CLIMATE ACTION PLAN

A CLIMATE-RESILIENT SINGAPORE

FOR A SUSTAINABLE FUTURE

Singapore's Climate Action Plan:
A Climate-Resilient Singapore, For a Sustainable Future

Published By:
Ministry of the Environment and Water Resources | Ministry of National Development
www.mewr.gov.sg | www.mnd.gov.sg
Singapore

In Collaboration With:
Agri-Food & Veterinary Authority of Singapore
Building and Construction Authority
Civil Aviation Authority of Singapore
Energy Market Authority
Housing & Development Board
Infocomm Development Authority of Singapore
JTC Corporation
Land Transport Authority
Maritime and Port Authority of Singapore
Ministry of Finance
Ministry of Health
National Climate Change Secretariat
National Environment Agency
National Parks Board
PUB, Singapore's National Water Agency
Singapore Land Authority
Urban Redevelopment Authority

ISBN: 978-981-11-0085-7

003 - 012 - 0115
Printing Paper From
Sustainable Sources

Design and Production by Green House Design + Communications

CONTENTS

CHAPTER

01

OUR CLIMATE FUTURE

OUR CLIMATE

Our earth's climate is changing. Heat waves are likely to be more frequent and longer-lasting, extreme rainfall will become more intense and frequent, and the global mean sea level will rise. In 2015, the Centre for Climate Research Singapore (CCRS) and the United Kingdom's Met Office Hadley Centre concluded Phase 1 of the Second National Climate Change Study[1]. The study analysed Singapore's climate up to the year 2100 and projected that Singapore is likely to become warmer, experience more frequent and heavier storms, and face rising sea levels.

WHAT DOES THIS MEAN FOR US?

Quite simply, all of us – in Singapore, and across the world – must act now, and act responsibly. Countries must work together to reduce our greenhouse gas emissions[2]. We must take immediate steps to preserve our environment for future generations.

Thunderstorms in Singapore

1 Phase 1 of the National Climate Change study can be found here: http://ccrs.weather.gov.sg/Publications-Second-National-Climate-Change-Study-Science-Reports. Phase 2 of the study, currently underway, makes use of the projections from Phase 1 to examine the climate change impacts on areas such as water resources and drainage, biodiversity and greenery, network infrastructure and building infrastructure.

2 More information on Singapore's plans to mitigate climate change and stabilise our long-term emissions can be found in the *Climate Action Plan: Take Action Today, For a Carbon-Efficient Singapore* booklet.

CLIMATE CHANGE AND SINGAPORE

Singapore is a low-lying, densely-populated tropical island city-state. We are vulnerable to the effects of climate change and variability. Three examples of Singapore experiencing the effects of climate change and variability are shown on the right.

While natural climate variability may have played a part in these recent events, extreme conditions are likely to become more intense and frequent due to climate change. It is therefore important for Singapore to prepare for climate change.

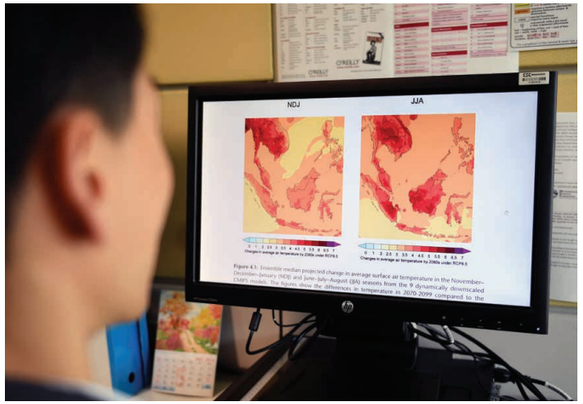
Dry Spell
13 Jan to 8 Feb 2014: Singapore experienced a record 27-day dry spell. Our desalination and NEWater plants had to operate near full capacity to meet our water needs.

Plankton Bloom
2015: Hot weather caused a plankton bloom in the Johor Straits, resulting in mass fish deaths.

Heavy Rainfall
2010, 2011 and 2013: Heavy rainfall contributed to major flash flood events in these three years, resulting in significant damage.

FORECASTING THE FUTURE CLIMATE

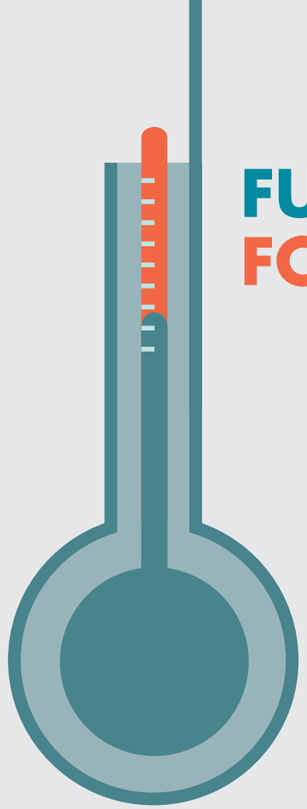
Global Climate Models (GCMs) are computer models that simulate the dynamic processes taking place in the atmosphere, land, and oceans. Such models help us understand the earth's future climate, and were used for the projections seen in the 5th Assessment Report (AR5)[3] of the Intergovernmental Panel on Climate Change (IPCC). However, global models are too coarse in spatial resolution to be used directly for assessing Singapore's adaptation needs. To provide better data for decision-making, the data from GCMs are "down-scaled" using Regional Climate Models (RCMs), which can simulate a region's climate in finer detail.



Forecasting future climate

3 These are reports published by IPCC on the full scientific and technical assessment of climate change.

FUTURE PROJECTIONS FOR SINGAPORE



WHY?

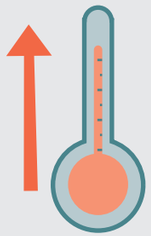
Higher greenhouse gas emissions lead to larger changes in the climate.

Feb and Jun to Sep **Nov to Jan**

RAINFALL

The contrast between the wet months (Nov to Jan) and dry months (Feb and Jun to Sep) are likely to become more pronounced. Increasing trends in both intensity and frequency of heavy rainfall events are expected as the world gets warmer.

Towards end of this century
1.4°C to 4.6°C



DAILY TEMPERATURE

Daily mean temperatures are projected to increase by 1.4°C to 4.6°C towards the end of this century (2070 to 2099), compared with the baseline period of 1980 to 2009.

SEA LEVEL

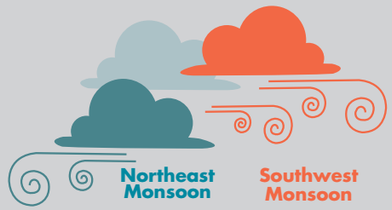
Sea levels are projected to rise between 0.25m and 0.76m in the last few decades of this century (2070 to 2099), compared with the baseline period of 1980 to 2009.

