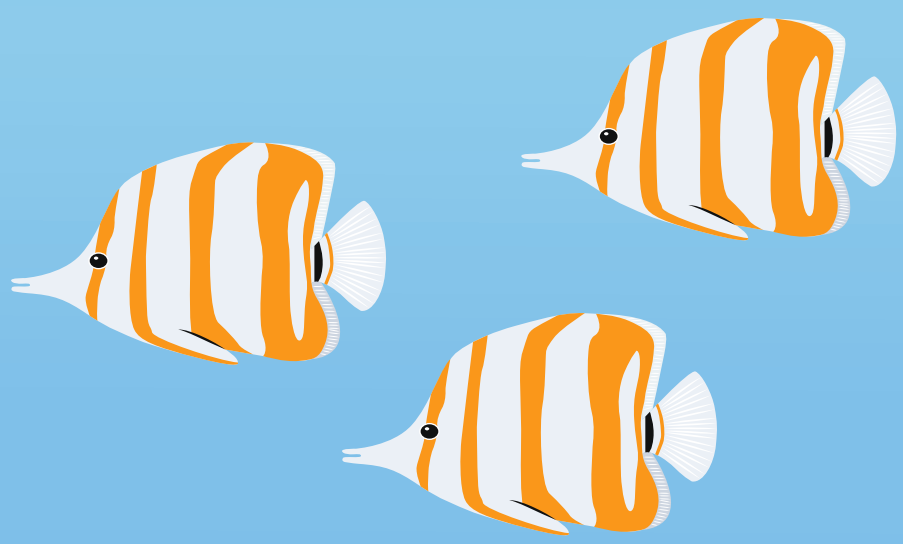


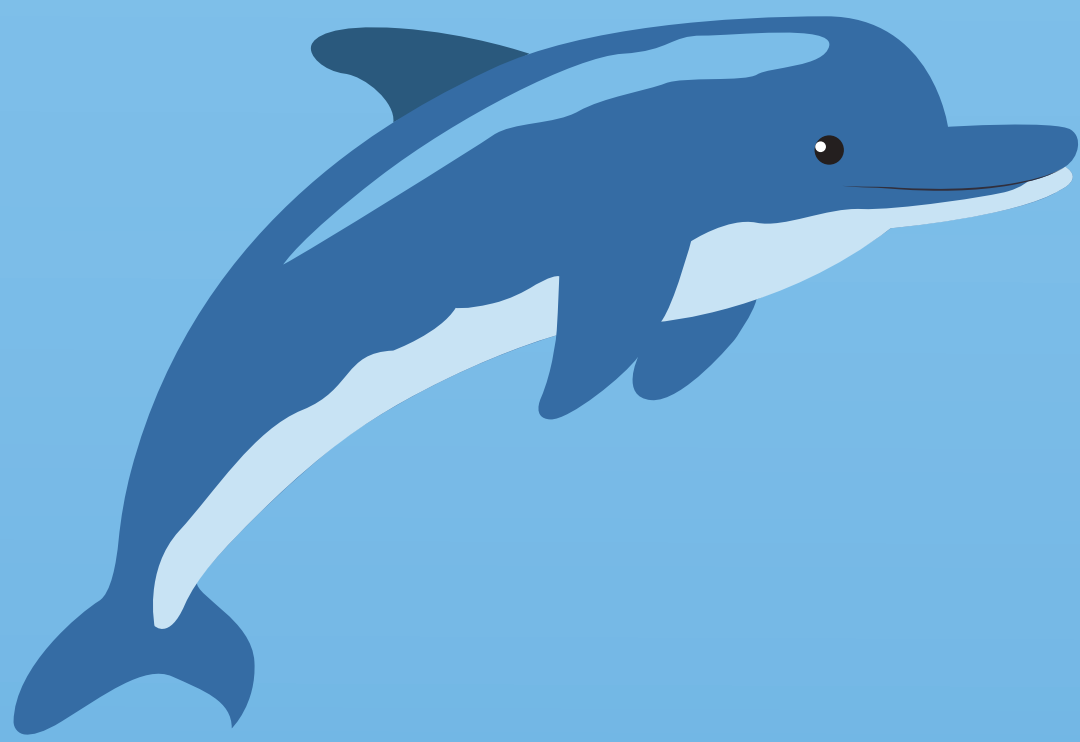


# R.I.S.E. TO THE CHALLENGE

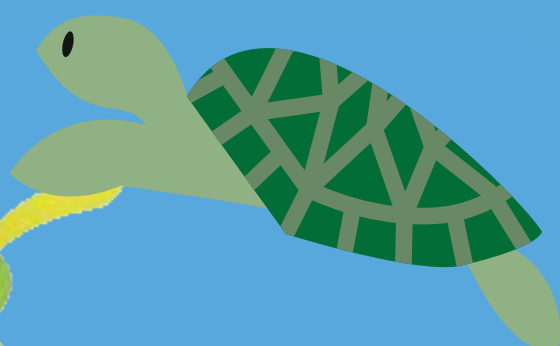
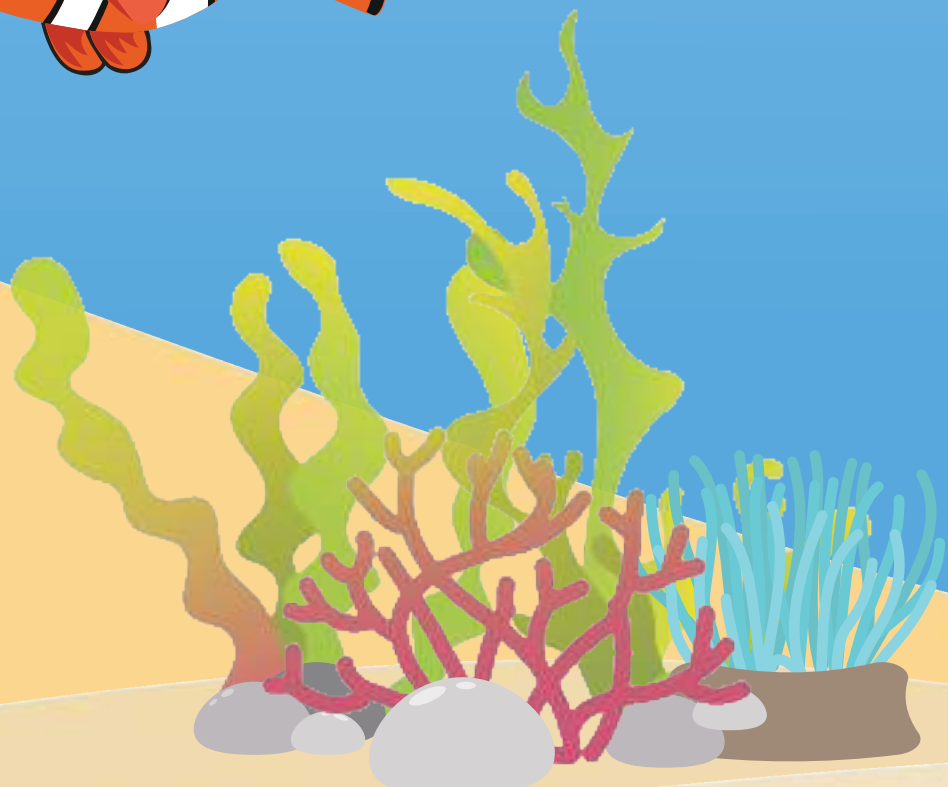
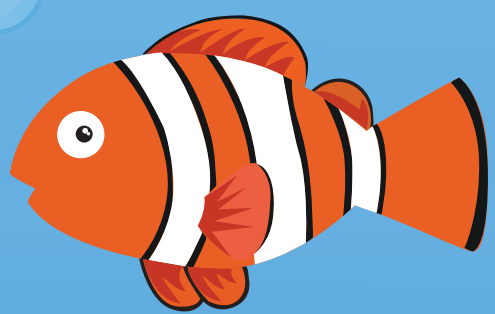
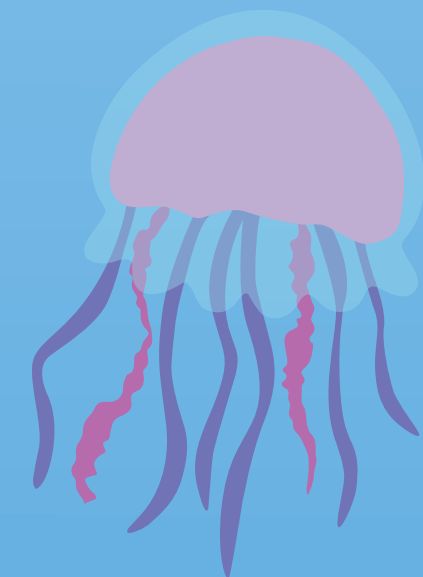
Featuring information about the global challenge of rising sea levels, from the factors contributing to rising sea levels to the impacts that rising sea levels have on our everyday lives.



Are we equipped with the knowledge to tackle this global problem?



Are you ready to R.I.S.E. to the Challenge?





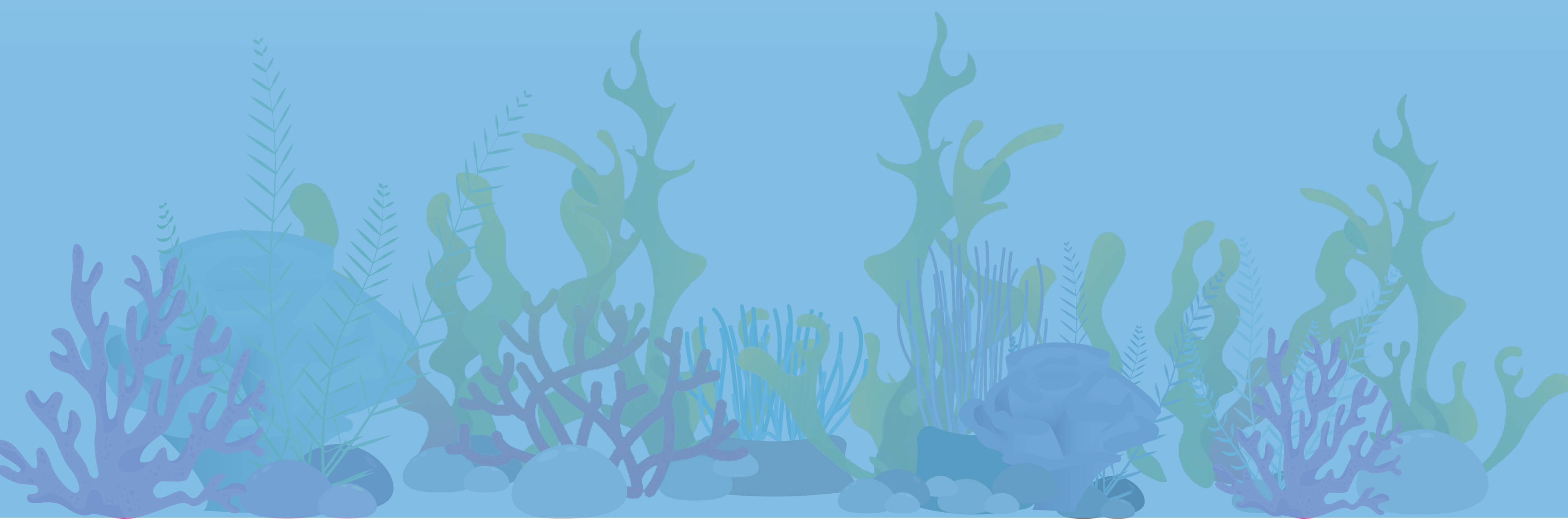
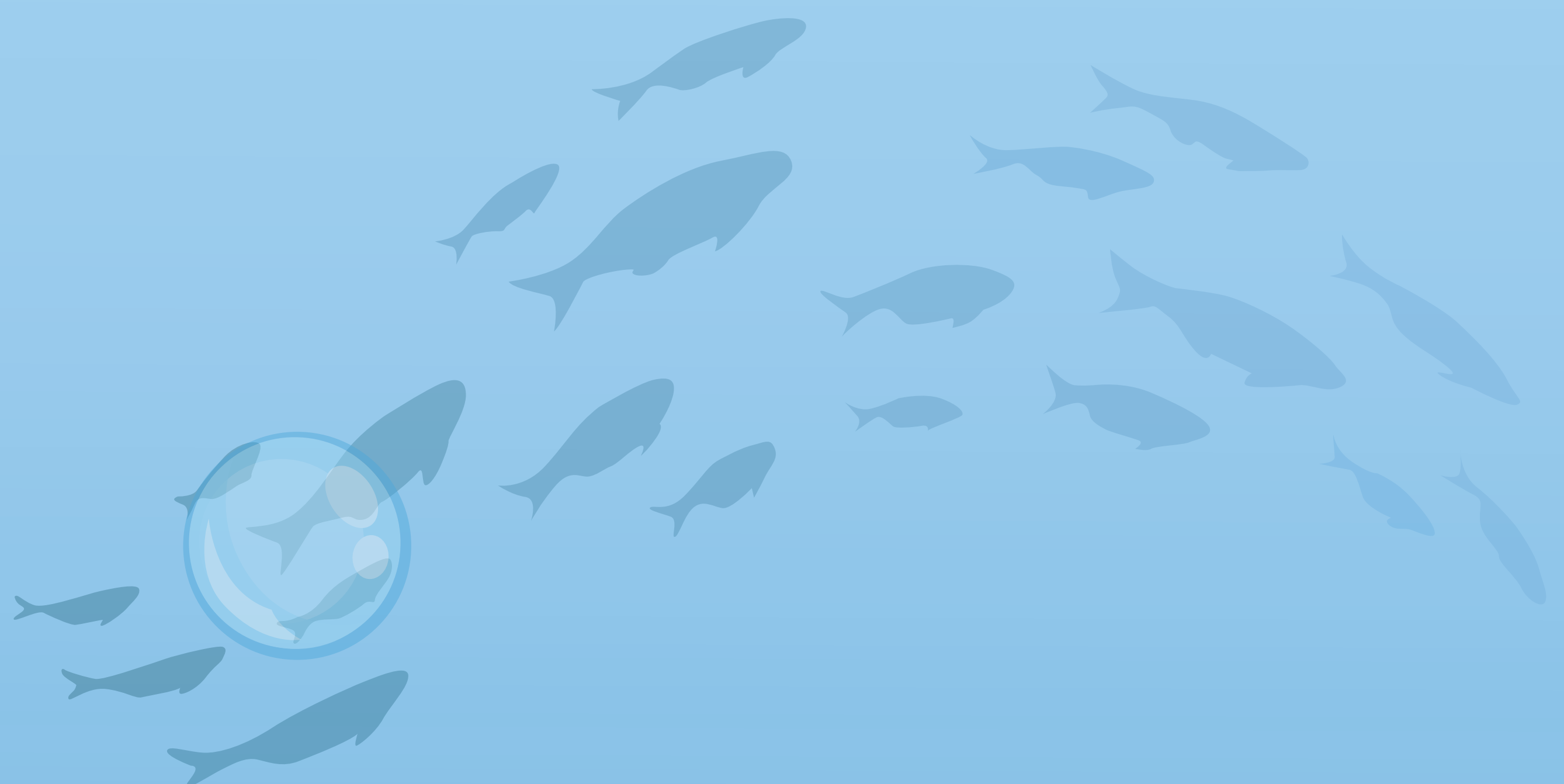
**This e-book was launched by**

**Mr Desmond Lee**

**Minister for National Development &  
Minister-in-charge of Social Services Integration**

**at the launch of the 'R.I.S.E. to the Challenge II'  
public outreach programme**

**on 22 August 2022**







## FOREWORD

Climate change is one of the gravest challenges mankind faces today. Global warming has resulted in rising sea levels, which makes Singapore, a low-lying island city-state, increasingly vulnerable.

At Keppel Land, we are committed to supporting the efforts of the Singapore government and the international community to advance climate action. In 2020, Keppel Land, in collaboration with the Sustainable Singapore Gallery, managed by PUB, launched 'R.I.S.E. to the Challenge', a programme aimed at raising awareness on the impact of rising sea levels and the urgent need for climate action.

Following the programme's success, Keppel Land has extended it for another two years, from August 2022 to 2024. The second phase, 'R.I.S.E. to the Challenge II', seeks to expand community outreach and engagement through new initiatives, including this e-book, which is based on the programme's rich exhibition content.

We believe in empowering lives through education and hope to share with you the importance of good environmental practices, the value of climate-smart actions, and show how each one of us can contribute to making a profound difference to the world.

Do join us on the journey to build a cleaner, greener world as we redefine urban spaces for a sustainable future!

**Louis Lim**  
CEO, Keppel Land  
22 August 2022





---

# CONTENTS

## CHAPTER 1

It's not so cool

## CHAPTER 2

We're in hot water

## CHAPTER 3

Still sitting ducks

## CHAPTER 4

Feeling salty

## CHAPTER 5

Breaking the banks

## CHAPTER 6

Swimming or drowning

## CHAPTER 7

Quelling the catastrophe

## CHAPTER 8

We're all in this together

©2022 Keppel Land Limited

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior written permission of the copyright owner.



# AN INTRODUCTION TO RISING SEA LEVELS

A series of exhibitions by Keppel Land on the pressing environmental issue of rising sea levels

WHAT IS...



