish underground aquifers. • Finally, treated water is released back into rivers and oceans. The BIOECODs approach emphasises maintaining natural landscapes and ecosystems, reducing the need for artificial structures: • Wetland areas are used to filter and treat water. Vegetations within wetlands help absorb pollutants and improve water quality. • Green spaces attract wildlife such as migratory birds, creating biodiverse environments that benefit both human and nature. • Swales (shallow channels) are designed to manage runoff and facilitate filtration, reducing erosion and promoting groundwater recharge. Water absorption at bioswales is highly efficient, typically taking less than an hour or even as little as half an hour during brief rains. There are ongoing plans to further treat water before their release into Sungai Kerian, ensuring that it meets stringent environmental standards. This comprehensive approach enhances water quality and nurtures green spaces that serve as vital ecological sanctuaries.

Stakeholder	Climate Change Initiative and Preparedness
Persatuan Aktivis Sahabat Alam (KUASA)	KUASA is active in Ipoh and Manjung, primarily supporting fishermen communities and addressing illegal logging in the Banjaran Titiwangsa region. In Penang, KUASA supports the fishermen community near Teluk Kumbar in opposing the reclamation projects in Bayan Lepas. KUASA also promotes mangrove planting for coastal protection at Seberang Perai, together with the Penang Inshore Fisherman Welfare Association (PIFWA). Since 2012, their work has focused on sandy coastal areas in Manjung, which are affected by aquaculture farms. Currently, KUASA is actively dedicated to climate adaptation efforts among indigenous communities in Gua Musang. The issues addressed include extreme weather events, monsoons, prolonged droughts, and associated challenges such as logistics and transportation disruptions, inadequate infrastructure, water scarcity, and agricultural difficulties due to changing climate conditions. KUASA's ongoing monitoring and data collection efforts in Gua Musang reveal rapid environmental changes due to illegal logging, which are significantly impacting indigenous communities. Over the past decade, their efforts have fostered community empowerment and adaptation initiatives. Furthermore, KUASA is currently preparing to launch a book titled "Adapting to Climate Change: Insights from the Gua Musang Indigenous Community", which documents their methods of adaptation by the Orang Asli communities. A roundtable discussion involving government agencies such as Jabatan Kemajuan Orang Asli (JAKOA) and the United Nations Development Programme (UNDP) is scheduled in August 2025 to advance these initiatives at the policy level.
Community Leader of Kg. Dodol, George Town	In 2019, proactive flood preparation measures were initiated for the village. A flood siren was installed, and in collaboration with the mosque committee of Masjid Hashim Yahaya, the MPKK organised a comprehensive flood preparation workshop. The workshop trained 40 participants from the village on flood risks, responses during floods, as well as childcare and hygiene practices during floods. The community conducts gotong-royong sessions every three months to clean drains and rivers. Thanks to funding from the state government, nets were installed to capture trash, and efforts were made to deepen the river. Furthermore, the MPKK conducts biannual surveys to understand the villagers' challenges and needs. Community volunteers also play a crucial role in distributing support and aid to those in need.
Community Leader of Flat Jalan Tengah, Bayan Lepas	The MPKK of Flat Jalan Tengah has yet to initiate any specific programme addressing climate change. However, they actively monitor conditions, particularly during periods of intense heat, and encourage residents to minimise outdoor activities during such times. The Chairman of the MPKK expressed that while there are no ongoing initiatives from the MPKK or residents, there is a strong willingness within the community to engage in preparedness programmes such as workshops, training sessions, and talks if facilitated by the government.
Community Leader of Kg. Permatang Damar Laut, Bayan Lepas	The MPKK has yet to conduct any training, talks, or workshops focused on climate change, as there are no significant concerns for natural disasters in Kg. Permatang Damar Laut. In response to the rising temperatures, the community has taken initiative by installing water sprays on rooftops. Some have installed additional fans, air conditioners or air regulators.
Encik Meerasa Mastan, Senior citizen from Kg. Dodol, George Town	Addressing the frequent floods in his area, Encik Meerasa believes his family is adequately prepared to handle these events. Since the 2017 floods, he has stored important documents in an emergency bag.

The following table summarises the suggestions to improve public resilience towards climate change by the stakeholders.

Table 14: Stakeholder Suggestions to Enhance Public Resilience to Climate Change.

Stakeholder	Suggestion to Improve Public Resilience Towards Climate Change
Occupational Health and Environment Unit, Public Health Division, Penang State Health Department	• Reduction of greenhouse gas emissions: Implementing a blueprint for carbon-neutral healthcare facilities to reduce emissions. • Developing climate-resilient healthcare infrastructure • Developing emergency response plans to respond effectively to climate-related health emergencies. • Establishment of Early Warning Systems to warn of climate-related health risks, particularly during floods. • Providing training on climate-related health issues to healthcare professionals. • Improving access to clean water and sanitation to mitigate health risks associated with climate change. • Raising awareness on the impact of climate change on health, as well as mitigation measures. • Supporting practices that enhance agricultural resilience and ensure food security in the face of climate change. • Creating services to support mental health for individuals affected by climate change.
Penang Disaster Management Unit (DMU)	DMU emphasised the importance of public education (particularly for the B40 group) on disaster awareness, evacuation protocols, and the importance of following the authorities' directives. Residents near rivers and coastal areas face additional risks from rising sea levels and other climate-related impact. These areas often host illegal settlements, which can complicate evacuation and relief efforts. Therefore, educating these vulnerable communities about climate-related disasters is crucial. Regular simulation drills and real-time exercises involving various stakeholders are needed to identify gaps in readiness and response, thereby ensuring coordination during actual disasters.
Penang Green Council (PGC)	To enhance public resilience to climate change, PGC adheres to the 'three H's' principle: Heart, Head, and Hands. • Heart: PGC prioritises raising awareness. By connecting climate change with local issues such as food availability and prices, PGC makes the concept more tangible and relevant to the community. • Head: PGC conducts diverse capacity-building programs tailored for different community segments, ensuring thorough understanding of both the scientific and practical aspects of climate change. • Hands: PGC facilitates community participation in environmental initiatives such as waste segregation and conservation projects, fostering a sense of ownership and responsibility. Furthermore, PGC acknowledges the importance of tailoring messages to specific communities. For instance, in flood-prone or heatwave-affected areas, PGC addresses pertinent issues these issues specifically. This approach allows PGC to effectively tackle challenges faced by diverse communities and bolster their resilience. Project outcomes are shared with the state government and relevant agencies.
River Engineering and Urban Drainage Research Centre (REDAC), USM	Balancing economic growth with environmental sustainability is a multifaceted challenge. Developers, often prioritising cost-efficiency, are increasingly embracing green concepts like green corridors and expanded green and blue spaces. Leading this shift are developers such as SP Setia and EcoWorld, yet broader adoption requires greater stakeholder commitment to these principles. Focus should be directed towards vulnerable populations. While construction costs are not inherently high, profit-driven contractors often result in inefficiencies, thereby elevating costs to levels comparable to standard construction practices. REDAC endeavours to bolster infrastructure and foster community engagement through robust research and development initiatives. Community involvement is essential, particularly in raising awareness on the impact of intense rainfall and potential flooding.

