ADAPTATION FUND

REQUEST FOR PROJECT/PROGRAMME FUNDING FROM THE ADAPTATION FUND

The annexed form should be completed and transmitted to the Adaptation Fund Board Secretariat by email or fax.

Please type in the responses using the template provided. The instructions attached to the form provide guidance to filling out the template.

Please note that a project/programme must be fully prepared (i.e., fully appraised for feasibility) when the request is submitted. The final project/programme document resulting from the appraisal process should be attached to this request for funding.

Complete documentation should be sent to:

The Adaptation Fund Board Secretariat
1818 H Street NW
MSN P4-400
Washington, D.C., 20433
U.S.A
Fax: +1 (202) 522-3240/5
Email: afbsec@adaptation-fund.org

ADAPTATION FUND

PROJECT/PROGRAMME PROPOSAL TO THE ADAPTATION FUND

PART I: PROJECT/PROGRAMME INFORMATION

Project/Programme Category:	Regular
Country/ies:	Malaysia
Title of Project/Programme:	Nature-based climate adaptation programme for the urban areas of Penang island
Type of Implementing Entity:	Multi-lateral implementing entity
Implementing Entity:	UN-Habitat
Executing Entities:	Ministry of Energy, Science, Technology, Science and Climate Change (MESTECC), Majlis Bandaraya Pulau Pinang (MBPP), Jabatan Pengairan Dan Saliran (JPS) Think City
Amount of Financing Requested:	$US 10,000,000

Project Summary

The main goal of the programme is to enhance urban resilience and reduce human and ecosystem health vulnerability to climate change impacts and extreme weather events by implementing nature-based solutions (NBS) to reduce surface temperatures and storm water runoff. The programme also seeks to increase social resilience and build institutional capacity.

Supported by an extended collaboration between stakeholders at local, regional and national levels (including government agencies, scientific support institutions and civil society), the programme has a strong community-focused approach, engaging with the most vulnerable groups of society in order to assess their main vulnerabilities in a collaborative effort.

The programme will pioneer the use of NBS solutions in Malaysia. It is designed to be demonstrative / proof of concept with a strong knowledge codification component so that it can be scaled in Malaysia and elsewhere in the region. It is structured around the following components:

Component 1: Built projects for greening Penang (USD 3,175,000)
Component 2: Built projects for stormwater and flood management (USD 2,725,000)
Component 3: Comprehensive vulnerability / baseline assessment and action plans in targeted communities (USD 160,000)
Component 4: Social resilience programme (USD 975,000)
Component 5: Institutional capacity and knowledge transfer platform (USD 1,306,014)

Project / Programme Background and Context

Introduction

Penang is a state located in north-western Malaysia, five degrees north of the equator. It has an area of 1,049 km^2 and comprises two local authorities – one covering Penang Island (Majlis Bandaraya Pulau Pinang) and the other the mainland (Majlis Bandaraya Seberang Peral). The former is one of the two major project partners. The state is further divided into five administrative districts which are further divided into mukims (sub-districts). Two urban mukims located on the island – George Town and Bayan Lepas – are the focus of a proposed nature-based solutions (NBS) climate adaptation programme (see Figure 1).

Image 1. View over George Town mukim and the UNESCO World Heritage Site.

Source: Image taken by Think City 2018

The goal of the adaptation programme for the urban areas of Penang Island is to use NBS to 1) reduce climate change impacts (increased temperature and stormwater) including threats to human life, infrastructure and property associated with extreme weather events; and 2) strengthen social resilience and institutional capacity. The programme includes a community-focused approach as well as a strong knowledge transfer component to ensure the methodology can be scaled and adopted in the near future by other cities in Malaysia and the region.

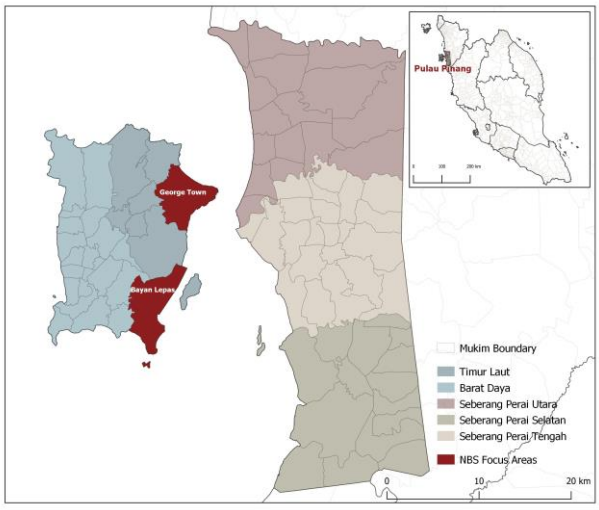


Figure 1: Penang State Administrative Regions and NBS Programme Focus Areas

Socio-economic context

Population

Penang state has an estimated population of 1,767,200, with 809,000 (46%) living on the island and 958,200 (54%) on the mainland, with densities of 26.9 people/ha and 12.8 people/ha respectively[1]. The Timur Laut district is the most densely populated with 45.9 people/ha.

Economy and labour force

Penang's gross domestic product (GDP) in 2018 was RM91.18 million (USD ~21.88 million), contributing

[1] Department of Statistics Malaysia (2019) *My Local Stats Pulau Pinang*. Putrajaya.

6.7% of national GDP[2]. Annual GDP growth of Penang was 5.1% while GDP per capita was RM52,937 (USD ~12,703). The economy (Table 1) is driven by an advanced manufacturing sector (including semiconductor, electrical & electronic and medical devices) and services (mainly cultural activities and tourism).

Table 1: Penang's GDP by type of economic activity at constant 2015 prices[3]

	RM million				% share to GDP			
Type of economic activity	**2015**	**2016**	**2017**	**2018**	**2015**	**2016**	**2017**	**2018**
Agriculture	2,084	1,988	2,032	1,968	2.7	2.4	2.3	2.2
Mining and quarrying	124	135	144	151	0.2	0.2	0.2	0.2
Manufacturing	33,597	35,411	37,426	39,460	43.0	42.9	43.1	43.3
Construction	2,712	2,984	2,689	2,586	3.5	3.6	3.1	2.8
Services	38,917	41,167	43,430	46,115	49.8	49.9	50.1	50.6
Utility, transport & storage and information & communication	8,617	9,468	10,168	10,967	11.0	11.5	11.7	12.0
Wholesale and retail trade, food & beverage and accommodation	12,356	13,061	13,906	14,976	15.8	15.8	16.0	16.4
Finance and insurance, real estate and business services	7,872	8,121	8,395	8,742	10.1	9.8	9.7	9.6
Other services	4,695	4,894	5,118	5,356	6.0	5.9	5.9	5.9
Government services	5,378	5,622	5,844	6,074	6.9	6.8	6.7	6.7
Import duties	712	808	1,017	894	0.9	1.0	1.2	1.0
GDP at purchasers' prices	78,146	82,493	86,738	91,175	100.0	100.0	100.0	100.0

Source: Department of Statistics Malaysia (2019) My Local Stats Pulau Pinang. Putrajaya

Penang's labour force is 849,400 people, with a participation rate of 67.7% (79.5% for men and 55.9% for women) and an unemployment rate of 2.2%[4]. The majority of jobs (95.7%) are located in urban areas. Reflecting GDP contributions, services accounts for 57.0% of jobs, followed by manufacturing 34.5%, construction 6.8%, agriculture, forestry and fishing 1.6%, and mining and quarrying 0.1%.

Income, poverty and vulnerability

The 2016 median monthly household income in Penang was RM5,409 (~USD1,296), 3.5% higher than the national median of RM5,228. There is an urban-rural divide with the median rural household income at 79.6% of urban households (i.e. RM4,365 versus RM5,477). Households on the island earn more than those in the mainland. Penang's Gini co-efficient was 0.356 versus 0.399 nationally.

Penang's households spent the largest proportion of total monthly expenditure on housing, water, electricity, gas and other fuels (RM1,232), amounting to nearly 30% of total expenses. This is followed by food and non-alcoholic beverages (15.9%; RM667.78).

Although Penang has nominal extreme poverty (0.1%), an estimated 10-20% of households are below the World Bank's upper middle-income International Poverty Line set at US$5.50 per day[5]. These households will bear the brunt of climate change impacts as they experience more severe exposure (e.g.

[2] Department of Statistics Malaysia (2019) *My Local Stats Pulau Pinang*. Putrajaya.
[3] Department of Statistics Malaysia (2019) *My Local Stats Pulau Pinang*. Putrajaya.
[4] Department of Statistics Malaysia (2019) *My Local Stats Pulau Pinang*. Putrajaya.
[5] Estimated from Department of Statistics Malaysia (2017) *Household Income and Basic Amenities Survey Report by State and Administrative District, Pulau Pinang 2016.* Putrajaya using the World Bank's upper middle-income International Poverty Line.

working as labourers outdoors) and at the same time have the least capacity to protect themselves from overheating, food shortage and natural hazards such as flooding and drought.

There are several vulnerable communities in Penang island: a) communities living in areas that are flood prone and coincide with the highest concentration of elderly in Penang; b) Low income groups with no access to air conditioning; c) Women and girls (women are the primary caregivers, which is demonstrated by their low labour force participation rate (59%).

Landuse and environment

Broadly, Penang island has an urban east coast, rural west coast and central green spine. Based on official data from the Department of Town and Country Planning, agriculture has the highest state landuse followed by forest and residential. There are marked differences between island and mainland, with the island being significantly more urbanised, but also having a higher proportion of forest (see Table 2).

Table 2: Penang's Landuse

	Island		Mainland		Total	
Land Use	Hectares	Percentage	Hectares	Percentage	Hectares	Percentage
Water Body	976.7	3.2	4,990.8	6.6	5,970.7	5.6
Forest	13,394.2	43.9	3,625.1	4.8	17,063.2	16.0
Industry	637.0	2.1	3,452.1	4.6	4,091.2	3.8
Infrastructure and Utility	130.0	0.4	771.6	1	902	0.8
Institution and Public Facilities	1,481.4	4.9	3,167.4	4.2	4,653.7	4.4
Commercial	585.1	1.9	1,323.5	1.7	1,910.5	1.8
Beach	18.0	0.1	-	0	18.0	<0.1
Mixed Development	1.7	<0.1	0.2	<0.1	1.9	<0.1
Transport	2,742.8	9.0	6,103.7	8.0	8,855.5	8.3
Agriculture	4,039.7	13.2	32,910.2	43.3	36,963.1	34.7
Residential	4,176.2	13.7	10,979.3	14.5	15,169.2	14.2
Vacant Lot	1,920.9	6.3	7,574.9	10	9,502.1	8.9
Open Space and Recreational Area	417.0	1.4	1,030.5	1.4	1,448.9	1.4
Total Area (Hectare)	3,0520.7	100	75,929.4	100	10,6550.1	100

Source: Department of Town and Country Planning

Images 2a and 2b. Remote sensing (Landsat 8) on landcover for Penang Island shows that in 2019 forest remains the highest (49.1%) though it has declined from 1988 (51.1%). Developed areas have increased from 15.9% in 1988 to 25.8% in 2019. The percentage of agriculture land remains steady at 14.5%, while shrubland and barren land have declined (11.5% to 8.7%; and 7.0% to 2.0% respectively). The significant increase of development in Penang island since 1988 has substantially increased paved areas, reducing stormwater natural onsite infiltration and contributing to runoff leading to flooding.

Source: Developed by Think City.

Penang state has 1,447 hectares of gazetted open spaces and recreational areas. Based on population figures for 2017, this equates to 8.3m^2 per capita, well short of the national standard 20m^2 per capita.[6] Based on this standard, the existing spaces are only enough for a population of 723,770 – less than half of Penang's current population. This is equivalent to a deficit of 1,204 ha of green and open space on the island, and 842 ha on the mainland.

Climate change impacts in Penang

Southeast Asia is one of the three regions in the world which will be hardest hit by climate change.[7] The main impacts in Malaysia will be increasing temperatures, increasingly frequent and severe extreme weather events as well as sea level rise. In Penang, however, the most significant impacts are the first two, as sea level rise is not estimated to have a significant impact in urban areas in 2050 under the most pessimistic scenarios.[8]

Increasing temperatures will severely impact Malaysia, a country with a tropical rainforest climate and uniformly high temperatures and humidity throughout the year. According to the World Health Organisation, in 2050 the country will experience 200 days per year with heatwaves (in a scenario of a 3°C increase by 2100),[9] compared with 20 days in the 1980s.[10] The impact of temperature rise in Malaysia will be most felt in cities, due to the urban heat island (UHI) effect, which can increase urban temperatures up to 8°C compared to the surrounding natural or rural areas. While the impacts on public health will be high, hospitals in the country currently do not systematically identify (and code accordingly) heat stress or heat stroke, instead registering these health impacts as being of respiratory or cardiac natures.

Changes in weather patterns are already manifesting. The estimates for climate change impact on the Malaysian economy are a 12% reduction of GDP/year in the long term (in a scenario of a 3°C increase by 2100).[11] The same study estimates for Australia a reduction of 1% GDP/year in the long term, 0.6% for

[6] Think City (2018) Pulau Pinang Green and Open Space Network Study
[7] IPCC (2018) 'Special Report on Global Warming of 1.5°C'
[8] Kulp, S.A., Strauss, B.H. (2019) 'New elevation data triple estimates of global vulnerability to sea-level rise and coastal flooding'. *Nat Commun,* 10, 4844 doi:10.1038/s41467-019-12808-z
[9] An approximate increase of 3°C by 2100 is the current estimation if all unconditional NDCs are implemented, according to the United in Science (2019) *High-level synthesis report of the latest climate science information convened by the Science Advisory Group of the UN Climate Action Summit 2019*.
[10] WHO (2015) 'Climate and Health Country profile for Malaysia'
[11] Kompas, T., Pham, V. H., & Che, T. N.(2018). The effects of climate change on GDP by country and the global economic gains from complying with the Paris Climate Accord. Earth's Future,6, 1153–1173. https://doi.org/10.1029/2018EF000922

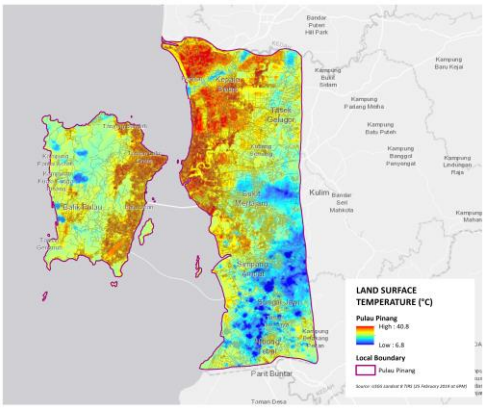
the USA and 0.2% for Canada. Consequently, the divide between Malaysia and developed countries' economies will increase. Another study suggests that changes in temperature and rainfall patterns are estimated to lead to a crop yield reduction of between 10 and 15%.[12] This will likely lead to an increase in food costs, which tend to impact disproportionately more vulnerable communities. This programme introduces concrete adaptation strategies and projects in order to reduce these impacts, as well as to increase social resilience and build institutional capacity.

Temperatures

Table 3 shows the magnitude of changes of annual and monthly mean temperatures at Bayan Lepas climate station during the 1951-2018 period. A significant increasing trend was found in both the annual and monthly mean temperatures from 1951 to 2018 at 95% confidence level, with magnitudes ranging from 0.18 to 0.27 °C/decade. The mean temperature (°C) increase from 1951 to 2018 is 1.50°C.

Table 3: Changes in mean temperature from 1951 to 2018 at Bayan Lepas station (trend at a 95% significance level)

	Mean Temp Change (°C)
Jan	**1.53**
Feb	**1.50**
Mar	**1.66**
Apr	**1.24**
May	**1.45**
Jun	**1.71**
Jul	**1.86**
Aug	**1.52**
Sep	**1.38**
Oct	**1.34**
Nov	**1.50**
Dec	**1.34**
Annual	**1.50**



Source: Produced by the USM's Climatology department, 2019

Image 3. Remote sensing (Landsat 8) for surface temperatures in Penang island. Urban areas are significantly higher than neighbouring natural or rural areas by approximately 8°C due to the urban heat island effect.