Towards end of this century (2070 to 2099)

Sea level rise between 0.25m and 0.76m

FREQUENCY OF WARM DAYS AND NIGHTS

More warm days and warm nights for Feb to Sep are projected throughout the 21st Century.



WIND

Singapore will continue to be influenced by the northeast and southwest monsoons with potential increase in wind speeds during northeast monsoon season.

CHAPTER

02

WHAT COULD HAPPEN?

RISKS WE FACE

The climate impacts that we face pose various risks to Singapore. These risks have been summarised on the next page.

Some of these impacts and risks may simply cause inconvenience, while others are more severe. For instance, flooding can result in injury, cause damage to property, and disrupt traffic. The increased risk of heat-induced and vector-borne illnesses can cause us to fall ill more frequently. Bush fires or uprooted trees can also cause serious injury. These risks are real and we must act now to reduce our risk exposure in the future.

Singapore's public sector has taken the lead on this. We have developed a range of climate change adaptation measures, designed with the protection of Singapore and Singaporeans in mind. The measures aim to minimise the adverse effects that climate change could have on the community, economy, and our daily lives. As a start, these measures bring us one step closer to our goal of enhancing Singapore's resilience to climate change.

CENTRE FOR CLIMATE RESEARCH SINGAPORE (CCRS)

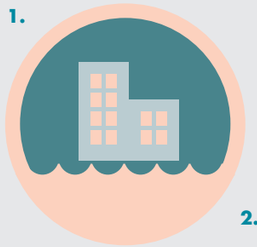
CCRS was established to develop research expertise in the weather and climate of Singapore and the wider Southeast Asia region. It undertakes projections of Singapore's future climate for long-term planning, as well as researches the characteristics and causes of extreme weather.

Centre for Climate Research Singapore

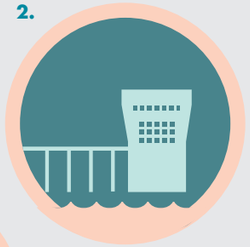
RISKS WE FACE

The climate impacts that we face pose risks to Singapore in the following six areas:

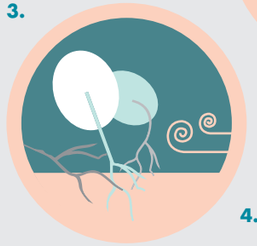
1.



2.

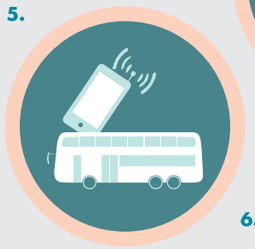


3.



4.

5.



6.

1. **Protecting Our Coasts**

   - Communities and property along Singapore's coastline could be affected by rising sea levels.

2. **Managing Our Water, Minimising Floods**

   - Our water supply may be affected by more frequent and severe droughts.
   - Intense rainfall and rising sea levels may increase the risk of flooding.

3. **Protecting Our Biodiversity and Greenery**

   - Trees could be damaged or uprooted due to strong winds.
   - Biodiversity may be affected by changes in temperature and rainfall.
   - There may be more bush fires due to temperature increase and low rainfall.

4. **Strengthening Resilience in Public Health and Our Food Supply**

   - Higher temperatures may affect human health and healthcare operations.
   - Vector/pest populations could increase due to higher temperatures and rainfall, increasing the incidence of diseases such as dengue.
   - Our imported food supplies could face disruption and price spikes, should production be affected by extreme weather.

5. **Keeping Our Essential Services Running Well**

   - Intense rainfall, sea level rise, and temperature changes could affect the operation of our telecommunications, power, and transport infrastructure.

6. **Keeping Our Buildings and Infrastructure Safe**

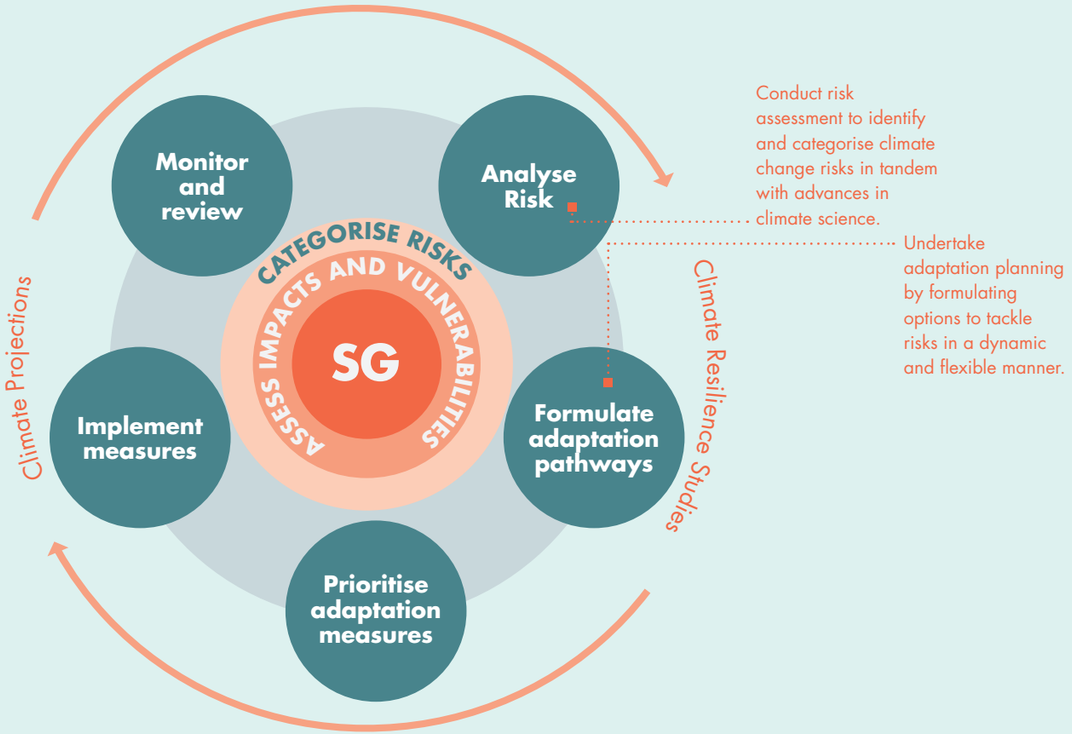
   - Safety and reliability of infrastructure could be impacted by strong winds and higher temperatures.
   - Increased rainfall could lead to slope instability.

STAYING RESILIENT

Singapore has developed a Resilience Framework to guide our plans for climate change adaptation. The framework helps us identify climate change risks to our people and property, and formulate adaptation plans to minimise the adverse effects of climate change on our lives.