Stakeholder	Suggestion to Improve Public Resilience Towards Climate Change
River Engineering and Urban Drainage Research Centre (REDAC), USM	Public education programs should target behavioural changes, emphasising responsible waste disposal practices. Advanced solutions are ineffective if public behaviour remains unchanged; thus, cultivating consistent messaging and fostering a mindset shift is imperative. Awareness campaigns should engage students and teenagers to instil ethical values from an early age. Recommendations include integrating these strategies into comprehensive reports and showcasing them at exhibitions. On top of that, REDAC emphasised the key role of enforcement, by drawing from practices in Singapore, where stringent regulations deter littering, demonstrating the efficacy of rigorous enforcement in promoting responsible behaviours.
Persatuan Aktivis Sahabat Alam (KUASA)	KUASA advocates that continuous efforts and enhanced grassroots involvement are imperative, as relying solely on government agencies may result in delays. In addition, it is crucial for young people to recognise and take action on climate issues, given the escalating severity of these challenges. Although KUASA focuses on rural indigenous communities while PNBCAP focuses on urban communities, the lessons learned are applicable across both contexts. Both communities are facing similar impacts of climate change, and KUASA's insights offer valuable perspectives for broader implementation. KUASA also shared several crucial insights from their climate adaptation programs: • Prioritise underlying issues that are exacerbating climate change before implementing adaptation programs. • Acknowledge that public awareness of climate change remains inadequate; authorities often mobilise only in response to widely publicised environmental issues. • Emphasise documenting processes to monitor changes and provide a reference for future initiatives. • Educate and support communities on the increasingly profound impact of climate change on their livelihoods.
Community Leader of Kg. Dodol, George Town	The MPKK encourage residents to participate in community programmes for flood preparedness, emphasising the significance of education on the causes and impacts of floods. Apart from that, MPKK provides aid such as dry food, clothing, blankets, mattresses, and monetary contributions. Unfortunately, not all residents received assistance as aid was distributed selectively and restricted to one representative per family. Some severely affected areas did not receive any support. The aid provided was also insufficient, and the distribution process was marred by issues as non-residents took aid intended for residents of Kg Dodol. The MPKK proposed to provide financial support directly to affected communities, an approach that would empower the community to address flood-related damages effectively.
Community Leader of Flat Jalan Tengah, Bayan Lepas	The MPKK stressed the importance of education on emergency preparedness and response protocols. This involves ensuring residents have access to contact information for disaster agencies and clear instructions on evacuation routes and shelters. Efforts should focus on education and awareness campaigns to equip the community for climate-related emergencies. These initiatives may include conducting emergency drills, distributing emergency kits, and establishing a community response team. They are crucial in empowering communities to effectively prepare for climate-related challenges.
Community Leader of Kg. Permatang Damar Laut, Bayan Lepas	The MPKK suggested trainings related to climate change to be provided to the communities in Kg. Permatang Damar Laut, specifically tailored to senior citizens and the fishing communities in the village. These trainings are best to be delivered by government agencies or authorised organisations to ensures confidence and support from the residents.
Encik Meerasa Mastan, Senior citizen from Kg. Dodol, George Town	After the floods, Encik Meerasa recounted receiving food aid distributed by the ADUN. He acknowledged that while the assistance helped his family survive during difficult times, it was barely enough to sustain them. Nevertheless, Encik Meerasa expressed gratitude for the support they did receive.
Puan Faridah Mohamad Jalil, Migrant worker residing in Bayan Lepas	Puan Faridah often seeks out assistance from the government, private sector, or NGOs to supplement her livelihood. However, a common obstacle is that they require long travel from her residence, which is at times not worthwhile. Furthermore, waiting at bus stops without adequate roofing or shade exposes her to the intense heat, adding to her challenges.

5. VULNERABILITY ASSESSMENT

Prior to the workshops, extensive outreach activities were conducted to ensure inclusivity and local relevance. A second round of open days was held, intended to gather further input and validate initial findings with the community. Held at key local markets in George Town and Bayan Lepas, the open days were crucial touchpoints to engage diverse groups.

The insights gathered informed the design of four Community Preparedness Workshops, held in February and March 2025 across Kg Makam, Lebuh Macallum, Jalan Tengah Selatan, and Kg Naran. These workshops brought the engagement full circle by translating feedback into targeted capacity-building.

Table 15: Community Preparedness Workshops Designed from Stakeholder Insights and Held Across Four Locations (February–March 2025).