Source: Image retrieved by Think City, 2019

Rainfall and flooding

Rainfall has been increasing and is predicted to increase further for all peninsular Malaysia. [13]

[12] Firdaus, R.B., Latiff, I.A., Borkotoky, P. (2012) 'The impact of climate change towards Malaysian paddy farmers', *Journal of Development and Agricultural Economics,* 5(2), pp. 57-66 doi: 10.5897/JDAE12.105

[13] Ministry of Energy, Environment, Science, Technology and Climate Change (2018) *Malaysia Third National Communication and Second Biennial Update Report to the UNFCCCs*

Table 4. Observed and projected rainfall in Malaysia

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)

Souce: Malaysia Third National Communication and Second Biennial Update Report to the UNFCCC (2018)

With an average annual rainfall for the past decade of 2,434mm, flooding is a major issue in Penang. In the past decade the average annual rainfall from 2010 to 2018 has seen an unusual high increase of 29.6% (Table 5) above NAHRIM's projections.

A combination of increased urbanisation, heavy rain and high tide inevitably results in floods as stormwaters are unable to discharge into the sea or infiltrate into the ground table. These two factors, expanding built areas resulting in reduced stormwater absorption capacity and increased volume of rain combined with yet a third factor, decaying infrastructure, inevitably lead Penang island to become increasingly exposed and sensitive to flooding.

Table 5. Average annual rainfall for Penang island (2010-2018) showing an increasing trend.

Year	Average Annual Rainfall (mm)
2010	2088.65
2011	2260.38
2012	2359.86
2013	2519.10
2014	2389.98
2015	2453.13
2016	2493.41
2017	2642.25
2018	2706.76

Source: Data provided by JPS.

Increased rainfall and changes in patterns are already causing significant damage in Penang. In 2016, 47 cases of floods, many of them flash floods, were reported, with the most urbanised districts - Seberang Perai Tengah (mainland) and Timur Laut (island) - reporting the highest occurrence (19 and 12 cases respectively).[14] This is evidence that the capacity of drainage infrastructure in urban areas is unable to cope with increasing rain intensity and putting human life, property and the economy at risk.

In November 2017 Penang was hit by its worst recorded floods, with 7 lives lost and half of urban areas submerged. A total of 159 areas reported being affected by floods, 68 of had never previously flooded.[15] Losses to manufacturing were estimated at RM200 million and RM300 million (~USD 48 to 72 million).[16] It also impacted 2,626 farmers and 3,464 hectares of agricultural land, with a total economic loss estimated of approximately RM5.7 million (~USD 1.37 million) . In the fisheries sector, the estimated losses were of approximately RM57.5 million (~USD 13.8 million).[17]

[14] Jabatan Pengairan dan Saliran Malaysia (2018) *Laporan Banjir Tahunan Bagi Tahun 2016/2017* [online]. Available at: http://h2o.water.gov.my/man_hp1/Banjir_Tahun1617.pdf (Accessed: 7 November 2019)
[15] Penang Institute & Economic Planning Division, Penang (2019) *Penang Economic and Development Report 2017/2018.* George Town, Penang: Penang Institute.
[16] Federation of Malaysian Manufacturers Penang, cited in The Star (2019) '1,000 companies lose RM300mil to Penang floods', *The Star*, 10 November 2017 [online]. Available at: https://www.thestar.com.my/business/business-news/2017/11/10/1000-companies-lose-rm300mil-to-penang-floods (Accessed: 7 November 2019)
[17] Penang Institute & Economic Planning Division, Penang (2019) *Penang Economic and Development Report 2017/2018.* George Town, Penang: Penang Institute.

Public health

The consequences of rising temperatures and more extreme weather associated with climate change now have immediate health consequences.[18] [19] [20] In Malaysia, this includes heat-stress related illness, injury from floods and storms, impacts on mental health due to loss of property and life, increased allergies due to weather changes, increased vector and water-borne diseases and potential malnutrition due to related to food insecurity.

There is research in Malaysia showing the impact of climate change on heat-related illnesses[21] and the growing threat of vector or water-borne diseases such as dengue, leptospirosis,[22] chikungunya and others.[23] A 2016 study revealed a potential increase of malarial cases by 15% with the rise in ambient temperature by 1.5°C in 2050 and positive correlation between rainfall and dengue and postulated that increased rainfall and surface temperature favoured the propagation and spread of dengue[24]. In Penang there has been a notable increase in dengue cases in recent years (Table 6) which supports that under current climate predictions the incidence of dengue and other vector or water-borne diseases is extremely likely to increase.

Table 6: Number of cases for major communicable diseases reported in Penang, 2012-2016.

Disease	2012	2013	2014	2015	2016
Dengue fever/Dengue hemorrhagic fever	791	1,053	3,141	5,830	2,756
Tuberculosis (all forms)	1,245	1,230	1,252	1,283	1,385
Measles	245	153	53	11	7
HIV infections (all forms)	137	111	110	103	105
Food poisoning	360	556	2,227	497	609
Hepatitis B	40	21	13	33	20
Syphilis (all forms)	87	95	57	63	57
Malaria	37	39	37	17	3
Hand, foot and mouth disease	1,579	1,205	1,449	758	3,019
Typhoid and paratyphoid fever	2	6	6	8	4
Leptospirosis	128	98	192	140	43
Influenza	216	785	380	642	-

Source: 2016 Annual Report, Penang State Health Department, Malaysia

The severity of the health impact is not just determined by the level of exposure (e.g. larger mosquito population) but also the sensitivity and adaptive capacity of the individuals or the community.[25] An outdoor worker (high exposure) with diabetes (higher sensitivity) who does not have the financial resources for air conditioning at her home or pay for higher medical bills (low adaptive capacity) would experience a very high vulnerability of her health due to climate change.

Despite the evidence, there is very limited awareness among the community and health practitioners.[26] As a result, climate related illnesses are not systematically diagnosed as such or wrongly coded. As a result, less accurate statistics severely limits the preparedness of the health system. Additional research and capacity building is therefore required to fill the large knowledge gaps in the Malaysian public health system.

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[18] Watts, N., Adger, W.N., Agnolucci, P., et al. (2015) "Health and climate change: policy responses to protect public health", The Lancet, Vol. 386 pp.1861-914 accessed on https://www.thelancet.com/pdfs/journals/lancet/PIIS0140-6736(15)60854-6.pdf

[19] Watts, N., Amann, M., Arnell, N., Ayeb-Karlsson, S., Belesova, K., Boykoff, M., Byass, P., et al. (2019), "The 2019 report of The Lancet Countdown on health and climate change: ensuring that the health of a child born today is not defined by a changing climate", *The Lancet*, Vol. 394 No. 10211, pp. 1836–1878.

[20] Beggs, P.J., Zhang, Y., Bambrick, H., Berry, H.L., Linnenluecke, M.K., Trueck, S., Bi, P., et al. (2019), "The 2019 report of the MJA Lancet Countdown on health and climate change: a turbulent year with mixed progress", *Medical Journal of Australia*, p. mja2.50405.

[21] Mansor, Z. Ismail, N.H., Ismail, R., Hashim, J.H. (2019), "Thirst as the threshold symptom to prevent worsening heat-related illness", *Medical Journal of Malaysia*, Vol. 74 No. 1, accessed online http://www.e-mjm.org/2019/v74n1/heat-related-illness.pdf

[22] Garba, B., Bahaman, A.R., Bejo, S.K., Zakaria, Z., Mutalib, A.R. and Bande, F. (2018), "Major epidemiological factors associated with leptospirosis in Malaysia", *Acta Tropica*, Elsevier, Vol. 178 No. September 2017, pp. 242–247.

[23] Servadio, J.L., Rosenthal, S.R., Carlson, L. and Bauer, C. (2018), "Climate patterns and mosquito-borne disease outbreaks in South and Southeast Asia", *Journal of Infection and Public Health*, King Saud Bin Abdulaziz University for Health Sciences, Vol. 11 No. 4, pp. 566–571.

[24] Tang, K.H.D. (2019), "Climate change in Malaysia: Trends, contributors, impacts, mitigation and adaptations", *Science of the Total Environment*, Elsevier B.V., Vol. 650 No. September, pp. 1858–1871.

[25] Turner, B.L., Kasperson, R.E., Matson, P.A., McCarthy, J.J., Corell, R.W., Christensen, L., Eckley, N., et al. (2003), "A framework for vulnerability analysis in sustainability science", *Proceedings of the National Academy of Sciences*, Vol. 100 No. 14, pp. 8074–8079.

[26] See previous footnote (Watts, 2019)

Rationale for the selection of focus areas

Two sub-districts or mukims have been selected as focus for the first phase of the nature-based climate adaptation programme for the urban areas of Penang island. They have been selected based on a combination of their likely climate change impacts, land use and community vulnerabilities.

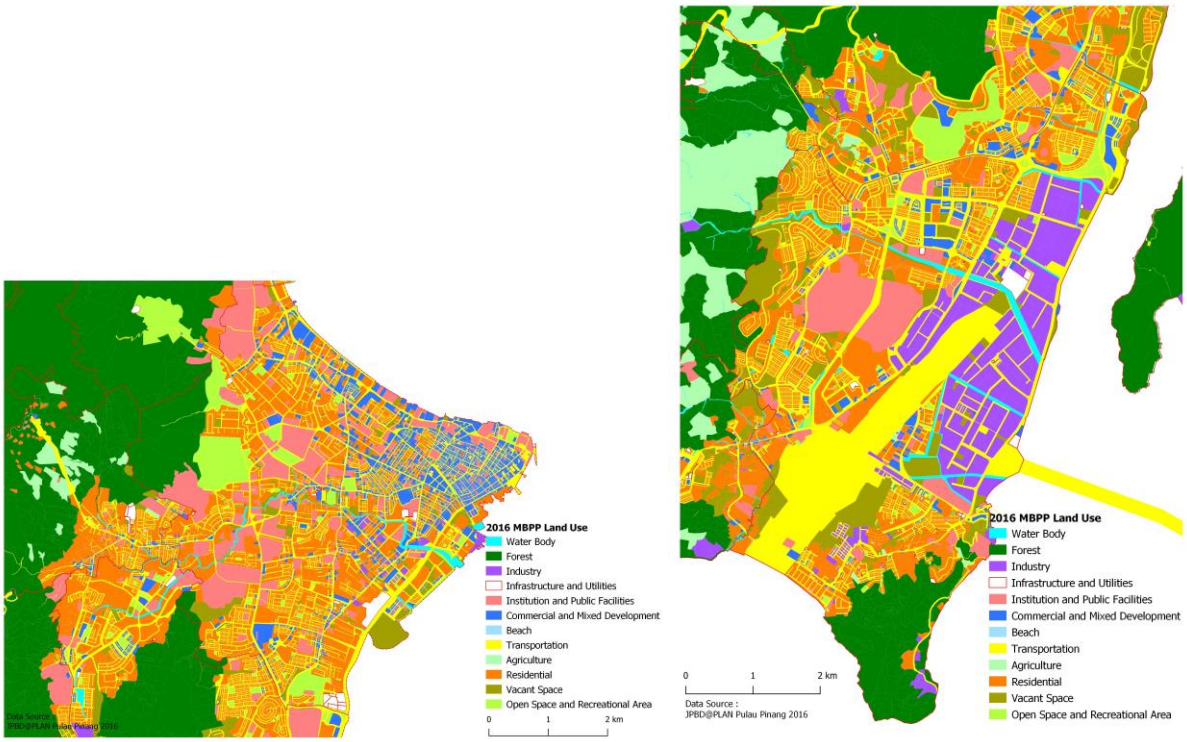
- **George Town** is the state's capital. The total area is 2,501 ha. As of the last census (2010) it had a population of 198,298, the equivalent of 79 people / ha. Land uses comprise a combination of residential, commercial and mixed-use shop lots. UNESCO listed the historical centre of George Town as a World Heritage Site in 2008. It is highly vulnerable to both increasing heat and flooding. George Town mukim is particular vulnerable due to having a significant flood-prone area coinciding with a high concentration of population of elderly people of 21% (41,000), which is above national average (14%) .
- **Bayan Lepas** is a larger area (2,898 ha) comprising Penang's airport and a large manufacturing zone. As of the last census it had a population of 122,654, the equivalent of 42 people / ha. As evident in Images 2a and 2b (page 7), the mukim has significantly urbanized in the last decade. While not as prone to severe flooding, it suffers from increased urban heat island effect, as verified by remote sensing surface temperatures. The presence of global electronic firms offers an opportunity for co-investment in greening the industrial estate.

Table 7: George Town and Bayan Lepas Mukim Population Data (2010)

2010 population	0-14 years		15-64 years		65 years plus		Total
Penang State	352,975	23%	1,074,902	70%	98,447	6%	1,526,324
George Town Mukim	35,515	18%	143,700	72%	19,083	10%	198,298
Bayan Lepas Mukim	28,801	23%	88,020	72%	5,833	5%	122,654

Source: JPBD, 2010

Images 4a and 4b. Landuse of the George Town and Bayan Lepas mukims. George Town (left) has a significant residential land use on the outskirts and a commercial and mixed-use city core, which is now listed as a UNESCO World Heritage Site. Bayan Lepas (right) is a newer area comprising an industrial manufacturing zone, airport and residential areas.

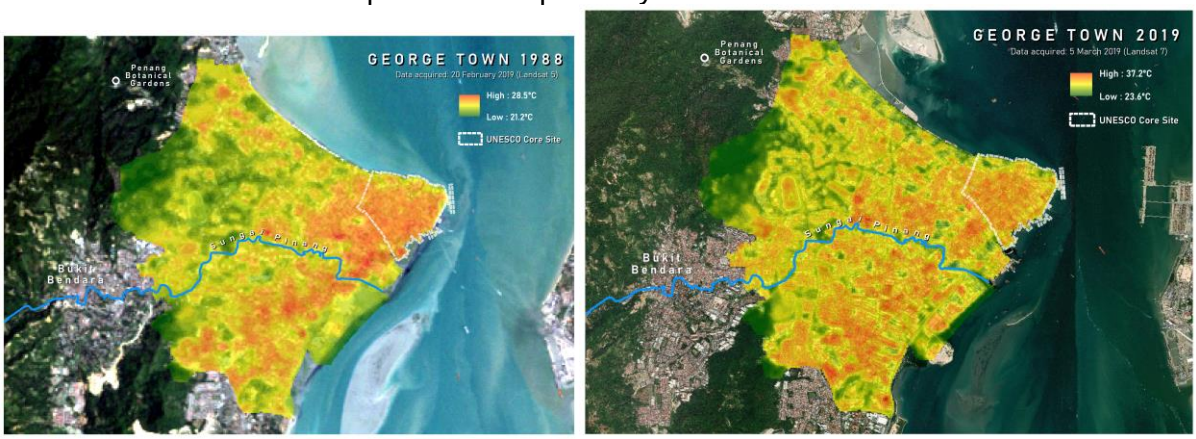


Source: JPBD, 2016. Land use for Georgetown (4a, left) and for Bayan Lepas (4b, right).