Some of our adaptation measures will require time to implement, while others may involve the construction of costly infrastructure. Our plans must be flexible and dynamic to accommodate future needs and the latest science. It is also important to consider how our measures would affect one another, so that we can implement them in the most efficient and effective manner.

SINGAPORE'S RESILIENCE FRAMEWORK



CHAPTER

03

ADAPTING TO CHANGE

This chapter will introduce the adaptation measures that are being implemented to protect our coastal areas, water supply, biodiversity and greenery, public health, food security, network infrastructure, and buildings from climate change.

PROTECTING OUR COASTS FROM SEA LEVEL RISE

As an island-state and a major port city, Singapore is defined by our coasts.

Our coastal areas also hold cherished memories for Singaporeans – many of us remember playing along beaches when we were children. However, these areas face the threat of rising sea levels as a result of climate change. Without timely action, some low-lying coastal areas in Singapore could experience flooding during severe coastal storms, or even become submerged over time as sea levels rise.

GEO-BAG WALL

In 2010, the Building and Construction Authority (BCA) carried out shoreline restoration works using a geo-bag seawall system to stabilise a section of the beach at East Coast Park. Geo-bags are large sand-filled bags, laid several metres into the ground to be level with the low tide. These help reduce sand erosion and preserve our beaches.

Geo-bags at East Coast Park

To protect these areas, we have strengthened our defences against coastal erosion and flooding. Today, over 70 per cent of Singapore's coastline is protected with hard structures such as seawalls and rock slopes. From 2011, we have also required all new reclaimed land to be at least four metres above the mean sea level, up from three metres previously. Roads near coastal areas, including a stretch of Changi Coast Road and Nicoll Drive, have also been raised to protect them from rising sea levels.

More will be done. BCA is conducting a Coastal Adaptation Study (CAS), which will provide us with more options on how we can protect them better over the long term.

High tide at East Coast Park

Low tide at East Coast Park

COMPOSITE STEPPED SEAWALL

At another stretch of East Coast Park, a composite stepped seawall has been built. Its lower half is made of rock, and its upper half is made of precast concrete blocks. The blocks also serve as lookout points for park users.

Composite stepped seawall at East Coast Park

MANAGING OUR WATER, MINIMISING FLOODS

With climate change, wet seasons could become wetter, and dry seasons could become drier. This poses varied challenges to how Singapore manages our water resources.

Ensuring Continued Water Supply for All

Singapore's water supply could face challenges from climate change, as dry seasons in Singapore are expected to worsen. Over the years, PUB, Singapore's National Water Agency, has spared no effort in diversifying Singapore's water supply so that we are not dependent solely on rainfall for our water needs. With alternative sources such as NEWater and desalinated water, PUB's "Four National Taps" strategy has made our water supply more resilient, even with the challenge of climate change.

In the coming years, PUB will complete our fifth NEWater plant and build our third and fourth desalination plants in Tuas and Marina East. PUB is also exploring building a fifth desalination plant on Jurong Island. By 2030, the total capacity of NEWater and desalination will be approximately twice what we have today, meeting about 80 per cent of Singapore's water demand.

We cannot expand our water supply indefinitely. We must manage our demand and reduce water use to more sustainable levels. All Singaporeans have to play their part by using only what is needed and making wise choices, such as doing laundry on a full load.

Tuaspring Desalination Plant

LINGGIU RUNS LOW

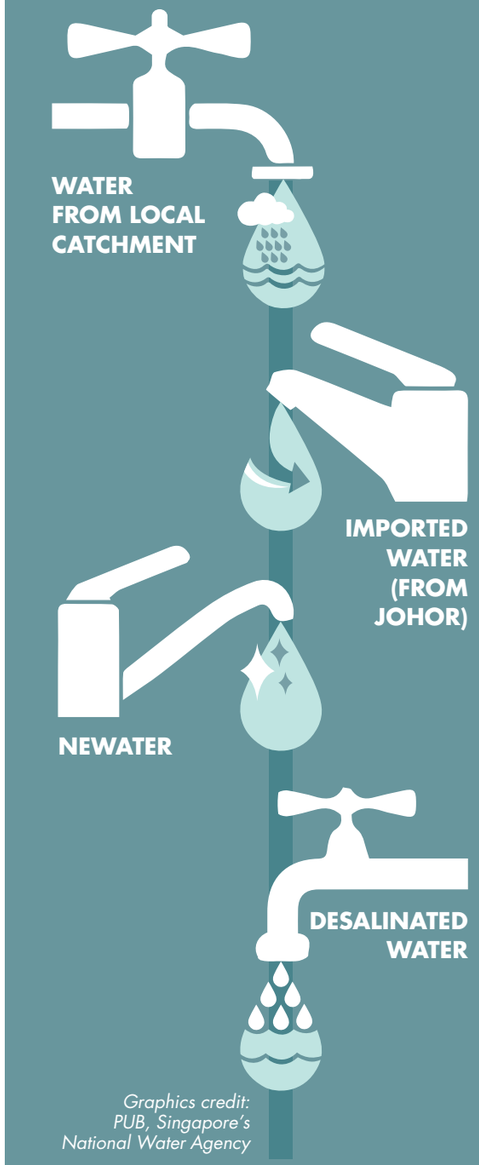
Linggiu Reservoir regulates the flow from Johor River, where Singapore extracts water for treatment and supply. In 2015, water reserves in Linggiu Reservoir plunged from a healthy 80 per cent to about 30 per cent in mid-2016 due to prolonged dry weather.

Linggiu Reservoir when full

Linggiu Reservoir during periods of prolonged dry weather

OUR FOUR NATIONAL TAPS

Our Four National Taps ensure sustainable and reliable water supply for Singapore.



Graphics credit: PUB, Singapore's National Water Agency

Protecting Singapore and Singaporeans from Floods

In the 1960s and 1970s, Singapore experienced major floods. Water levels were waist-high, causing chaos and disruptions – even resulting in some deaths. Over the last 50 years, we have invested heavily in drainage, bringing down the number of flood-prone areas significantly. However, occasional intense rains can still overwhelm our drains.

With climate change, Singapore may experience more intense rainfall events more frequently. If we do not plan in advance, major flooding could recur and cause disruptions that inconvenience Singaporeans or even result in damage.

To minimise such flood events, PUB seeks to capture, redirect, and keep excess rainwater at bay through its "Source-Pathway-Receptor" approach. By building detention tanks, widening drains, and raising ground levels across Singapore, PUB has implemented a range of measures to mitigate flood risk in Singapore and protect Singaporeans.