	Community	Location	Date	Participant numbers	Descriptions
1	Kg. Makam	George Town	23 March 2025	20	Flood and Heat Prone
2	Bayan Baru	Bayan Lepas	9 March 2025	26	Flood and Heat Prone
3	Kg. Naran	Bayan Lepas	15 March 2025	23	Flood Prone
4	Lebuh Macallum	George Town	15 March 2025	31	Heat Prone

5.1. Gaps in Resilience

Many buildings in George Town and Bayan Lepas are underprepared for climate change, due mainly to several factors:

1. Economic Constraints
Limited financial resources hinder communities from investing in essential infrastructure upgrades and resilience measures. Vulnerable groups often lack access to cooling equipment during heatwaves, which increases risk of heatstroke and dehydration. At the same time, low-income households are more likely to reside in areas with high flood risk and lack the means to relocate or flood-proof their homes. The economic burden of flood recovery is particularly high for these groups, as they may not have sufficient savings to repair and rebuild.

2. Infrastructure
In many areas, the existing infrastructure is inadequately designed to handle extreme weather events. Drainage systems, for instance, are often improperly sized and poorly maintained, leading to frequent flash floods after rainfall. Additionally, floods can occur due to the backflow of seawater during high tides, thus inundating low-lying areas. These floods can cause substantial property damage and pose serious health risks due to waterborne diseases. Upgrading and maintaining infrastructure to meet modern standards is essential to mitigate these risks.

3. Building Structure
The design of many buildings hinders natural ventilation, contributing to the urban heat island effect. Poorly ventilated buildings trap heat, exacerbating the impact of heatwaves and requires more energy to cool. The use of asbestos and zinc roofing further contributes to heat retention. These materials have low reflectivity and high absorption rates, making structures susceptible to overheating. Promoting building designs that enhance natural ventilation and reduce heat retention is crucial for improving overall resilience.

4. Information Dissemination
Timely and accurate information is vital for responses to climate-related emergencies. However, many residents do not receive early warnings or critical information on extreme weather events. This communication gap can be attributed to language barriers, limited access to communication channels or a lack of awareness about the state's official alert system. Ensuring that all community members have timely access to reliable information is essential for preparedness and response.

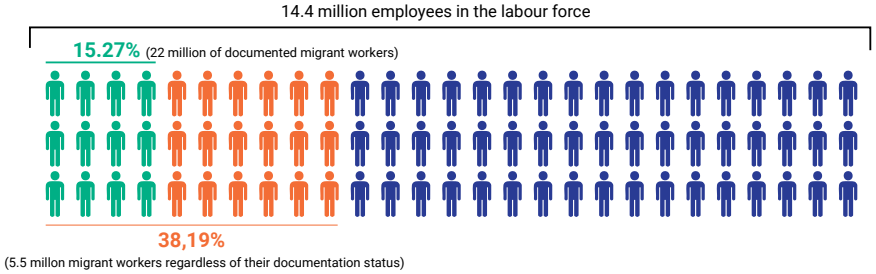
5. Public Awareness and Preparedness
There is a general lack of awareness among residents regarding necessary actions during heatwaves and floods. This deficiency in knowledge is particularly concerning for vulnerable communities. Many are also unaware of the appropriate procedures and evacuation routes in the event of a disaster. Community education programs and regular evacuation drills can enhance public preparedness and resilience.

5.2. Prioritised Challenges for the Vulnerable Communities

5.2.1. Migrant Workers

According to the Malaysian Department of Statistics, approximately 3 million migrants reside in Malaysia as of July 2023, accounting for 8.9% of the country's population. Between 2018 and 2020, the World Bank estimated that Malaysia's migrant population ranged from 2.6- 5.5 million, comprising 1.4- 2 million documented individuals and an additional 1.2- 3.5 million undocumented individuals. Most migrants originate from countries such as Indonesia, Bangladesh, Myanmar, and Nepal, with smaller groups coming from India, Cambodia, and Laos. They contribute significantly to the economy, particularly in industries like manufacturing, agriculture, plantations, hospitality, security, and domestic work.

Figure 23: Department of Statistics Malaysia (DoSM), 2022.



Migrants in George Town and Bayan Lepas face heightened vulnerabilities that amplify their exposure to climate crises. Many are undocumented, excluding them from social safety nets and public assistance programs, particularly during extreme weather events such as flash floods. In Bayan Lepas, a significant number of migrants reside in informal housing, often in low-lying, flood-prone areas near industrial zones. These temporary dwellings are poorly constructed, offering little protection against storms and tidal surges. In George Town, where historic and aging infrastructure dominates, migrants often live in shared, overcrowded quarters, with limited access to more resilient housing options.

5.2.2. Low-Income Women

Lower-income women in George Town and Bayan Lepas face distinct challenges that make them particularly vulnerable to the impact of climate change. Many of them are responsible for household care, which restricts their ability to engage in disaster preparedness or recovery efforts. Additionally, many are employed in informal sectors with minimal job security, leaving them exposed to income losses caused by climate-related disruptions. Safety concerns also arise during climate-induced displacement, as women face increased risks of violence or exploitation in temporary shelters.

5.2.3. Elderly and Low-Income Individuals

Penang is undergoing a demographic transition, with a growing share of elderly residents. The proportion of individuals aged 65 and above increased from 3.5% in 1970 to 9.4% in 2021, exceeding the national average of 7.4%. Meanwhile, population aged below 15 dropped from 41.1% (1970) to 19.3% (2022), while the working-age group (15–64 years) rose from 55.6% to 73.3% over the same period. Penang's median age of 32.7 years in 2021 ranks as the second highest in Malaysia, reflecting its ageing demographic.