Urban Health Island Effect

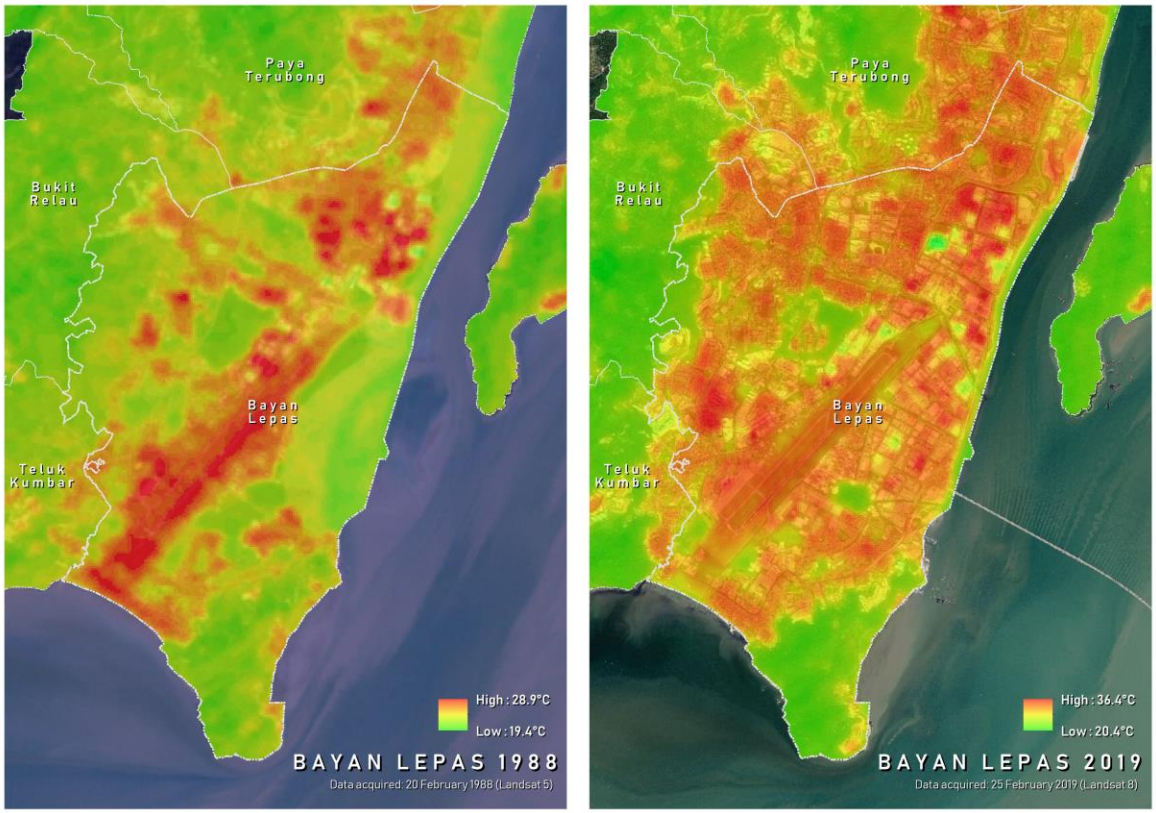
Both the George Town and Bayan Lepas mukims have significant and increasing heat island effects (Images 5a, 5b, 6a & 6b).

Images 5a and 5b. Remote sensing (Landsat 8) data on surface temperatures in 1988 and 2019 shows a stark increase for George Town Mukim: the temperature range in 1988 has a minimum of 21.2°C and a maximum of 28.5 °C but in 2019, the minimum is of 23.6°C and the maximum of 37.2°C. The increase in surface temperature in 31 years is of 8.7°C and 2.4°C maximum and minimum temperatures respectively.

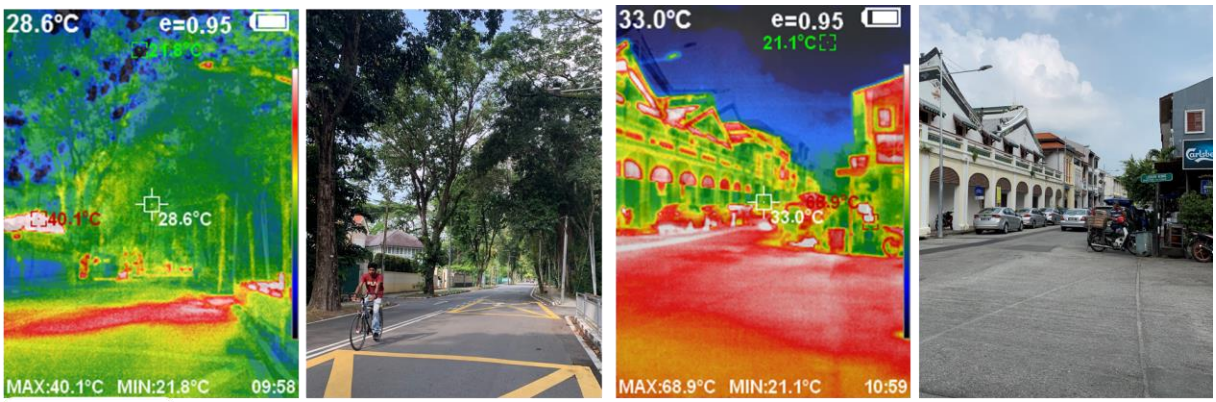


Source: Images retrieved by Think City.

Images 6a and 6b. Remote sensing (Landsat 8) data on surface temperatures in 1988 and 2019 shows a stark increase for the Bayan Lepas Mukim: the temperature range in 1988 has a minimum of 19.4°C with a maximum of 28.9°C but in 2019, the minimum is of 20.4°C and the maximum of 36.4°C. The increase in surface temperature in 31 years is of 7.5°C and 1°C maximum and minimum temperatures respectively. The impact of recent urbanisation is very visible by the expanding warming areas which coincide with built up areas.



Images 7a, 7b, 7c, 7d. Thermal imagery of George Town streets highlight the impact of materials and shading on surface temperatures. Images 7a and 7c (taken at similar times) show a marked difference in temperatures in shaded areas and bitumen road surfaces. Image 8c is taken in the George Town World Heritage Site, which is significantly hotter than other urban areas.

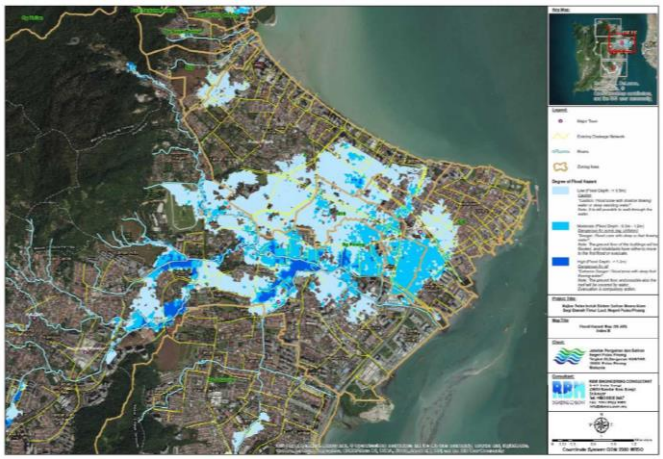


Source: Images taken by Think City.

Flooding

The George Town Mukim in one of the island's main flood prone areas, mostly concentrated upstream from the Penang River.

Image 8. Flood risk for George Town mukim.



Source: RBM (2018) Flood mitigation report for Penang island.

Focus of the proposal

The focus of the programme is to enhance urban resilience and reduce human and ecosystem health vulnerability to climate change impacts and extreme weather events by implementing nature-based solutions to reduce surface temperatures and storm water runoff, as well as to increase social resilience and build institutional capacity. It is a result of the identification of the most significant climate impacts to the urban areas of Penang island: increased rainfall leading to flooding and increased temperatures leading to public health impacts.

Supported by an unprecedented collaboration between stakeholders at local, regional and national levels (including government agencies, scientific support institutions and civil society), the programme has a strong community-focused approach, engaging with the most vulnerable

groups of society in order to assess their main vulnerabilities in a collaborative effort (including vulnerable groups, women, disabled, and low income people - designated as B40 in Malaysia, i.e. the bottom 40% of Malaysian households by income).

Table 8. Summary of target locations and vulnerabilities

Location	**Critical infrastructures**	**Community**	**Climate hazards**	**Underlying vulnerability**
George Town mukim (sub-district)	George Town World Heritage Site Cruise and ferry terminal Roads	Ethnically diverse Culturally rich Mixed income	Flooding Storm surge High urban heat island effect/extreme heat	Traditional communities living in heritage areas High proportion of low cost housing, presence of low income families Above average concentration of elderly population of 21% (41,000) on flood-prone area
Bayan Lepas-mukim (sub district)	High-tech manufacturing zone International Airport Roads Bridges	Middle income families High proportion of migrant workers High tech manufacturing cluster of industries Supporting SMEs	High urban heat island effect	Manufacturing workers (migrant) High concentration of school children (percentage of 15%)

Project / Programme Objectives:
Goals

The main goal of the programme is to enhance urban resilience and reduce human and ecosystem health vulnerability to climate change impacts and extreme weather events by implementing nature-based solutions in order to improve stormwater management to reduce flooding, as well as improving microclimatic regulation, reducing the urban heat island effect and overall temperatures.

The programme seeks also to improve social resilience (with a particular focus on the most vulnerable communities) and to build institutional capacity.

Adopting a comprehensive approach in which a diversified set of components (i.e. urban greening, urban agriculture, public health) is implemented in one specific location reflects the acknowledgement of the complexity and interrelation of the multiple coexisting environmental and social dimensions. It will also allow to develop the programme as a pilot project which can be scaled in other cities in Malaysia and Southeast Asia.

Objectives

Community-level

1) To support the implementation of nature-based solutions to reduce flooding and the urban heat island effect (UHI) and overall temperatures.
2) To strengthen the capacity of local communities to respond to extreme weather events by raising awareness and capacity development training.

Ward-level

3) To support the implementation of resilience actions that target women, youth and other vulnerable communities.
4) To promote urban agriculture and food security at different levels, including training.

City-level

5) To reduce overall temperatures (due to reducing the UHI effect).
6) To reduce incidence and severity of flooding and damage to infrastructure and private property.
7) To strengthen institutional capacity and coordination between different stakeholders in climate-related issues, improving response to extreme weather events.

National level

8) Development of the first municipal climate change adaptation programme, providing reference and methodology (as well as specific tools), for other cities in Malaysia to adopt, via the knowledge transfer platform.
9) Development of the list of climate-resilient street trees for Malaysia (developed together with Jabatan Landskap Negara, the National Institute of Landscape Architecture and Botanical Experts).
10) Development of a public health programme which will include a pilot project to monitor heat related illness in selected hospitals in Penang (as there is no systematic identification of heat related illness in hospitals in Malaysia) providing reference and methodology (as well as specific tools), for other cities in Malaysia to adopt.

Project / Programme Components and Financing

Table 9. Programme components and financing

Project/Programme Components	Expected Concrete Outputs	Expected Outcomes	Amount (US$)
Component 1. Adaptation to the urban heat island effect through urban greening	Output 1.1. New tree-line streets / Connected canopies constructed	Outcome 1.1. Reduction of overall urban atmosphere temperatures by 1°C 5-7 years after project completion	775,000
	Output 1.2. Pocket parks / vacant spaces constructed	Outcome 1.2. Reduction of hard surfaces, resulting in the reduction of the urban heat island effect in the city	950,000
	Output 1.3. Green parking spaces constructed	Outcome 1.3. Reduction of hard surfaces and increased shading, hence reducing the urban heat island effect in the city	625,000

	Output 1.4. Green facades constructed (Built structures greening)	Outcome 1.4. Reduction of temperatures in the streets and inside buildings Stormwater retention on rooftops reducing flooding	200,000
	Output 1.5. Green rooftops constructed (Built structures greening)	Outcome 1.5. Reduction of temperatures in the streets and inside the buildings	225,000
	Output 1.6. Urban agriculture programme initiated	Outcome 1.6. New urban agriculture gardens are incorporated in the city Training sessions will take place in a total number of (4/month) 240 sessions in total	400,000
Component 2. Improved stormwater management	Output 2.1 Blue-green corridors developed	Outcome 2.1. Temporary storage of stormwater, reducing flooding	1,550,000
	Output 2.2. New upstream retention ponds constructed	Outcome 2.2. Temporary storage of stormwater, reducing flooding	725,000
	Output 2.3. Swales and infiltration wells restored and constructed	Outcome 2.3. Temporary storage of stormwater, reducing flooding	450,000
Component 3. Comprehensive vulnerability / baseline assessment and action plans for social resilience strengthening developed for George Town and Bayan Lepas mukims	Output 3.1. Capacity development support for vulnerability assessment and climate change-related planning provided to the two mukims.	Outcome 3.1. Increased awareness on systems assessment, including private property, infrastructure and natural assets; improved planning for adaptation.	160,000
Component 4. Strengthening social resilience	Output 4.1. School-level awareness programme developed and implemented	Outcome 4.1. Increased school building resilience, greater levels of knowledge and awareness among students, teachers and educational authorities.	575,000
	Output 4.2. Women and girls programme developed and implemented	Outcome 4.2. Reduced gender vulnerability asymmetries	400,000

Component 5. Building institutional capacity to adapt to climate change	Output 5.1. Communications and knowledge platform developed and implemented	Outcome 5.1. Project implementation to be fully transparent. Information of strategies and projects to be made available to other municipalities in Malaysia and in the Southeast Asia region for replication.	550,000
	Output 5.2. Penang Climate Board created	Outcome 5.2. A unit created in connection to the municipality will monitor and evaluate all climate-related risks, addressing the problem from with a fully comprehensive perspective	285,000
	Output 5.3. Climate related-public health programme developed and initiated	Outcome 5.3. Comprehensive public health programme, including pilot project monitoring heat related illness in selected hospitals in Penang	471,014
6. Project/Programme Execution cost			875,576
7. Total Project/Programme Cost			9,216,590
8. Project/Programme Cycle Management Fee charged by the Implementing Entity (if applicable)			783,410
Amount of Financing Requested			10,000,000

Projected Calendar:

Table 10. Programme calendar

Milestones	Expected Dates
Start of Project/Programme Implementation	November 2020
Mid-term Review (if planned)	April 2023
Project/Programme Closing	December 2025
Terminal Evaluation	March 2026

PART II: PROJECT / PROGRAMME JUSTIFICATION

A. Programme components

Climate change impacts in the urban areas of Penang island have been accelerating in the past decades. Even though sea level rise is not at threatening levels, increasing temperatures, rainfall and number of extreme weather events leading to flooding are threatening the island and its inhabitants' safety, future development and prosperity. It is necessary to implement adaptation measures and projects which can help overcome these challenges.

Nature-based solutions (NBS) have recently highlighted as a key concept in policy and management for achieving alignment of environmental and societal goals.[27] Having been found to be a possible major solution for climate change, they are now recommended for implementation at a global scale,[28] being supported by multiple international organisations, as is the case with the UN. The benefits extend beyond climate change, as nature-based solutions' impact is multifunctional, being advantageous at many different levels, such as social, public health, biodiversity and financial, having been proven to be highly beneficial in terms of cost-benefit ratios.

In cities, NBS have an instrumental role to play in transitioning to a more liveable and sustainable future high-density model.[29] The introduction of green spaces (particularly strategically placed street trees) have been proven to be the most effective strategy to control rising temperatures[30]. In fact, the introduction of vegetation can play an important role in changing the urban climate closer to a state prior to climate change impacts.[31]

Analysis and planning play an important role, as green spaces must be introduced in strategic locations to achieve optimised results, taking advantage of parameters such as solar orientation, air circulation and others. Strategic planning includes choosing the most beneficial typology of space, planting and species, in general as well as for each specific location; for street trees, leaf organisation and canopy shape have in general the biggest impact (sparse crowns with large leaves have a higher cooling capacity)[32]. Tropical Southeast Asia has some particular advantages in terms of NBS implementation due to its climate, as vegetation growing ratios are significantly higher than for other climates.