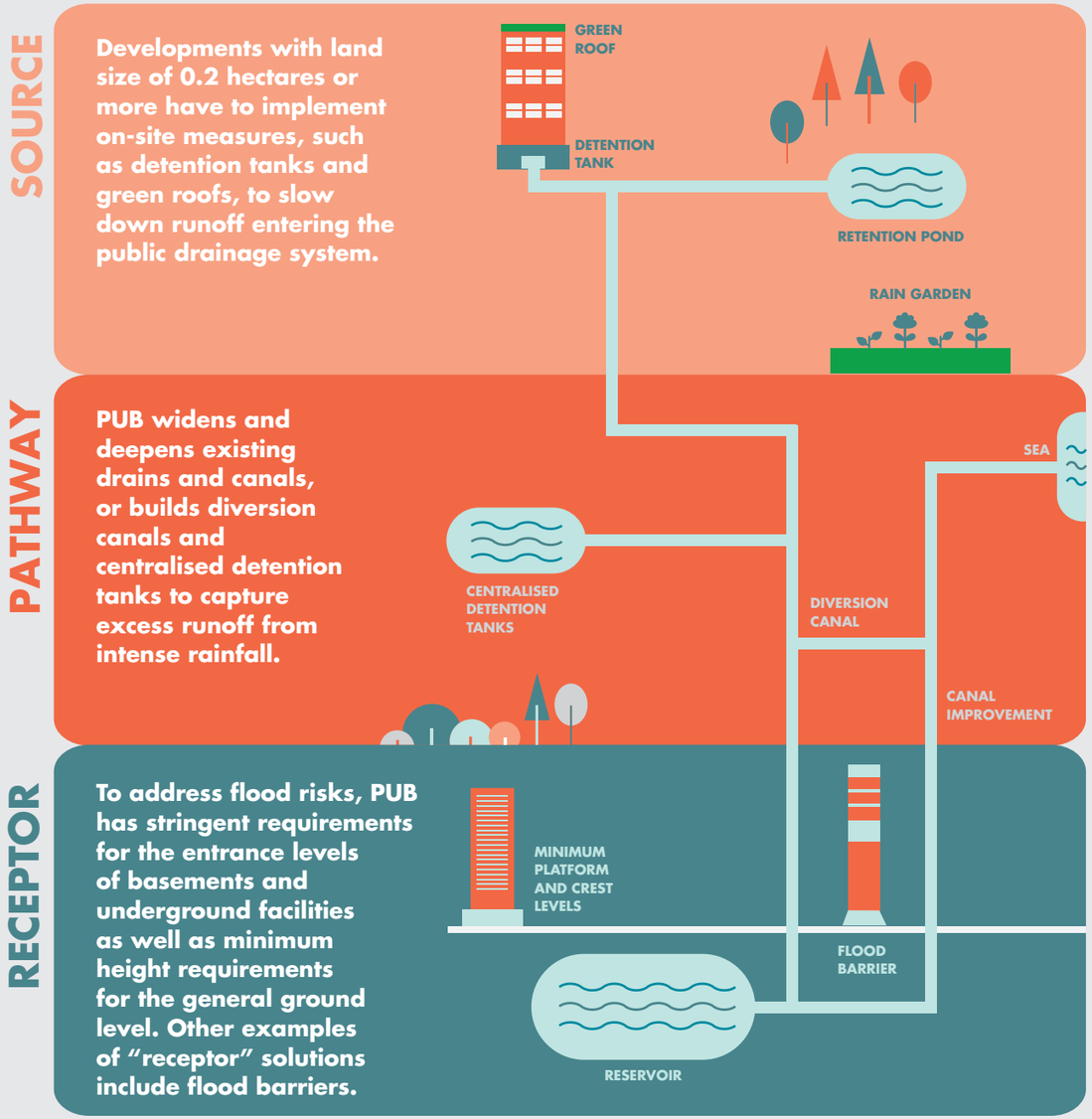
In land-scarce Singapore, another possible way of storing excess stormwater is to capture and store it underground. PUB is currently studying the feasibility of an innovative underground drainage and reservoir system, where tunnels will bring excess stormwater into underground caverns for storage. This system has the potential to reduce flood risks.

This raised development in Robinson Road is an example of a local measure to reduce flood risks in building developments.

HELPING SINGAPOREANS DO THEIR PART

The Mandatory Water Efficiency Labelling Scheme (MWELS) requires water fittings such as taps, urinals, and mixers as well as washing machines to be affixed with water-efficient labels when they are sold. This makes it easier for all of us to opt for more water efficient appliances to help conserve water.

THE SOURCE-PATHWAY-RECEPTOR APPROACH



At Orchard Road, PUB is building a new 2km diversion canal and a new underground detention tank near the Singapore Botanic Gardens. Stormwater from the upstream section of the Stamford Canal Catchment system will flow into the new diversion canal towards the Singapore River, and eventually into the Marina Reservoir. A detention tank, with a storage capacity of about 38,000 cubic metres of water, will capture excess stormwater, which will be pumped back into the drains after the rain subsides.

PROTECTING OUR BIODIVERSITY AND GREENERY

Our City's Trees and Biodiversity

The 3 million roadside trees are an essential part of Singapore's landscape. They define our City in a Garden, and provide shade and cover from our tropical weather. But some trees are especially tall and certain species are fragile. This makes them likely to fall or be uprooted in strong gales or periods of heavy rain, which could inconvenience or even cause harm to the public. Singapore is also home to a large variety of flora and fauna, many of which are vulnerable to climate change. For example, coral bleaching occurred in 1998 and 2010 due to high sea surface temperatures (SSTs).

To ensure that our trees are in good health and resilient to climate change, the National Parks Board (NParks) inspects trees along major roads and areas with high human activity at least once a year. If needed, trees are pruned to reduce the size and weight of their crowns so they can better withstand strong winds. Storm-vulnerable trees have also been replaced with hardier species. NParks also studies tree uprooting to better diagnose its causes.

To protect Singapore's marine biodiversity, NParks established Singapore's first marine park at the Sisters' Islands in 2014. The marine park is an ecosystem inhabited by rare and endangered marine animals. Other measures to protect Singapore's biodiversity include restoring mangrove areas in Singapore.

Bush Fires

Prolonged hot and dry weather can cause bush fires. If they are not attended to promptly, the fires may spread and lead to a loss of greenery and biodiversity. These fires could also result in property damage and danger to people in the vicinity. To protect our biodiversity and Singaporeans, Singapore Civil Defence Force (SCDF) will step up patrols at fire hot spot areas to detect fire risks and swiftly put out any fires. In addition, SCDF, together with NParks and the Meteorological Services Singapore (MSS), will develop a Fire Probability Index to indicate the risk of bush fires for different areas. Together, these measures will allow us to deal with bush fires more efficiently, even as Singapore experiences hotter and drier weather.

