

2. Vulnerability and Adaptation

Climate Change Projections

2.1. According to the IPCC Fourth Assessment Report (AR4), global temperatures are projected to rise by 1.1 to 6.4°C, while global mean sea levels are projected to rise by 18 to 59 cm over 1990 levels by around 2100, based on future scenarios of varying global emission levels. Temperature extremes, heat waves and heavy rainfall events are projected to become more frequent as well. For Southeast Asia, the IPCC AR4 projects a warming similar to global mean warming. Annual rainfall in Southeast Asia is also projected to increase by about 7%¹.

Singapore's Vulnerability to Climate Change

2.2. As a relatively low-lying, densely populated island in the tropics, Singapore is affected by climate change. Much of the island is less than 15m above sea level, with a generally flat coast. With a population of about 4.7 million within its 193km coastline, Singapore is one of the most densely populated countries in the world. In addition, Singapore has a relatively high uniform temperature and abundant rainfall, and is also situated in a region in which communicable diseases such as dengue are endemic.

2.3. Given these circumstances, the potential impacts of climate change on Singapore include:

- a) Increased flooding
- b) Coastal land loss
- c) Water resource scarcity
- d) Public health impact from resurgence of diseases
- e) Heat stress
- f) Increased energy demand
- g) Impacts on biodiversity

These potential impacts are not due solely to climate change, but can be aggravated by adverse global climate change.

2.4. We are aware of these vulnerabilities to climate change. As a result of our environmental and developmental planning in the past, we have existing measures in place that help address the potential climate change impacts. These are elaborated in the section on "Adaptation Measures" below.

¹ Based on the projections of 21 models, the predicted annual rainfall changes for Southeast Asia range from -2% to +15% with a median change of +7%.

2.5. At the same time, we recognise the need to continue improving our understanding of the detailed effects and resulting impacts of climate change on Singapore. NEA, in consultation with other government agencies, has commissioned a study of Singapore's vulnerability to climate change. This study will project climate change effects such as temperature, sea level and rainfall patterns in Singapore in the next century, and the impacts of such effects like increased flooding and impacts on water resources.

2.6. The study team is led by the Tropical Marine Science Institute of National University of Singapore (NUS), and comprises both local and foreign experts. A number of the foreign experts have been actively involved in the drafting and review of IPCC reports as well. The results of the study will facilitate the identification of new adaptation measures as well as the review of existing adaptation measures.

Adaptation Measures

Flooding

2.7. A higher sea level will make it more difficult for rainwater to drain into the sea. This can aggravate inland flooding during storm surges (when seawater is pushed toward the shore by the force of the winds swirling around the storm) and rainstorms. Since 1991, the Public Utilities Board (PUB) requires new reclamation projects to be built to a level 125 cm above the highest recorded tide level. This addresses the IPCC AR4's sea level rise projection of 59 cm by the end of the 21st century under the worst case scenario assessed.

2.8. The development of drainage infrastructure in Singapore over the last 30 years has also reduced flood-prone areas from 3200 ha in the 1970s to 124 ha today. PUB will reduce it to less than 66 ha by 2011 through the development and improvement of drainage infrastructure in Singapore (e.g. widening and deepening of drains and canals), the completion of the Marina Barrage, as well as other flood alleviation projects. This will reduce the possibility of increased inland flooding due to climate change.

2.9. In addition, PUB has a deliberate policy to raise low-lying areas in conjunction with redevelopment proposals.

Coastal Land Loss

2.10. A sea level rise of up to 59 cm can result in some coastal erosion and land loss in Singapore, particularly as Singapore has a relatively flat coastline. Currently, about 70% to 80% of Singapore's coastal areas have hard wall or stone embankments, which help protect against coastal erosion. The rest are either natural areas such as beaches and mangroves. Increased erosion could impact recreational areas at the coasts, such as East Coast Park, Sungei Buloh, Pasir Ris Park, West Coast Park, and Sentosa. The

Singapore's National Climate Change Strategy

Government will look at adapting to sea level rise through the protection of our foreshore and coastal areas as the need arises. Existing revetments (which protect against erosion) may have to be strengthened and reinforced while natural areas may have to be protected using different coastal defense systems.

Water Resource Scarcity

2.11. A rise in sea level can also result in seawater flowing into some of Singapore's coastal reservoirs - a process known as saltwater intrusion. However, seawater intrusion into our reservoirs is unlikely as most of our reservoir dams are much higher than the AR4's projected sea level rise and if need be, the gate structures for the dams can be raised.