Street trees' impact is particularly relevant in the urban context, as they require limited area at ground level and provide the broadest protection from radiation exposure to people, animals, structures and its materials, hence reducing the UHI effect.[33] Even just a few trees have been proven to significantly reduce excessive heat.[34] The positive impact of green spaces in urban

[27] Cohen-Shacham, E., Walters, G., Janzen, C. and Maginnis, S. (eds.) (2016). *Nature-based Solutions to address global societal challenges*. Gland, Switzerland: IUCN. xiii + 97pp

[28] Griscom, B., Adams, J., Ellis, P., Houghton, R., Lomax, G., Miteva, D., Schlesinger, W., Shoch, D., Siikamäki, J., Smith, P., Woodbury, P., Zganjar, C., Blackman, A., Campari, J., T Conant, R., Delgado, C., Elias, P., Gopalakrishna, T., R Hamsik, M., Fargione, J. (2017). 'Natural climate solutions'. *Proceedings of the National Academy of Sciences*. 114 (44) 11645-116

[29] Emilsson, T. and Sang, A.O. (2017) 'Impacts of Climate Change on Urban Areas and Nature-Based Solutions for Adaptation' in Kabisch, N., Korn, H. Stadler, J. & Bonn, A. (eds) *Nature-based Solutions for Climate Adaptation in Urban Areas. Linkages between Science, Policy and Practice*. Springer Open, pp. 15-27

[30] Kardan, O., Gozdyra, P., Misic, B., Moola, F., Palmer, L.J., Paus, T., Berman, M.G. (2015) 'Neighborhood greenspace and health in a large urban center'. *Nature – Scientific Reports*. 5, 11610–11610.

[31] Cohen-Shacham, E., Walters, G., Janzen, C. and Maginnis, S. (eds.) (2016). *Nature-based Solutions to address global societal challenges*. Gland, Switzerland: IUCN. xiii + 97pp

[32] Leuzinger S, Vogt R, Körner C (2010) 'Tree surface temperature in an urban environment'. *Agric For Meteorol* 150(1). pp. 56–62.

[33] Lenzholzer, S. (2012) 'Research and design for thermal comfort in Dutch urban squares'. *Resources, Conservation and Recycling*, 64, pp.39-48.

[34] Lindén, J., Fonti, P., Esper, J. (2016) 'Temporal variations in microclimate cooling induced by urban trees in Mainz, Germany'. *Urban Forestry & Urban Greening*, 20, pp.198-209

contexts is well documented also in terms of public health. They provide cooling effects that can contribute to reduce stress factors that stem from overheating, leading to health-related impairments that may result in increased mortality rates.[35] They have also been proven to reduce obesity, cardiovascular diseases, blood pressure, respiratory diseases and diabetes.[36] Additional benefits include the improvement of social cohesion, economic and aesthetic added values. [37]

Microclimate regulation achieved by planting green spaces will furthermore reduce the impact of heat waves[38], which will significantly increase in Malaysia. The UHI effect in Penang can be observed in Image 3, p.9 clearly showing the correspondence of higher temperatures with more densely built areas.

The UHI effect and overall temperatures' reduction achieved by the introduction of green spaces, in particular street trees, is supported not only by the extensive research mentioned above but by several projects. Such is the case with the Medellin NBS project, where local authorities have planted green corridors along 18 roads and 12 waterways and reduced temperatures in more than 2°C, in some cases reaching 3°C[39], winning the Ashden award, *Cooling by Nature*.

Adaptation strategies addressing flooding are urgent for Penang. Studies[40] have recommended the increase of green spaces for stormwater retention, as well as the creation of a linear park with retention areas in the Pinang River. However, a more flexible approach to stormwater management is needed to address the challenges associated with changes in rainfall patterns. City managers need to introduce a more resilient approach combining soft and hard infrastructures. A sustainable drainage systems' approach is behind the concept of the sponge-city, which has achieved remarkable results in reducing floods.[41]

For this to be achieved, research has shown the need to address biophysical uncertainties (e.g. soil absorption, groundwater table level fluctuation). The way to address these uncertainties is to develop research and implement seasonal stormwater retention upstream areas, as well as swales and infiltration wells downstream and monitoring their impact in flood mitigation.

This programme aims to introduce a climate-conscious approach in the design of green spaces in the urban areas of Penang (either public or private), in which concerns regarding reducing temperatures and seasonally storing storm water will be an integral part of the process.

All of the project's proposed outcomes take into account sustainability; in terms of nature-based solutions, both financial and environmental sustainability, as these are far more cost-effective than existing alternatives, and mitigate climate change by sequestering carbon. The knowledge management component also promotes both financial and environmental sustainability at a national level. In terms of sustainable investments, demonstrating to the government its cost-

[36] Ulmer, J.M., Wolf, K.L., Backman, D.R., Tretheway, R.L., Blain, C.J.A., O'Neil-Dunne, J.P.M., Frank, L.D. (2016), 'Multiple health benefits of urban tree canopy: The mounting evidence for a green prescription'. *Health & Place*, 42, pp.54-62.
[37] Soares, A.L., Rego, F.C., McPherson, E.G., Simpson, J.R., Peper, P.J., Xiao, Q. (2011) 'Benefits and costs of street trees in Lisbon, Portugal'. *Urban Forestry & Urban Greening*, 10, pp.69-78.
[38] Lindén, J., Fonti, P., Esper, J. (2016) 'Temporal variations in microclimate cooling induced by urban trees in Mainz, Germany'. *Urban Forestry & Urban Greening*, 20, pp.198-209
[39] https://www.ashden.org/winners/alcald%C3%ADa-de-medell%C3%ADn
[40] DRR – Team Mission Report Malaysia (2018), Kingdom of the Netherlands.
[41] Chan F.K.S., Griffiths, J.A., Higgitt, D., Xu, S., Zhu, F., Tang, Y., Xu, Y., Thorne, C.R., (2018) '"Sponge City" in China—A breakthrough of planning and flood risk management in the urban context', Land Use Policy, 76, pp. 772-778 https://doi.org/10.1016/j.landusepol.2018.03.005

effectiveness in Penang and other cities while likely promote their implementation by these entities from existing budgets.

Remote sensing

To develop the plans, it is necessary to identify the most heat stressed areas, which can be achieved using remote sensing. As the main cause of UHI is the composition of land surfaces, linking Land Surface Temperatures (LST) and land cover data can substantially assist nature-based cooling strategies as they can quantify and predict direct and indirect cooling benefits of green spaces[42]. Climatic fluctuations and anomalies will be observed and analysed using chronological remote sensing as well as observing recorded anthropogenic impacts, which play significant roles in regional, national and global climate adaptation, planning, mitigation and projection. Attaining high-resolution remote sensing data will enable the identification of buildings and neighbourhoods which exacerbate the UHI effect. This will allow for targeted intervention, introducing green spaces and promoting air flow in the most heat stressed areas.

Scenario and impact modelling (to be developed by the National Hydrological Institute Malaysia (NAHRIM) and local university Universiti Sains Malaysia (USM) experts will also assist in developing the detailed plans.

Remote sensing will, therefore, be used in this programme at three different levels: 1) identifying the most heat stressed urban areas as priorities for intervention; 2) monitoring the development of the pilot projects in order to identify the most effective strategies for replication - research through design (RTD); 3) monitoring and evaluation of the programme's impacts.

The programme's components are as follows

Component 1: Adaptation to the urban heat island effect through urban greening
This component focuses on reducing the impact of increasing temperatures by introducing different green elements, such as street trees, rooftop gardens, pocket parks and blue-green corridors. The introduction of these green elements will contribute to reduce the UHI and, therefore, overall urban temperatures.

This component comprises six different groups of activities:
1.1 New tree-lined streets / Connected canopies constructed. Introducing new tree-lined streets in both George Town and Bayan Lepas mukims and completing the alignments in streets that are already partially shaded by street trees. The most heat stressed areas were mapped in order to identify the areas in which strategically introduced street trees will be planted in order to reduce the temperatures. The budget was calculated based on the number of trees to be planted. At concept note stage this activity was costed based on the assumption that 3,690 trees would be planted at a cost of USD210 per tree.
1.2 Pocket parks / vacant spaces constructed. Vacant spaces are converted into pocket parks or urban gardens, with a microclimate-oriented design, in order to reduce hard surfaces and add shade (both aiming to reduce the urban heat island effect). Vacant spaces which can become small green urban spaces were mapped and the areas calculated in order to develop a budget

[42] Zhang, Y., Murray, A. and Turner, B. (2017). 'Optimizing green space locations to reduce daytime and night-time urban heat island effects in Phoenix, Arizona'. *Landscape and Urban Planning*, 165, pp.162-171.

with reference costs provided by contractors. At concept note stage this activity was costed based on the assumption that an area of 10,555 m2 would be planted at a cost of USD90 per square meter.

1.3 Green parking spaces constructed. Introducing trees in car parks, for shading and UHI reduction. This will be done in both George Town and Bayan Lepas mukims, but more in the latter, due to the greater number and size of car parks in the Bayan Lepas manufacturing zone. Due to the small space occupied by tree pits, the number of car park spaces will be reduced by no more than 10%. To determine the cost of this activity, the existing car parks were mapped, and preliminary tree planting activities developed in order to determine the number of trees necessary and the budget calculated with reference costs provided by contractors and suppliers. Based on this the budget assumes 2,975 trees would be planted at a cost of USD210 per tree.

1.4 Green facades constructed (Built structures greening). It will be developed as a grants programme. The existing buildings in which green facades can be installed were identified and a preliminary budget calculated with reference costs provided by contractors and suppliers. Based on this the budget assumes a vertical area of 1,110 m2 would be planted at a cost of USD180 per square meter.

1.5 Green rooftops constructed (Built structures greening). It will be developed as a grants programme. The existing buildings in which rooftop gardens can be installed were identified and a preliminary budget calculated with reference costs provided by contractors and suppliers. Based on this, the budget assumes an area of 3,750 m2 would be planted at a cost of USD60 per square meter (no trees introduced).

1.6 Urban agriculture programme initiated. Identification of some vacant spaces in order to add urban agriculture as well as training sessions. It will be developed as a grants programme. Vacant spaces with potential for urban agriculture were identified and areas calculated in order to budget this sub-component with reference costs for construction and training provided by contractors and NGOs working in this field.

The nature-based climate adaptation programme for the urban areas of Penang island includes the greening of four waterways (in total approximately 14 km) and 32 streets and roads corridors (in total approximately 42 km). Using as reference green spaces impact in UHI reduction and case studies such as the Medellin project, it is reasonable to expect temperatures to decrease approximately 1-1.5°C five to seven years in surrounding areas after project implementation. Evaluation and monitoring of temperatures will provide assessment regarding the effectiveness of the proposal.

One important study resulting of this programme is the identification of climate-resilient urban trees species for Malaysia (which has not been developed yet). This study is important because, as climate changes in the future, certain tree species will not be able to cope; it is essential to plant trees in the present that will be able to survive (and, hopefully, thrive) in the climate that Penang will have in 2050. This study will be developed during the programme in collaboration with the National Institute of Landscape Architecture (Jabatan Landskap Negara) and local botanic experts.

The budget allocated to component 1, Greening urban Penang is of USD 3,175,000. The budget was calculated by mapping and calculating all areas and then consulting with contractors and suppliers to establish reference costs. Similar existing projects in Malaysia were also identified and their budget used as reference. The outputs with the highest budgets, 1.2 pocket parks/vacant spaces (USD 900,000) and 1.1 new tree-lined streets/connected canopies,

(USD 750,000) are the ones which will be implemented more extensively and are estimated to have the biggest impact in terms of heat stress reduction. In the case of output 1.6, urban agriculture, the total budget is higher than the budget presented here (USD 400,000), as several sponsors have committed to support it; the Adaptation Fund is being asked to pay just part of it.

Component 2: Improved stormwater management

Flooding in Penang has increased due mainly to the increase of annual rainfall and rainfall patterns and impervious surfaces due to urbanisation.

The programme includes a comprehensive nature-based approach to flood management including upstream retention, expanding blue-green corridors, and restoring and adding swales and infiltration wells where possible.

This component comprises three different outputs:

2.1. Blue-green corridors developed

Rivers are natural topography corridors for stormwater circulation, so every time there's increased rainfall, their levels rise, which often leads to flooding of neighbouring areas. Keeping the rivers free of hard materials and modelling the river margins in different levels / platforms may constrain the path of water and protect neighbouring urbanised areas. The association of green spaces with the blue corridors is essential, as it allows for the infiltration of stormwater to the groundwater table. Water retention capacity will be increased associated with the rivers in the urban areas of Penang island even though their margins have limited space. This will be made with temporarily flooded areas – mangroves around river mouths areas which may have been removed their reinstatement will be considered as a priority. Blue-green corridors will also have additional benefits in reducing heat beyond stormwater management.

The greening of parts of the Sungai Pinang is currently being studied by the project team, including by experts from the local university. UN-Habitat and Think City are working are doing further work to understand if this is feasible and can be done in compliance with the Environmental and Social Policy of the Adaptation Fund. We will seek to present this in a full proposal, with a more comprehensive justification.

The budget assumes an area of 17,220 m2 would be developed at a cost of USD90 per square meter.

2.2. New upstream retention ponds constructed

Due to a combination of increased built up areas and increased rainfall, stormwater runoff leads to flooding in lower lying areas, which both in George Town and Bayan Lepas mukims are located in the heavily urbanised areas. In order to avoid this, it is essential to retain stormwater in ponds upstream so they won't runoff to downstream areas. Retention ponds also allow for slow infiltration of stormwater to the groundwater table. The most crucial areas in which to introduce retention ponds are currently being identified by experts associated to the programme - a dedicated task force was established in 2019 with different experts in stormwater management to map the most important areas in which to retain the water, and the full study is expected to be completed in August 2020.

Upstream retention areas are locations that store water in periods of heavier rainfall. In Penang, the existing drainage system is threatened by high tides and storm surges combined with a relatively small impact of sea level rise in island. Therefore, when heavy rainfall occurs simultaneously with high tides and storm surges, the drained water is pushed back inland by the tide, causing a backflow in the drainage system, which the system can't cope with, leading to severe flooding. [43] It is essential, because of this, to retain the water upstream, not allowing it to reach either rivers or the drainage system. It has been proved that, using a combination of nature-based solutions for stormwater management, peak discharge of a catchment can be reduced by more than 50%.[44] Because of this adaptation effectiveness, the project design team and all stakeholders agree that upstream retention is a critical intervention to prevent flooding in the highly urbanized area of Penang.

The areas identified for upstream retention are mostly green spaces associated with rivers but also to some isolated crucial green spaces, such as sports grounds and vacant land, which are heavily pressured hydrologically due to morphology reasons. Green buffers and vegetation will be added to all alternatives.

The budget assumes an area of 12,080 m2 would be developed at a cost of USD60 per square meter.

2.3. Swales and infiltration wells restored and constructed

Swales are vegetalised open drains which, unlike typical drains, not only collect stormwater but also allow for its infiltration to the groundwater table along its full extension. This approach seeks to reduce the accumulation of stormwater downstream, which in case of heavy rainfall often leads to flooding and possible damages of drainage infrastructure.

[43] Understanding stormwater inundation. www.coast.noaa.gov. Retrieved on April 17th 2020 from https://coast.noaa.gov/stormwater-floods/understand/
[44] Qiu, Y., Ichiba, A., Scherzer, D., Tchiguirinskaya, I. (2018) 'Evaluation of nature-based solutions for stormwater management with a fully distributed model in semi-urban catchment'. UrbanRain18, 11 th International Workshop on Precipitation in Urban Areas.

Infiltration wells are solutions used for heavily urbanised areas, as they provide stormwater retention and fast infiltration to the ground water table using several deep layers of aggregates of different dimension, with the function of accelerating and retaining stormwater.

The budget assumes that 1,880 m2 of swales will be added at a cost of USD90 per square meter and 2,545 m3 of infiltration wells at a cost of USD110 per cubic meter.