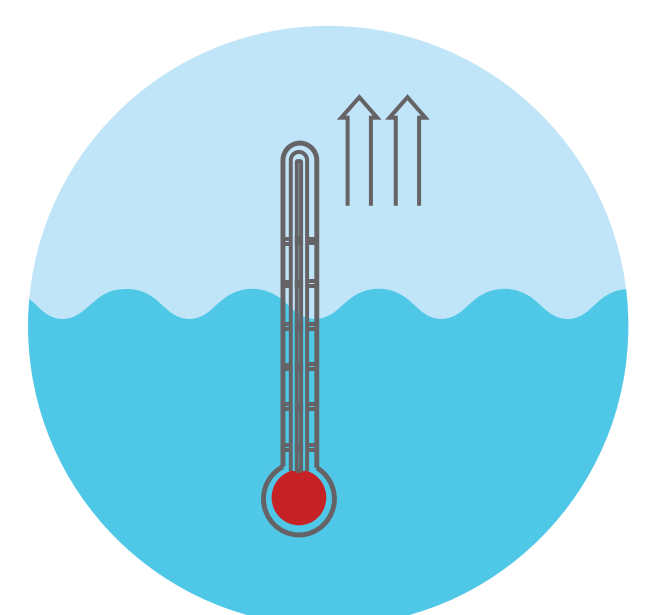
Human Activities



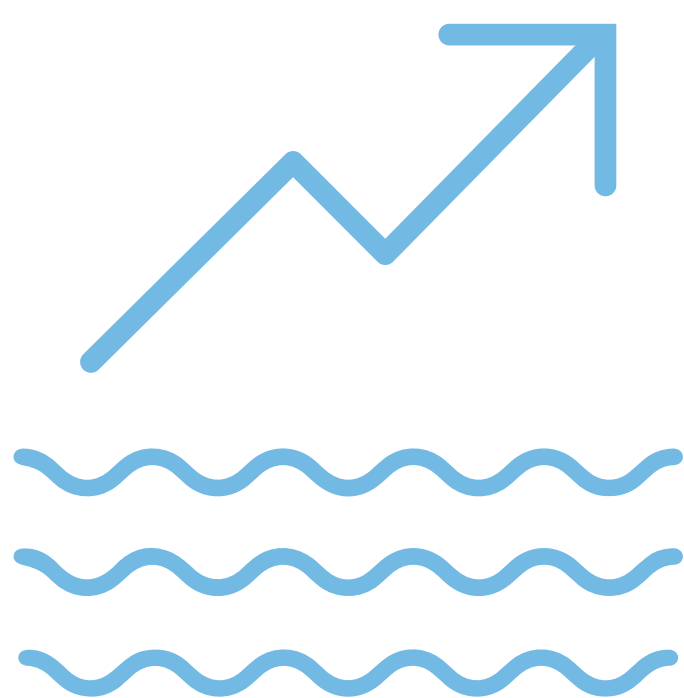
Release Greenhouse Gases & Generate Carbon Footprint



Global Warming

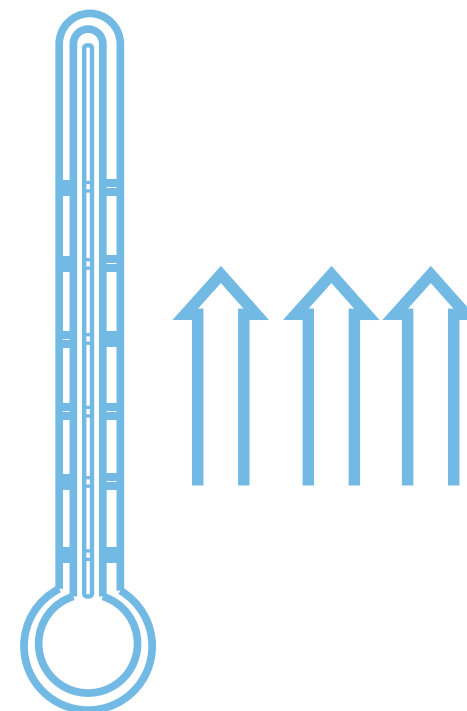


Climate Change & Rising Sea Levels



**Rising Sea Levels**

An increase in the level of the world's oceans as a result of global warming and climate change.



**Global Warming**

An increase in the average temperature of air and oceans in all parts of the world.



**Carbon Footprint**

The impact that an action, an item, a lifestyle, a company or a country has on climate change.



**Climate Change**

The long-term change in weather patterns, such as temperature and rainfall, in a region over a long period of time.





## **CHAPTER 1:** It's not so cool

In the first chapter of this series, discover what causes sea levels to rise and how your actions can make a difference in reducing the impact of this global problem.



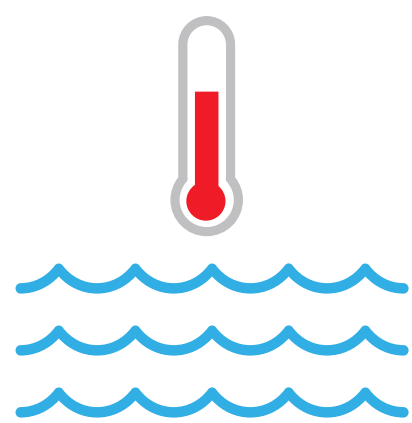
# WHY DO RISING SEA LEVELS MATTER?

## Why Addressing Sea Level Rise Is Important

### 1. Climate Change

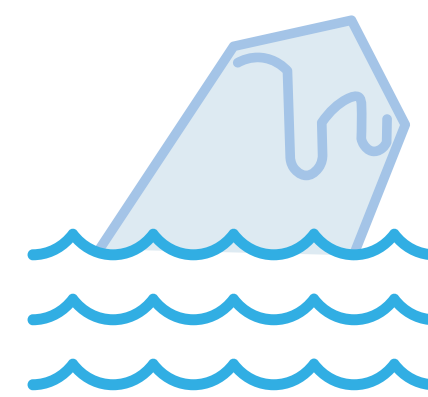
#### Thermal Expansion

Rising temperatures in our world mean warmer waters, which causes oceans to expand. In turn, sea levels rise.

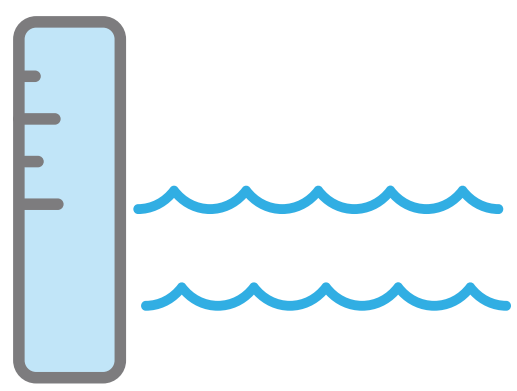


#### Melting Ice

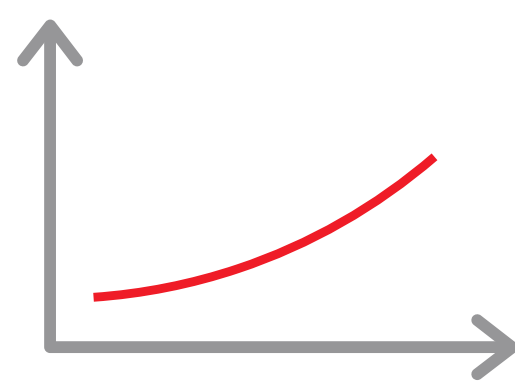
Global warming is causing glaciers and ice sheets in the Antarctic and Greenland to melt. This causes sea levels to rise.



### 2. Slow Response



Sea levels are now **19cm higher** than they were at the start of the 20th century.



Sea levels will continue rising over the next few centuries and up to 6m by the end of the century if all the ice sheets in Greenland melt.

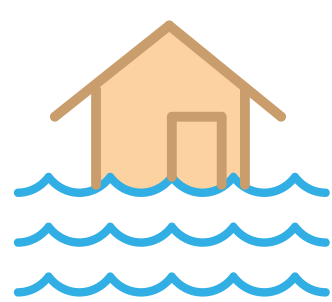


Preventing sea level rise is possible, but... the effects will not be immediate, as oceans respond to changing temperatures very slowly.

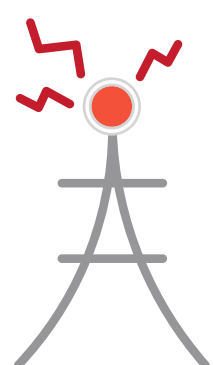
### 3. Coastal Risks

#### When Sea Levels Rise,

- More floods may occur around the world



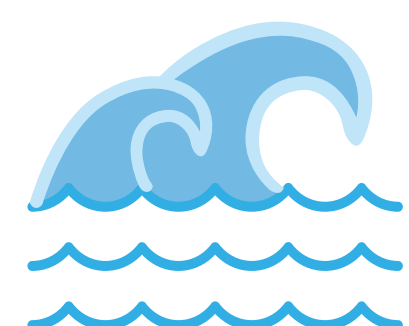
- Infrastructure may be affected if they lie in the path of rising seas



- Dangerous weather events such as hurricanes and typhoons will become more intense



- Possibility of more frequent storm surge events



Source: City of Greater Geraldton



# RISING SEA LEVELS & SINGAPORE

Rising sea levels will pose a threat to Singapore, which is a low-lying island. This means that we are at greater risk of more floods.

Singapore, being near the equator, is **more vulnerable to climate change effects** than the global model suggests.

## A Visual Representation



\*For illustration purposes only

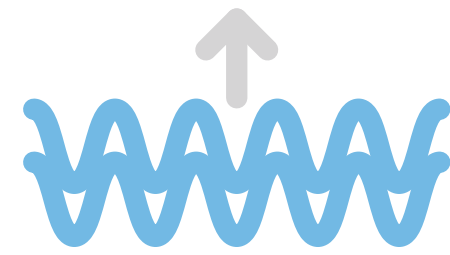
### Legend

- Less than 5m above sea level
- About 15m above sea level
- More than 20m above sea level

- Much of Singapore lies only 15m above the mean sea level
- About 30% of the island lies less than 5m above the mean sea level
- By 2100, Singapore is projected to experience:
  - Mean sea level rise of up to 1 metre
  - An increase in daily mean temperatures by as high as 4.6°C, and
  - More extreme and intense weather events, which may lead to more frequent floods.

## In The Event of:

  
Rise In Mean  
Sea Level

+   
High Tides

+   
High Surges

Sea levels could rise by up to **4m** above the current mean, and overwhelm Singapore's low-lying coastal areas.

Source: Centre for Climate Research Singapore

# WHAT HAPPENS IF SEA LEVELS CONTINUE RISING?

Globally, sea levels rose faster than in the 20th century, and observations and projections suggest that it will rise at an even higher rate in the 21st century.

If sea levels do not stop rising, we may see these possible consequences in the next 80 years around the world:

1.



As many as **216 MILLION** people displaced from their homes

2.



Fish, birds and plants losing their habitats

3.



More unpredictable weather patterns

4.



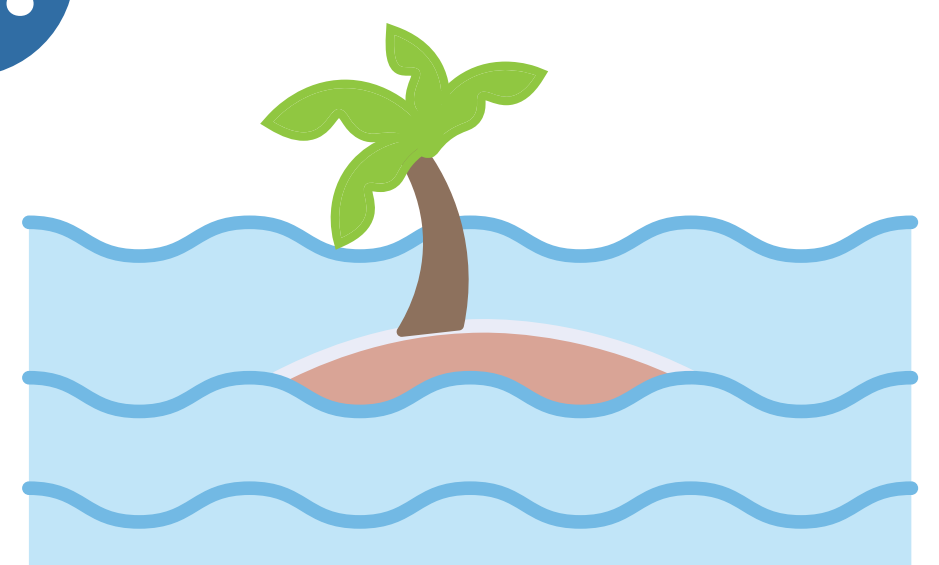
Bigger storms with more powerful storm surges

5.



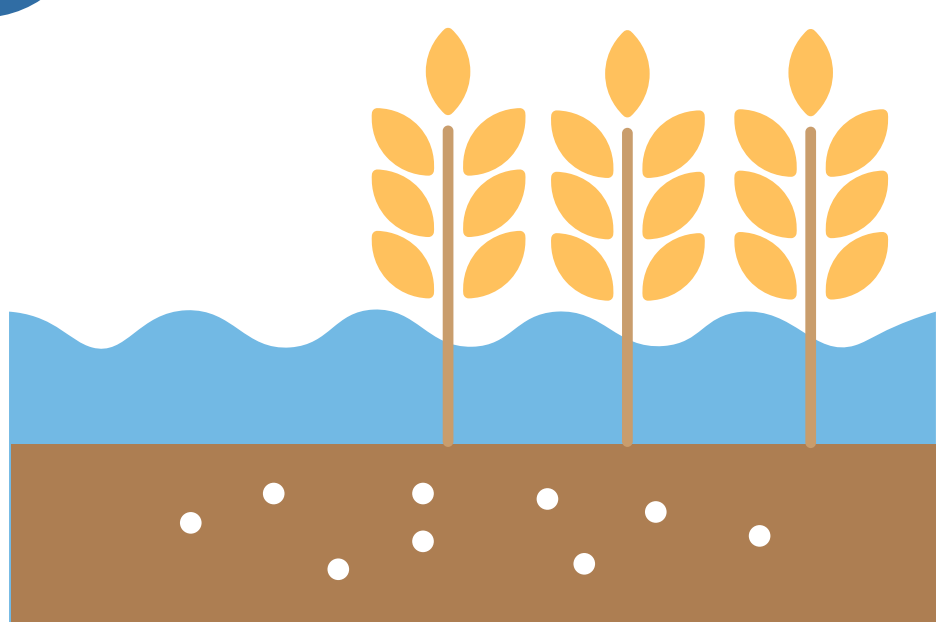
Floods on a scale that occurred every **500 years** may occur every **5 years** instead

6.



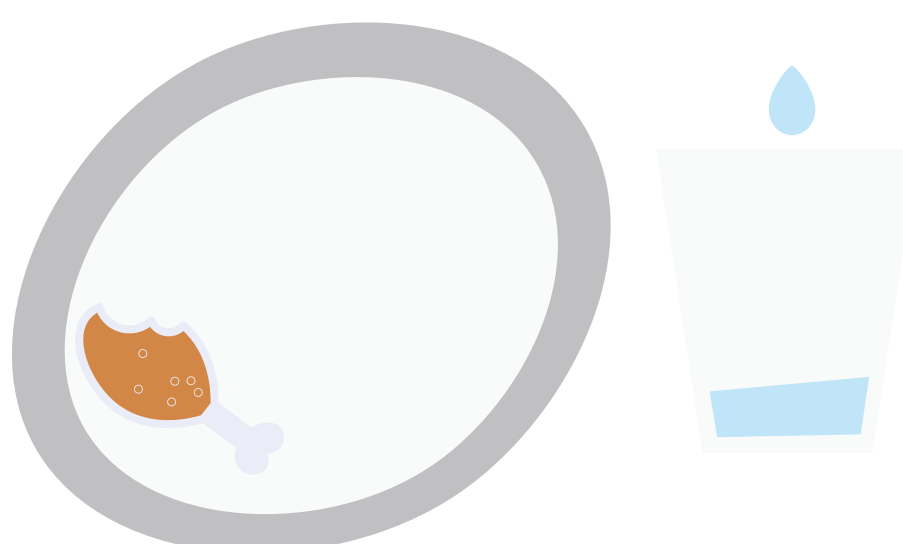
Low-lying islands completely submerged

7.



Seawater moving inland, contaminating aquifers and agricultural soil

8.



Increased **food & water shortage**

9.



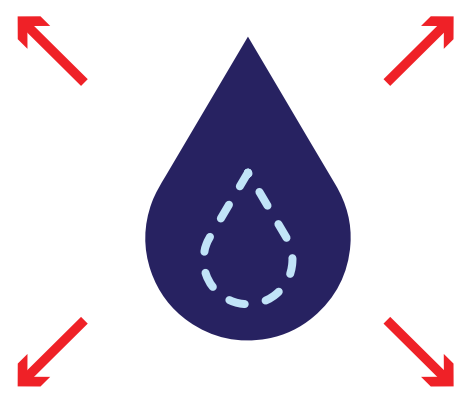
30% more water from melted ice caps pulled towards the equator



# WHY ARE SEA LEVELS RISING?

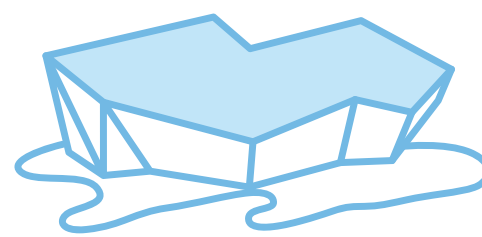
The change in sea levels is linked to three primary factors, all induced by ongoing global climate change:

## Thermal Expansion



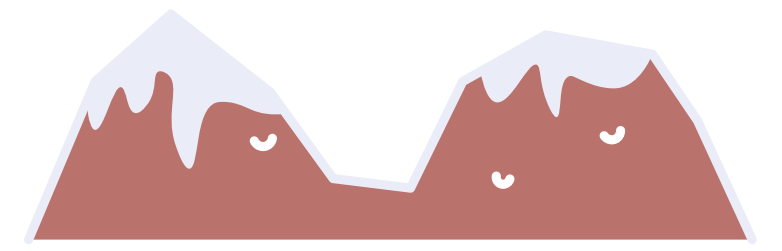
When water heats up, it expands. About half of the sea level rise over the past 25 years is attributable to warmer oceans simply occupying more space.

## Melting Glaciers



Persistently higher temperatures caused by global warming have led to greater-than-average summer melting of glaciers and diminished snowfall due to later winters and earlier springs. That creates an imbalance between runoff and ocean evaporation, causing sea levels to rise.

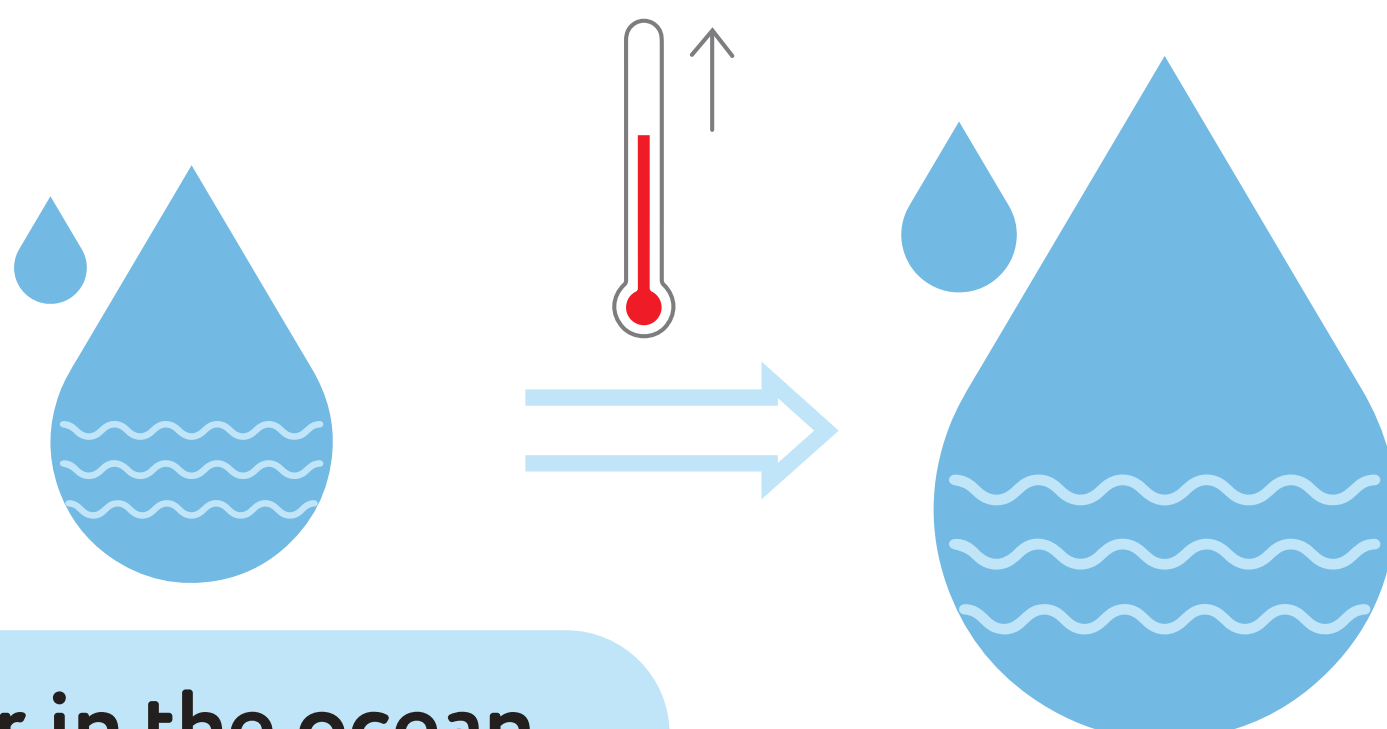
## The loss of Greenland's and Antarctica's ice sheets



As with mountain glaciers, increased heat is causing the massive ice sheets that cover Greenland and Antarctica to melt more quickly.