2.12. Rising global temperatures can also change rainfall patterns and affect the amount of water stored in reservoirs. The unpredictability in rainfall can cause difficulties in capacity planning of water resources. However, the introduction of NEWater and desalination, which are not rainfall dependent, has diversified and increased the resilience of our water supply, even during prolonged dry spells.



Marina Barrage

Coming True

"In 20 years, it is possible that there could be breakthroughs in technology, both anti-pollution and filtration. Then we can dam up, or put a barrage at the mouth of the Marina, the neck that joins the sea. And we will have a huge fresh water lake."

These words, expressed by Minister Mentor Lee Kuan Yew about two decades ago, will be realised. At the mouth of the Marina Channel, the construction of the \$226 million Marina Barrage will be completed by end 2007. The unique 3-in-1 Marina Barrage project will not only help to increase Singapore's water supply and alleviate flooding, it will also create a lifestyle attraction right in the heart of the city.

Water Supply

The Marina Barrage will increase our local water supply source, which is one of the four national taps. With the Barrage in place, the Marina Basin will turn into a body of freshwater through natural flushing in one to two years, similar to the Kranji and Lower Seletar Reservoir schemes. The new Marina Reservoir will add to the local water supply and increase the water catchment from half to two-thirds of Singapore.

Flood Control

The Marina Barrage is also part of a comprehensive flood control scheme to alleviate flooding in the low-lying areas in the city, such as Boat Quay, Shenton Way, Geylang, Chinatown and Jalan Besar. The barrage will separate the seawater from the freshwater and act as a tidal barrier to keep out the high tides.

Lifestyle Attraction

The Marina Basin will become a scenic water body no longer subjected to tidal variations. The entire reservoir is envisioned to be a lively, vibrant and exciting place where people can enjoy themselves not only on land but the waters. In addition to the cruises and water taxis today, the new Marina Basin can be the venue for many international and local sporting events and activities, adding to the vibrancy of the Basin.

Heat Stress

2.13. Warmer temperatures due to both climate change as well as the urban heat island effect² can lead to greater use of air-conditioning and increase Singapore's energy demand. Higher annual temperatures may also mean more frequent and more severe episodes of warm weather, leading to increased occurrences of heat stress and discomfort, particularly among the elderly, the sick and those without access to air-conditioning.

2.14. Measures that can lower ambient temperature include increasing the amount of greenery in the city (e.g. city parks, rooftop gardens, vertical greening in buildings) and modifying building layouts and designs (e.g. using building materials with better thermal properties, lighter-coloured building surfaces, designing building interiors and exterior building layouts for better ventilation and maximising the wind tunnel effect).

2.15. The Urban Redevelopment Authority (URA) and the National Parks Board (NParks) have been working closely to plan and provide greenery islandwide, such as providing parks and green open spaces, and planting along roads and around developments. URA and NParks have also been promoting rooftop and vertical greenery on our residential and commercial

² The urban heat island effect refers to the phenomenon whereby urban areas are warmer than rural areas, largely due to the replacement of natural land cover with pavement, buildings and other infrastructure.

buildings through planning guidelines and incentives. The Housing Development Board (HDB) is in the process of introducing rooftop greenery to multi-storey carparks and residential buildings where feasible.

Planning our City in a Garden

Although Singapore has long been known as the Garden City, keeping our greenery healthy and verdant requires continual care and nurturing. The National Parks Board's (NParks) comprehensive programme of greenery maintenance and upgrading saw the planting of 62,600 trees in 2006. Meanwhile, Singapore residents can look forward to a seamless green mantle of tree-lined avenues and boulevards as NParks further intensifies our streetscape greenery.

To give greater character and differentiation to Singapore's streetscape greenery, which forms the backbone of the Garden City, NParks will be implementing the Streetscape Greenery Master Plan (SGMP) along major roads across the island. The SGMP will intensify our streetscape greenery along various ecological themes and character. Examples include *Coastal Treatment* for roads near the coast, and *Forest Treatment* for roads near forested areas.

Community In Bloom

To nurture a gardening culture, NParks launched the 'Community In Bloom' programme aimed at inculcating a passion for gardening and developing a greater appreciation for greenery. There are currently over 200 active gardening groups under the 'Community In Bloom' Programme. NParks advises participating gardeners on how to maintain their plants well, and also offers horticultural expertise such as gardening advice and guidelines for residents on how to start their own gardens. This encourages community bonding where residents will come together to exchange gardening tips.