Adaptation strategies addressing flooding are crucial and urgent for Penang, considering the increase in rainfall and the damages caused by the latest floods. Flood mitigation studies specific for Penang island have previous identified the need for an increase of green spaces for water retention, along the Pinang River as well as in upstream retention.[45]

To face the challenges, a sponge-city approach should be adopted, identifying upstream areas that are more heavily pressured hydrologically to be converted (partially or seasonally), into retaining/storing water functional spaces. Introducing swales and infiltration wells downstream will also reduce impacts. With this goal in mind, the programme includes as co-implementing partners NAHRIM (Institut Penyelidikan Hydraulic Kebangsaan Malaysia, the National Hydraulic Research Institute of Malaysia) and USM (Universiti Sains Malaysia, the local university). A partnership for knowledge sharing is being established with the Sponge Cities Research Institute of Tsinghua University Innovation Center in Zhuhai, China.

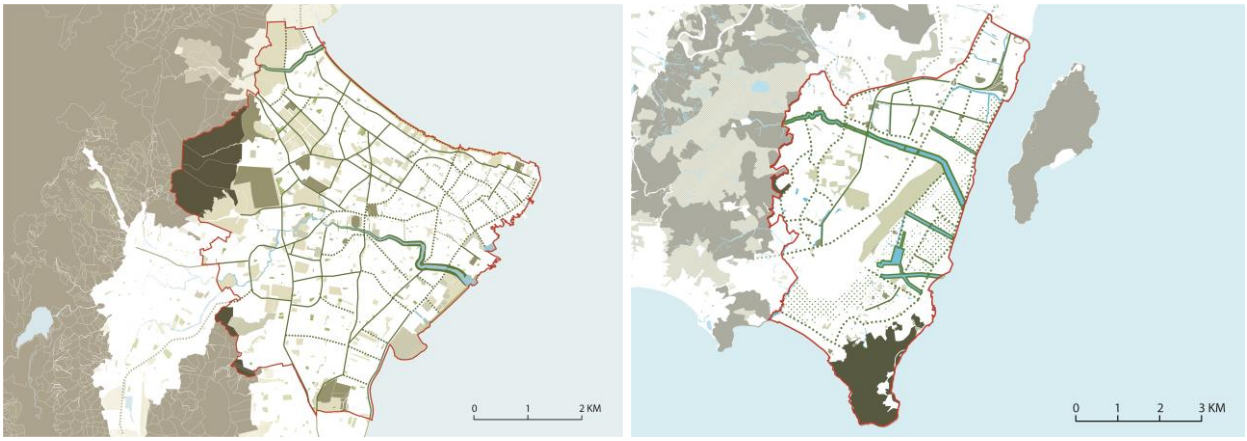
The Department of Irrigation and Drainage's latest flood mitigation plan for Penang island from 2013[46] did not include nature-based solutions such as retention ponds; it will be updated in 2020 and will integrate the nature-based elements developed during the programme.

The total budget for the physical activities for Component 2 on stormwater and flood management is USD 2,725,000. The three sub-components were mapped, the areas calculated and estimate costs obtained by consulting suppliers and contractors. The output with the highest budget, blue-green corridors (USD 1,550,000) has a higher cost per square meter than the upstream retention sub-component (with a budget of USD 725,000), as river corridors must be developed with a higher degree of complexity (including access and use by the population) than retention ponds. The budget for the upstream retention areas was calculated according to an estimate of volume of water which may be needed to retain, and the areas in which the volume can be reasonably stored, estimated by the team of experts developing the project. The Swales and infiltration wells sub-component (USD 450,000) has a high cost per square meter of construction but will be implemented in substantially fewer areas than the other two sub-components and has, therefore, a lower budget.

The plans below show the areas for green infrastructure extension in both George Town and Bayan Lepas mukims.

Images 9a and 9b. Green infrastructure plans for George Town and Bayan Lepas mukims, including blue and green corridors and upstream retention, developed for the nature-based programme.

[45] DRR – Team Mission Report Malaysia (2018), Kingdom of the Netherlands.
[46] Department of Irrigation and Drainage Penang (2013) *Stormwater management and drainage masterplan study for Pulau Pinang* Executive summary.



Source: Plans developed by Think City 2019.

Component 3: Comprehensive vulnerability / baseline assessment and action plans for social resilience strengthening developed for George Town and Bayan Lepas mukims.

Output:

3.1. Capacity development support for vulnerability assessment and climate-change related planning provided for the two mukims.

Having the Adaptation Fund Outcome 1 in mind, as well as regional priorities, this component focuses on laying the groundwork for reducing vulnerability to climate change impacts and hazards. Community-level resilience is the focus in the two targeted mukims, George Town and Bayan Lepas. It will include:

1) Conducting climate change vulnerability assessment.
2) Producing action plans that identify resilience investment and priorities.
3) Conducting a survey on the willingness to pay / green infrastructure revenue to ensure that infrastructure generates revenue that can be re-invested in operations, maintenance and upgrading. A special survey targeted at the private sector in the industrial area of Bayan Lepas will be conducted in order to assess willingness to pay in the near future.

The goal of this in-depth vulnerability assessment and resulting action plans is to gain as much insight and understanding of all issues and needs as possible, as well as to increase ownership and institutionalise and support priority interventions.

The vulnerability assessment and adaptation action planning will be guided by the Planning for Climate Change framework (P4CC). These principles are strategic, as implementation should be value-based and should make the best use of resources available. The programme should engage as many stakeholders as possible throughout the project life cycle and integrated them in a unified approach to climate change adaptation: the development of the programme has already achieved a significant engagement so far (see the organisational structure description in component 5, Building Institutional Capacity).
Gender assessment will be a strong component of the vulnerability baseline assessment. Women in Penang are identified as vulnerable in particular low-income groups as they are primary caregivers which is indicated by a low labour force participation rate (59%). A

preliminary gender assessment in vulnerable communities is in progress and will be included in the full proposal.

The budget for the comprehensive vulnerability baseline assessment and actions plans was calculated by comparing with similar studies' budgets for reference and by consulting with the city council and consultants working in this field,

Component 4: Strengthening social resilience

The social resilience programme has two main outputs:

4.1. School-level awareness programme developed and implemented

The schools programme is focused on educating young people. Creating game and technology based learning with input from youth will be appealing and can reach major proportions of students (over 10,000 secondary school students). This knowledge component is supplemented with training in urban agriculture in the school grounds. It will also include training in climate change specific issues, particularly in extreme weather events and disaster situations, but also in the science behind climate change and in mitigation strategies.

4.2. Women and girls programme developed and implemented

The women and girls programme's aim is to reduce gender vulnerability asymmetry and strengthen agency within the overall programmes geographic focus areas. Partnering with the Women's Centre for Change, Penang's most widely recognised Women's organisation, will provide wide access to women and girls. A series of engagements will bring together women NGOs, climate experts and women and girls to co-produce adaptation resources on various topics from extreme heat to urban agriculture and establish a network of peer educators for distribution and building a social support network.[47] The programme will also include a component to promote women's participation in decision-making processes related to climate change adaptation and mitigation strategies and plans. The programme will reach 25% of B40 women and girls of George Town and Bayan Lepas mukims, which corresponds to an approximate number of 16,000 women and girls.

Activities under this component will target different types of vulnerable communities: a) areas that are periodically flooded and coincide with the highest concentration rate of elderly population in Penang; b) Low income groups (known locally as B40 communities) c) women and girls. Community engagements have shown that the B40 population in George Town Mukim describes the impacts of heatwaves to be initially in the health of children (more specifically babies) and elderly people. As such, this impacts also the caregivers, which are predominantly women. The main benefits will be to reduce exposure to flooding and heat and to empower and reduce pressure on women.

The budget for the social resilience component was estimated by consulting with the city council and different NGOs with experience in this area.

Component 5: Building institutional capacity to adapt to climate change.

[47] Hashagen, S., Kennedy, J., Paterson, A. and Sharp, C. 2011. Doing with, not to: Community resilience and Co-production The Implications for NHS Education for Scotland. Scottish Community Development Centre. Accessed at https://www.nes.scot.nhs.uk/media/555269/doing_with_-_not_to_final_version.pdf

Institutional capacity will be reinforced via three outputs:

5.1 Communications and knowledge platform developed and implemented

The knowledge management platform will allow the capturing and dissemination of results from the programme not only to other mukims and districts in Penang state but also to other cities in Malaysia, with enhanced replication potential. It will also ensure full transparency in the implementation process, with all stakeholders being informed of strategies, monitoring and evaluation tools and results. A dedicated website will be created and monthly reports will be sent to all stakeholders.
The project development team views the knowledge management component as a central part of the programme, with the strong belief that it will have national impact. The online platform will be designed to capture the methods and impacts of the programme in a format that can be readily transferred to other Malaysian municipalities with the support from MESTECC and NAHRIM). The Penang Climate Board will act as the main repository of the knowhow within the Penang state government and be used to drive the programme beyond the Bayan Lepas and George Town mukims. However the board's primary purpose is to become a dedicated unit to address climate change specific issues holistically.

The organizational structure proposed for the programme is composed by multiple entities at local, municipal, regional and national levels, also including civil society and academic institutions. MESTECC (the Ministry of energy, science, technology and climate change) will be an executing entity (as the National Designated Authority), as well as MBPP (city council), JPS (the Department of irrigation and drainage) and Think City (as the local project manager), together with Penang Green Council. Supporting executing entities include the Penang state government (with an important role in terms of coordinating and integrating areas in between MBPP and JPS jurisdictions), Jabatan Landskap Negara (the National Institute of Landscape Architecture) with whom the list of climate-resilience street trees for Malaysia will be developed and mainstreamed into national policy; Plan Malaysia; Perhilitan (National Institute of Wildlife); and Perhutanan (National Forestry Institute). As supporting scientific entities, USM (Universities Sains Malaysia, the local university, which has allocated a multidisciplinary team to support the programme); NHARIM, the National Hydrology Research Institute; MRSA (Malaysian Remote Sensing Agency). As supporting NGOs and CSOs, MERCY Malaysia, WCC (Women's Centre for Change, a Penang organisation focused on women's rights) and WWF Malaysia (other organisations are expected to join in the future).

Specific benefits of intra-municipal cooperation for the implementation of NBS strategies have been identified in research. Besides enhancing the overall performance and speed of implementation of the programme, capacity building and knowledge transfer will be additional benefits for the institutions and departments involved. Beyond Penang, inter-municipal exchange platforms can serve as a multiplying factor in mainstreaming NBS into urban planning. The benefits of implementing the first NBS climate adaptation programme in Malaysia can therefore extend to the regional and national levels.

Streamlining information regarding municipal adaptation will help other cities in Malaysia and in the Southeast Asia region to develop their own climate adaptation programmes with a focus not only on resiliency but also on sustainability.

The creation of a knowledge transfer platform will allow for the mainstreaming of the programme's methodology as well as the assessment of the different strategies and of projects' effectiveness. This will include (but will not be limited to): the monitoring of the flood impacts and

temperatures reduction, the assessment of impact of the pilot projects, as well as the list of climate-resilient street trees species specific for Malaysia. The communications plan activities will be managed and mainstreamed via this platform. The platform will have an advocacy role at local as well as at national level.

5.2 Penang Climate Board created

The creation of the Penang Climate Board aims to create the conditions for an integrative and all-encompassing approach to all issues related to climate change, as a multi-layered comprehensive coordinated response to climate related risks should be prioritised. The climate board will manage different projects, as will be the case with the public health programme.
The goal is to create a dedicated unit to centralize all issues related to climate change - the Penang Climate Board, and it will be under the supervision of the local city council.

5.3 Climate-related public health programme developed and initiated.

Public health issues should be addressed in adaptation projects, as climate change will be significantly impact physical, mental and community health. In the recent *Lancet Countdown on Health and Climate Change*[48] it is stated that climate change affects people across the life span and children will be affected the worst. The Penang public health programme focusses on the same geographic area as the other strategies. Its purpose is to measure for the first time current public health impact and set up a system for monitoring change that can also measure health improvements resulting from the environmental strategies.

The strategy of using NBS for the climate adaptation of urban areas in Penang will also result in several co-benefits in terms of public health and wellbeing. Research over the past years has significantly developed and demonstrated the following effects: reduced anxiety and depression, decreased stress, increased immunity, better control of non-communicable diseases (NCDs)[49] [50], increased vitamin D production (sun exposure), denser social connections[51], reduced aggression[52] and improved learning and intellectual development in children[53]. The pathways to these benefits are interrelated and mediated for example, green and thermo-comfortable spaces encourage outdoor physical activity which in turn is linked to reduction in depression[54], reduction in weight, prevention and better management of NCDs.

Three action areas make up the public health programme:

1. Measure the extreme heat impact on hospital admissions and mortality rates for better surveillance and feeding into future preparedness and community prevention strategies.

[48] Watts N., Amann M., Arnell N. et al. (2019) The 2019 report of The Lancet Countdown on health and climate change: ensuring that the health of a child born today is not defined by a changing climate. Lancet. 394:1836-78.
[49] Kardan, O., Gozdyra, P., Misic, B., Moola, F., Palmer, L.J., Paus, T., Berman, M.G. (2015) 'Neighborhood greenspace and health in a large urban center'. *Nature – Scientific Reports*. 5, 11610–11610. DOI: 10.1038/srep11610
[50] Ulmer, J.M., Wolf, K.L., Backman, D.R., Tretheway, R.L., Blain, C.J.A., O'Neil-Dunne, J.P.M., Frank, L.D. (2016), 'Multiple health benefits of urban tree canopy: The mounting evidence for a green prescription'. *Health & Place*, 42, pp.54-62.
[51] Ulmer, J.M., Wolf, K.L., Backman, D.R., Tretheway, R.L., Blain, C.J.A., O'Neil-Dunne, J.P.M., Frank, L.D. (2016), 'Multiple health benefits of urban tree canopy: The mounting evidence for a green prescription'. *Health & Place*, 42, pp.54-62.
[52] Kuo, F.E., Sullivan, W.C. (2001) 'Agression and violence in the inner city: effects of environment via mental fatigue'. *Environmental Behavior*, 33, pp.543-571.
[53] Haaland, C. van den Bosch, C.K. (2015) 'Challenges and strategies for urban green-space planning in cities undergoing densification: A review'. *Urban Forest & Urban Greening*, 14, pp.760-771.
[54] Ulmer, J.M., Wolf, K.L., Backman, D.R., Tretheway, R.L., Blain, C.J.A., O'Neil-Dunne, J.P.M., Frank, L.D. (2016), 'Multiple health benefits of urban tree canopy: The mounting evidence for a green prescription'. *Health & Place*, 42, pp.54-62.

The research evidence highlights that there are certain temperature points when hospital admissions soar and death rates sharply rise[55]. The conditions are not limited to heat stress and stroke but many other conditions from kidney related diseases[56] to injuries (increased violence) and suicides.[57] [58] The study would select a number of hospitals to correlate access hospital admissions (those higher than usual) with heat wave events. As there is no lag time between symptoms and heat wave event, same days can be compared. The second part of this study would analyse death records[59] to assess increase death with heat waves.

2. Correlate climate sensitive communicable diseases with climate data and assess trends that can be used for public health interventions and assess the impact of adaptation initiatives.

Dengue, Leptospirosis, Chikungunya and other communicable diseases are on the rise due to climate change.[60] As a tropical city, most of these diseases are already endemic but the conditions for breeding and transmission are become even more favourable. This study will explore increases in specific communicable disease with certain weather conditions. Here lag times have to be considered, e.g. the lag between breeding cycles of mosquitoes or rats and increase in disease outbreaks.

3. Workforce Development: Raise awareness and upskill health professionals and administrators to improve recognition of relevant symptoms, understanding of correct coding and shape their community outreach and education programmes.

When doctors, hospital administrators and public health officials are more aware of the links between climate change and health, particularly when local data is available, medical conditions are more likely to be linked to specific climate change events such as a heat wave. This in turn can lead to more accurate coding which results in more accurate data feeding into the other proposed action areas and community outreach/education programmes. Strategies could include PhD scholarships for climate and health research and supporting the Medical Association of Malaysia, Penang Chapter to facilitate upskilling, awareness raising and building a community of practice that is interested in more closely linking with the adaptation fund.