Source: National Geographic

## Thermal Expansion



Water in the ocean expands as it warms up, filling larger volumes.

The ocean absorbs more than 90% of the heat that greenhouse gases trap in the Earth's atmosphere.



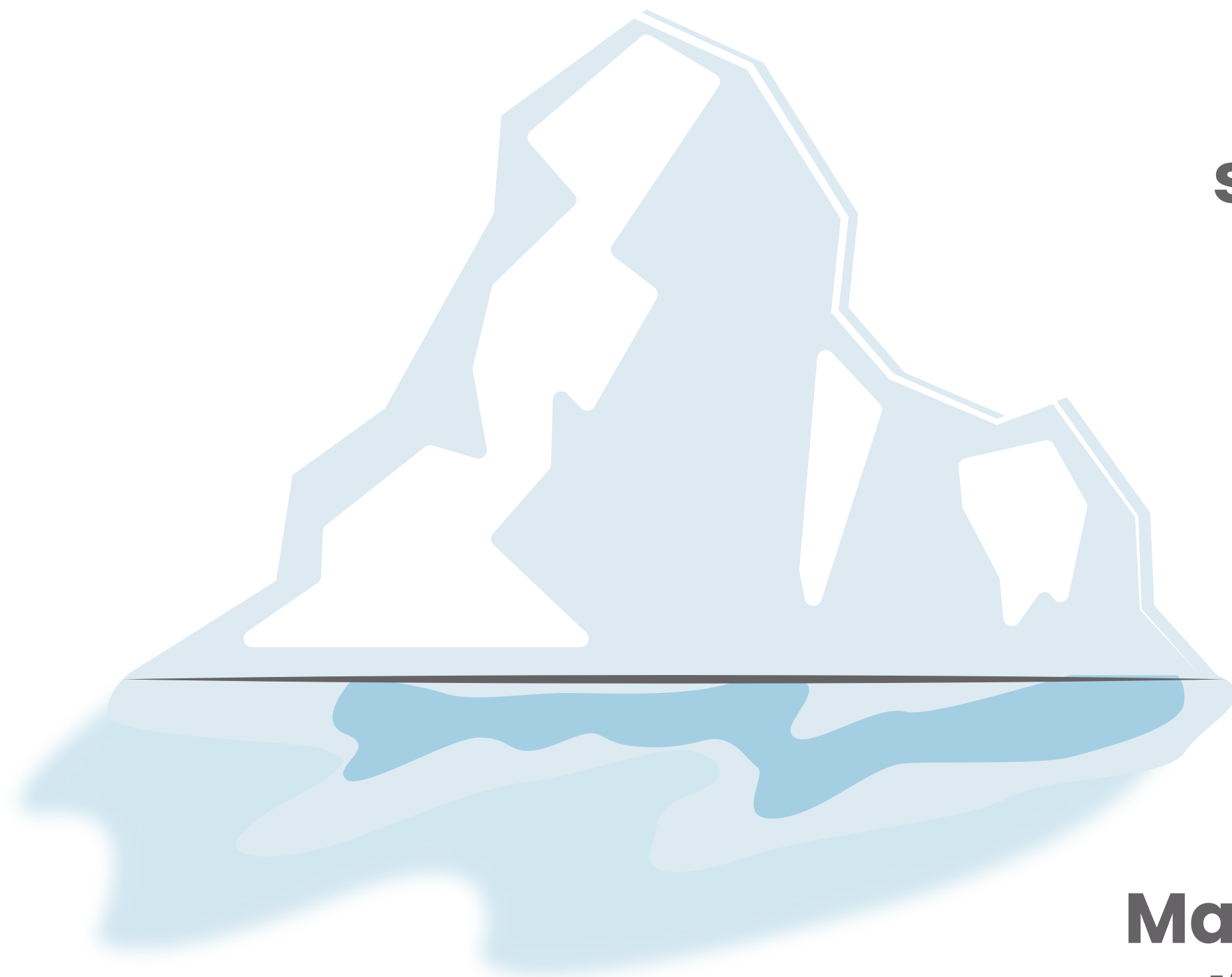
This makes thermal expansion a significant contributor to global sea level rise.

“ Thermal expansion of the ocean has contributed about **half of the 7 centimetres** of global mean sea level rise **over the last 25 years.** ”

- Steve Nerem, member of NASA's Sea Level Change team

Source: NASA

## Melting Ice



Mountain glaciers

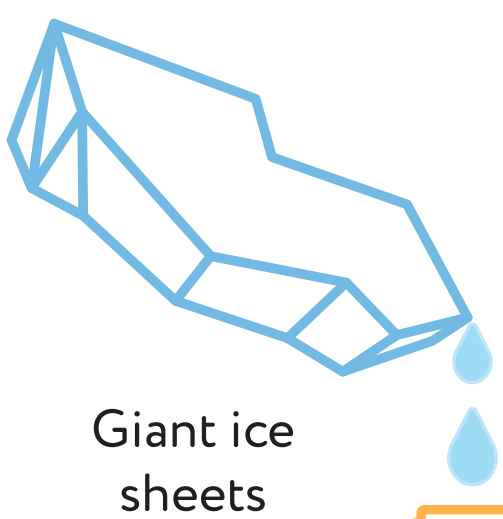
The world's glaciers are the smallest they have ever been in human history.

$\frac{1}{3}$  of measured sea level rise comes from melting mountain glaciers — the same contribution as the Greenland ice sheet and more than the contribution of the Antarctic ice sheet.

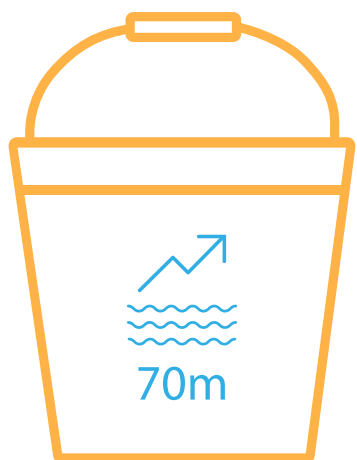
Many of the world's glaciers may disappear in the next century.

Source: Nature Climate Change, National Geographic

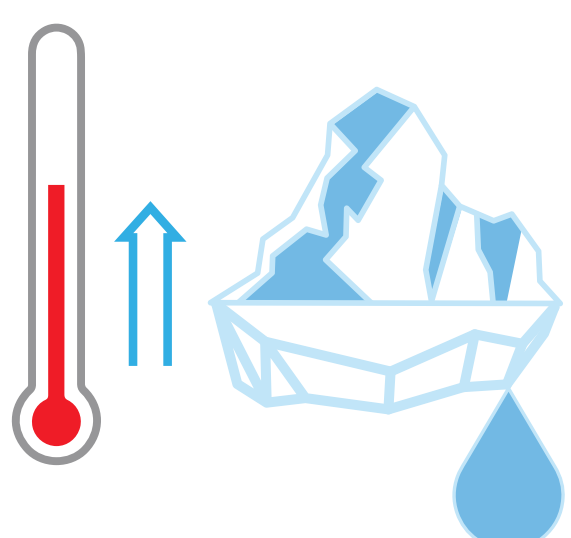
## How Does The Melting Of Land-Based Ice Contribute To Rising Sea Levels?



Giant ice sheets



Antarctica & Greenland contain enough **ice** to raise sea levels by about **70m** if they all melted.

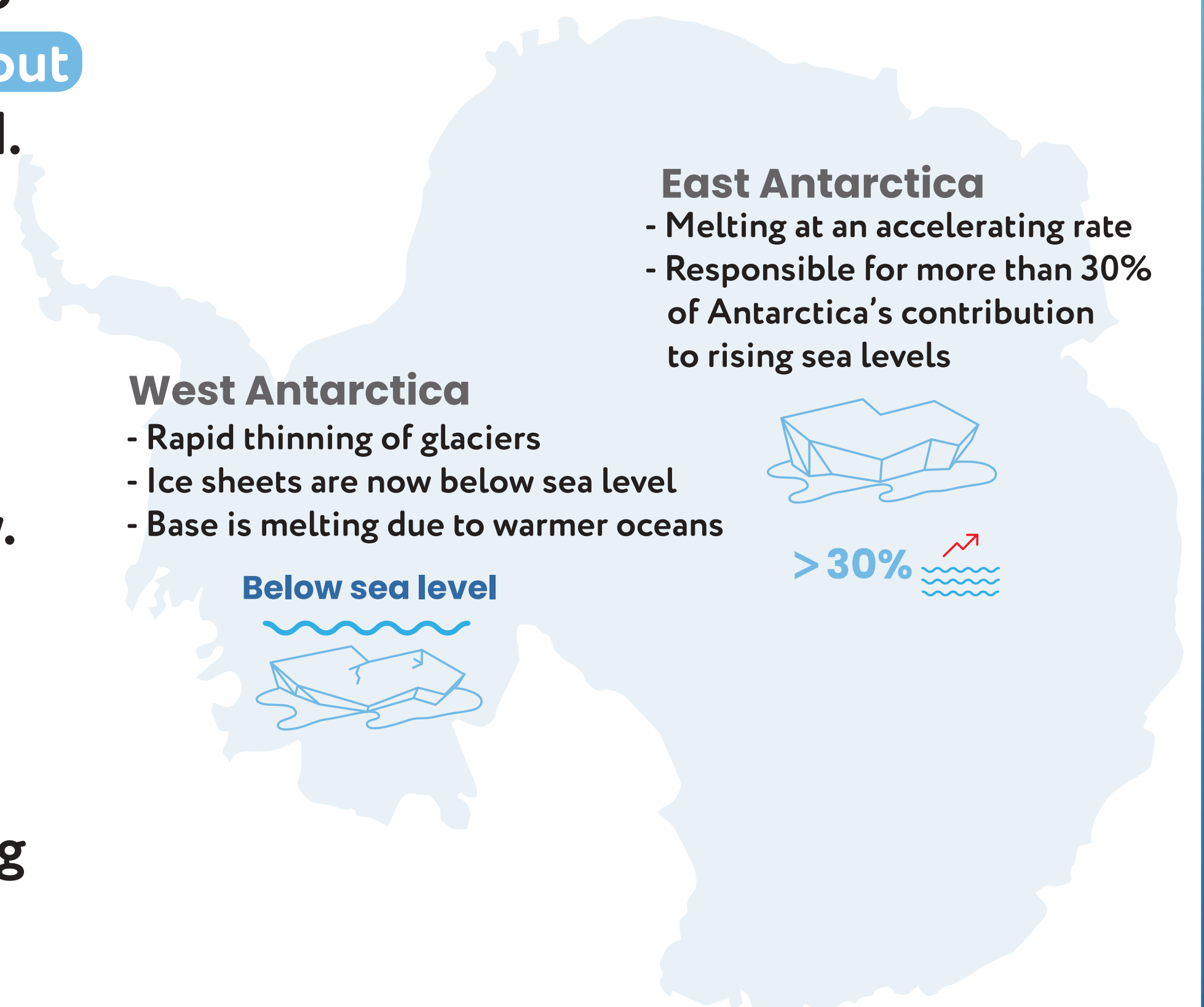


Glaciers are **melting faster** than they accumulate new snow.

As these ice sheets and glaciers melt, the water eventually runs into the oceans, causing **sea levels to rise.**

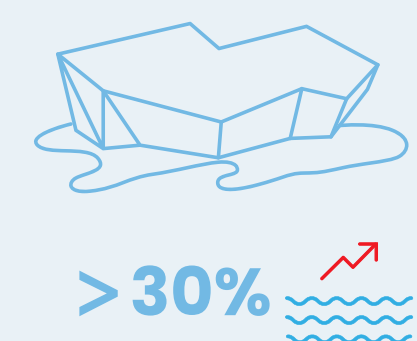


Overall, Antarctica sends **six times** more ice plunging into the sea each year than it did in 1979.



**West Antarctica**  
- Rapid thinning of glaciers  
- Ice sheets are now below sea level  
- Base is melting due to warmer oceans

**East Antarctica**  
- Melting at an accelerating rate  
- Responsible for more than 30% of Antarctica's contribution to rising sea levels



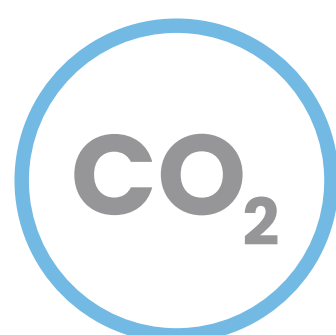
Source: The Straits Times



# WHY IS THERE MORE HEAT IN OUR OCEANS?

## How Carbon Dioxide Is Heating Up The Planet, Making Our Oceans Warmer

Carbon dioxide is a gas that contributes to the greenhouse effect.



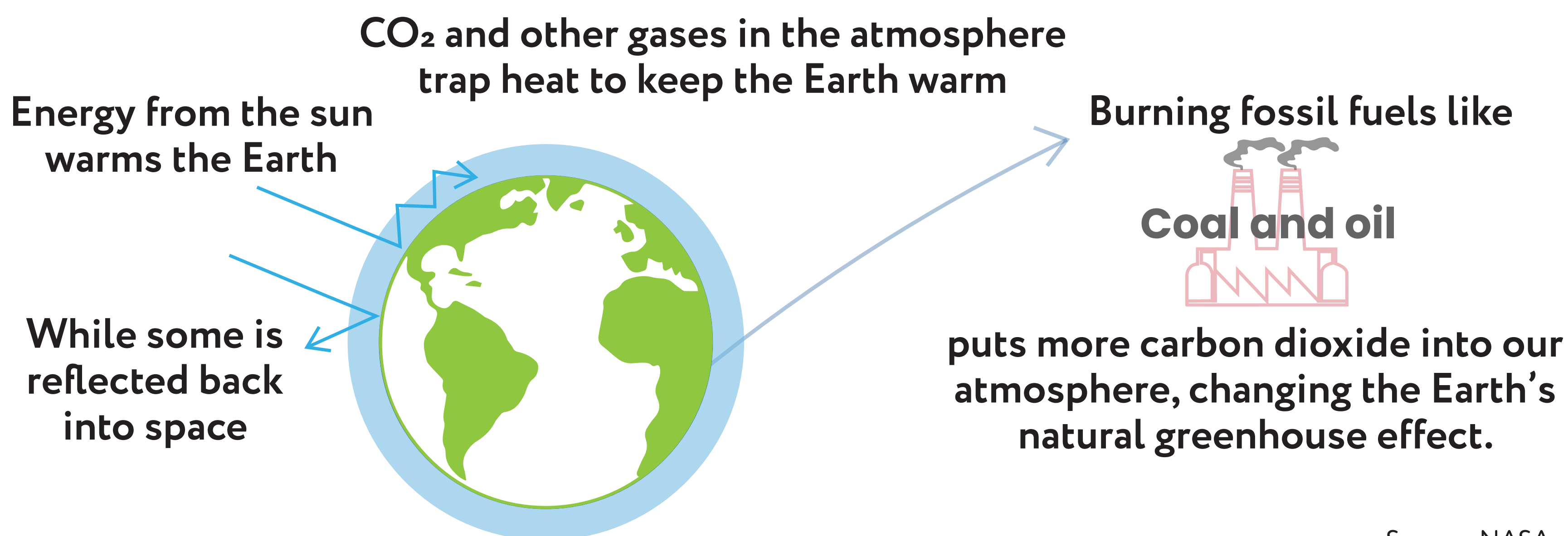
The greenhouse effect occurs when gases in the Earth's atmosphere trap the Sun's heat. This process makes the Earth much warmer than it would be without the gases.

With the atmosphere, the Earth's average temperature is 15°C. Otherwise, the Earth will be as cold as the moon. (That's an average of -153°C!)

However...

if more carbon dioxide exists in the atmosphere, the Earth on average will become warmer.

This is global warming.



Source: NASA

“2019 concluded a decade of exceptional global heat, retreating ice and record sea level rise driven by greenhouse gases from human activities.”

Source: World Meteorological Organization

## And In 2018 Alone,

### Greece

A wildfire east of the capital Athens killed at least 74 people.



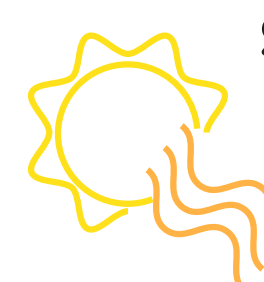
### Japan

Temperatures near Tokyo rose to a record high of 41.1°C.



The Korean Peninsula, Scandinavia, the UK, Greece, Sweden and the US

All of them experienced severe heatwaves that killed dozens and triggered wildfires.