To ensure that our trees are in good health and resilient to climate change, the National Parks Board (NParks) inspects trees along major roads and areas with high human activity at least once a year.

FALLEN TREES AT MANDAI ROAD, FEBRUARY 2011

A microburst is an intense downward rush of air that spreads violently at ground level. It can result in strong straight-line winds capable of knocking over entire trees. In February 2011, a microburst over Upper Seletar Reservoir damaged some 40 hectares of forest (about 55 football fields!) within the Central Catchment Nature Reserve, uprooting or snapping virtually all the big trees there.

Botanists from the National University of Singapore (NUS) have been tracking the subsequent recovery in forest structure and composition. These findings will help us understand how local secondary forests recover from such events.

Fallen trees at Mandai in 2011

MONITORING SEA SURFACE TEMPERATURE AT SISTERS' ISLANDS MARINE PARK

Singapore's Sisters' Islands Marine Park

The rich marine biodiversity in Singapore – home to more than 250 species of corals – is under threat from rising SSTs, ocean acidification, stronger and more intense rainfall, and rising sea levels.

To better understand the most immediate threat related to rising SSTs, a bleaching monitoring programme has been initiated at the Sisters' Islands Marine Park. The findings can be used to develop targeted measures to protect the most ecologically-sensitive groups of marine animals and plants.

RESTORING PULAU TEKONG'S MANGROVES

In the past, scouring – where mud is washed away by water swirling around tree roots – was observed, causing shoreline erosion. Higher sea levels are also expected to further degrade the mangrove forests in Pulau Tekong. To arrest this, we have applied both "hard" and "soft" engineering solutions.

The northeastern coastline of Pulau Tekong accounts for

90 HECTARES

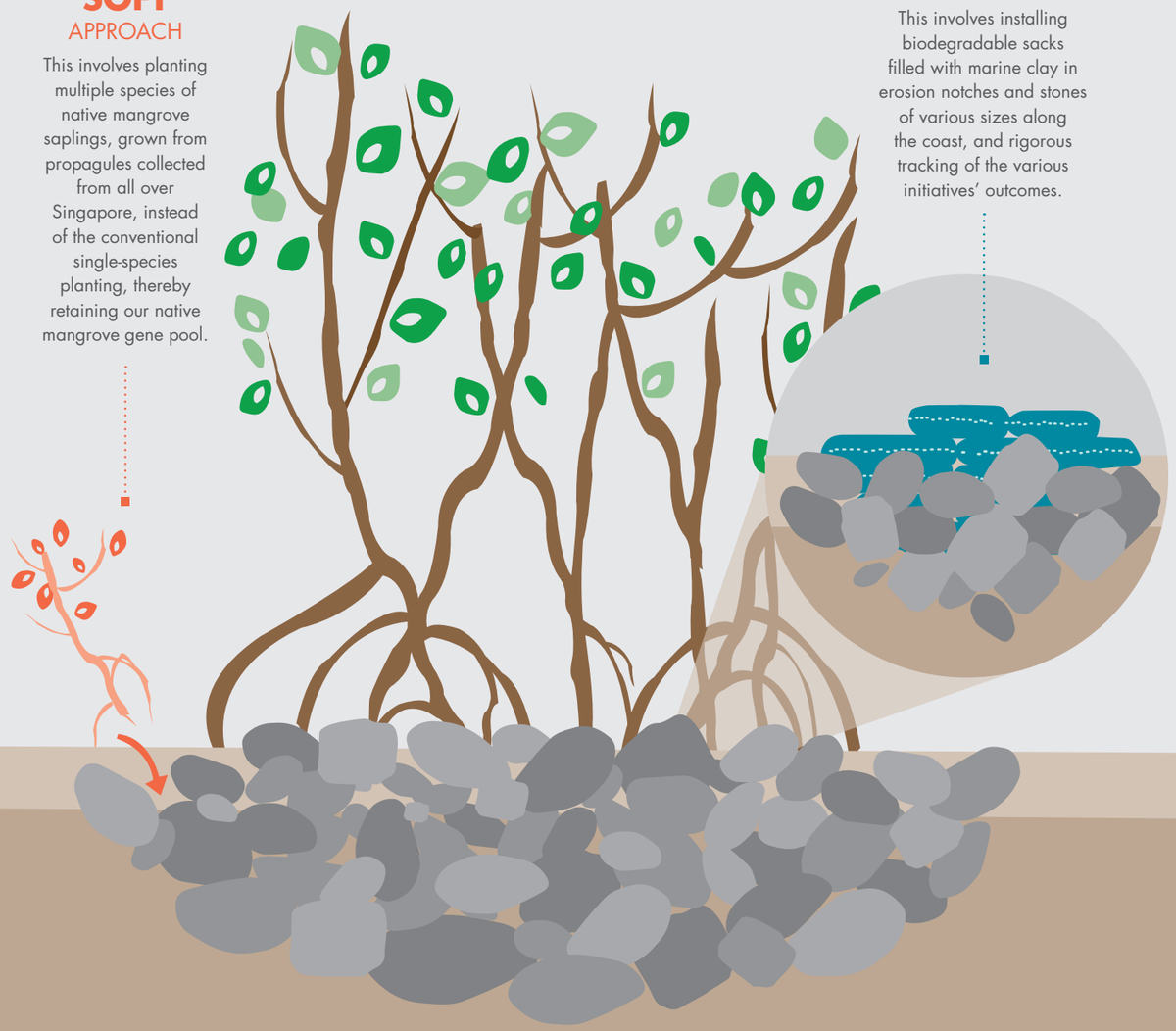
of pristine mangrove forest.

SOFT
APPROACH

This involves planting multiple species of native mangrove saplings, grown from propagules collected from all over Singapore, instead of the conventional single-species planting, thereby retaining our native mangrove gene pool.

HARD
APPROACH

This involves installing biodegradable sacks filled with marine clay in erosion notches and stones of various sizes along the coast, and rigorous tracking of the various initiatives' outcomes.



STRENGTHENING RESILIENCE IN PUBLIC HEALTH AND OUR FOOD SUPPLY

Vector-Borne Diseases

Climate change also poses threats to our health. For example, changes in the weather pattern, such as temperature increase, could create prime conditions for mosquitoes to breed and viruses to replicate faster, leading to an increase in the infective vector population and transmission of dengue. We have already seen similar trends in late 2015, when there was a spike in dengue cases partly due to weather changes caused by the El Niño. Currently, the National Environment Agency (NEA) has in place a nation-wide programme to fight dengue – but we will need to do more as we prepare for harsher conditions in the future. While innovative solutions such as *Wolbachia* technology could help to suppress the mosquito population, sustained efforts by the community to eradicate mosquito breeding habitats remain key to preventing dengue.