Component 5, Building Institutional Capacity, is particularly relevant for this programme. It was designed to impact as much as possible other cities in Malaysia, in accordance with the intentions of the National Designated Authority, and it has a total budget of USD 1,306,014 for three outputs. The budget was allocated based on a combination of discussions with the senior leadership of the main project partners, the community consultation process and technical advice. The output 5.1 is the most relevant in terms of actively transmitting methodology and data to other cities in the country and, the budget of USD 550,000 was estimated by consulting with firms providing services in this field and by comparing reference costs of similar existing platforms in the region. The budget for output 5.2. was provided by the city council, as they had been planning for the creation of a similar unit (although exclusively dedicated to Disaster Risk

[55] Beggs PJ., Zhang Y., Bambrick H. et al. (2019) The 2019 report of the MJA-Lancet Countdown on health and climate change: a turbulent year with mixed progress. Medical Journal of Australia. Published online 14. November 2019. doi: 10.5694/mja2.50405
[56] Hanson AL, Bi P, Ryan P, Nitschke M, Pisaniello D, Tucker G (2008). The effect of heat waves on hospital admissions for renal disease in a temperate city of Australia. International Journal of Epidemiology. 37:1359-65.
[57] Beggs PJ., Zhang Y., Bambrick H. et al. (2019) The 2019 report of the MJA-Lancet Countdown on health and climate change: a turbulent year with mixed progress. Medical Journal of Australia. Published online 14. November 2019. doi: 10.5694/mja2.50405
[58] Davis RE, Novicoff WM (2018). The impact of Heat Waves on Emergency department Admissions in Charlottesville, Virginia, U.S.A. International Journal of Environmental Research and Public Health. 15 (7):1436 doi: 10.3390/ijerph15071436
[59] Linares C, Diaz J (2007). Impact of high temperatures on hospital admissions: comparative analysis with previous studies about mortality (Madrid). European Journal of Public Health. 18 (3): 317-322.
[60] Garba B., Bahaman AR, Bejo SK et al. (2018) Major epidemiological factors associated with leptospirosis in Malaysia. Acta Tropica. 178: 242-247.

Reduction). The budget for output 5.3., was estimated by consulting with different public health experts.
Components 1 and 2 constitute the built components of the programme to which 70,7% of all components' funding will be allocated. The high budget results from the type and specific nature of these activities and their intended outcomes: substantial results in terms of temperatures reduction and stormwater management improvement. Component 5, institutional capacity has the third highest budget, as it is the intention of all stakeholders to extend the benefits of the programme to other cities in Malaysia, and is in-line with the policy of the national government. The social vulnerability component (4) has a lower but still substantial budget, capable of leading to transformative change. The component with the lowest budget is Component 3, the vulnerability baseline assessment and action plans. 6

B. Economic, social and environmental benefits

Table 11. Economic, social and environmental benefits

Type of benefit	Baseline	With/after the project
Economic	• Increase of extreme weather events resulting in floods, impact on private property and public infrastructure, economic losses and worsen livelihood conditions. • Increased impact to human health due to heat stress. • Decreased productivity for outdoor workers. • Increased negative impact in agriculture and overall ecosystem health due to weather irregularity and extreme events.	• Reduced losses on private property due to flooding. • Reduced losses on public infrastructure due to flooding. • Reduced impact to human health due to flooding. • Reduced impact to human health due to heat stress. • Reduced impact on crop yields and ecosystem health via biodiversity supporting measures. • Reduced disruption to business due to flooding
Social	• Extreme weather events such as floods and heatwaves are considered co-drivers of poverty and result in social problems such as sanitation, food security and so on. • Damage to infrastructure and property resulting of flooding have a disproportional impact on the most vulnerable communities (the poorest, the elderly, the young and the disabled people). • Heat stress has a severe impact in public physical and mental health.	• Reduced social impacts in poverty areas. • Reduced damage to infrastructure. • More resilient vulnerable communities. • Reduced public health impacts. • Reduced mental health problems due to extreme weather events', flooding, displacement and heat stress impact on the population.
Environmental	• Extreme weather events such as floods and heatwaves have a severe impact on ecosystems and biodiversity.	• Reduced human impact in environmental degradation.

	• Long term stress such as heat stress can have a severe impact on ecosystems and biodiversity.	• More balanced ecosystem health. • Reduced loss of urban biodiversity. • Sustained and enhanced capacity of ecosystems to provide life-supporting services

The programme will also result in an accessory benefit, although it is not the focus of this proposal: mitigating climate change, as overall temperatures being reduced will lead to reduced use of air conditioning and of energetic costs.

A cost-benefit analysis of the programme's components will be developed for the full proposal stage and a more detailed cost-benefit study during the programme, to be developed by environmental economists supporting the programme.

C. Cost effectiveness

NBS are well known for being considerably cost-effective in terms of climate change adaptation.[61]

The programme aims to be cost-effective also by:

a) Reducing impacts to public health.
b) Reducing impacts to infrastructure and private property due to flooding.
c) Reducing damage to ecosystem health and loss of biodiversity.

Other positive aspects are effectiveness of operations, community engagement and adequate selection of technical options.

Approximately 70% of the investments will be directed to built interventions, maximizing the direct beneficiaries of the project. The investments in strategies and actions will be directed to:

a) greatly benefit the implementation of the built projects;
b) strengthen the community's awareness and resilience;
c) strengthen local, regional and national levels' institutional capacity and planning policy.

Table 12. Brief cost effectiveness analysis of proposed adaptation options

Proposed action	Cost effectiveness criteria		Alternative action	Cost effectiveness criteria	
Greening urban Penang / heat reduction	Future cost of climate change	✓	Built structures for shading and introducing pedestrian air	Future cost of climate change	X
	Project efficiency	✓		Project efficiency	X

[61] Doswald, N. et al. (2014) 'Effectiveness of ecosystem-based approaches for adaptation: review of the evidence-base'. *Climate and Development,* 6, pp.185–201.

	Community involvement	✓	conditioned streets	Community involvement	-
	Cost/feasibility	✓		Cost/feasibility	X
	Environmental and safeguarding risks	✓		Environmental and safeguarding risks	X
Stormwater management	Future cost of climate change	✓	Significantly extend hard drainage infrastructure	Future cost of climate change	-
	Project efficiency	✓		Project efficiency	X
	Community involvement	✓		Community involvement	-
	Cost/feasibility	✓		Cost/feasibility	X
	Environmental and safeguarding risks	✓		Environmental and safeguarding risks	X
Comprehensive vulnerability / baseline assessment and action plans for social resilience strengthening in mukims George Town and Bayan Lepas	Future cost of climate change	✓	Programmes for vulnerability self-assessment and awareness, post disaster assistance and relocation	Future cost of climate change	✓
	Project efficiency	✓		Project efficiency	X
	Community involvement	✓		Community involvement	✓
	Cost/feasibility	✓		Cost/feasibility	X
	Environmental and safeguarding risks	✓		Environmental and safeguarding risks	✓
Strengthening social resilience	Future cost of climate change	✓	Women and youth posttraumatic support centre; Temporary shelters; School temporary relocation..	Future cost of climate change	X
	Project efficiency	✓		Project efficiency	X
	Community involvement	✓		Community involvement	X
	Cost/feasibility	✓		Cost/feasibility	X
	Environmental and safeguarding risks	✓		Environmental and safeguarding risks	X
Building institutional capacity	Future cost of climate change	✓	Developing new climate adaptation studies for each municipal programme; Climate-related programmes to be developed for all organizations and city council departments. New national level policy from the Malaysian Ministry of Health.	Future cost of climate change	✓
	Project efficiency	✓		Project efficiency	X
	Community involvement	✓		Community involvement	✓
	Cost/feasibility	✓		Cost/feasibility	X
	Environmental and safeguarding risks	✓		Environmental and safeguarding risks	✓

D. Consistency with national or sub-national strategies

The 11th Malaysia Plan 2016-2020 is Malaysia's five-year development plan towards realising its Vision 2020 and has been mapped against the UN's Agenda 2030 and its direction filters down in sub-national plans. The Nature-Based Climate Adaptation Programme for the Urban Areas of Penang Island is consistent with the 11th Malaysia Plan, notably Focus Area D Strengthening Resilience Against Climate Change and Natural Disasters – and is aligned with programme strategies as follows:

Programme area: Stormwater management

The Department of Irrigation and Drainage Malaysia (JPS) will use alternative and new technologies, including multifunctional mechanisms, to mitigate floods and encourage investment. For example, retention ponds, besides mitigating floods, will also be used as artificial wetlands for water quality improvement, habitat grounds for wildlife and recreational parks. Retention ponds with aesthetic improvements will increase the commercial value of land surrounding the area.

In addition, the JPS and relevant agencies will strengthen long-term flood mitigation solutions through implementation of Integrated Water Resource Management, Integrated River Basin Management and Integrated Flood Management. This includes the implementation of integrated solutions using a combination of structural components (e.g. retention ponds, diversion and river improvement works) and non-structural components (e.g. flood maps, flood warning system and flood proofing).

Programme area: Vulnerability assessments

The Government will implement strategies to raise the income and wealth ownership of the B40 (Bottom 40%) households, address the increasing cost of living and strengthen delivery mechanisms for supporting B40 households. The Government is also committed to introduce the Multidimensional Poverty Index (MPI) to ensure that vulnerability and quality of life is measured in addition to income. The use of the MPI will ensure that policy deliberations will shift beyond poverty, to include vulnerability as well and complement the Poverty Line Income.

Programme area: Institutional capacity: Knowledge transfer, climate board, public health programme

Communication, education and public awareness (CEPA) programmes engaging all levels of society will be enhanced to increase awareness about the environment, climate change adaptation and mitigation, conserving natural resources, and the role of green growth in raising productivity. This will instil a sense of shared responsibility among all stakeholders including federal and state governments, the private sector, academia, NGOs and the community towards comprehensive and coordinated efforts for better quality of life.

In addition to the 11th Malaysia Plan, the National Environmental Health Action Plan[62] was recently launched. It is a national level method of planning and implementing comprehensive

[62] http://nehapmalaysia.moh.gov.my/

and holistic actions with regard to the health of the environment and how to address climate change and health issues.

Social resilience building: Women and schools

The Government will improve the effectiveness of CEPA programmes by coordinating and integrating public awareness messages communicated by different public sector agencies and on different themes, including demand side management, transport, energy consumption, recycling, biodiversity conservation, climate change, disaster risk management and environmental pollution. Better coordination will increase understanding, visibility and retention of such messages, ensuring the right messages are communicated to the correct target audiences, such as women and school children.[63]

Several related policies have been developed by the government to ensure that climate resilient development is able to fulfill the national sustainability agenda.

Ministry of Energy, Science, Technology, Environment & Climate Change (MESTECC).[64]

MESTECC's vision is to ensure energy sustainability and wealth creation through science and technology, and environmental sustainability. The federal agency has four key missions: 1) managing energy resources, 2) creating growth opportunities through investment in science and technology, 3) preserving the environment through education, awareness and enforcement, and 4) leading climate change adaptation and mitigation measures to ensure the country's resilience. Most, if not all, of these are in development: establishing a National Climate Change Centre (NCCC); developing climate change mitigation and adaptation plans; and drafting a Climate Change Act 2021 bill. Recently, a draft final report on a National Low Carbon Cities Masterplan has been developed which draws out a guide for the implementation of low carbon cities at the state and local level.

The programme is fully aligned with the *Malaysia Third National Communication and Second Biennial Update Report to the UNFCCC*, developed by the Ministry of Energy, Environment, Science, Technology and Climate Change and finalised in 2018 in terms of the development of relevant adaptation strategies.

With regards to the state of Penang, both the Penang State Government and the Penang Island City Council have a general greening policy which tackles waste management and greening schemes. They are currently developing policies to address climate change.

Penang State Government

Prior to the State's Penang 2030 vision, a Cleaner Greener Penang policy was formed to beautify Penang's image as a green and clean state and to improve the liveability of its built environment with a focus on waste management. Under Penang 2030 one of its four primary thrusts is to invest in the built environment to improve the state's resilience through the

63 Eleventh Malaysia Plan 2016-2020: https://www.talentcorp.com.my/clients/TalentCorp_2016_7A6571AE-D9D0-4175-B35D-99EC514F2D24/contentms/img/publication/RMKe-11%20Book.pdf

64 http://inisiatif.mestecc.gov.my/core/3rd_sector/3.4.2_ms.html & http://inisiatif.mestecc.gov.my/core/3rd_sector/3.4.3_ms.html

development and implementation of a climate change adaptation plan. The State is concurrently developing the Penang Green Agenda which aims to identify and prioritise environmental targets including strategies to mitigate and adapt to climate change.

Penang Island City Council

The City Council adopted the State's Cleaner Greener Penang initiative as a general road map to deliver a cleaner and greener city and improve the quality of life in Penang. Some of these initiatives include a bike sharing system, energy efficient lighting, plogging and tree-planting programmes. The city council is currently developing a low carbon cities framework to guide future urban development in the state.

E. Compliance with relevant national technical standards and the Environmental and Social Policy of the Adaptation Fund.

The Nature-Based Climate Adaptation Programme for the Urban Areas of Penang Island is cognizant of complying with relevant technical standards and will take due care to do so.

Compliance will be ensured with all national technical standards as well as UN-Habitat and Adaptation Fund Environmental and Social, and Gender Policy requirements.

The programme is in accordance with two national regulation plans, the National Landscape Master Plan and the National Urbanisation regulations, which provide mostly guidelines but also a few technical standards. The National Landscape Master Plan regulations provides guidelines on green urban spaces, softscape and hardscape and on the protection of Malaysian landscape. The National Urbanisation Plan regulations provides guidelines on urban open spaces, recreational and sports areas.