Source: The Straits Times

# OUR IMPACT ON GLOBAL WARMING

## How Do Our Actions Affect Global Warming?



Fuel

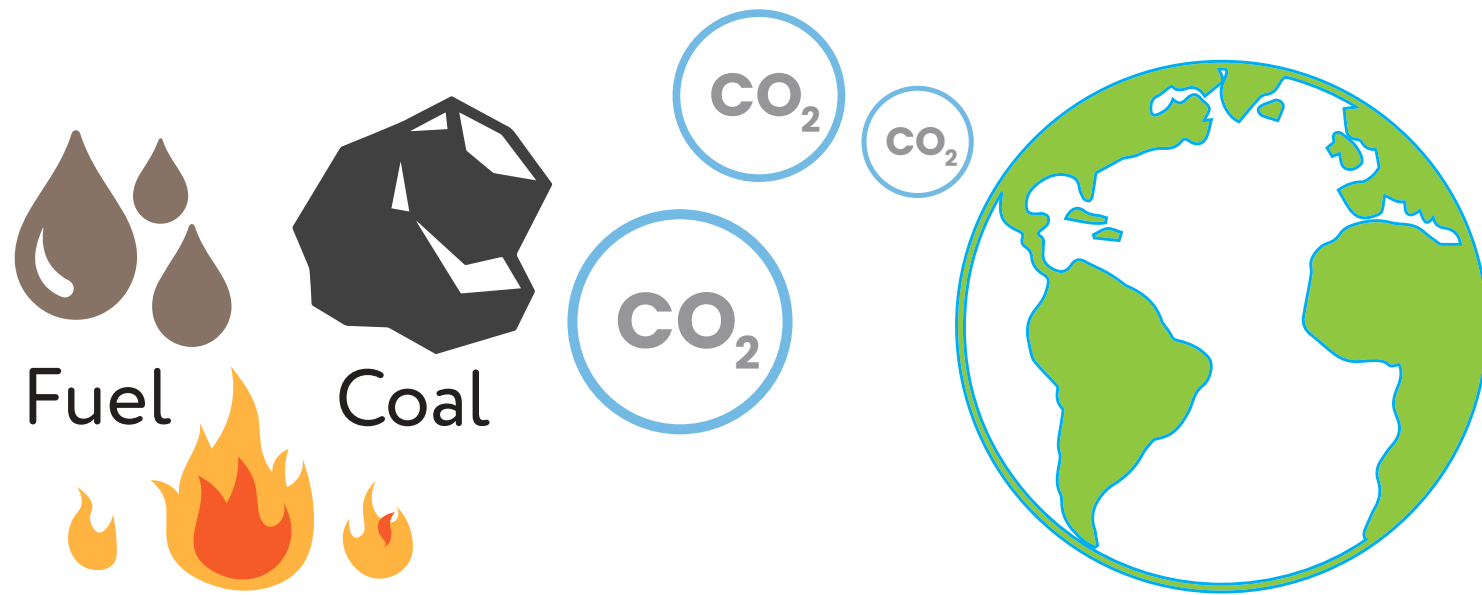
&



Coal  
(Hydrocarbons)



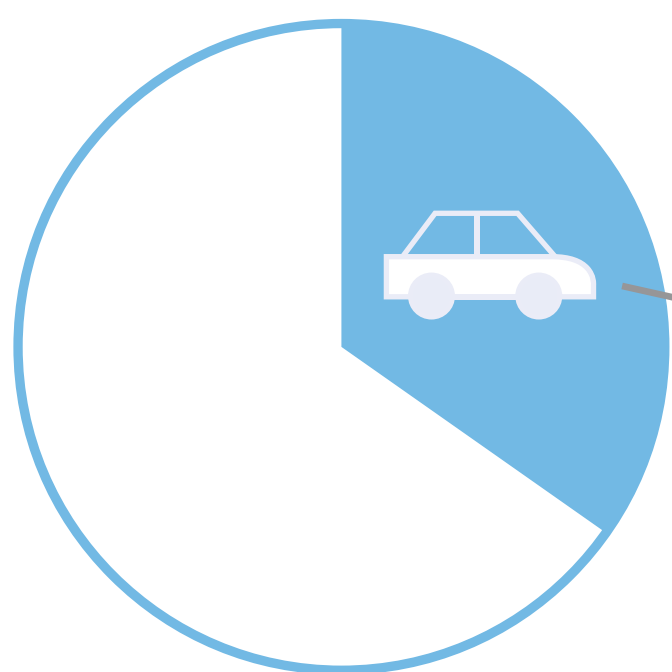
**Main sources  
of energy**



**Burning fuel and coal releases a great amount of carbon dioxide (CO<sub>2</sub>) into the Earth's atmosphere.**

Source: Earth Observatory of Singapore

## In Singapore,



Transport sector

**Private cars  
contribute  
more than 1/3 of  
emissions**

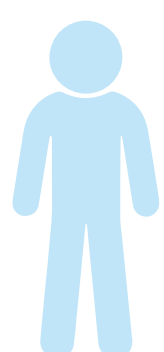
**Going car-free can save  
2.4 tonnes of greenhouse gas  
emissions a year**

Source: IOPScience, National Climate Change Secretariat

## Did You Know?

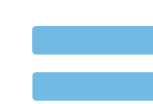
  
**An average  
transatlantic  
round-trip flight**

**Can release  
around 1.6  
tonnes of  
greenhouse  
gas**



**Average yearly  
emissions of  
1 person in India**

**Buying produce or items  
that are imported from  
neighbouring countries**



**Lower carbon footprint  
than those imported from  
faraway countries**

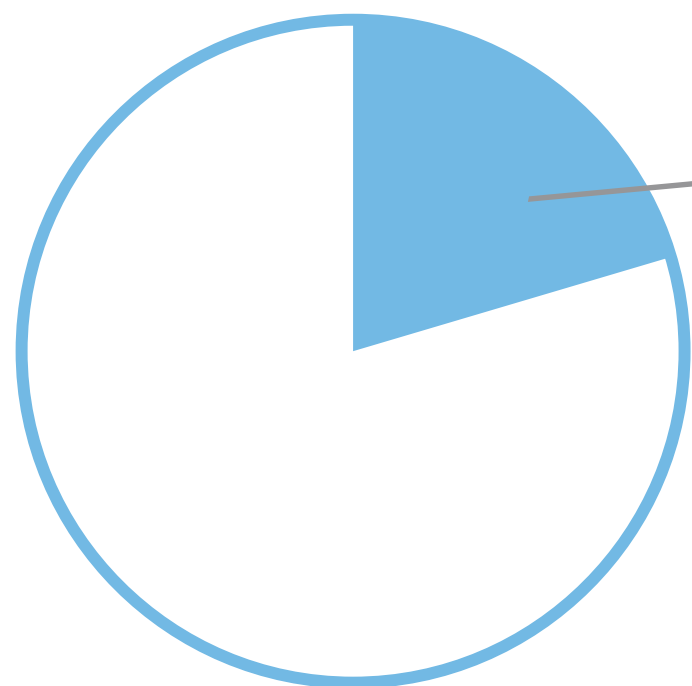


Source: National Climate Change Secretariat



## A Recent Survey On Food Waste In Singapore:

1,002 respondents



Less than a quarter could be classified as "smart consumers"

Source: Singapore Environment Council



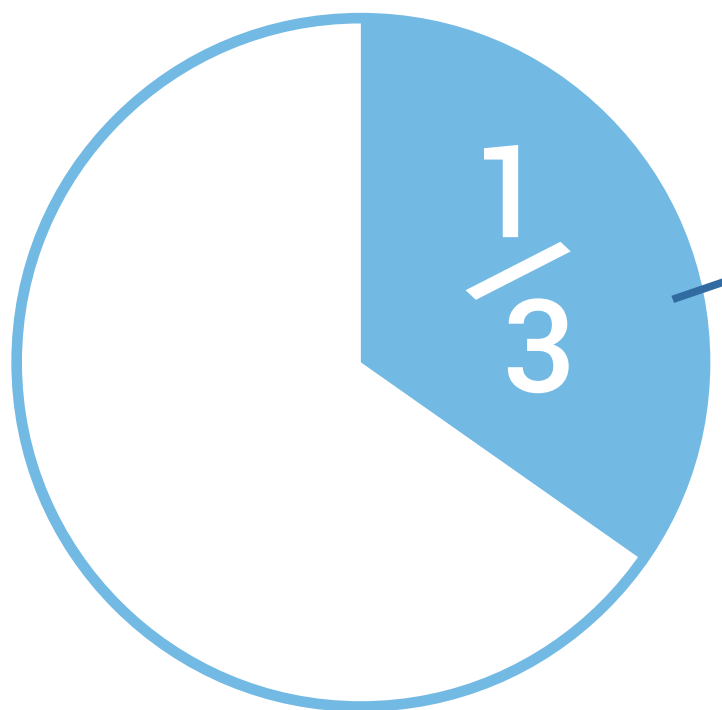
Individuals can adopt a low-carbon diet by incorporating plant-based food as much as possible.

**"Smart Consumers"** refer to those who consume all food items bought, do not throw away unconsumed food, and are not swayed by promotional offers to buy excess food items that are potentially wasted.

### The Cost

An estimated 23% of greenhouse gas emissions come from agriculture, livestock, and the land needed to raise them.

## A 2017 Study Found That:



A third of people in Singapore have thrown away clothing after wearing it just once

Source: YouGov

To reduce consumption, we can opt for second-hand goods like clothes or furniture & donate our clothes if they are in good condition as clothing should not be placed in the recycling bin

In 2019, Singapore generated **168,000 tonnes** of textile or leather waste, of which only **4%** was recycled.

The clothing sector contributes to around **3% of the world's global production emissions of carbon dioxide**, mostly because of the energy used to produce the clothes.

Source: CNA

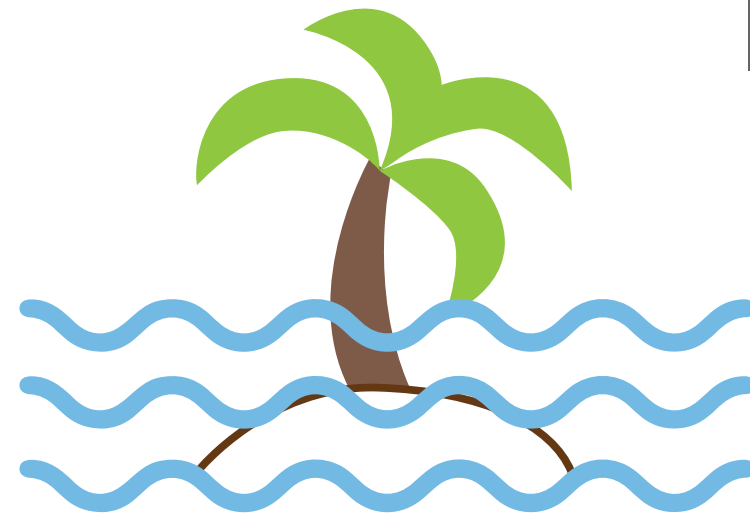
# THE WORLD IS DROWNING

## How Has The World Been Impacted By Rising Sea Levels?



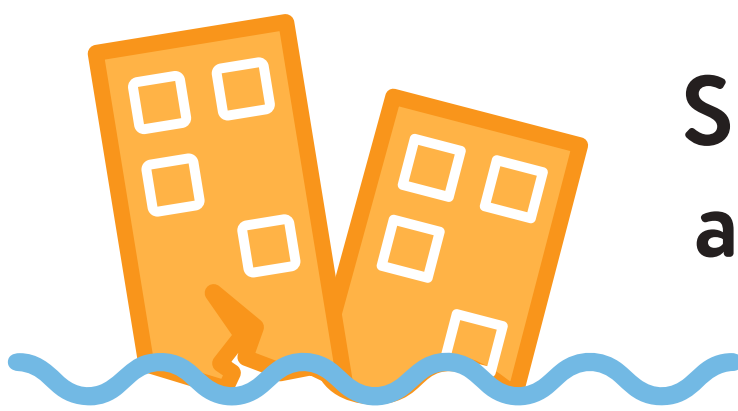
### In the Maldives

90 inhabited islands experience annual flooding



### In the Pacific Ocean

5 Solomon Islands disappeared as a result of being swallowed by rising seas



### In Vietnam

Several resort buildings are at risk of collapsing due to land erosion

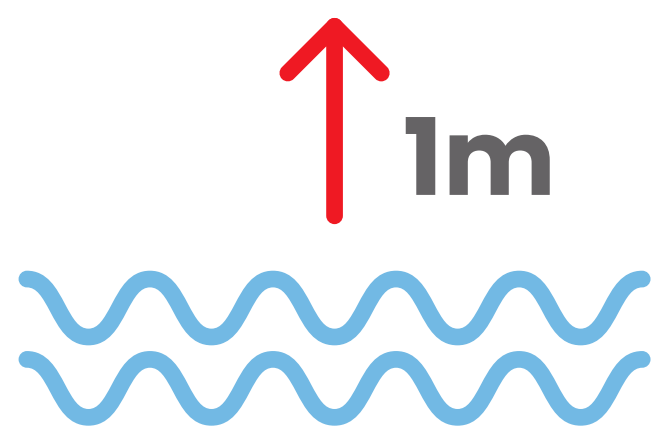


### In Indonesia

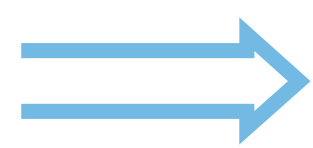
Jakarta is the fastest-sinking city - at 5 to 10cm per year

Source: CNA

## In Nature,

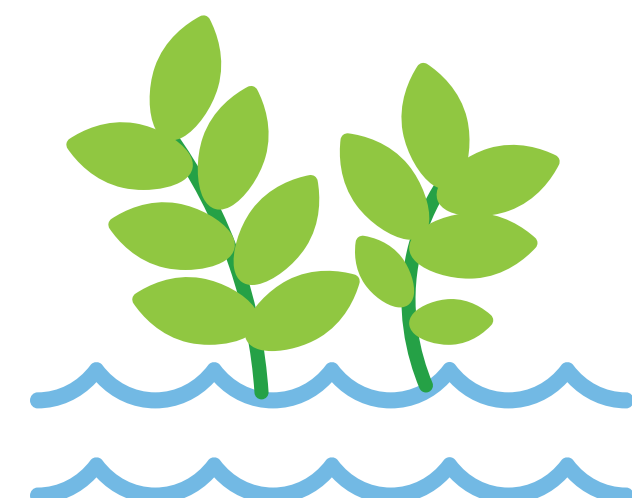


Rise in sea level



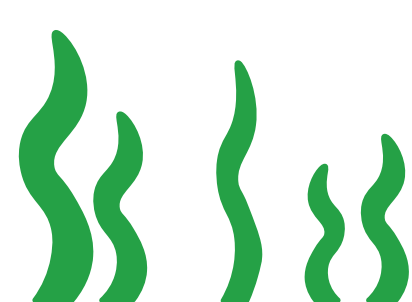
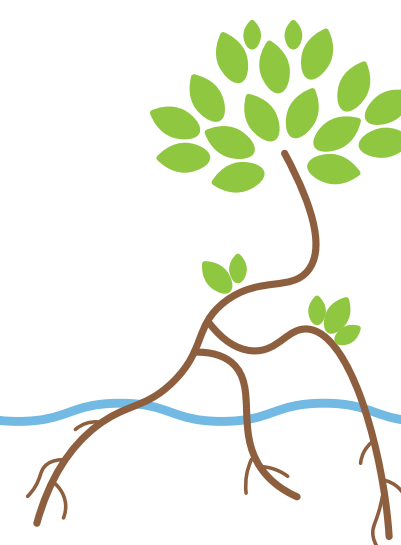
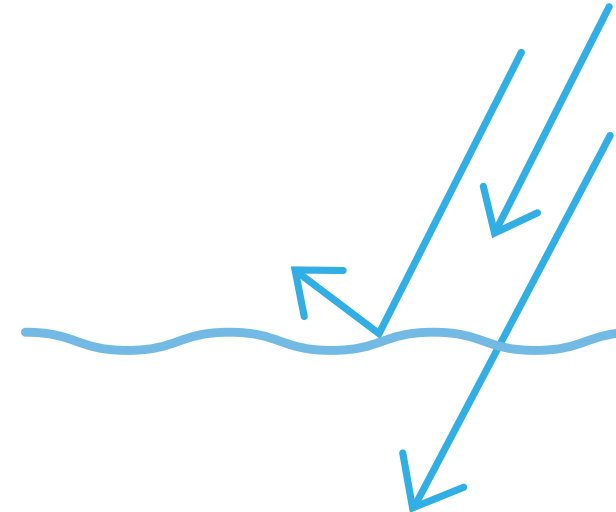
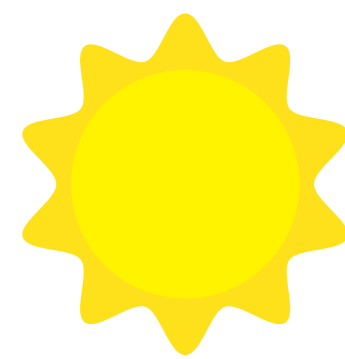
Impacts the coastline

&



Is one of the causes of critical coastal wetland habitat and mangrove loss

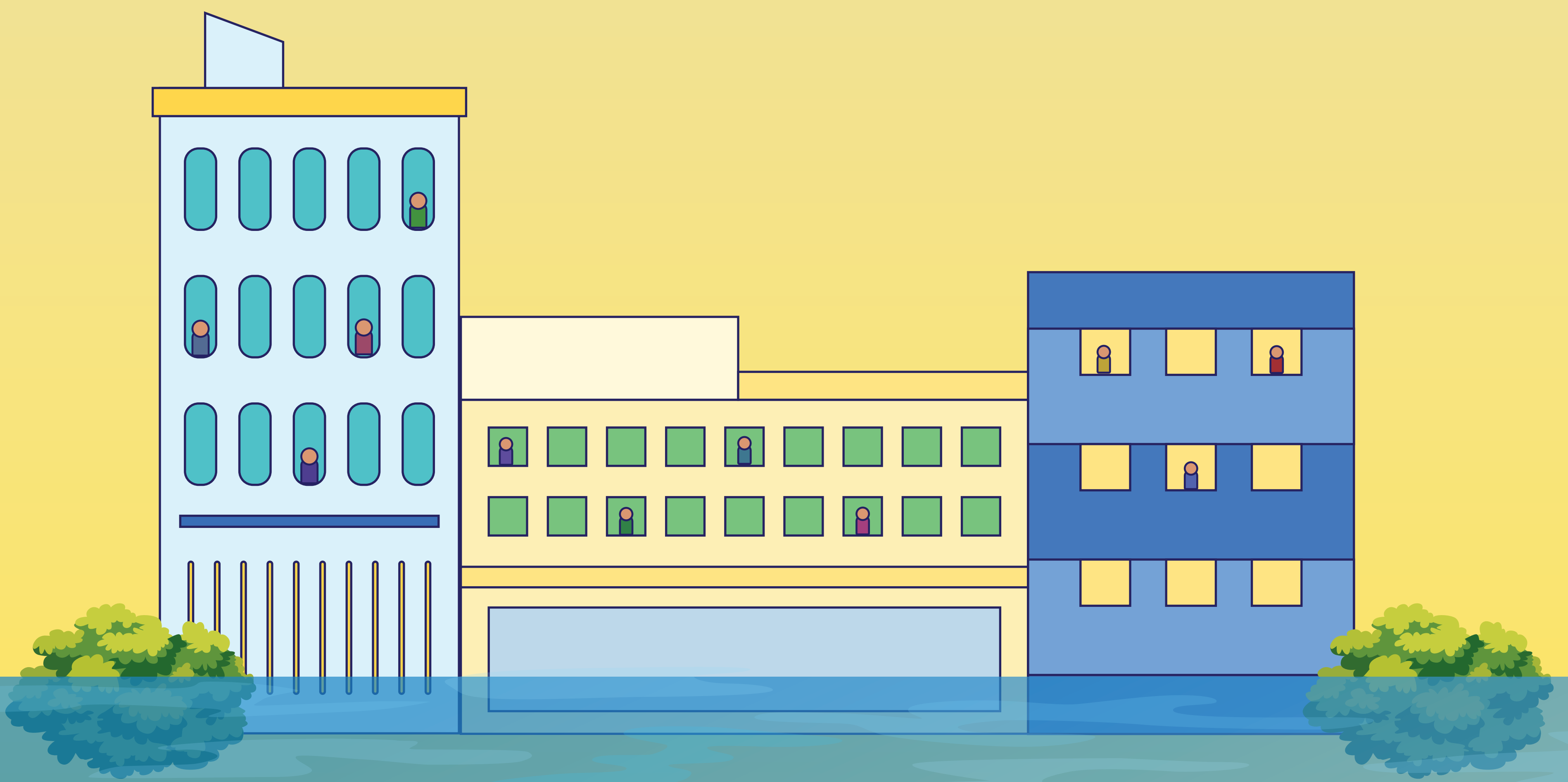
The amount of light reaching offshore plants dependent on photosynthesis could be reduced



Mangrove ecosystems require stable sea levels for long-term survival

Source: WWF



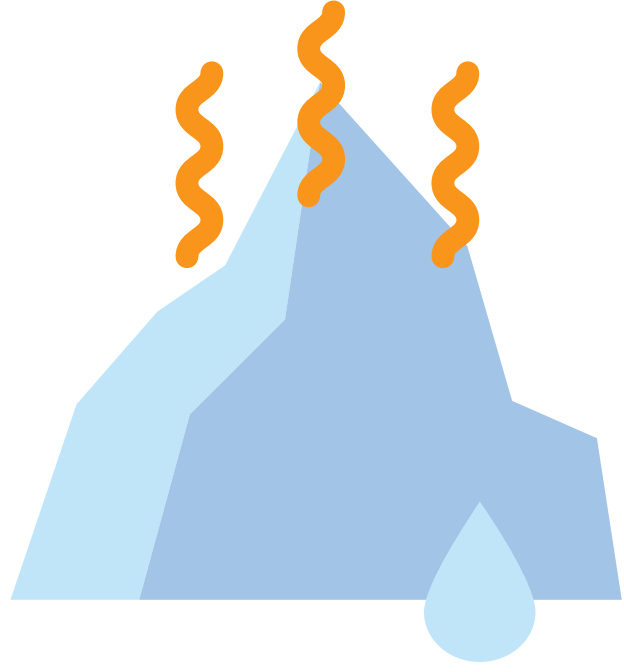


## **CHAPTER 2:** We're in hot water

In the second chapter of this series, we examine the problem of rising sea levels from a Singaporean lens. Find out what our nation has done in the past to prevent flooding, whether your homes are susceptible to rising sea levels and what the nation intends to do moving forward.