FIGHTING *AEDES* MOSQUITO-BORNE DISEASES

Wolbachia bacteria occur naturally in over 60 per cent of all insect species, including some mosquito species. NEA is exploring the feasibility of using male *Wolbachia*-carrying *Aedes aegypti* mosquitoes to help suppress the *Aedes aegypti* mosquito population. *Aedes aegypti* mosquitoes are dengue vectors. Studies have shown that when male *Wolbachia-Aedes aegypti* mosquitoes mate with female *Aedes aegypti* mosquitoes without *Wolbachia*, the females produce eggs that do not hatch, thereby reducing the *Aedes aegypti* population over time.

Wolbachia bacteria occur naturally in over

60 PER CENT

of all insect species, including some mosquitoes.

MALE MOSQUITO WITH *WOLBACHIA*

FEMALE MOSQUITO WITHOUT *WOLBACHIA*

This phenomenon is known as Cytoplasmic Incompatibility (CI).

Adjusting to a Warmer Environment

Climate change will lead to more warm days. Apart from discomfort, we could experience a range of heat-induced illnesses, including heat rashes, heat cramps, heat exhaustion, and heat stroke. By taking simple steps such as drinking enough water and staying in the shade, we can easily minimise the risk of heat injury during warmer weather. Currently, the Ministry of Health (MOH) is also working with MSS to develop a heat stress information system for the public. This system will provide information that can help us plan and manage our outdoor activities.

A jogger taking care to hydrate while exercising in hot weather.

MANAGING HEAT STRESS

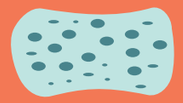
We can all keep ourselves and our loved ones safe by taking precautionary measures to avoid heat-induced illnesses, such as:

Wearing loose-fitting, heat-permeable and light-coloured clothing

Drinking fluids to stay hydrated

Taking more breaks in between activities

Reducing outdoor activities during the hottest time of the day, or staying in the shade



Sponging with cold water

Planning sports and exercise activities in the cooler hours of the day

Watching for early signs of heat-induced illnesses, and seeking medical attention if conditions persist or worsen

Ensuring a Resilient Food Supply

Climate change could also spell trouble for Singapore's most beloved culture – our food! As we import more than 90 per cent of our food supply, crop failure and low crop yields in the region will affect the supply of items such as rice and vegetables to Singapore. Fisheries are also expected to have smaller catches, affecting the fish and seafood products available to us.

To minimise the risk of food supply disruptions, the Agri-Food and Veterinary Authority of Singapore (AVA) pursues a diversification strategy. This means that Singapore currently imports our food from countries in a variety of regions. This minimises potential disruptions to our food supply if a particular region is hit by extreme weather events, and protects us against sudden food shortages and price volatility. Back at home, local food production helps to supplement our food supply. AVA is working closely with local farmers to ensure that they are prepared for climate change. This includes implementing programmes to boost productivity, conducting research and development to aid technology adoption by local farms, and working with private sector partners to develop innovative solutions. Beyond our shores, AVA also works with international and regional partners to enhance global food security.

INDOOR FARMING

Given Singapore's land scarcity and reliance on imports, indoor farming technologies can improve our food supply resilience. At Panasonic Factory Solutions Asia Pacific, multi-tier racks with LED lighting are used to grow vegetables such as lettuce, mizuna, rocket, and mini red radish in optimised conditions. The farm complies with strict hygiene and sanitation standards, and embraces total process automation systems for greater productivity.

Farming indoors in Singapore

CLOSED CONTAINMENT AQUACULTURE

Closed Containment Aquaculture Systems (CCAS) such as Recirculating Aquaculture Systems enable fish to be protected from adverse environmental conditions. Farms with such systems can also achieve higher productivity, better space optimisation, and water resource efficiency.

At Singapore Aquaculture Technologies' fish farm, around 50 tonnes of seabass are reared a year in CCAS. The system involves pumping seawater from a depth of four metres which is then treated, thus lowering the farm's risk against plankton bloom and other aquatic diseases.

Closed Containment Aquaculture in Singapore

KEEPING OUR ESSENTIAL SERVICES RUNNING WELL

Public Transport

On a typical day, over 2.7 million passenger trips are taken on our Mass Rapid Transit (MRT) networks. Climate change could affect these passengers as our underground MRT stations may be susceptible to flooding during intense rainfall. To protect our commuters and rail transport infrastructure, the Land Transport Authority (LTA) has installed flood barriers at the entrances and openings of low-lying underground MRT stations. In the future, new underground MRT stations will also have to meet requirements for enhanced flood protection.

Raised steps at an entrance to Orchard MRT station

Air Connectivity

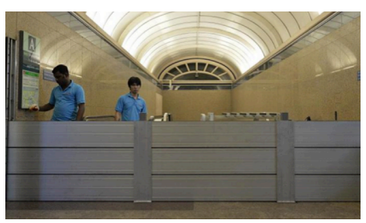
Singapore's air connectivity is a hallmark of our global reputation. In 2015, more than 55.4 million passengers passed through Changi Airport; more can be expected as we seek to expand our air connectivity. Climate change could pose tough challenges as Changi Airport faces flood risks from more intense rainfall and rising sea levels. Initial steps to minimise these risks have already been taken. For instance, significant upgrades to the drainage system at Changi Airport are in progress, with detention tanks and pumps being installed. In addition, the future Terminal 5 will be built 5.5m above the mean sea level, which is higher than other areas in Singapore. To ensure the smooth travel of passengers, the Civil Aviation Authority of Singapore (CAAS) will continue to monitor the overall resilience of Changi Airport.

Sea Connectivity

Singapore is home to one of the world's busiest hub ports. Currently, more than 130,000 ships call at Singapore and more than 30.9 million 20-foot equivalent units (TEUs) of containers pass through our ports annually. While existing port facilities are protected from near-term sea level rise, the Maritime Port Authority of Singapore (MPA) will monitor and

PROTECTING OUR SUBWAYS FROM FLOODS

LTA has designed and installed a variety of flood barriers at various underground MRT stations. Rigorous on-site testing has been carried out to ensure the barriers are watertight.



Stackable flood barriers at the entrance to an underground MRT station

implement further measures when facilities are upgraded or redeveloped. For the new Tuas terminal, the latest sea level rise projections have been factored into its design and it will be built more than two metres higher than the highest water level observed.