PlanMalaysia's planning guidelines include a few standards related to green neighbourhoods[65], rooftop gardens[66] and back lanes.[67]

The organisations in charge of executing the programme will also comply with the Malaysian technical standard MS ISO 14001:2015, which is identical to ISO 14001:2015, *Environmental management systems - Requirements with guidance for use, published by the International Organization for Standardization (ISO).*'

Table 13. Compliance with relevant national technical standards and tools

Expected Output or	Relevant rules,	Compliance, procedure	Screening against

65 https://www.townplan.gov.my/index.php/en/agensi/penerbitan-planmalaysia/garis-panduan-perancangan/2083-5-gp024-gpp-kejiranan-hijau/file

66 https://www.townplan.gov.my/index.php/en/agensi/penerbitan-planmalaysia/garis-panduan-perancangan/2082-4-gp014-a-gpp-taman-atas-bumbung/file

67 https://www.townplan.gov.my/index.php/en/agensi/penerbitan-planmalaysia/garis-panduan-perancangan/2090-12-gp025-gpp-lorong-belakang/file

Intervention	regulations, standards and procedures	and authorities involved	AF ESP Principles
Output 1.1. New tree-line streets / Connected canopies constructed **Output 1.2.** Pocket parks / vacant spaces constructed **Output 1.3.** Green parking spaces constructed **Output 1.4.** Green facades constructed (Built structures greening) **Output 1.5.** Green rooftops constructed (Built structures greening) **Output 1.6.** Urban agriculture programme initiated **Output 2.1.** Blue-green corridors developed **Output 2.2.** Upstream retention constructed **Output 2.3.** Swales and infiltration wells constructed **Output 3.1.** Capacity development support for vulnerability assessment and climate change-related planning provided to the two mukims. **Output 4.1.** School-level awareness programme developed and implemented **Output 4.2.** Women and girls programme developed and	11th Malaysia Plan 2016-2020: Anchoring Growth on People; dated 2015 12th Malaysia Plan 2021-2025; pending parliamentary approval National Policy on Climate Change; dated 2019 National Policy on Biological Diversity 2016-2025; dated 2016 National Landscape Master Plan; dated 2011 National Environmental Health Action Plan, dated 2007 Cleaner, Greener Penang state initiative; launched 2010 Penang 2030: A Family-focused green and smart state that inspires the nation; dated 2018 Penang Green Agenda; expected 2020 publication date Low Carbon City Framework (LCCF); Performance Criteria 2,3 and 10; dated 2011 Urban Stormwater Management Manuel for Malaysia 2011; dated 2011 National Urbanisation Plan, dated 2006 Malaysia Standard ISO14001:2015: Environmental management	Collaboration with the national government will be part of the process of promoting the social programmes output, raising public awareness, and using their multidimensional poverty index to conduct the vulnerability assessments. Outputs 1.1 to 2.3, focused on implementing nature-based solutions, will require co-implementing partners such as The Penang State Government, The Department of Irrigation and Drainage (JPS), NAHRIM (National Hydrology Research Institute), National Institute of Landscape Architecture, the National Forestry Institute, and so on, to ensure the appropriate procedures are followed. Several knowledge-exchange partnerships will be established, most notably with the Smart Utilities Research Institute of Tsinghua University Innovation Center in Zhuhai, China, to discuss the design of sponge cities. The project aims to partner with the Women's Centre for Change, Penang's most widely recognised women's organisation, to ensure gender inclusive outputs. To deliver Penang 2030,	All principles will be considered when producing the outputs. No environmental and social principles are expected to be triggered as a result of this action When carrying out outputs 1.1 to 1.6 and outputs 2.1 to 2.3, particular importance will be placed maintaining AF ESP Principles 1 2, 3, 8, 9, and 10, due to their relevance to the delivery process. When carrying out output 3.1, AF ESP Principles 3, 4, 5, 6, 7, and 8 will be observed to ensure all vulnerabilities are accounted for. When carrying out outputs 4.1 to 4.2, special focus will be placed aligning with AF ESP Principles 2, 3, 4 and 5 so as to achieve equitable and inclusive outputs. When carrying out outputs 5.1 to 5.3, observing AF ESP Principles 2, 3, and 4 will be especially important for the delivery of equitable and inclusive outputs.

implemented **Output 5.1.** Communications and knowledge platform developed and implemented **Output 5.2.** Penang Climate Board created **Output 5.3.** Climate-related public health programme developed and initiated	systems, dated 2015 Kejiranan Hijau guidelines (Green Neighbourhood); dated 2012 Lorong Belakang (Lorong Belakang); dated 2014 Taman Atas Bumbumg guidelines (Rooftop Gardens); dated 2012	the Cleaner Greener initiative, and meet the necessary compliance procedures for each output, the project will work closely with Penang State Government and the Penang Island City Council. The Mistry of Energy, Science, Technology, and Climate Change (MESTECC) will be the executive entity for the Penang Climate Board output.	

The programme may result in adjustments to national technical standards. Some outputs, such as the selection of climate-resilient street trees for Malaysia, to be developed together with Jabatan Landskap Negara (National Institute of Landscape Architects), will have an impact on policy and urban design guidelines and, possibly, on technical standards as well, in what relates to specific construction details for tree pits.

F. Duplication with other funding sources

The Penang state government has allocated for the year RM150 million in funds to implement 8 flood mitigation projects to reduce flood occurrence risk in hotspots area funds for flood mitigation projects, which will include mostly drainage infrastructure and approximately 15% of nature-based solutions.

No other relevant nature-based climate adaptation projects are being proposed for Penang island external to the programme and the projects listed below and. It is, however, possible that there will be social vulnerability reduction initiatives being developed parallel to the programme by NGOs without the team's knowledge. Most investments from Penang government are mitigation-focused (solar panels and so on). These are complementary and not overlapping measures.

The significant projects from the city council (MBPP) are:

a) Tree planting in George Town and Bayan Lepas for 2020/2021 – budget of RM 250,000.
b) Backlanes greening in Kampung Malabar, Lebuh Cintra and Lebuh Chulia for 2020/2021 - budget of RM 800,000.
c) Backlanes greening in People's court area for 2020/2021 – budget of RM 1,000,000.
d) Grant offer for application by public and organizations to encourage Green Initiatives / Green Building Institute (GBI) certifications - budget of RM 1,000,000 (undetermined timeline).
e) There will be additional co funding to some components of the programme. Since the concept note was submitted to the Adaptation Fund, the programme has

received the Climathon Global Cities Award from EIT Climate-KIC, in the amount of Euros 60,000. This amount will be allocated mostly to the study of climate-resilient street trees for Malaysia. Naturally adjustments will be made to the budget before the final proposal is submitted and during the development of the programme.

The additional co funding for urban agriculture is as follows:
RM 200,000 (Habitat Foundation – RM 35,000; Sultan Idris University – RM 10,000; US State department/US embassy – RM 25,000; Penang state government – RM 40,000; Homegrown farms – RM 30,000; Chief Minister Incorporated – RM 60,000).

G. Learning and knowledge management

At a local level, a participatory approach involving communities and local authorities in planning and implementation will lead to increased local awareness and knowledge on climate change risks and adaptation. Pilot projects will contribute to sharing lessons and evaluate the best strategies.

At city level, transfer of results and lessons learnt to other communities across Penang state will be promoted. All information will be consolidated in reports and fully accessible online via the knowledge management platform, which will, naturally, also be available nationally and internationally. Beyond reports, specific tools and guidelines will also be available to all levels.

As the programme is designed to be demonstrative / proof of concept with a strong knowledge codification component, to be scaled in Malaysia and elsewhere in the region, both national and international levels are particularly important. To that end, the full proposal will seek to track and measure all the project's adaptation benefits, and use its knowledge management-related activities to promote and replicate both the benefits and the MRV system that tracks them.

At national level, knowledge transfer will benefit other vulnerable municipalities by mainstreaming municipality adaptation methodology and assessment of effectiveness of the different strategies. Partnering ministries, government agencies, CSOs and scientific support institutions (as NAHRIM) in the programme will facilitate countrywide dissemination of strategies and methodology, including in terms of policy. By partnering with NAHRIM for monitoring and modelling purposes, effective knowledge consolidation will trigger institutional learning processes, allowing for replication and scaling of strategies nation-wide.

Beyond the knowledge transfer online platform, MESTECC and NAHRIM will help to mainstream municipal climate adaptation framework and methodology to all cities in Malaysia in multiple formats.

At international level there are several knowledge-exchange partnerships being discussed, most notably with the Smart Utilities Research Institute of Tsinghua University Innovation Center in Zhuhai, China, focused on sponge cities design.Since the concept note was submitted to the Adaptation Fund, the programme has received the Climathon Global Cities Award from EIT Climate-KIC. This already allowed for international exposure, and the award is comprised of scientific support from the Crowther Lab and ETH Zurich university, beyond the monetary reward.

UN-Habitat will also provide a knowledge platform for the programme via a number of international dissemination mechanisms.

A communications plan established in the inception phase of the project and managed in association with the knowledge management plan, will contribute to ensure active knowledge dissemination at all levels.

Table 14. Learning and Knowledge Programme Components

Expected concrete outputs	Learning objectives & indicators	Knowledge products
1.1 In-depth comprehensive vulnerability / baseline assessment and action plans for social resilience strengthening in mukims George Town and Bayan Lepas	a) Improved climate change - sensitive planning at community and city level	Mukims climate action plans
1.2. Extensive tree alignments will be introduced in existing streets	b) Impact of street trees on temperature reduction	List of climate-resilient street trees' species for Malaysia (developed together with Jabatan Landskap Negara and botanic experts, to be incorporated in policy) Scientific reports and articles
1.3. New climate-conscious green areas will be built in vacant spaces in urban areas	c) Impact of small green urban spaces on temperature reduction	Scientific reports and articles
1.4. Existing car parks will be shaded by trees	d) Impact of tree-shading in car parks and asphalt	Scientific reports, toolkits and articles
1.5. Green will be introduced to facades	e) Impact of green facades in street temperature	Scientific reports, toolkits and articles
1.6. New green roofs	f) Impact of green roofs in reducing the UHI effect	Scientific reports, toolkits and articles
1.7. New urban agriculture plots will be introduced, and training provided	g) Improving resilience and diet of communities	List of species for urban agriculture in Penang and how different species can contribute to reduce nutrient-deficiency Toolkits
1.8. Climate-conscious green elements will be added to existing river corridors to promote temperature reduction, air circulation and stormwater storage and retention	h) Impact of river corridors in temperature reduction and stormwater retention capacity	Scientific reports and articles
1.9. Storage and retention areas will be introduced in strategic areas upstream in order to reduce flooding	i) Impact of upstream retention areas in reducing flooding downstream	Scientific reports and articles
1.10. Swales and infiltration wells will be introduced in urban areas	j) Impact of swales and infiltration wells in reducing flooding	Scientific reports and articles
1.11 Schools programme	k) Increased awareness of main challenges youth faces	Reports

1.12 Women and girls programme	l) Improved understanding of gender-biased climate vulnerability m) Equal gender representation in climate-related decision making processes	Reports Standards for gender representation in climate-related decision making
1.13. Creation of a knowledge transfer platform and a communications plan	n) understanding how knowledge dissemination will be extended to other vulnerable communities	Online knowledge transfer platform Monthly reports sent to all stakeholders
1.14. Creation of the Penang climate board, a unit in the municipality to address climate-related issues	o) improve understanding of how effective a climate dedicated unit in the city council will be and its impact in different municipality departments' decisions	Scientific reports and articles
1.15. Development of a climate-related public health programme	p) contribute to the understanding of the impact of climate change in public health in Malaysia	Scientific reports and articles

H. Consultative process

During the development of the programme a multipronged community and stakeholder consultation methodology was undertaken that included a series of one-on-one meetings, two workshops, six focus group discussions (FGD) and a survey. The workshops were attended by 77 local people, the focus groups by 53 and the survey was answered by 324 people.

A display outlining the programme was installed as part of the Penang Climate Action Week (the first of its kind to take place in Malaysia). An additional workshop on climate adaptation was held by the Penang State Government in November 2019 as part of its Penang2030 initiative and was attended by 35 participants from multiple organisations.

The goal of the engagement was to gain insights on the impacts of climate change, self-identified vulnerabilities, as well as to identify the main concerns and possible strategies for adaptation. Nature-based solutions were presented and advantages and challenges of implementation discussed with the community and key stakeholders. Most consultation activities took place in October and November 2019.

FGDs were held in communities vulnerable to climate change impacts: a) UNESCO World Heritage Site (vulnerable to floods, heat stress and extreme weather events), b) Sungai Pinang community (the most flood-prone area of the city), c) Air Itam (low income communities). Other relevant stakeholders engaged were significant industry players, different CSOs, some of them representative of vulnerable groups (women and youth) and various government and non-government agencies.

Table 15. Stakeholders and communities engaged

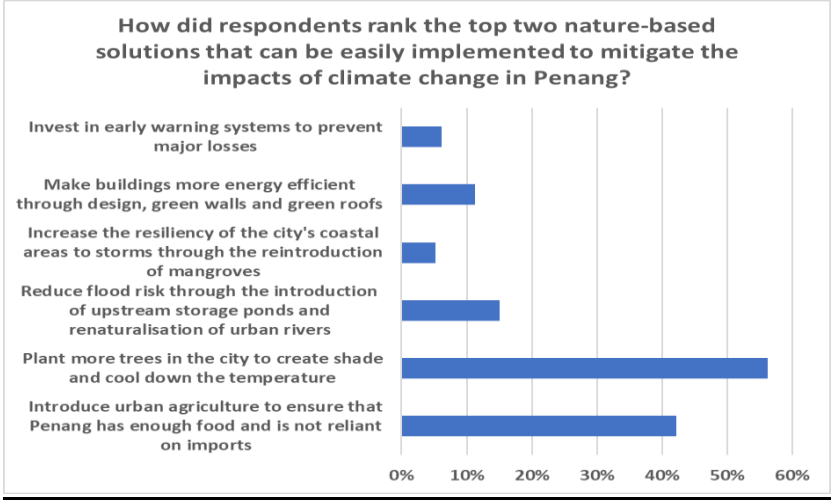
Communities	World Heritage Site	Communities	Lim Jetty
			Acheh Mosque
			People's court
	Sungai Pinang		Hasnim Yahya Mosque
			Taman Free School

			Jalan Perak
	Air Itam		Kampung Melayu
			Kampung Pisang
			Taman Lumba Kuda
			Masjid Negeri
CSOs	Penang Youth Development Centre		
	Youth Parliament of Malaysia		
	Penang Women Development Corporation		
	Women and Family Development committee		
	Penang Deaf Association		
	Penang Forum		
	Water Watch Penang		
	Persatuan Ilmu Murni Pulau Pinang		
	Malaysia Nature Society		
Industry	Penang Skills Development Corporation		
	Penang Development Corporation		
	LLA Arkitet		
	Perunding YAA		
	PAM (Malaysian Architects Association)		
	CREST		
	ILAM (Malaysian Landscape Architects Association)		
	Real Estate & Housing Developers' Association		
	Construction Industry Development Board		
	Perbadanan Bekalan Air Pulau Pinang		
	Penang Hill Corporation		
	Master Builders Association Malaysia		
Government	Majilis Bandaraya Pulau Pinang urban services		
	Jabatan Kerja Raya (Public Works Department)		
	EXCO YB Phee Boon Poh (State minister for Social Harmony and Environment)		
	EXCO YB Zairil KHir Johari (State minister for Public Works and Flood Mitigation)		
	Penang Green Council		
	Jabatan Pengairan Dan Saliran (Drainage and Irrigation Department)		
	Chief Minister Incorporated		
	BPEN (State Economic Planning Unit)		
	Plan Malaysia		
	Jabatan Kerja Raya (Public Works Department)		
	Pegis Penang		
	Majlis Bandaraya Seberang Perai		
	Bahagian Kerajaan Tempatan		
	Malaysia Green Building Council		
	Implementation Coordination Unit		
	Jabatan Alam Sekitar		
	Penang 2030		
Institutions	Penang Institute		
	Habitat Foundation		
	Penang Botanical Garden		
	Universiti Sains Malaysia		

Findings

- All stakeholders agreed that Penang is vulnerable to climate change impacts due to its geographic location, however, awareness varies between groups.
- All stakeholders mention increased temperatures and flooding as the main impacts' changes in terms of climate in Penang island.
- Flooding was the impact highlighted for George Town mukim and temperature rise for the Bayan Lepas mukim.
- Vulnerable communities identified an increase of heat-related diseases (flu, fever and so on), mainly linked to the elderly and children.
- Vulnerable communities identified mental health impacts of heat, such as increased irritability, and emotional stress related to storms.
- Some stakeholders – not all – were able to link their socio-economic wellbeing to climate change impacts.
- The use of NBS for the urban areas of Penang island was overwhelmingly supported but some obstacles were highlighted, such as operational challenges and contestation over responsibility.
- Residential as well as commercial areas have reported losses due to flooding (in a range of RM10,000 to 50,000) and associated limited mobility.
- Lack of community organisation identified in non-commercial areas, making it difficult to organise a response in times of crisis.
- In the George Town mukim consultation, new tree lined streets were consistently rated has having a high impact but challenging to implement due to impact of the root system in the pavement and maintenance costs.
- In the Bayan Lepas mukim consultation, the NBS prioritised was new tree lined streets as well as greening car parks. Green roofs were considered to be of low to medium impact but of easy implementation.

Figure 2. Results of the Penang Climate Adaptation Survey



Conclusions

- Climate change awareness is needed for the entire population but youth groups were identified as being particularly unaware of climate change risks. This may signal the need to develop specific awareness programmes dedicated to this age group.
- Challenges identified in relation to the implementation of NBS are often a result of technical implementation errors, as is the case with trees falling during storms. The reason for this to happen in Penang is more often due to the lack of proper development of the root system, which curtails its structural function (due to lack of adequate sizing of the tree pit and the wrong choice of tree species) than to the intensity of winds.
- Increase of heat-related diseases in the elderly and children may pose a risk of overburdening women, due to their role as main caregivers.
- Despite the seven casualties in the floods of 2017, health is mentioned more in association to heat stress than to flooding.
- Even though NBS implementation in Penang was supported, some mentioned construction as being a disruptive.
- Upstream retention is not prioritised possibly because it is a technical, unfamiliar term and concept and its potential for reducing flooding is not fully understood.