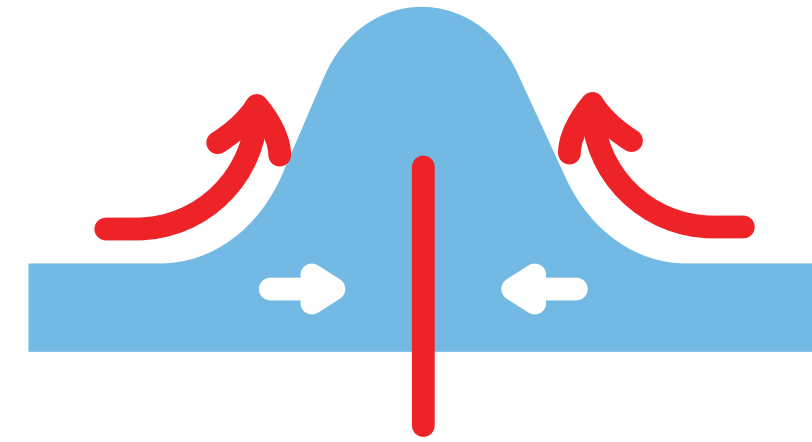
# HOW IS SINGAPORE AFFECTED BY RISING SEA LEVELS?

1. When the polar caps in Greenland and Antarctica melt, the ice mass is reduced,



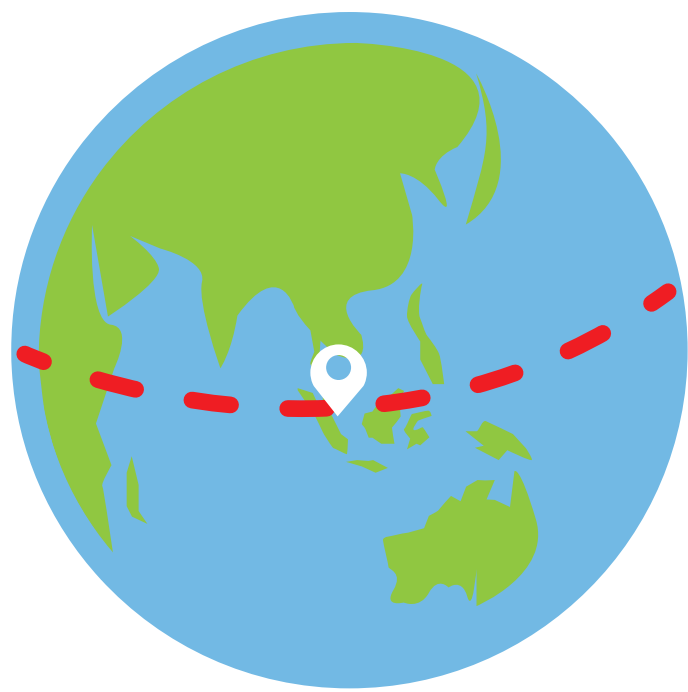
and the gravitational pull from the ice sheets decreases.

2. As a result, more melted ice and seawater gravitate towards the equator,



raising sea levels even further.

3. Singapore, being near the equator,



is more vulnerable to climate change.

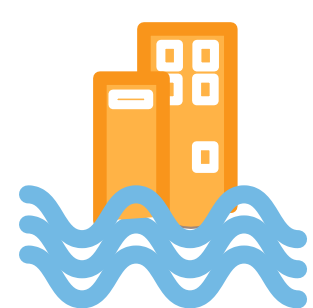
4. There will be shifts in rainfall patterns



leading to more severe flooding and droughts.

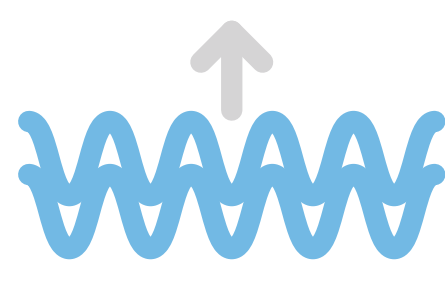
Source: The Straits Times & CNA

## In The Event of:



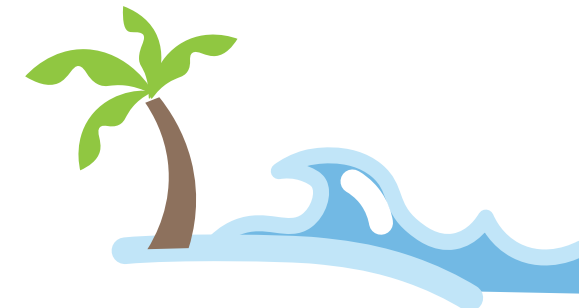
Rise In Mean Sea Level

+

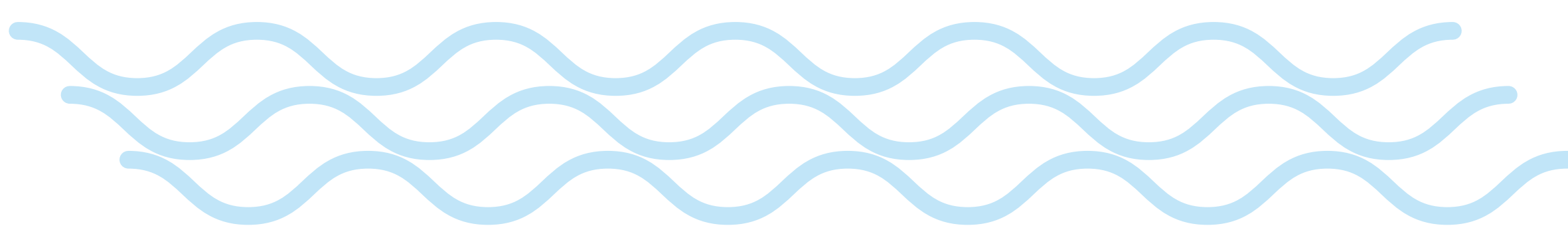


High Tides

+



High Surges



Sea levels could rise by up to **4m** above the current mean, and overwhelm Singapore's low-lying coastal areas.

Source: Centre for Climate Research Singapore



# WHAT WILL HAPPEN TO US WHEN SEA LEVELS RISE?

## Is Your Home At Risk Of Flooding?



\*For illustration purposes only

- Less than 5m above sea level
- About 15m above sea level
- More than 20m above sea level

One-third of Singapore, including the Central Business District, is less than 5m above the mean sea level.

## List Of Low-Lying Areas In Singapore (as at May 2019):

### West

- Hong Kah area
- Second Chin Bee Road

### North

- Admiralty Road West near Sembawang shipyard
- Mimosa Walk

### East

- Bedok South Road
- Chin Cheng Avenue
- Lorong Buangkok
- Meyer Road
- MINDEF's Changi Camp
- New Upper Changi Road
- Rose Lane
- Tanjong Katong Road South
- Upp East Coast Road



### Central

- |                       |                      |                        |                     |
|-----------------------|----------------------|------------------------|---------------------|
| - Alexandra Road      | - Indus Road         | - King George's Avenue | - South Bridge Road |
| - Beach Road          | - Jalan Besar area   | - Langsat Road area    | - Stevens Road      |
| - Bugis area          | - Jalan Benaan Kapal | - Lower Delta Road     | - Tanglin Road      |
| - Commonwealth Avenue | - Jalan Gembira      | - River Valley Road    | - Zion Rd           |
| - Farrer Park area    | - Jalan Mashor       | - Sennett Estate       |                     |

Source: Public Utilities Board

# WHAT DID SINGAPORE EXPERIENCE IN THE PAST?

Some events Singapore experienced as a result of climate change:

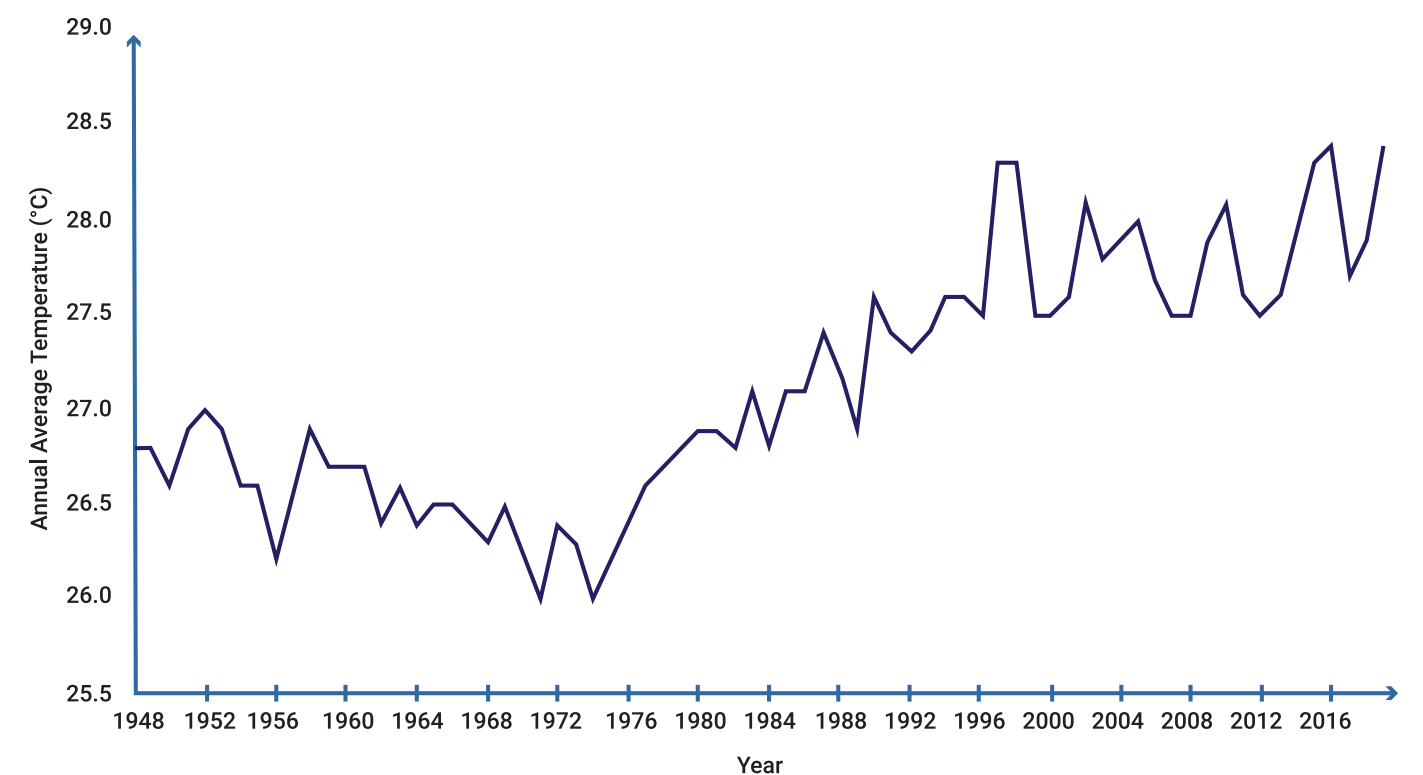
**1970s**



Singapore's continuous temperature records since 1948 show that the island has warmed notably in the mid-1970s when rapid urbanisation took place.

**THEN**

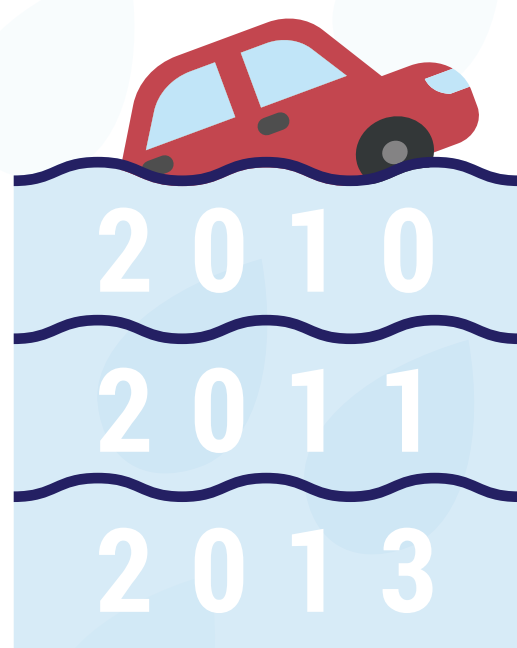
**1977 Onward**



Eight of the ten warmest years on record in Singapore occurred in the 21st century. The ten warmest years took place after 1997.

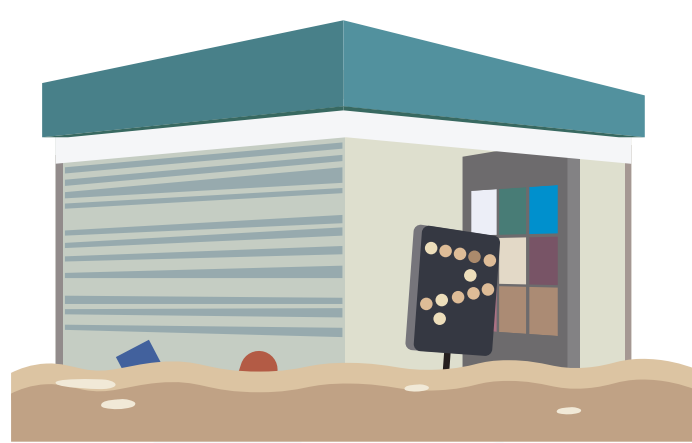
**2010s**

**Intense Rainfall**



**Major flash floods**

On 16 June 2010, morning rainstorms resulted in flash floods along Orchard Road. Rainwater flowed into the basements of several buildings, including Lucky Plaza, Liat Towers, Tong Building and Delfi Orchard.



Affected shops, such as fast food restaurants, food courts and cafes, reported heavy losses in infrastructure and equipment.

Source: Meteorological Service Singapore, Eco-Business & The Straits Times

**2014**

**Two record dry spells from January to March 2014**

**Dry spells lasted 27 days**

**Jan 13**

A dry spell is defined by Meteorological Service Singapore as a period of at least 15 consecutive days with daily total rainfall of less than 1mm, averaged over rainfall stations with long-term records across the island.

**Feb 8**

**Feb 17**

Barely any rain fell in the period of January 13 to February 8, and February 17 to March 15, beating the previous 2008 record of 18 days.

**Mar 15**



**2019**

September 2019 was the **warmest, driest month** in Singapore since September 1997

September 1997



Mean daily maximum temperature

**32.2°C**

September 2019

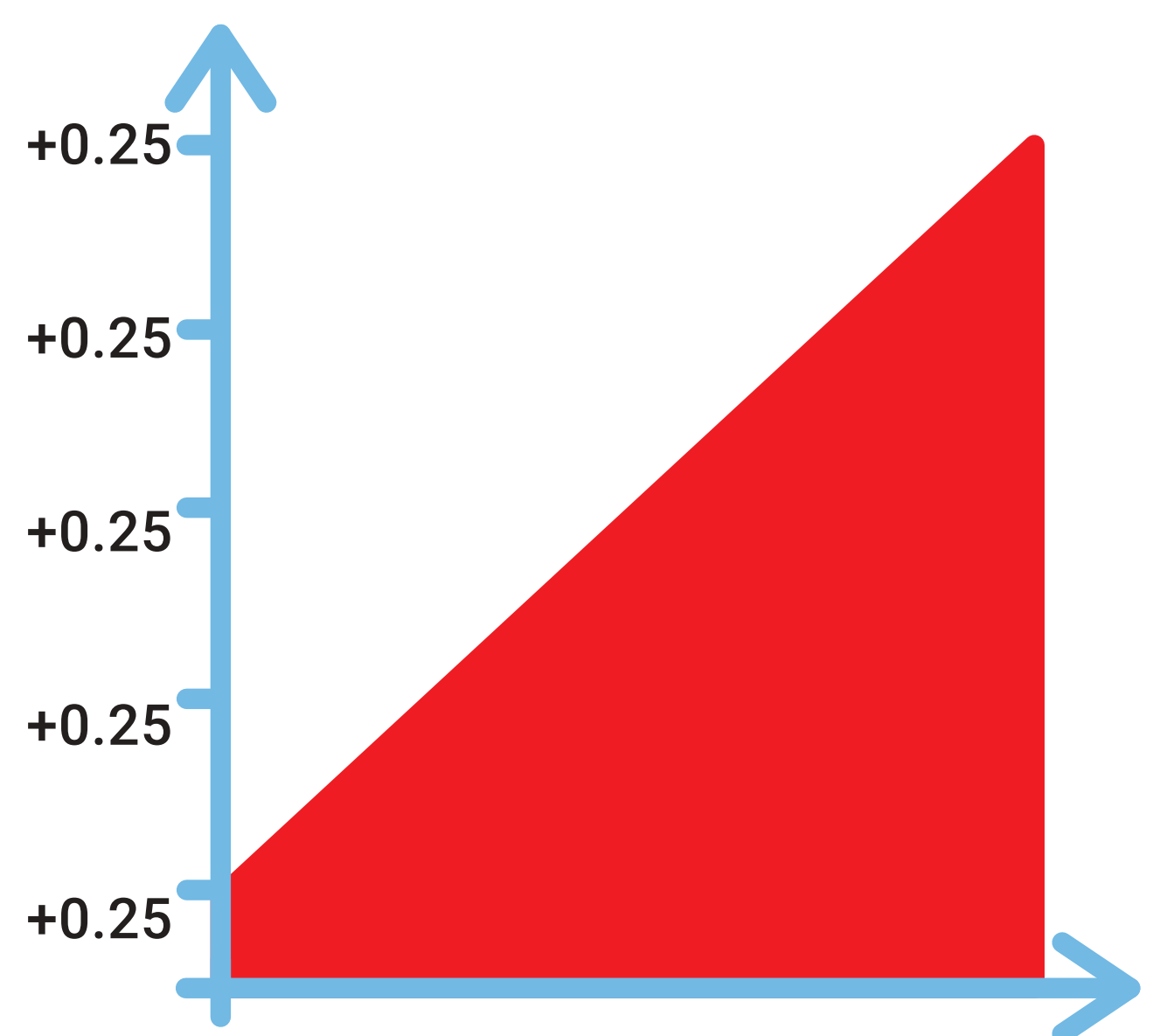


Mean daily maximum temperature

**33°C**

**NOW**

**Presently**

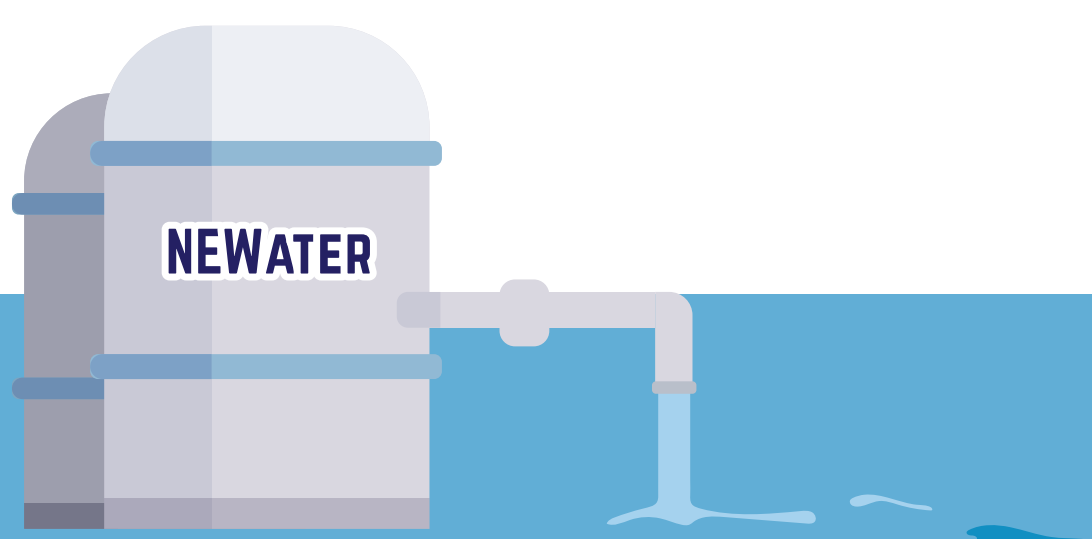


Mean surface air temperature in Singapore has risen by an average of 0.25°C per decade between 1948 and today, which is about double the global trend of 0.12°C per decade from 1958 to 2012.