Energy and Telecommunications

From computers in the office, to the lamps lining our streets, washing machines at home, and smartphones in our pockets – electricity is an essential part of life in a modern city. In Singapore, severe disruptions in electricity have been very rare. However, based on initial studies, we understand that as ambient temperatures increase, the generation capacity of our power stations could be reduced and this may cause potential interruptions to our electricity supply. Floods could also disrupt the operation of our power stations; electricity demand may also rise beyond projections due to population and economic growth, placing additional stress on our energy infrastructure. The Energy Market Authority (EMA) will factor in these effects as it maps out plans to enhance the resilience of Singapore's power stations and electricity supply.

Similarly, our telecommunications infrastructure will face challenges from climate change, as stronger and more frequent rainfall could result in floods that lead to localised disruptions. With over 8 million mobile subscriptions and 1.3 million home broadband subscriptions in Singapore, any prolonged service disruptions will have implications. The Infocomm Development Authority of Singapore (IDA) will continue to work closely with service providers as it seeks to strengthen the resilience of these services.

KEEPING OUR BUILDINGS AND INFRASTRUCTURE SAFE

Buildings

It is essential for the buildings we live and work in to be protected from the effects of climate change. Analyses so far have indicated that the structural integrity of buildings in Singapore will not be affected by the projected changes in temperature, rainfall, and wind speeds as long as the buildings adhere to building codes and are properly maintained. As many buildings in Singapore are constructed and maintained by private developers and owners, the private sector plays an indispensable role in helping us keep our buildings safe. BCA and the Housing & Development Board (HDB) are conducting additional studies to further understand the potential effects of higher temperatures, rainfall, and wind speeds on buildings and building attachments, to recommend adaptation measures to enhance the resilience of our buildings.

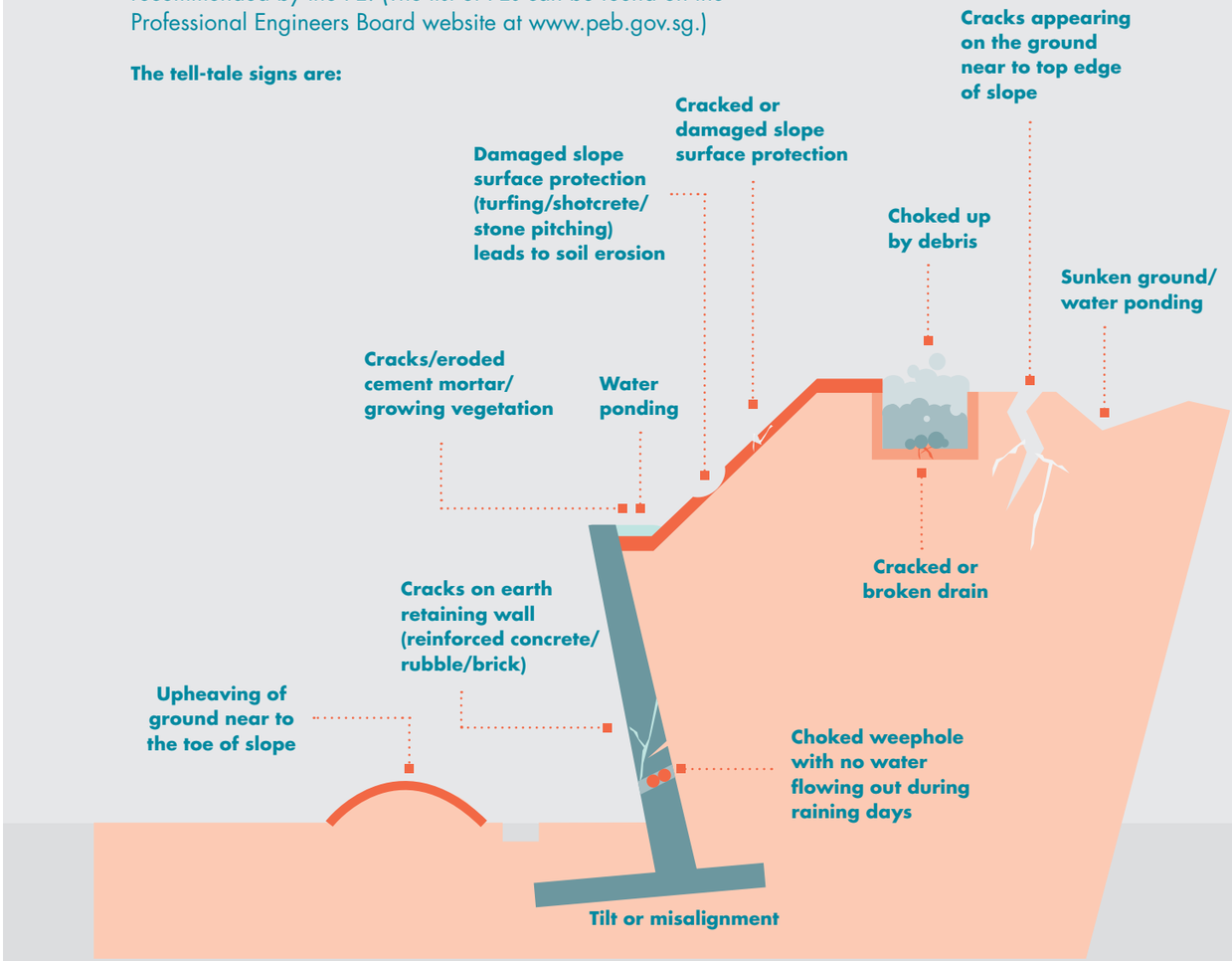
Slope Failure

Slope failures, or instances where slopes become unstable or collapse, are dangerous occurrences that could result in serious injury or property damage. The presence of cracks near the top edge of a slope is usually a tell-tale sign of an unstable slope. With climate change, heavier and more frequent rainfall could affect the stability of our slopes, triggering slope failures. While remedial actions can be effective in rectifying unstable slopes, BCA is currently studying appropriate and holistic adaptation strategies that can address the increased risk of slope failure due to climate change.

TELL-TALE SIGNS OF SLOPE FAILURE AND RECTIFICATION STEPS

BCA conducts regular outreach programmes to educate slope owners on how to detect defective slopes and rectify them. If there are tell-tale signs of slope failure, owners and management corporations should engage a Professional Engineer (PE) in the Civil, Structural, or Geotechnical disciplines to inspect, assess, and recommend rectification measures. The defects should then be rectified, as recommended by the PE. (The list of PEs can be found on the Professional Engineers Board website at www.peb.gov.sg.)