Older adults in Penang face significant challenges during climate-related disasters, especially floods. Mobility issues make evacuation particularly difficult, as limited accessibility and a lack of age-friendly infrastructure compounds the risks. Flooded streets, damaged walkways, and a scarcity of accessible transportation options leave many elderly individuals stranded. This is exacerbated by health vulnerabilities, as older adults are more prone to heat-related illnesses and complications.

An attendee from the open day noted that social isolation leaves many elderly individuals in low-income households without the support network required in evacuation or post-disaster recovery. For example, during floods in George Town, older adults have struggled to move to higher grounds or salvage essential belongings due to mobility challenges and a lack of assistance. These issues highlight the importance of accessible evacuation routes, community-based support systems, and inclusive disaster planning.

5.2.4. People with Disabilities

During periods of extreme heat, many people with disabilities face difficulties staying safe. Moving to cooler places can be challenging, and some may have health conditions that affect their bodies' response to heat. Access to cooling facilities like air-conditioned spaces is often limited, especially for those from lower-income areas. A lack of green spaces and cooling infrastructure in the city adds to the problem.

Physical barriers such as flooded roads can prevent people with disabilities from evacuating safely. Mobility aids may not work in flood conditions, and many rely on caregivers who may not be able to reach them quickly. Emergency information is not always accessible, and evacuation centres often lack basic facilities like ramps or accessible toilets. These factors make it harder for people with disabilities to respond to emergencies and to recover from them.

Currently, disaster management in Penang tends to focus more on responding to crises rather than preparing for them. There is limited planning that considers the needs of people with disabilities, while public awareness on disaster preparedness remains low. Coordination among agencies, NGOs, and communities needs to be improved to ensure that no one is left behind during emergencies.

To reduce these risks, Penang needs more inclusive policies. This includes better urban planning with more green and accessible spaces, improved communication and evacuation systems, and emergency shelters that meet the needs of all residents. Ensuring people with disabilities are part of disaster planning is key to building a more resilient and inclusive city.

5.2.5. Low-Income School Children

Low-income school children in Penang are especially vulnerable to extreme heat and floods due to poverty, inadequate infrastructure, and limited adaptive capacity. These factors significantly affect their health, education, and well-being.

Many schools in low-income areas lack proper cooling areas or facilities, and adequate access to clean water, which increases health risks during heatwaves and reducing students' ability to concentrate and learn effectively. These children often rely on walking or public transport, making commutes difficult and unsafe during extreme heat.

Floods further disrupt education by damaging school facilities and blocking access. Poor sanitation and increased exposure to waterborne diseases compound health risks. Flood events often lead to higher absenteeism and dropout rates, especially when families face financial strain.

Addressing these challenges requires improving school infrastructure for heat and flood resilience, ensuring access to water and sanitation, providing flexible learning options during extreme weather, and supporting vulnerable families. Without targeted interventions, climate change will deepen educational inequalities among low-income children in Penang.

6. TOOLKIT DEVELOPMENT

To strengthen community resilience in Penang, PNBCAP developed a Heatwave and Flooding Training Toolkit in response to the growing threats of extreme weather. This toolkit aims to equip vulnerable communities with practical knowledge, promote local ownership, and support long-term adaptation to heatwaves and flooding.

Objectives

The Heatwave and Flooding Training Toolkit was developed to strengthen community preparedness and resilience in Penang, particularly in response to the increasing risks posed by extreme weather events. This toolkit offers clear, actionable guidance, empowering residents to protect themselves, their families, and their communities from heatwaves and floods. The key objectives of the toolkit include:

- **To provide accessible climate adaptation information**
  The toolkit offers practical, easy-to-understand instructions on key aspects of climate adaptation, including early warning systems, emergency response procedures, and post-disaster recovery steps.
- **To address the needs of vulnerable groups**
  Special focus is given to low-income households, senior citizens, children, persons with disabilities (PWD), and migrant workers, who are particularly at risk during extreme weather events.
- **To standardise climate adaptation practices**
  The toolkit provides a replicable and adaptable framework for local authorities and community leaders to integrate climate resilience training into their communities, ensuring consistency across the region.
- **To foster local ownership and self-management**
  By encouraging communities to take responsibility for disaster preparedness, the toolkit reduces reliance on external support and builds local capacity for effective response.
- **To build long-term resilience against extreme weather**
  Ultimately, the toolkit is a comprehensive resource designed to help communities understand climate risks, take proactive action, and enhance their long-term resilience to heatwaves and floods.
- **To ensure accessibility across diverse audiences**
  The toolkit is developed in both Bahasa Melayu and English. It is made available as a printed booklet and in PDF format to cater to different preferences.
- **To effectively reach and empower target communities**
  Designed for community leaders (MPKK), local NGOs, schoolteachers, youth groups, and vulnerable populations, such as low-income women, senior citizens, persons with disabilities (PWDs), migrant workers, and school children, the toolkit aims to support inclusive disaster preparedness and climate resilience.

6.1. Toolkit Development

6.1.1. Heatwave Preparedness Toolkit

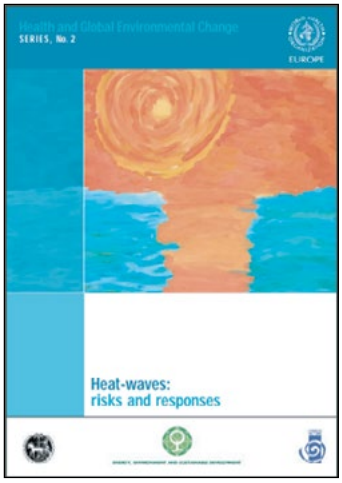
The Heatwave Toolkit was developed as a practical guide for vulnerable communities and community leaders to better understand, prepare for, and respond to extreme heat events. Considering the increasing frequency and severity of heatwaves, the toolkit aims to equip those most at risk with clear, accessible information centred on health protection and community resilience.