The multipronged community consultation adopted used different techniques to solicit community and stakeholders' views. The survey results legitimise the inclusion of an urban agriculture component, but other forums suggested that vulnerable groups were more concerned about heat stress and the risk of flooding. The consultation also helped shape the project components, for example extra support for caregivers (mostly women) as heat stress has demonstrated to have a major impact on children and elderly's health. The full consultation document is available upon request.

I. Justification

Table 16. Project justification

Outcomes / planned activities	Baseline (without AF)	Additional (with AF)	Comment and alternative adaptation scenarios
Outcome 1.1. Reduction of overall urban atmosphere temperatures by 1°C 5-7 years after project completion.	Increased heat stress. Specific vulnerable groups, as outdoor workers, children and the elderly becoming more exposed.	Reduced temperatures and heat stress.	Introduction of artificial shading in the streets (research shows its impact will be significantly lower than that of street trees). Introduction of air conditioning in the streets, furthering climate change problems (production of carbon dioxide) and vulnerabilities (by increasing reliance and pressure on the power grid, exposing the population to power outages).
Outcome 1.2. Reduction of hard surfaces, resulting in the reduction of the urban heat island effect in the city.	Cumulative impact of urban heal island effect and climate warming increasing the temperature above the mean atmosphere temperature.	No additional temperature increase due to the urban heat island effect.	Adding a coating that reduces heat absorption to pavement. Tests developed in Penang by Think City demonstrate that this type of coating may reduce the temperature of temperature up to 8C degrees, while hard/surfaces/soft surfaces can differ in up to 30C degrees.
Outcome 1.3. Reduction of temperatures in the streets and inside buildings.	Increased temperatures and dependency on air conditioning. Increased energy costs, disproportionally impacting vulnerable communities.	Reduced temperatures in urban areas and therefore, in households. Reduced reliance on air conditioning and costs with energy costs.	To reduce disproportional impact to vulnerable communities, possibly creating a support programme to finance low income households' energy costs.
Outcome 1.4. New urban agriculture gardens are incorporated in the city. Training sessions will take place in a number of (4/month) 240 sessions in total.	Increased costs of food disproportionally impacting the most vulnerable communities.	Community gains knowledge on urban agriculture and nutrition, Community grows their own produce. Reduced nutrient deficiency. Reduced food miles	Policies and initiatives supporting low income communities' access to produce and nutrition.
Temporary storage of stormwater, reducing flooding	Increased flooding.	Reduction in economic losses (private property and infrastructure) and negative impacts to public health, natural assets and ecosystems.	Significant extension of the drainage hard infrastructure. Although Penang urban areas are not very vulnerable to sea level rise, drainage infrastructure could be impacted, as there's a risk that stormwater could not be drained in a situation of combined high tide and heavy rainfall

Outcome 1.5. Increased awareness on systems assessment, including private property, infrastructure and natural assets; improved planning for adaptation.	Vulnerable community with little awareness regarding climate risks in general and on critical infrastructure and private property.	Community is aware, critical infrastructure and property become more resilient. New projects developed include climate adaptation measures.	No alternatives to awareness on climate change and improved planning for adaptation were identified.
Outcome 1.6. Increased school building resilience, greater levels of knowledge and awareness among students, teachers and educational authorities.	Youth is unaware of climate risks (as verified in community consultation). Schools are vulnerable to disruptions resulting of extreme weather events. Youth is uninformed and untrained on urban agriculture. School grounds do not fulfil their potential in temporary stormwater retention.	Youth becomes aware of climate risks and trained in urban agriculture. Schools are prepared to deal with extreme weather events.	Other programmes directed at youth on climate change awareness may be developed at national level.
Outcome 1.7. Reduced gender vulnerability asymmetries.	Women are disproportionally impacted by climate change. Women are not represented equally in climate-related decision-making processes. Increase of heat-related diseases in children and elderly people place an additional burden on women as the main caregivers.	Women are aware of climate-related risks and given tools to deal with specific challenges, such as children and elderly heat-related diseases. Quotas for women representation in Penang climate-related decision-making processes.	Other programmes directed at youth on climate change awareness may be developed at national level.

Outcome 1.8. Project implementation to be fully transparent. Information of strategies and projects to be made available to other municipalities in Malaysia and in the Southeast Asia region for replication.	Knowledge transfer and dissemination is not developed in terms of municipal climate adaptation.	Knowledge transfer will increase and the likelihood of follow up finance for additional investment will be increased. Other vulnerable communities in Malaysia and in the Southeast Asia region can access knowledge developed in the programme, which may assist with the development of their own climate adaptation projects and plans.	Without the knowledge transfer platform the chances of wider knowledge generation resulting of the programme and follow-up financing would be limited.
Outcome 1.9. Penang climate board: a unit created in connection with the municipality will monitor and evaluate all climate-related risks, addressing the problem with a comprehensive perspective.	There is no city council department addressing climate change in a holistic, integrated way.	The creation of a dedicated and centralised unit addressing climate related risks and challenges will be of great significance in increasing resilience in Penang island.	National and regional level dedicated units for climate related risks and challenges.
Outcome 1.10. Comprehensive public health programme, including pilot project monitoring heat related illness in selected hospitals in Penang.	Heat-related diseases such as heat stress and heat stroke are not identified and coded accordingly in hospitals, therefore there is no data related to public health impact of heat waves and temperature rise.	Heat-related and other climate-related diseases are identified by hospitals and research can be developed in order to identify measures which can be put in place to reduce the risks.	A programme addressing specific climate-related public health risks developed at national level.

J. Sustainability

Institutional
The programme is aligned with Malaysian national goals in terms of adaptation initiatives. It is expected that the programme will contribute to the adaptation of other municipalities in Malaysia via knowledge transfer platform and replication of strategies.

Penang2030 was launched in 2018 by the Penang State Government with the headline to be a "family focused, green and smart state that inspires the nation'. One its four overarching themes is to invest in the built environment to improve resilience. There is an explicit initiative to implement a climate adaption programme underpinned by nature based solutions, sponge city principles and partnerships with international agencies (www.penang2030.com).

Social
Community consultation had a significant impact in designing the programme. When the projects are implemented, communities will gain greater awareness of climate change impacts and the need for adaptation. Additional benefits are added training and skills in urban agriculture and building and maintaining green infrastructure.

By directly addressing the needs and engaging with vulnerable communities (B40, women and girls and youth) the programme will also contribute to reduce unbalances in the social dynamics in what relates to vulnerability to climate impacts.

Economic
Adaptation measures are essential in order to reduce economic losses, mainly from flooding. As exemplified previously in the cost-benefit analysis, one flood in 2017 caused significant damages; avoiding floods would have a significant positive impact in limiting damages and economic losses.

Financial
When action plans are completed under component 3, a study will be conducted to identify national, regional and local financial sustainability models. Willingness to pay engagements and studies will be conducted, particularly directed to the private business community of Bayan Lepas mukim.

Environmental

It is of utmost importance that no component of the project (particularly built components 1 and 2) has any negative impacts in the ecosystem. Beyond the botanical experts consulting for the programme, both Perhilitan (National Institute of Wildlife) and Perhutanan (Forestry National Institute) were invited to participate as supporting executing entities, to which they have agreed. All elements (plant species and projects) will be reviewed by these two entities in order to confirm they have no negative impact in local ecosystems or wildlife.

K. Environmental and social impacts and risks

Risks associated with the creation of green spaces are mainly associated with possible negative ecosystem impacts of species introduced. By having Perhilitan (National Institute of Wildlife) and Perhutanan (Forestry National Institute) as supporting executing entities, analysing and validating the species proposed, this risk is greatly reduced.

In the community consultation stage two other risks were identified. The first risk was the possibility of trees falling during storms and damaging property or endangering lives. Trees falling during storms occasionally happens in Penang, not due to the intensity of winds, by as result of technical implementation errors resulting in the lack of proper development of the root system. Two main reasons for this were identified: small and inadequately designed tree pits and the wrong choice of tree species may lead to an abnormal development of

trees, in which the canopy is not balanced in size by the root system, severely endangering its natural structure. This risk will be mitigated by the development of a list of climate-resilient street trees for Malaysia, in partnership with Jabatan Landskap Negara and local botanical experts as well as typical construction details for street trees' pits.

The second risk identified in community consultation was the disturbance of the normal life of citizens during construction. This risk will be mitigated by having a strong and detailed planning phase, which will allow to reduce the duration of the construction works to the minimum and, therefore, also reduce the disturbance of the citizens' routines.

Table 17. Risk Mitigation Actions

Checklist of environmental and social principles	No further assessment anticipated required for compliance	Potential impacts and risks – further assessment and management required for compliance
Compliance with the Law	X	
Access and Equity		X
Marginalized and Vulnerable Groups		X
Human Rights	X	
Gender Equity and Women's Empowerment		X
Core Labour Rights		X
Indigenous Peoples	X	
Involuntary Resettlement		X
Protection of Natural Habitats		X
Conservation of Biological Diversity		X
Climate Change		X
Pollution Prevention and Resource Efficiency		X
Public Health		X
Physical and Cultural Heritage		X
Lands and Soil Conservation	X	

A full risk and impact assessment, and Environmental and Social Management plan will be prepared at full proposal stage, if the concept note is successful.

Table 18. ESP risks and possible mitigation measures for further analysis at full proposal

Adaptation Fund environmental and social principles	Possible risks	Possible mitigation measures
Compliance with the Law	None beyond the compliance issues identified in Part II Section E of this proposal document	
Access and Equity	Certain groups may have less access to training or to green infrastructure or urban agriculture or specific groups may have privileged access	Community management rules ensuring equal access is guaranteed, enforced through monitoring and legal agreements (where necessary)
Marginalised and Vulnerable Groups	There are some refugees in the Bayan Lepas area who are vulnerable to discrimination. Other forms of racial discrimination	Community management must ensure equal access extends to refugees and migrant population and equal treatment among
Human Rights	None, other than those issues in Marginalised and Vulnerable Groups, Gender Equality and Women's Empowerment, Core Labour Rights and Involuntary Resettlement	
Gender Equity and Women's Empowerment	Women not having equal representation in decision making processes, women are excluded from activities under the programme,	Quotas for female participation and inclusion in decision making at all levels

	such as training and urban agriculture	
Core Labour Rights	People working on the project may have improper contracts, working conditions, unsatisfactory occupational health and safety or there could be discrimination against women at work.	Proper contracts, in compliance with ILO standards and occupational health and safety standards in line with international best practices.
Indigenous Peoples	There are no indigenous people in Penang island	-
Involuntary Resettlement	Involuntary resettlement or disruption of access arising from construction	Proposed interventions only on state land
Protection of Natural Habitats	Damage to local ecosystems due to introduction of dangerous species of flora	Perhilitan and Perhutanan to review all projects to make sure no dangerous species is proposed
Conservation of Biological Diversity	Damage to local ecosystems due to introduction of dangerous species of flora	Perhilitan and Perhutanan to review all projects to make sure no dangerous species is proposed
Climate Change	Inefficient sourcing of materials may generate emissions. Poor construction/planning may lead to “mal-adaptation”	Preferring local materials in the procurement process. Multi-stakeholder consultation and approval process for designs
Pollution Prevention and Resource Efficiency	Built projects will generate waste	Incorporate waste management and disposal into design
Public Health	Construction sites pose a risk to the public if not properly managed and demarcated. Water-related activities pose contamination risks	Zero-accident construction site management. Practices to ensure water sources are not contaminated
Physical and Cultural Heritage	Penang old town is a UNESCO World Heritage Site	Consultation with UNESCO, Department of Heritage Conservation (MBPP) and George Town World Heritage Incorporated about implementing the project in accordance with heritage preservation principles.
Lands and Soil Conservation	No risks identified beyond those highlighted in Protection of Natural Habitats	

PART IV: ENDORSEMENT BY GOVERNMENT AND CERTIFICATION BY THE IMPLEMENTING ENTITY

A. Record of endorsement on behalf of the government[68] *Provide the name and position of the government official and indicate date of endorsement. If this is a regional project/programme, list the endorsing officials all the participating countries. The endorsement letter(s) should be attached as an annex to the project/programme proposal. Please attach the endorsement letter(s) with this template; add as many participating governments if a regional project/programme:*

Dr. K. Nagulendran, National Designated Authority to the Adaptation Fund, Ministry of Energy, Science, Technology, Environment and Climate Change	Date*: 16 January 2020*

KEMENTERIAN TENAGA, SAINS, TEKNOLOGI, ALAM SEKITAR DAN PERUBAHAN IKLIM
MINISTRY OF ENERGY, SCIENCE, TECHNOLOGY, ENVIRONMENT AND CLIMATE CHANGE
Aras 1-7, Blok C4 & C5, Kompleks C
Pusat Pentadbiran Kerajaan Persekutuan
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MALAYSIA

TEL : 603 – 8000 8000
FAKS : 603 – 8888 9070

Our reference : MESTECC.SAS.S.800-2/9/2 Jld. 2 (11)
Date : 16 January 2020

Adaptation Fund Board Secretariat
c/o Global Environment Facility
Mail stop: N 7-700
1818 H Street NW
Washington DC 20433
USA

Dear Sir/Madam,

SUBJECT: ENDORSEMENT OF NATURE-BASED CLIMATE ADAPTATION PROGRAMME FOR THE URBAN AREAS OF PENANG ISLAND

In my capacity as the Designated Authority for the Adaptation Fund of Malaysia, I confirm that the above national programme is in accordance with the national priorities in implementing adaptation projects to ensure that more sustainable urban planning can be implemented to reduce impacts and risks of climate change to urban areas in Malaysia.

Accordingly, I am pleased to endorse the above project programme to receive support from the Adaptation Fund. If approved, the project will be implemented by the United Nations Human Settlements Programme (UN-Habitat), Penang Island City Council, Department of Drainage and Irrigation (DID) and Think City Sdn. Bhd. Several other ministries, sub-national authorities, non-governmental organisations and scientific institutions will also be involved in the implementation of this project.

The project concept note builds on the state, district and municipal level planning process and goals, seeking to mainstream climate change adaptation. The project design is based on numerous in-depth engagements; in close consultation with scientific institutions and national governmental entities and sub-national authorities. The programme aims to support the

[6] Each Party shall designate and communicate to the secretariat the authority that will endorse on behalf of the national government the projects and programmes proposed by the implementing entities.

implementation of Malaysia's Nationally Determined Contribution, as well as further development of the Adaptation Plan, as well as to be mainstreamed in other urban areas in Malaysia.

Thank you.

Yours sincerely,

(DR. K. NAGULENDRAN)
National Designated Authority to the Adaptation Fund
Ministry of Energy, Science, Technology, Environment and Climate Change
Malaysia

B. Implementing Entity certification

Provide the name and signature of the Implementing Entity Coordinator and the date of signature. Provide also the project/programme contact person's name, telephone number and email address

Implementing Entity Certification

I certify that this proposal has been prepared in accordance with the guidelines provided by the Adaptation Fund Board and prevailing national development and adaptation plans, including the 11th Malaysia Plan 2016-2020, the Third National Communication to the UNFCCC and its Nationally Determined Contribution to the Paris Agreement. Subject to the approval of the Adaptation Fund Board, I commit to implementing the project in compliance with the Environmental and Social Policy of the Adaptation Fund and on the understanding that the implementing entity will be fully (legally and financially) responsible for the implementation of the project.	
Raf Tuts, Director, Global Solutions Division, UN-Habitat	
Date: 16th April 2020	Tel and email: +254-20-762-3726; raf.tuts@un.org
Project Contact Person: Marcus Mayr, Programme Management Officer, Programme Development Branch	
Tel: +254 723 697 563	
Email: Marcus.mayr @ un.org	