**2014**

February 2014 was the **driest month since 1869** with just 0.2mm of rainfall

Desalination and NEWater plants operated at near full capacity to meet water demand.



National water agency PUB pumped 20 to 30 million gallons of NEWater into reservoirs each day from late January to February 2014 to maintain their water levels.

**2016**

**2016 & 2019**

Daily mean temperature

**28.4°C**

Two of Singapore's **hottest years** on record

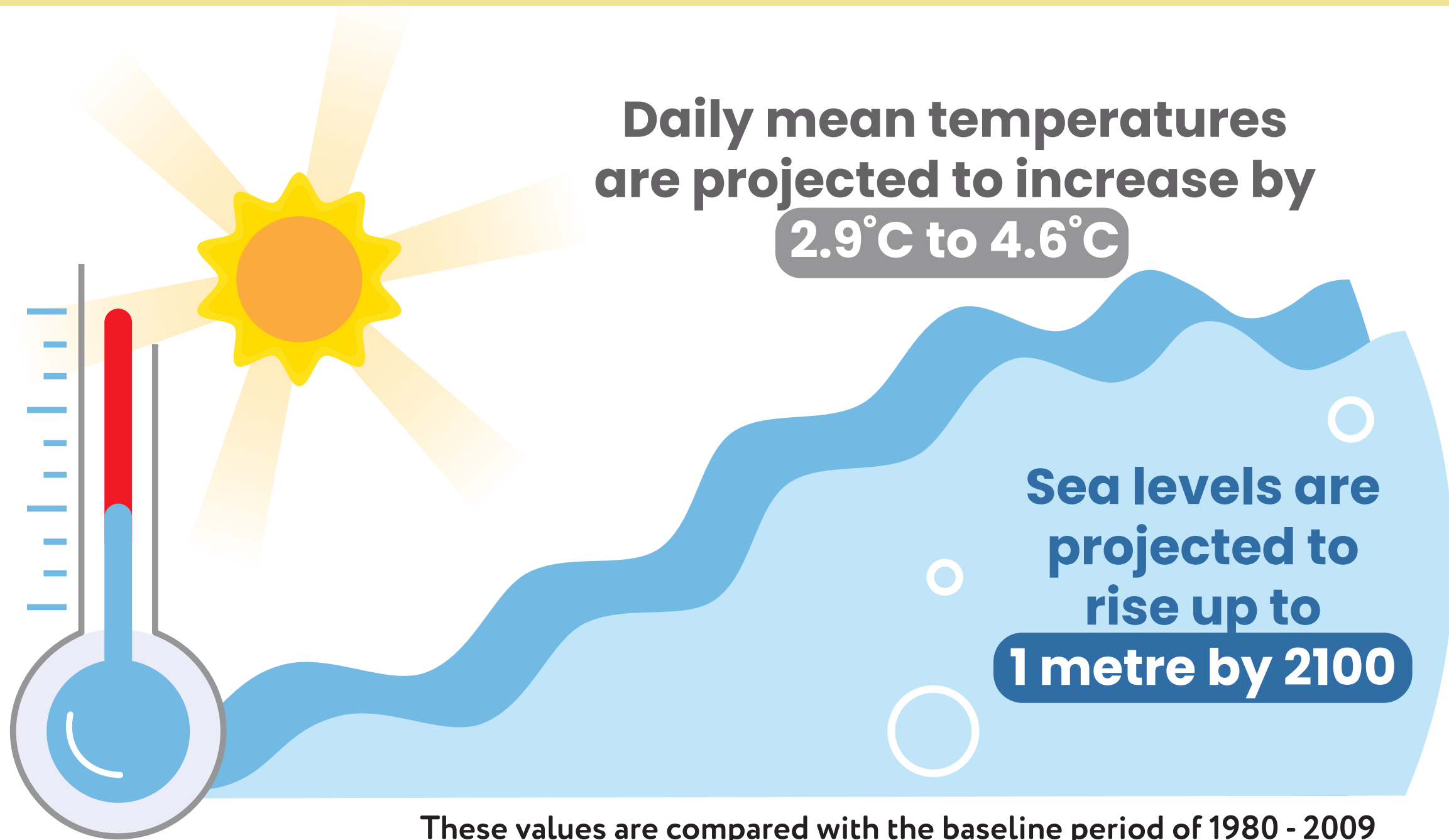
A mean temperature of 27.94°C from 2010 to 2019 also made it the hottest decade ever.

Source: Meteorological Service Singapore, Eco-Business & The Straits Times

# WHAT MIGHT HAPPEN TO SINGAPORE?

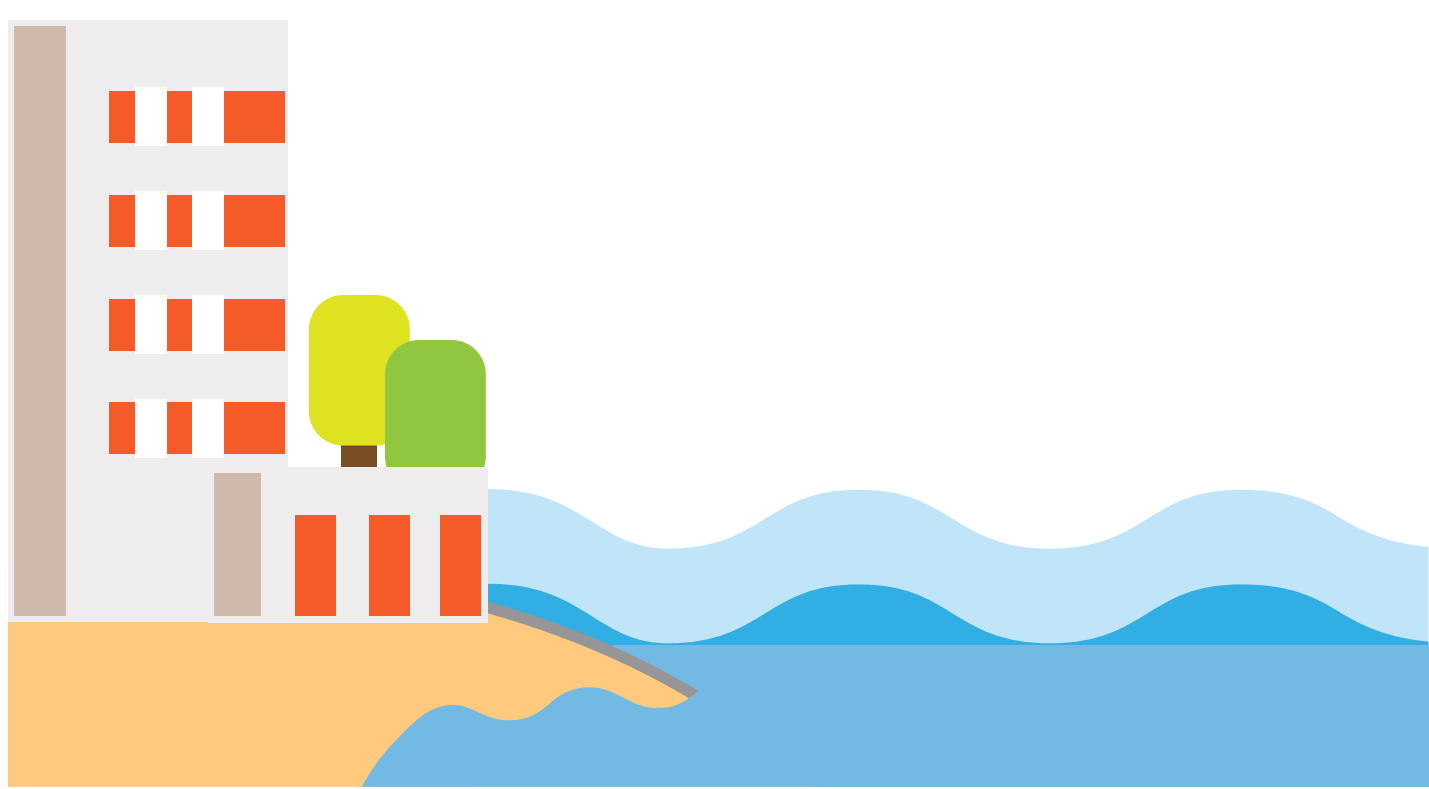
If we do not start doing something now, this is what Singapore could look like in the future.

## In The Last Few Decades Of This Century (2070 to 2099):



## What Are The Risks?

### 1. Our Coasts



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

The Centre for Climate Research Singapore projected that the country could experience a mean sea level rise of up to 1 metre by 2100.

"What about a high emission (scenario)? We're looking at a full 1.5 metres for Singapore ... that's our best estimate."

Benjamin Horton, climate scientist

To protect residents and infrastructure, Singapore must plan for a greater sea level rise in the event that climate change worsens.

If sea levels rise more than **2.5 metres**

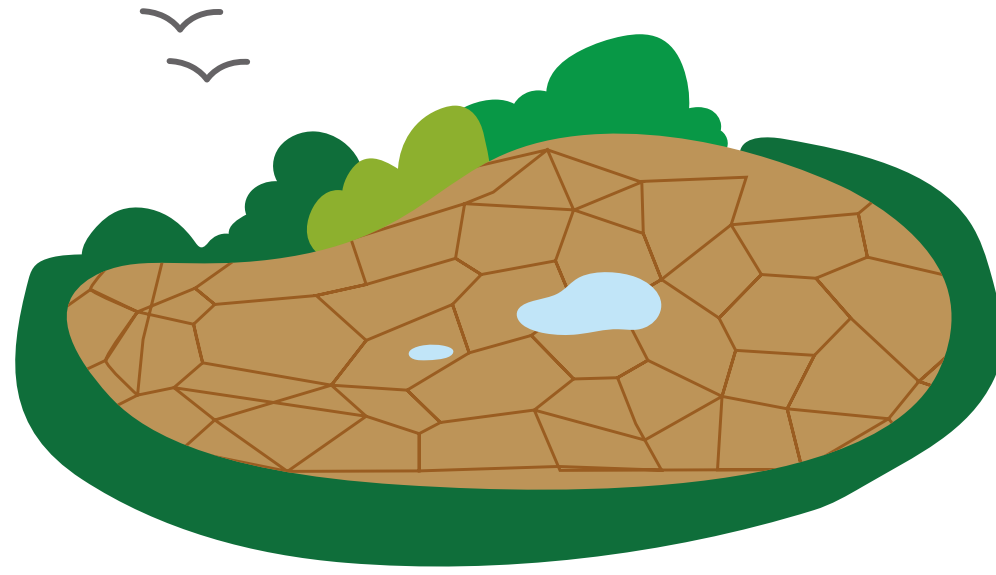
Inland areas like **Bishan & Toa Payoh** could be at risk of flooding

Source: National Climate Change Secretariat & CNA



## 2. Water Supply & Floods

Periods of drought can affect the reliability of Singapore's water supply.



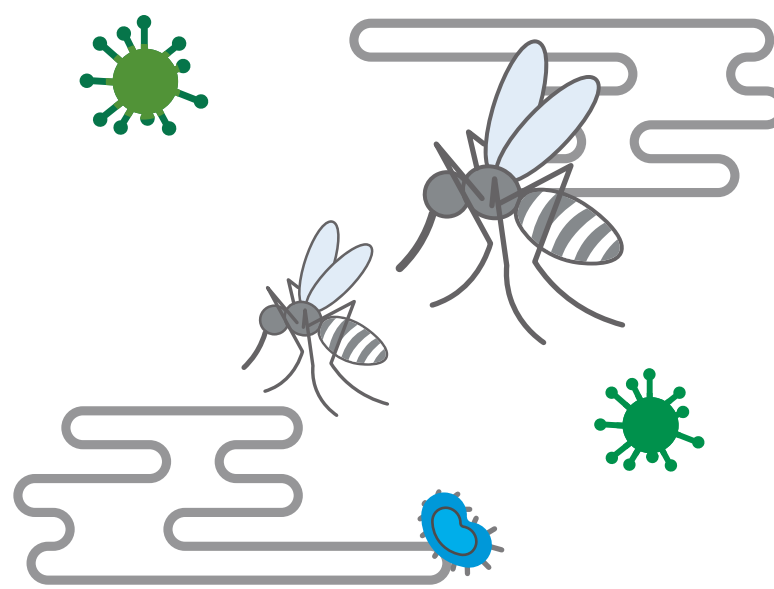
Sudden intense rainfall could lead to flash floods.



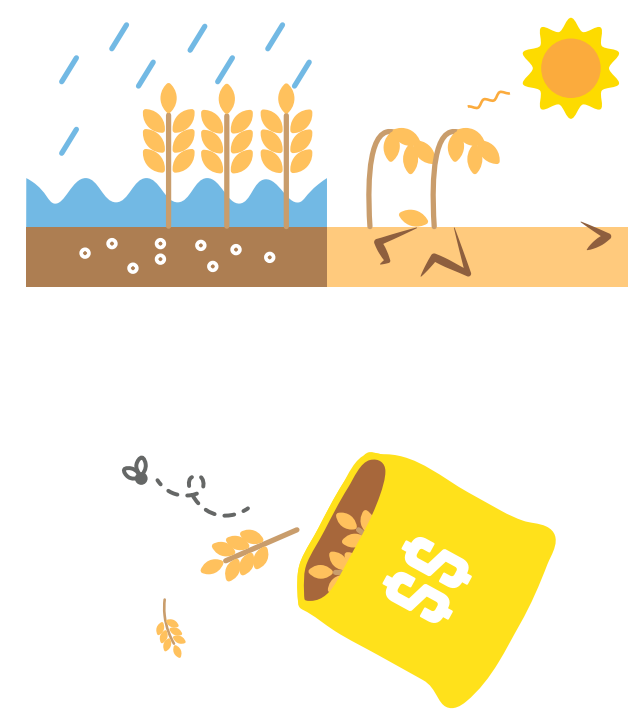
## 3. Public Health & Food Supply



Higher temperatures may increase the chance of people experiencing heat-induced illnesses, including heat rashes, heat cramps, heat exhaustion, and heat stroke.



Vector and pest populations could increase due to higher temperatures and rainfall, increasing the incidence of diseases such as dengue.



Should food production be affected by extreme weather, our imported food supplies could face disruption and price spikes.

## 4. Essential Services

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



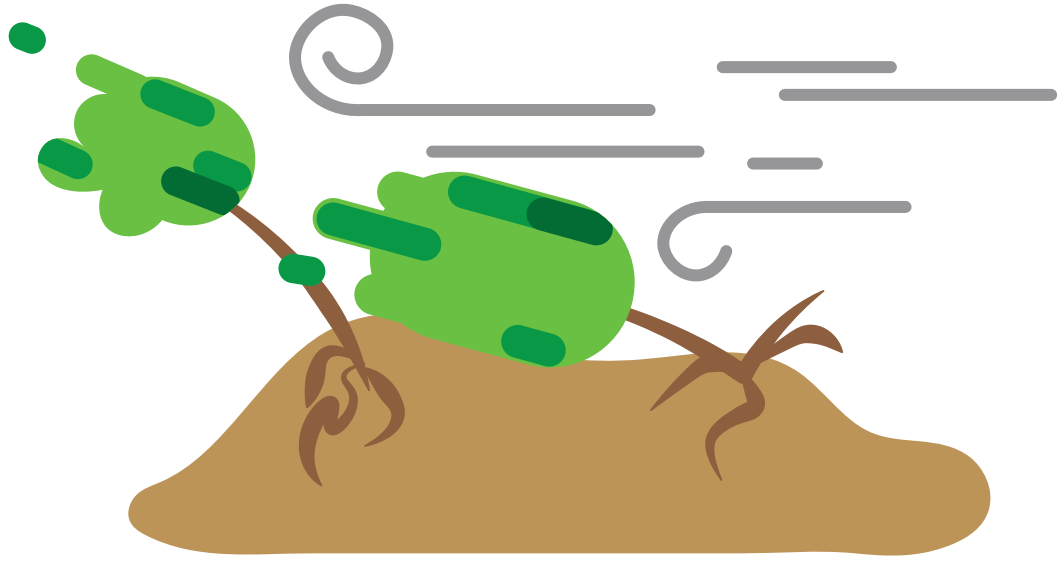
Singapore's underground MRT stations may be susceptible to flooding during intense rainfall, affecting over 2.7 million passenger trips a day.

Changi Airport also faces flood risks from more intense rainfall and rising sea levels. This is why Changi Airport T5 will be designed to be 5.5m above the mean sea level.