Higher Energy Demand

2.16. To mitigate the increase in the amount of energy used by air-conditioning, the Building & Construction Authority (BCA) and NEA are implementing measures to further improve energy efficiency in our buildings. For example, under the Building Control Act, air-conditioned buildings must be designed with a high-performance building envelope that meets the prescribed Envelope Thermal Transfer Value (ETTV), currently set at 50W/m². BCA has completed a study with NUS to review the ETTV standards and to explore the possibility of extending the ETTV regulations to residential buildings. The findings from the study were taken into consideration in the proposal to stipulate minimum Green Mark standards for new buildings, leading to amendments to the Building Control Act. The minimum Green Mark standards take effect in early 2008.

Green Mark

BCA Green Mark is a green building rating system to evaluate a building for its environmental impact and performance. It provides a comprehensive framework for assessing building performance and environmental friendliness. From early 2008 onwards, all new buildings and existing buildings undergoing major retrofitting works with gross floor area above 2000m² must meet the Green Mark Certified standard.

Buildings are awarded the BCA Green Mark based on five key criteria:

- a) Energy Efficiency
- b) Water Efficiency
- c) Site/Project Development and Management (Building Management and Operation for existing buildings)
- d) Good Indoor Environmental Quality and Environmental Protection
- e) Innovation

Under the Green Mark assessment system, points are awarded for incorporating environmentally-friendly features. The total number of points obtained indicates the environmental-friendliness of the building design.

The assessment process consists of an initial assessment leading to the award of the Green Mark. Subsequently, buildings are required to have triennial assessments. This is to ensure that the Green Mark building continues to be well maintained.

Green Mark Award Rating

Green Mark Points	Green Mark Rating
85 and above	Green Mark Platinum
80 to <85	Green Mark Gold ^{PLUS}
70 to <80	Green Mark Gold
50 to <70	Green Mark Certified

Apart from achieving the minimum points in each rating scale, the project has to meet all requirements, and score a minimum of 50 per cent of the points in each category, except the Innovation category.

Public Health Impact from Resurgence of Diseases

2.17. Singapore is situated in a region in which vector-borne diseases, particularly dengue, are endemic. Dengue patterns are affected by many factors, including climate. NEA is studying the link between climatic factors such as temperature, humidity and rainfall with dengue cases. Preliminary results indicate that the number of dengue cases in Singapore are correlated with the ambient temperature.

2.18. To address dengue, NEA has put in place a comprehensive mosquito surveillance, control and enforcement system, which includes pre-

emptive action to suppress the mosquito vector population, dengue-related research undertaken by the Environmental Health Institute and a review of building designs to reduce potential breeding habitats (e.g. roof gutters in new buildings have been prohibited except in special circumstances).



Impacts on Island and Marine Biodiversity

2.19. A rise in sea level can lead to loss of mangroves, which will not only represent a loss of biodiversity, but can also further aggravate coastal erosion rates. A rise in seawater temperature as a result of global warming can also have a negative impact on marine life e.g. coral bleaching.

2.20. The National Parks Board (NParks) is looking into the role of our nature reserves in carbon sequestration and is monitoring long-term tree diversity, tree growth and survival in marked study plots. The role of coral reefs around our southern islands is also acknowledged, both for sequestering carbon and mitigating storm damage and erosion. A coral nursery has therefore been established off Palau Semakau. This coral nursery will enable us to proactively enhance existing marine habitats by maximizing the survival of naturally occurring corals.

2.21. Mangroves help to protect coasts against erosion and NParks is developing pre-emptive management strategies to counter mangrove erosion at some coastal areas. Singapore cannot prevent global trends from affecting seawater temperatures locally, but will seek to mitigate any additional influences on seawater quality through measures such as the release of cooling water or sedimentation.

Further Measures to Adapt to Climate Change

Singapore's National Climate Change Strategy

2.22. Climate change is a long-term phenomenon and its impacts will be felt for decades. The Ministry of National Development leads an inter-agency Taskforce to review existing infrastructural adaptation measures, as part of the overall government's approach to address climate change. Government agencies will continue to work closely together to assess the possible impacts of climate change on Singapore, regularly review the sufficiency of Singapore's existing adaptation measures, identify new measures as necessary and establish national systems to actively monitor and manage these impacts.