International and National Reference

The development process for the project was informed by a robust set of public health and climate resources. These include national and international guidelines aimed at managing the risks of heatwaves, protecting public health, and enhancing resilience to climate change. Key references include:

- **Pelan Tindakan Pengurusan Risiko Kesihatan Akibat Gelombang Haba** (Heatwave Risk Management Action Plan) by the Ministry of Health Malaysia (KKM): This document provides a comprehensive framework for addressing the public health risks associated with heatwaves, focusing on early warning signs, public health education, and targeted interventions to protect vulnerable populations.
- **World Health Organisation's (WHO) Public Health Advice on Preventing Health Effects of Heat and Heatwaves Risks and Responses**: This global guideline offers advice on how to mitigate the impacts of extreme heat events on human health, particularly in urban environments. It includes strategies for heat-health action plans, community engagement, and coordination between public health authorities and emergency services.
- **Heatwave Guide for Cities by the International Red Cross Red Crescent Movement**: This publication is a resource for urban centres to plan for and respond to heatwaves. It highlights the need for infrastructure improvements, public awareness campaigns, and community-based initiatives to reduce heat exposure and its associated health risks.
- **MET Malaysia**: Local definitions and climate data provided by MET Malaysia were instrumental in synchronising the toolkit with the national understanding of heatwave thresholds, triggers, and forecasting systems. This ensured that the content remained accurate, relevant, and responsive to Malaysia's specific climatic conditions.

Additionally, the toolkit was shaped in close consultation with public health professionals, including Dr Sharifah Hildah from the Department of Occupational and Environmental Health (KPAS-KKM), Pulau Pinang, ensuring that both global best practices and local health priorities were reflected.



The Heatwave Preparedness Toolkit is structured around three core areas and a trainer guide chapter to aid communities in understanding, responding to, and recovering from heatwave events.

Table 16: Structure of the Heatwave Preparedness Toolkit and Trainer Guide.

Chapter 1 Introduction	This chapter introduces the Heatwave Preparedness Module developed under the Penang Nature-based Climate Adaptation Programme (PNBCAP). It explains the purpose of the module, which is to raise awareness and improve community preparedness for extreme heat events.
Chapter 2 Heatwave Definition	This chapter provides clear guidance on how to identify a heatwave in the Malaysian context, using criteria established by MET Malaysia. This enables communities to take timely and informed action when extreme heat is occurring or anticipated.
Chapter 3 Heatwave Impacts	This chapter explores both the direct and indirect effects of heatwaves. It details how extreme heat can cause health issues and impact infrastructure. This section also gives special focus to **vulnerable groups** (children, elderly, people with disabilities, outdoor workers, etc.) and describes how heat affects both physical and mental health.
Chapter 4 Preparation for Heatwave	This chapter outlines **practical actions** that individuals, families, and communities can take to prepare for, respond to, and recover from a heatwave. This includes early preparation ahead of the heat season, adopting protective measures during extreme heat, and fostering resilience post-event.
Chapter 5 Trainer Guide	This section supports facilitators and community leaders in delivering the module effectively. It includes three practical training modules: **Module 1: Identifying Individuals at Risk** **Module 2: Mapping Community Heat Risk** **Module 3: Preventing and Reducing Health Impacts**

6.1.2. Flooding Preparedness Toolkit

The Flooding Preparedness Toolkit was developed as a practical guide for vulnerable communities and community leaders to better understand, prepare for, and develop resilience against floods. With the increasing frequency of flood and their significant effects, the toolkit aims to equip vulnerable communities with knowledge, skills and strategies to reduce flood disaster risks.

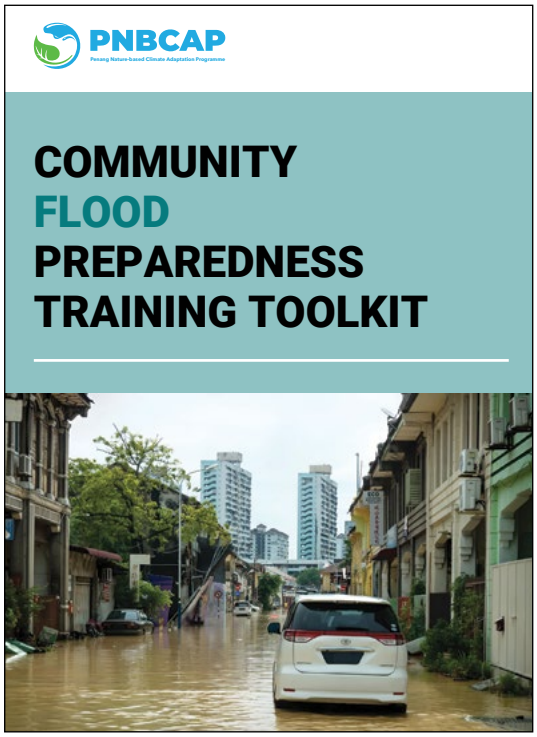
International and National Reference

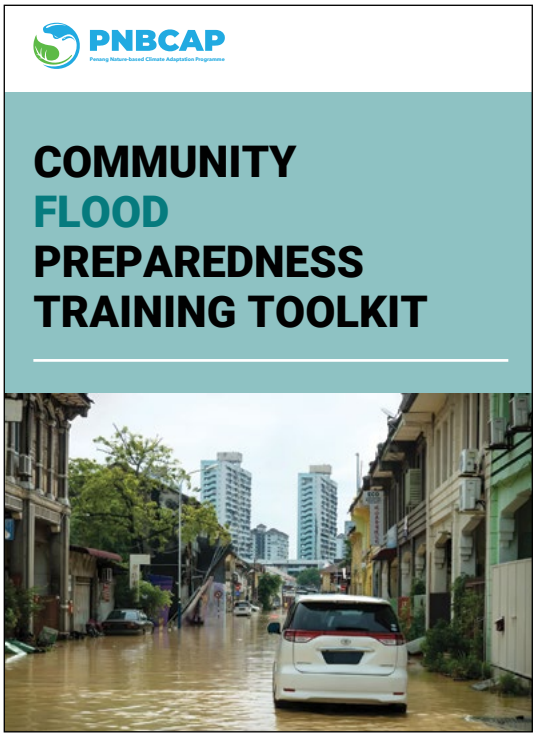
The development process for the project was guided by a comprehensive collection of essential public health and climate resources. These resources encompassed both national and international guidelines focused on mitigating flood risks, safeguarding public health and bolstering flood resilience. Key references included:

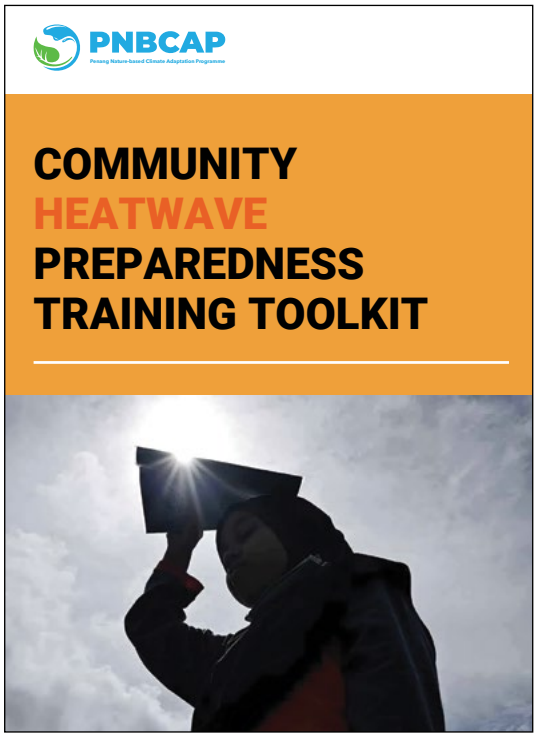
- **Penang Alert Official Portal** by the Penang State Government: A comprehensive website providing real-time updates and information on various emergencies and disasters. The portal features weather alerts, disaster-related information, and public announcements.
- **Kesiapsiagaan Menghadapi Bencana: Banjir & Pandemik COVID-19 (Disaster Preparedness: Floods & the COVID-19 Pandemic)** by National Disaster Management Agency (NADMA): Outlines the Standard Operation Procedures (SOPs), coordination, and health protocols to manage floods and COVID-19 simultaneously.
- **Pelan Tindakan Menghadapi Banjir (Flood Response Plan)** by the Ministry of Health Malaysia (KKM): Outlines the strategies for flood management, focusing on prevention, preparedness, emergency response and recovery to ensure health and safety during floods.
- **MyPublic InfoBanjir** by Department of Drainage (JPS): An application that provides real-time updates on flood warnings, water levels, and rainfall data.
- **myCuaca** by Malaysian Meteorological Department (MET Malaysia): A mobile application that provides real-time weather forecasts, warnings and updates on weather.

6.2. Published Modules

The toolkit is a living document. It will continue to evolve in line with new evidence, policy developments, and feedback from communities involved in the programme. As such, it will remain flexible and responsive to the changing realities of climate risk and community needs.







Access the training toolkits by clicking the link or scanning the QR code.

6.3. Community Preparedness Workshop

As part of PNBCAP's broader efforts to strengthen climate resilience, community workshops were conducted in high-risk areas to empower residents with the knowledge and skills needed to face extreme weather events. These workshops focused on raising awareness, building emergency response capabilities, and promoting practical, community-led adaptation strategies for heatwaves and flooding.

Objectives

As part of the PNBCAP initiative, a series of community workshops was conducted to build local capacity in responding to climate-related challenges, particularly heatwaves and floods. These workshops aimed to equip residents with the knowledge, practical skills, and tools necessary to enhance resilience and take proactive measures at the community level. The objectives of the workshops included:

1. **To raise awareness of climate risks and enhance understanding of extreme weather events**
   Educate participants on the health, social, and economic impacts of heatwaves and floods, while providing knowledge on the causes and effects of climate change. This enables informed decision-making and fosters long-term preparedness for extreme weather.
2. **To equip residents with emergency response skills**
   Offer hands-on training in first aid, evacuation procedures, and the use of early warning systems to improve local response capacity during emergencies.
3. **To promote cooperation, social resilience, and community-led action**
   Encourage collaboration among residents, community leaders, local authorities, and emergency services to strengthen coordinated action. This fosters a sense of shared responsibility, empowering residents to take initiative in preparing for and responding to climate threats.
4. **To introduce practical adaptation strategies**
   Share low-cost, accessible measures such as household flood protection and cooling techniques to reduce vulnerability at the household level.
5. **To empower advocacy for long-term resilience**
   Enable communities to engage constructively with policymakers, advocating for improved infrastructure and climate adaptation planning.

6.3.1. Four Pilot Communities

Kg. Makam, George Town

The workshop in Kg. Makam was conducted on 23 March 2025. Kg. Makam is a traditional Malay *kampung* comprised primarily of wooden houses, and it was selected for its significant vulnerability to both heat and flooding. Located adjacent to Sungai Pinang, the village is prone to flooding. In 2017, a major flood severely impacted the entire village.

The village is predominantly inhabited by Malay Muslims, as the land is *tanah wakaf* administered by the Penang Islamic Religious Department (JAIPP). Kg Makam's population mainly consists of older adults, many of whom have lived in the area for decades. The community is highly intergenerational, with elderly residents often caring for grandchildren and participating in communal activities. The workshop was attended by elderly women, young children, the *bilal* from the local mosque, and representatives from the MBPP office.

As the first site for the pilot workshop, Kg. Makam provided valuable insights that informed the refinement of the toolkit. Participant feedback helped shape the content and delivery methods, ensuring that they were appropriate to the local context and responsive to the lived experiences of residents.