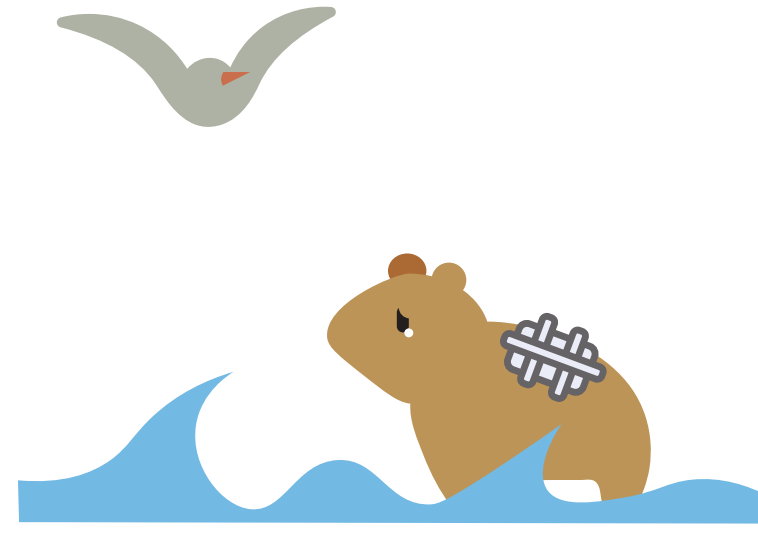
Singapore is home to one of the world's busiest hub ports. The new Tuas Port will be built to 5m above the mean sea level to protect it from rising sea levels.

Source: National Climate Change Secretariat

## 5. Biodiversity And Greenery



Trees could be damaged or uprooted due to strong winds.

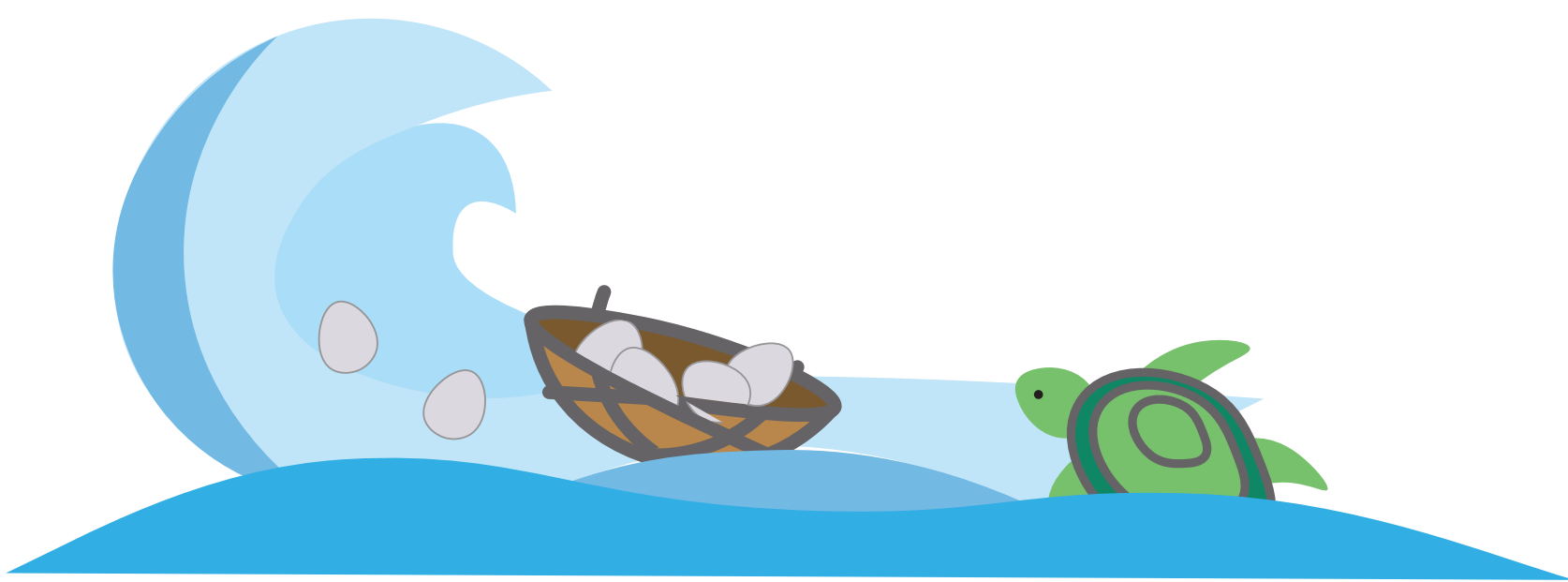
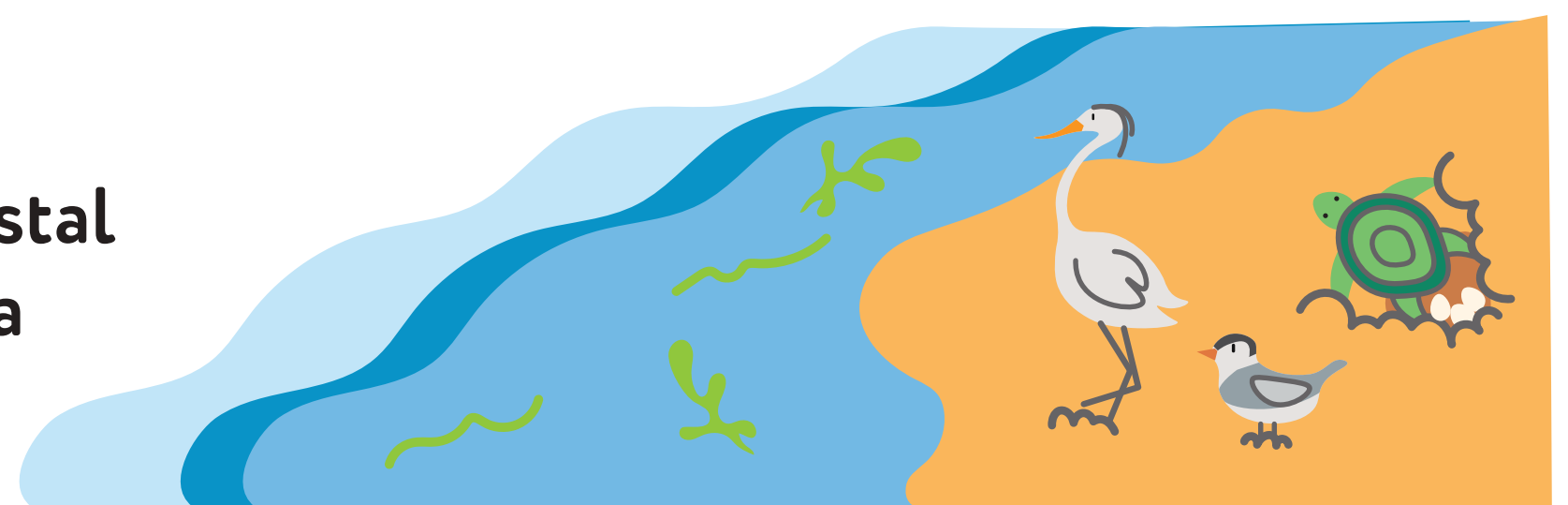


Biodiversity may be affected by changes in temperature and rainfall.

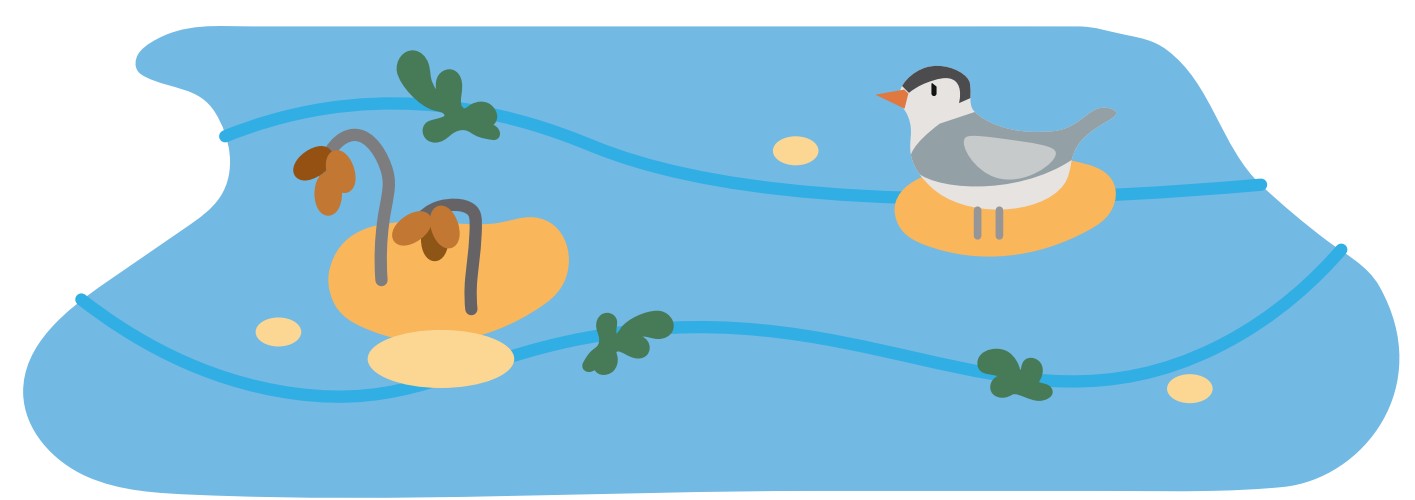


There may be more bush fires due to temperature increase and low rainfall.

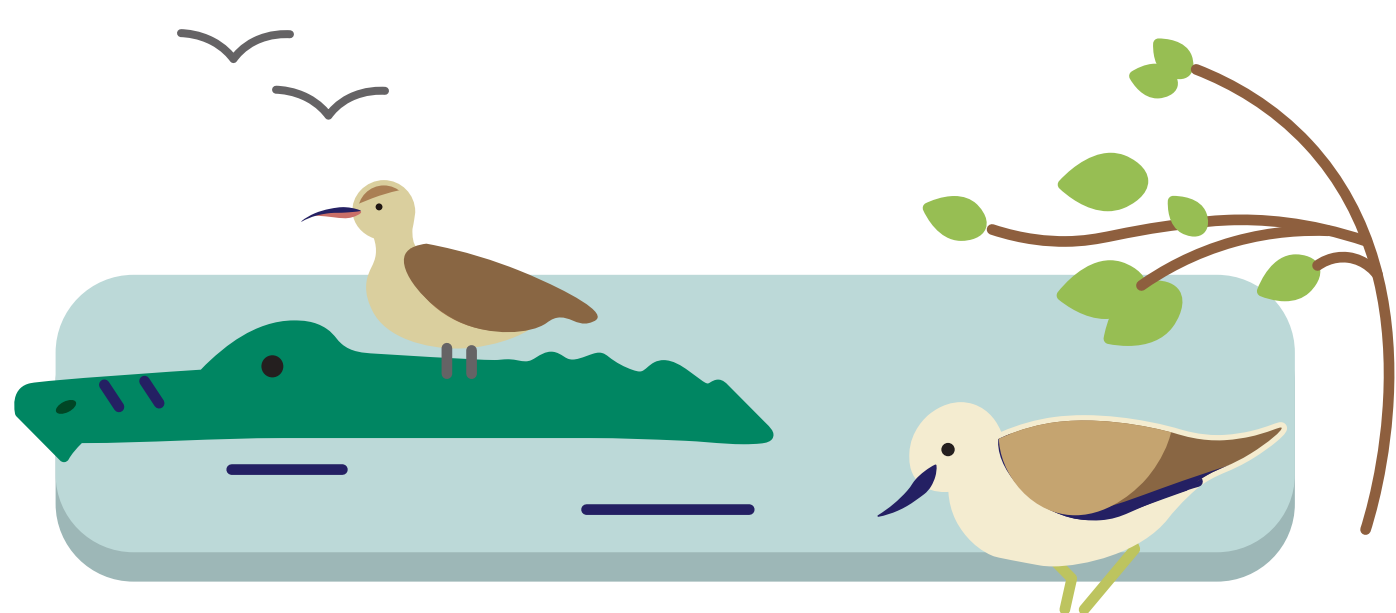
Many forms of wildlife make coastal areas their home. As the rising ocean erodes the shoreline and floods the areas in which coastal animals live, animals like shorebirds and sea turtles could potentially lose their homes.



Their delicate nests may be swept away by flooding, an especially big problem for endangered animals like sea turtles that can't afford to lose any offspring.



Their habitats may be so damaged by flooding or changes in the surrounding plant life that they can no longer survive in the environment.



Apart from coastal areas, mangroves are also home to a vibrant and diverse range of wildlife. Furthermore, they act as an important pit stop for migratory birds such as the whimbrel, common greenshank and common redshank.



However, mangroves may also be eroded by rising sea levels. Without mangrove forests, the wildlife will no longer have a home to live in or places to rest in, and this would ultimately lead to their extinction in the long run.

Source: National Climate Change Secretariat & The Straits Times



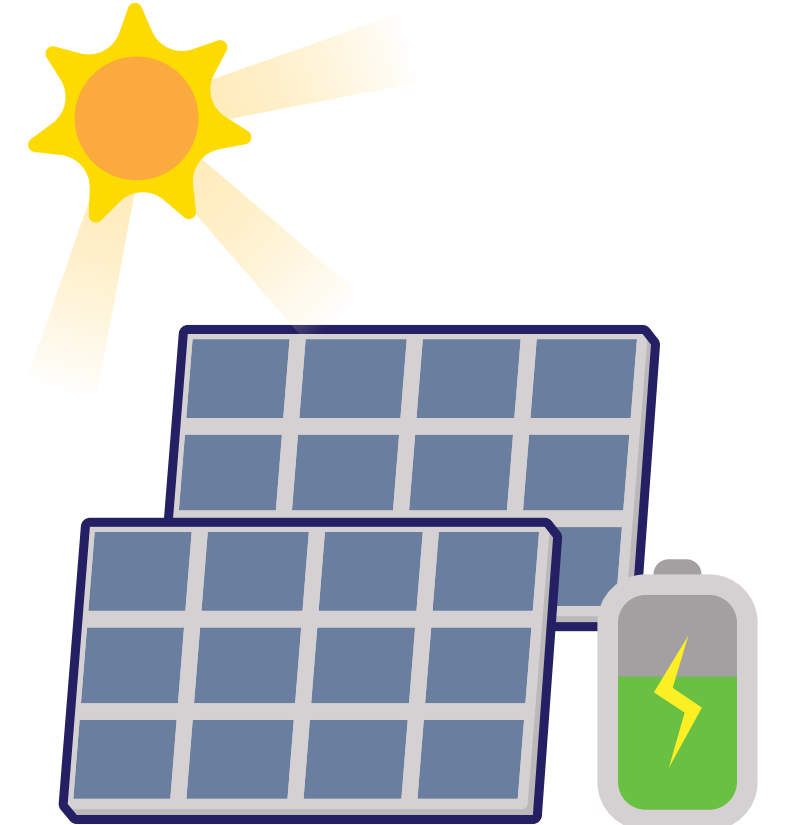
# HOW ARE WE FIGHTING SEA LEVEL RISE?

## What Has Singapore Done?

We implemented a carbon tax in 2019, with the intention of increasing it over the next ten years.



We are using solar energy and have installed large-scale solar panels that float in our reservoirs and off our shorelines in the sea.



## What Is Singapore Doing?

The Singapore Green Plan 2030 was announced in February 2021 and it details our targets & initiatives for national sustainability for the next 10 years.

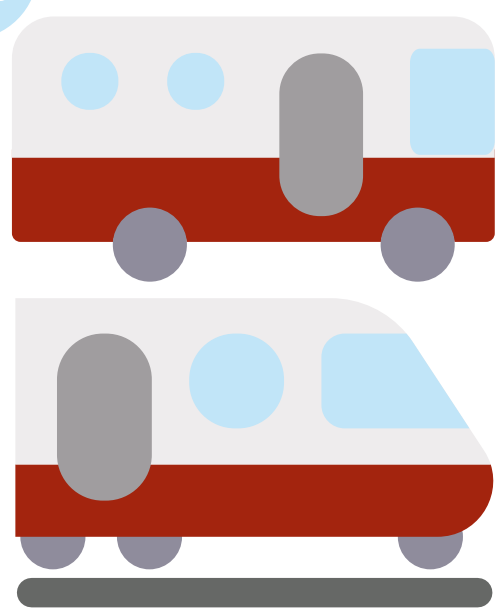
Some of our targets include:

1.



Increasing the land area of nature parks by over 50% from the 2020 baseline and having every household within 10-minute walk from a park.

2.



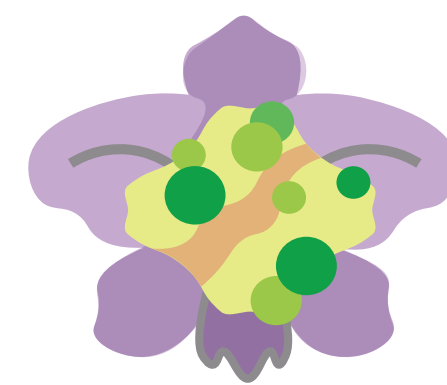
75% of commuters taking mass public transport by 2030.

3.



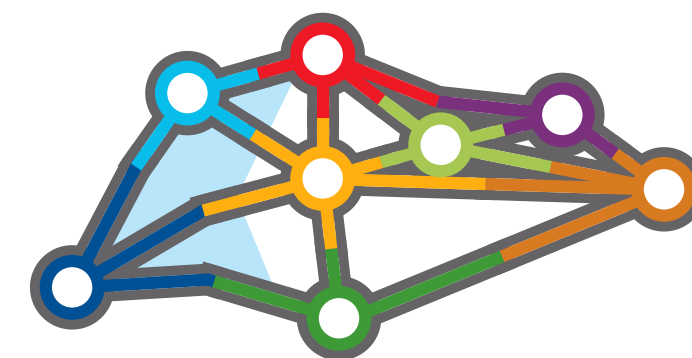
Making 80% of buildings in Singapore green by 2030.

1.



Incorporating natural designs in 140ha of parks and gardens, and restoring and enhancing 30ha of forest, marine, and coastal habitats.

2.



Expanding our rail network over the next decade.

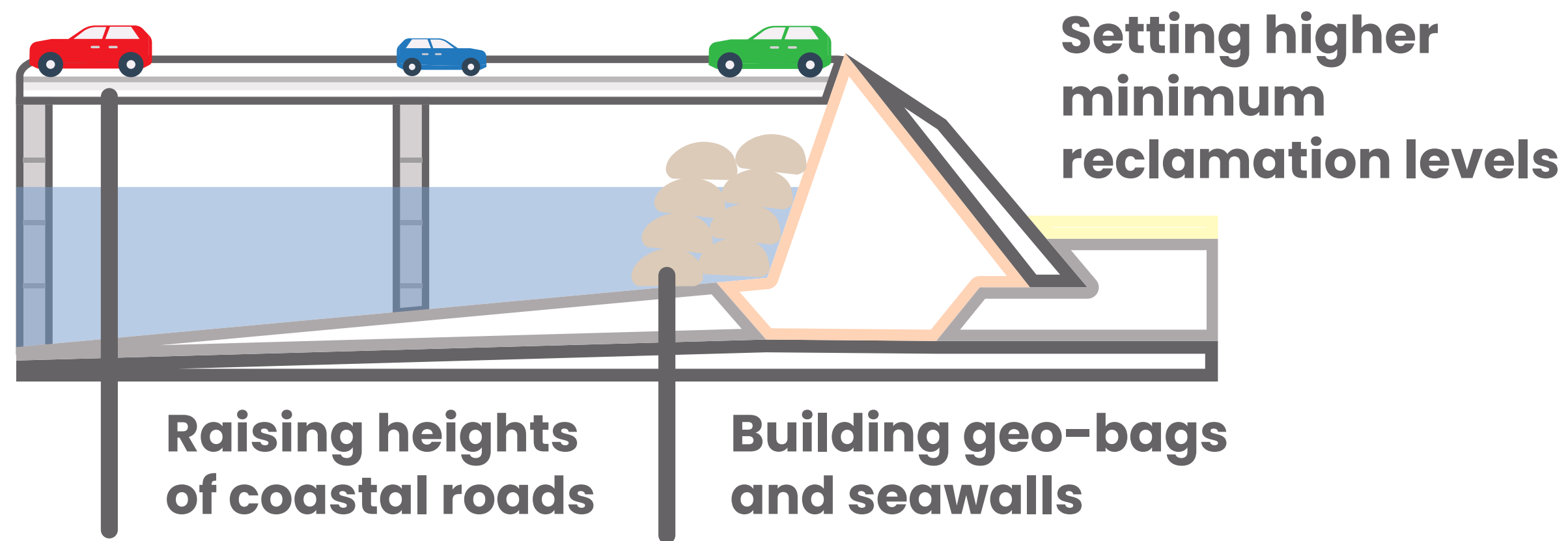
3.