The tell-tale signs are:



Cross section showing various tell-tale signs of deflective slopes

CHAPTER

04

NEXT STEPS

Our adaptation plans provide the foundation to proactively manage our physical environment, and protect Singaporeans from the adverse effects of climate change. We will continue to monitor climate change impacts closely and study their effects on Singapore. As our understanding of climate science and risk management grows, we will also continue to refine our measures and put in place new ones where necessary.

However, climate change resilience must extend beyond physical adaptation measures from the public sector. Resilience must involve the entire community, including individuals and businesses, with everyone playing a role. All of us have a part to play whether through lifestyle adjustments or changes to business processes. Private enterprises must review business continuity plans to cater for disruptions caused by extreme weather events. Our people also need to be mentally prepared for a changing environment. Making adjustments earlier will make the transition easier, as we get used to our changing climate.

Together, we must harness the opportunities available to overcome the challenges ahead, and make Singapore a safer, more resilient, and sustainable home for us and our children.

Little things that every Singaporean can do to help make Singapore climate-friendly and sustainable are:

At home

- Use energy-efficient appliances and switch them off when not in use.
- Reduce, reuse, and recycle. Avoid using disposable plastic packaging, bags, and utensils.
- Conserve water and choose water-efficient appliances.
- Use a fan or set the air-conditioner to 25°C.
- Minimise risks of vector-borne diseases like dengue – do the 5-step Mozzie Wipeout.

At work

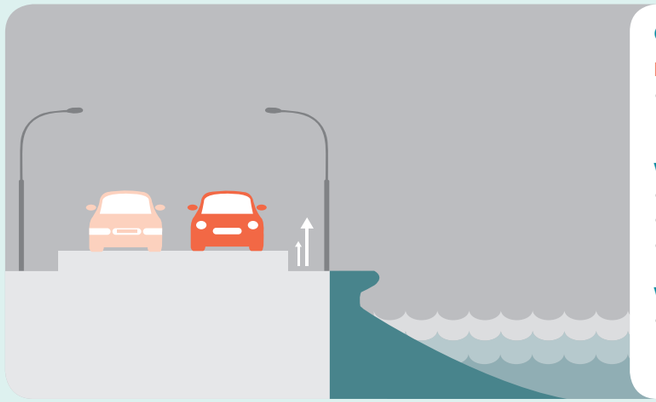
- Switch off the computer when leaving the office.
- Turn off the lights during lunch hours.
- Take precautionary measures when outdoors on hot and humid days to reduce the risk of heat-induced illnesses – wear loose-fitting clothes and drink more fluids.

While commuting

- Use public transport.
- Consider cycling or walking.

A climate-friendly and sustainable future for our children

SUMMARY OF ADAPTATION EFFORTS



COASTAL PROTECTION

Key risks

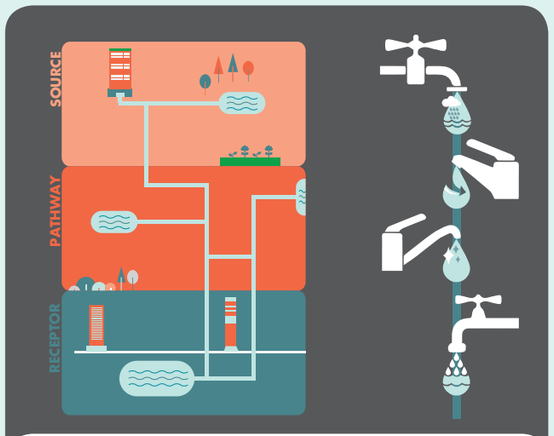
- Communities and property along Singapore's coastline could be affected by rising sea levels

What we have done

- Set higher minimum reclamation levels
- Built geo-bags and seawalls
- Raised the height of some coastal roads

What we are doing

- Coastal Adaptation Study to identify options to better protect our coasts over the long term



WATER RESOURCES AND DRAINAGE

Key risks

- Our water supply may be affected by more frequent and severe droughts
- Intense rainfall and rising sea levels may increase the risk of flooding

What we have done

- Diversified our water supply: Four National Taps
- Created a water conservation programme
- Created a water efficiency scheme
- Designed a stormwater management system (Source-Pathway-Receptor Approach)

What we are doing

- Build a fifth NEWater plant and two new desalination plants
- Study feasibility of an innovative underground drainage and reservoir system

BIODIVERSITY AND GREENERY

Key risks

- Trees could be damaged or uprooted due to strong winds
- Biodiversity may be affected by changes in temperature and rainfall
- There may be more bush fires due to temperature increase and low rainfall

What we have done

- Set up marine conservation area
- Started efforts to restore and conserve Singapore's mangroves
- Stepped-up patrols at fire hot spots
- Increased and intensified tree inspections

What we are doing

- Develop Fire Probability Index
- Improve habitat management and restoration

PUBLIC HEALTH AND FOOD SECURITY

Key risks

- Higher temperatures may affect human health and healthcare operations
- Vector/pest populations could increase due to higher temperatures and rainfall, increasing the incidence of diseases such as dengue
- Our imported food supplies could face disruption and price spikes, should production be affected by extreme weather

What we have done

- Created a nation-wide programme to suppress mosquito vector population
- Promoted workplace safety and health guidelines to manage heat stress
- Implemented a food diversification strategy
- Enhanced local food production by raising productivity and capability of local farmers

What we are doing

- Develop heat index and advisories for the public
- Review current vector control regime
- Continue to support local farmers

NETWORK INFRASTRUCTURE

Key risks

- Intense rainfall, sea level rise, and temperature changes could affect the operation of our telecommunications, power, and transport infrastructure

What we have done

- Installed flood barriers at existing underground MRT stations in low-lying areas
- Commenced upgrading of existing airport drainage system

What we are doing

- Review resilience of power stations, transport, and telecommunication infrastructure against localised flooding and temperature changes
- Build Changi Airport Terminal 5 5.5m above mean sea level

BUILDING, STRUCTURE AND INFRASTRUCTURE

Key risks

- Safety and reliability of infrastructure could be impacted by strong winds and higher temperatures
- Increased rainfall could lead to slope instability

What we have done

- Implemented periodic structural inspection to ensure structural defects are detected and rectified

What we are doing

- Study impact of climate change on buildings and structures
- Study impact of climate change on slope stability and integrity

More copies of this booklet can be requested from NCCS_Contact@nccs.gov.sg

Electronic versions are available at www.nccs.gov.sg/resources/publications

Images contributed by:
Agri-Food & Veterinary Authority of Singapore
Building and Construction Authority
Civil Aviation Authority of Singapore
Land Transport Authority
National Environment Agency
National Parks Board
Panasonic Factory Solutions Asia Pacific
PUB, Singapore's National Water Agency
Singapore Aquaculture Technologies (SAT) Pte Ltd

Ministry of the Environment
and Water Resources