Figure 24: Dr Sharifah presenting on the effects of heat on health.

Figure 25: Women mapping out flood evacuation routes during a community resilience workshop, showcasing their role in local disaster preparedness.

Lebuh Macallum, George Town

Lebuh Macallum was selected as a workshop location due to its status as a heat-prone urban area and the specific vulnerabilities faced by its residents. Located in the heart of George Town, the neighbourhood is densely populated and characterised by predominantly low- to medium-cost high-rise flats, including developments such as Gat Lebuh Macallum Flats and Sri Saujana Apartments.

The community consists largely of ethnic Chinese and Indians, with a significant proportion of elderly residents alongside working adults and young children. The built environment, marked by limited green spaces and high-density concrete structures, contributes to the urban heat island effect, making the area particularly susceptible to extreme heat.

The workshop held on 15 March 2025 attracted a diverse group of participants, including senior citizens, youth, and local community representatives. Participants came from various ethnic backgrounds, namely Malay, Indian, and Chinese.

Figure 26: Group photo with participants from the workshop at Lebuh Macallum, featuring a diverse mix of seniors, youth, and community members from Malay, Indian, and Chinese backgrounds.

Figure 27: Participants join the quizzes for a chance to win prizes during the interactive sessions.

Kg. Naran, Bayan Lepas

The workshop in Kg. Naran was held on 15 March 2025. Kg. Naran was selected due to its location in a flood-prone area, making it an ideal site for the workshop. Situated right next to the Penang International Airport, the village consists of low-density housing and is predominantly inhabited by Chinese residents. The community faces significant flood risks due to its proximity to the airport and low-lying terrain.

The workshop was well-attended by residents, including the community leader, young adults, person with disability (PWD) and senior citizens. Given the predominantly Chinese background of the participants, the workshop was conducted in Mandarin to ensure clear communication and comprehension. The residents expressed their gratitude for the workshop, emphasising the importance of such initiatives in enhancing their preparedness for flood events.

Figure 28: Participants receiving waterproof emergency grab bags equipped with flood preparedness tools such as a torchlight and whistle.

Figure 29: Mr. Lim, a well-connected community member, assisted with the organisation of the training session.

6.3.2. Participant Engagement & Feedback Highlights

The training programme recorded strong attendance and meaningful engagement, even though they were held during Ramadhan. The sessions were attended by a diverse group of participants, and the feedback received highlighted the relevance, usefulness, and positive impact of the workshops. Expert involvement further enhanced trust and the quality of interaction.

Attendance and Diversity

- **83% average attendance** (target: 30 per community)
- High turnout **despite Ramadhan**
- **Diverse participation** by age and ethnicity
- Lower diversity in certain areas (e.g., Kg. Naran: Chinese majority; Kg. Makam: Malay women)

Participants Feedback

- **Overwhelmingly positive** survey responses
- Participants gained knowledge, requested more sessions
- Kg. Naran residents felt **appreciated & included**

Key Takeaways

- **High engagement** Community members showed strong commitment and interest by attending actively during Ramadhan.
- **Community felt empowered** Participants felt heard, valued, and were confident to share and apply what they have learned within their communities.
- **Experts enhanced the impact** The involvement of the Penang Health Department and disaster officials boosted credibility, addressed real concerns, and built lasting trust.

6.4. Challenges and Adaptation

While the programme was successfully delivered, several challenges emerged during planning and implementation. These were addressed through adaptive strategies to ensure meaningful participation and lasting impact.

Key Challenges in Implementation

1. **Timing of Workshops**
   The workshops were held during Ramadhan, which affected attendance due to fasting and reduced daytime activity. Scheduling had to be adjusted to accommodate religious commitments without compromising outreach.
2. **Engaging Local Authorities (MPKK)**
   Gaining the support of the MPKK was critical but time-consuming. Multiple rounds of discussions were required to secure their commitment and clarify the programme's benefits to the community.
3. **Low Initial Community Participation**
   The lack of familiarity with the programme and absence of incentives led to low turnout. Community members were hesitant to commit time without clear, immediate benefits.
4. **Toolkit Development Delays**
   Creating the Heatwave and Flooding Training Toolkit required expert validation, especially from the Penang Health Department. This resulted in multiple revisions and delayed the finalisation of materials.
5. **Balancing Simplicity and Scientific Accuracy**
   Ensuring that content of the toolkit was scientifically accurate yet easily understood by all community members was a major challenge. The team had to distill complex health information into accessible forms.

To encourage participation, the training session incorporated interactive methods such as group discussions, hands-on exercises, and local case studies that resonated with the participants' experiences. Feedback was collected to improve the content, format, and delivery methods for future training sessions; ensuring that they remain relevant, inclusive, and responsive to the evolving needs of communities facing climate challenges. To encourage participation, the team has carried out the following steps:

1. **Responsive Adjustments**
   The team adapted by offering incentives such as rice to encourage attendance. Participation improved markedly, showing that small tangible rewards are effective, especially in low-income areas.
2. **Interactive and Inclusive Activities**
   Workshops included activities like grab bag preparation, heat risk identification with thermal cameras, and mapping of vulnerable areas. These hands-on elements increased community involvement and ownership.
3. **Tailored Scheduling**
   Sessions were rescheduled and structured flexibly to suit participants' availability, particularly around religious events. This improved attendance and reduced scheduling conflicts.
4. **Improved Communication with Stakeholders**
   Greater effort was made to communicate the roles and benefits of the programme to both community members and local authorities, ensuring better alignment and support.
5. **Structured Incentive Programs (Future Recommendation)**
   A formalised incentive scheme—ranging from food to household items or certification—could sustain interest and recognise participation.

7.

FUTURE PATHWAYS: COMMUNITY TRAINING, SCALING AND INTEGRATION

Following the initial rollout, the next phase of the training programme will focus on expanding its reach, deepening its impact, and embedding it within broader climate resilience efforts. Future annual trainings will continue to take place in the same locations until 2027, with the aim of strengthening the adaptive capacity of local communities over time through consistent engagement and progressive learning.

To support continuity and community ownership, a local leader has been identified from each participating location. These leaders will serve as focal points for coordinating future sessions, mobilising participants, and guiding local adaptation efforts. Attendance lists have been collected to track participation and engagement, and to ensure that outreach remains inclusive and representative.

Scaling and Replication

To broaden the reach of the training programme, partnerships with local governments, academic institutions, and community-based organisations will be strengthened. These collaborations will facilitate the expansion of training into additional *mukims* and districts beyond the initial pilot areas. In addition, cross-cutting partnerships will be enhanced through the integration of school-based programmes and public health components. Schools will serve as key platforms for climate education and early preparedness, while collaboration with the public health sector will ensure that training materials also address health-related risks such as heat stress, disease outbreaks, and overall community well-being. Digital resources and documentation will be made available publicly to support replication efforts nationwide. These cross-sector efforts aim to institutionalise resilience and embed climate adaptation as a shared responsibility across all levels of society.

To support scaling and consistent implementation, the training toolkit will be expanded and adapted for broader use. This includes the development of modular, locally relevant materials that can be tailored to diverse community contexts.

Facilitators will be equipped through structured training-of-trainers programmes, enabling local champions to deliver effective and culturally appropriate sessions. This capacity-building approach ensures that knowledge is retained and disseminated within communities over the long term.

Dissemination will be supported through both digital and print formats, including the publication of toolkits, guides, and real-world case studies. These resources will be designed for ease of access and usability across a range of stakeholder groups.

A robust Monitoring, Evaluation, and Learning (MEL) framework will be embedded to assess training effectiveness and guide programme improvements. A continuous feedback loop will capture local insights, measure outcomes, and support ongoing refinement of the content and delivery methods. This adaptive learning process will enhance long-term relevance, effectiveness, and impact.

Integration with MASH and Broader Programmes

The training programme will be closely linked with the Malaysian Adaptation Sharing Hub (MASH)—the national knowledge management platform aimed at capturing and disseminating adaptation practices. By contributing training materials, impact stories, methodologies, and evaluation results to MASH, the initiative ensures knowledge continuity, transparency, and accessibility for stakeholders across Malaysia.

Through the integration of MASH and PEARL website/app and reporting mechanisms, insights from these trainings can inform policy, guide programme refinement, and inspire action in other municipalities. This integration also strengthens the training's alignment with national climate adaptation strategies, including the Malaysia National Adaptation Plan (MyNAP), supported by key partners such as UN-Habitat, the Adaptation Fund, Think City, NAHRIM, MBPP, JPS, and NRES (formerly known as KASA).

In addition to MASH, future trainings will explore synergies with other components of the programme, including urban greening efforts, climate-resilient infrastructure design, and community-driven planning processes. Embedding climate resilience across these sectors ensures a holistic, systems-based approach to building adaptive capacity in vulnerable urban and peri-urban areas.

8.
CONCLUSION

The Penang Nature-based Climate Adaptation Programme (PNBCAP) has offered valuable insights into strengthening community resilience in the face of climate change, particularly in relation to heatwaves and flooding. Through pilot workshops in George Town and Bayan Lepas, the programme demonstrated the effectiveness of localised, community-driven approaches to adaptation—fostering awareness, building capacity, and encouraging proactive engagement across vulnerable groups.

Central to this initiative is the Penang Vulnerability Assessment and Action Plans in Social Resilience Strengthening, guided by the UN-Habitat Planning for Climate Change framework. This framework is well-suited to Penang's urban context, where integrating climate strategies into broader development goals is critical. It supports the design of targeted, inclusive action plans—particularly adapted for low- and middle-income communities—reflecting Penang's diverse socio-economic landscape.

The action plan specifically addresses the vulnerabilities of urban communities in George Town and Bayan Lepas. These areas face heightened climate risks due to their geographic exposure, land use patterns, and population profiles. Vulnerable groups—including low-income households, migrant workers, older adults, women, children, and individuals with disabilities—remain the programme's priorities.

The methodology employed involves a combination of technical assessments and participatory strategies. Exposure, sensitivity, and adaptive capacity analyses are used to evaluate community risk, supported by community screening and Focus Group Discussions (FGDs) that ensured that local insights guide decision-making. These form the foundation for detailed, place-based action plans that balance immediate needs with long-term resilience goals.

Despite initial timing and logistical constraints, strategic planning—including incentive mechanisms and localised training—ensured strong participation and engagement. Collaboration with healthcare and disaster risk professionals added both credibility and depth, while workshop feedback informed the ongoing refinement of toolkits and training.

Looking ahead, PNBCAP will scale its work through additional workshops and community engagements across high-risk areas in Penang. The programme's alignment with the UN-Habitat framework ensures that future interventions are both evidence-based and context-sensitive, with strong potential for replication in other urban settings in Malaysia.

Key recommendations from the action plan include:

- **Promoting Community Awareness** of climate risks, especially heat-related health impacts.
- **Fostering Social Cohesion** to strengthen support networks during crises.
- **Improving Flood Resilience** through community-led local authority collaboration on early warning systems and resource stockpiling.
- **Enhancing Emergency Preparedness** via education on first aid, evacuation, and survival.
- **Increasing Understanding of Waterway Management** to reduce flood risks.
- **Strengthening Long-term Resilience** by encouraging the use of community spaces and inclusive engagement.

By continuing to centre community voices and build partnerships with local institutions, PNBCAP is well-positioned to create a durable, inclusive, and adaptable model for climate resilience in Penang—one that supports shared responsibility and long-term sustainability in the face of growing climate challenges.

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