Raising the sustainability standards of our buildings through the Singapore Green Building Masterplan.

Source: Ministry of Sustainability and the Environment & The Prime Minister's Office

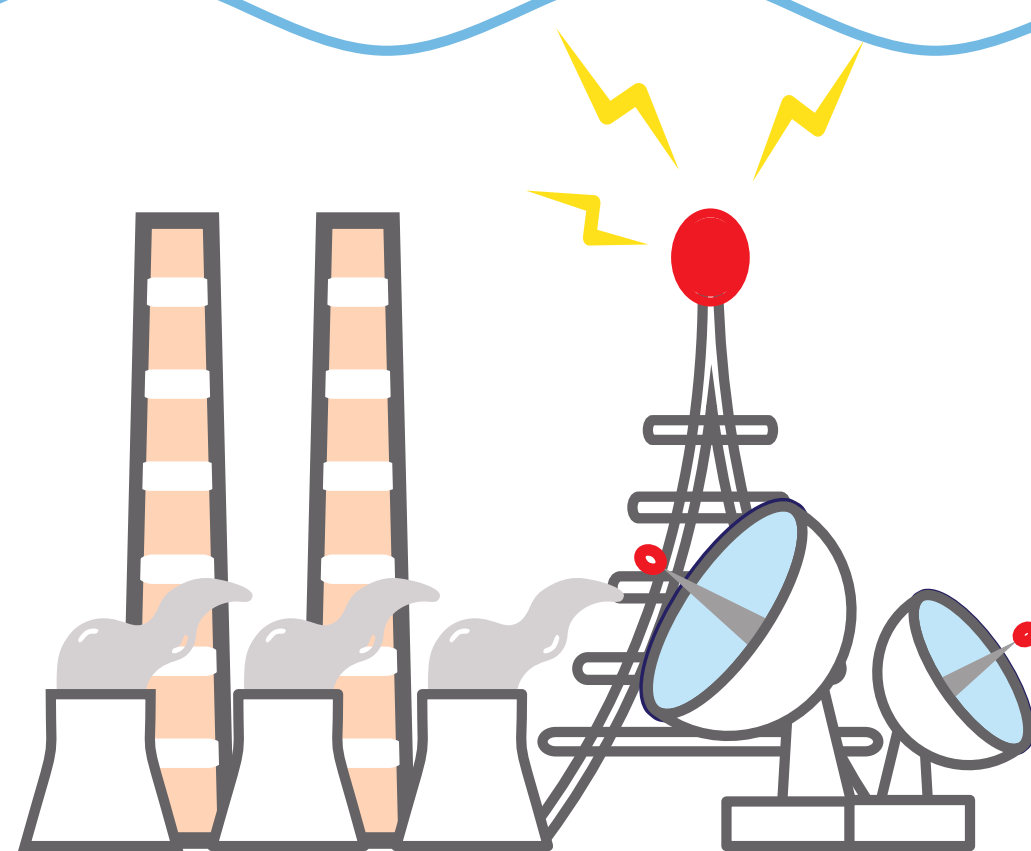
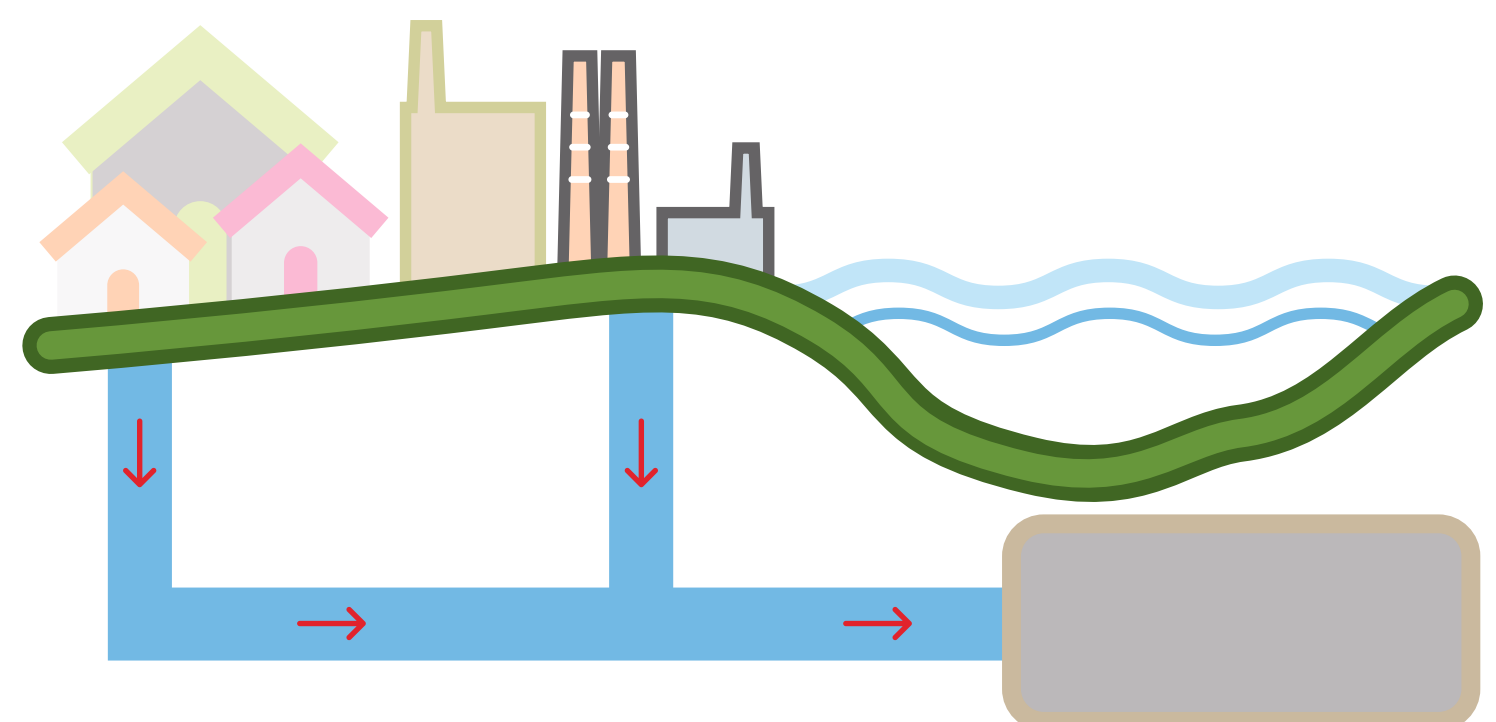
# HOW ARE WE PROTECTING THE VULNERABLE COMMUNITIES?



## Designing a stormwater management system



## Studying the feasibility of an innovative underground drainage and reservoir system



## Reviewing the resilience of power stations, transport, and telecommunication infrastructure against localised flooding and temperature changes

## Installing flood barriers at existing underground MRT stations in low-lying areas



Source: National Climate Change Secretariat & The Prime Minister's Office





## **CHAPTER 3:** Still sitting ducks

In the third chapter of this series, we examine the problem of rising sea levels through the eyes of other lifeforms on our planet. What animals have to adapt to a warmer planet? What happens when saltwater starts invading freshwater habitats? How are the animals at the North and South Poles affected?

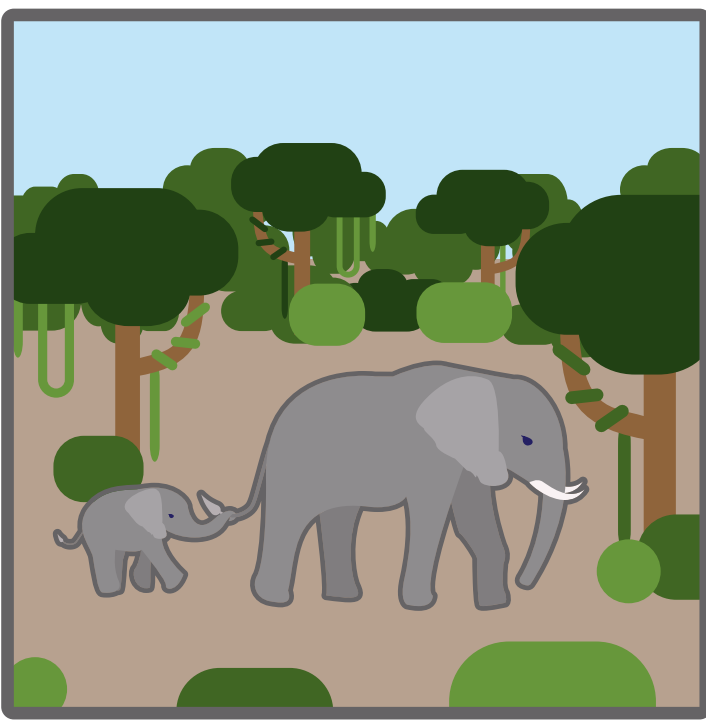


# HOW DO RISING SEA LEVELS AFFECT WILDLIFE?

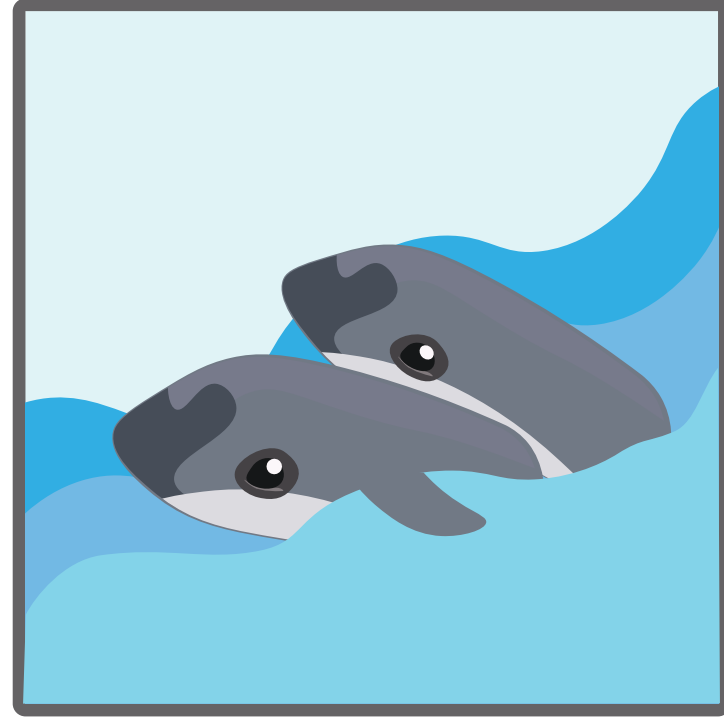
**Endemic Animals Are Animals That Are Found Only In A Specific Area. They Will Be Hit Hardest In a Warming World.**

**Many of the planet's most cherished creatures will wind up on the path to extinction unless humanity stops loading the atmosphere with carbon dioxide and methane!**

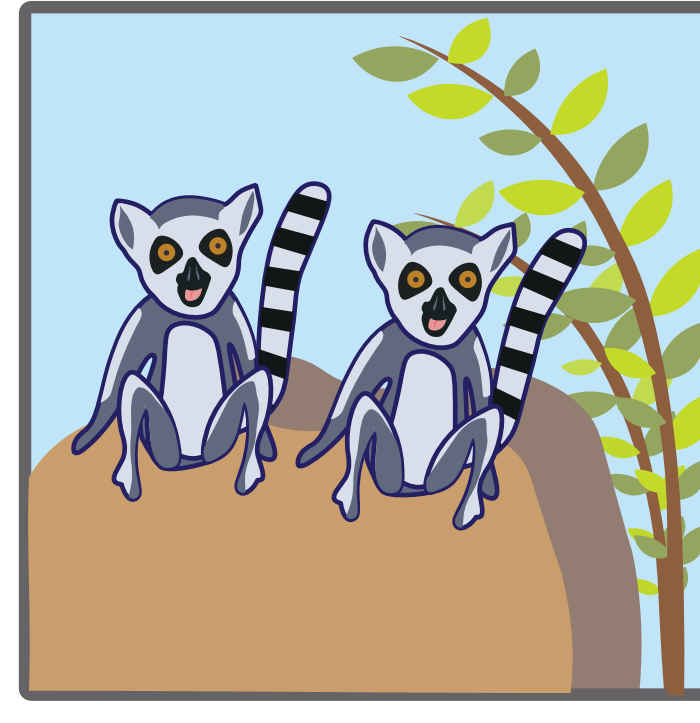
Below are some examples of animals that are at risk of extinction.



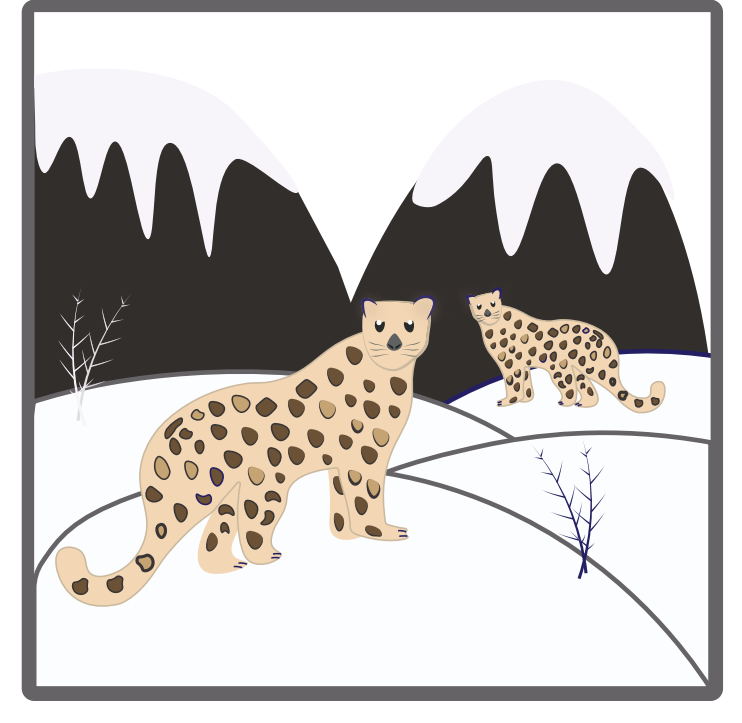
**Forest elephants in Central Africa**



**Vaquitas in the Gulf of California**

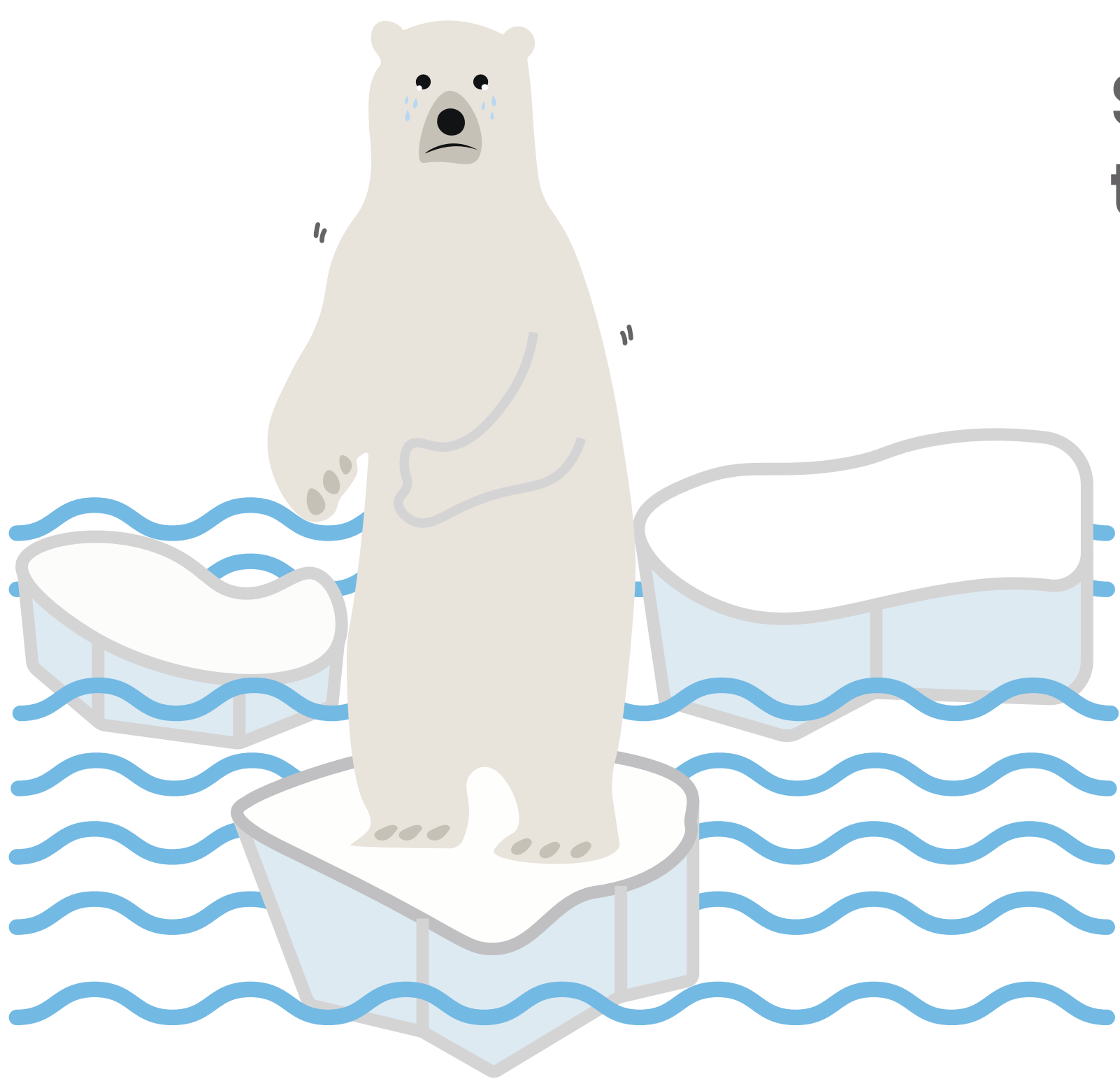


**Lemurs in Madagascar**



**Snow leopards in the Himalayas**

Source: CNA



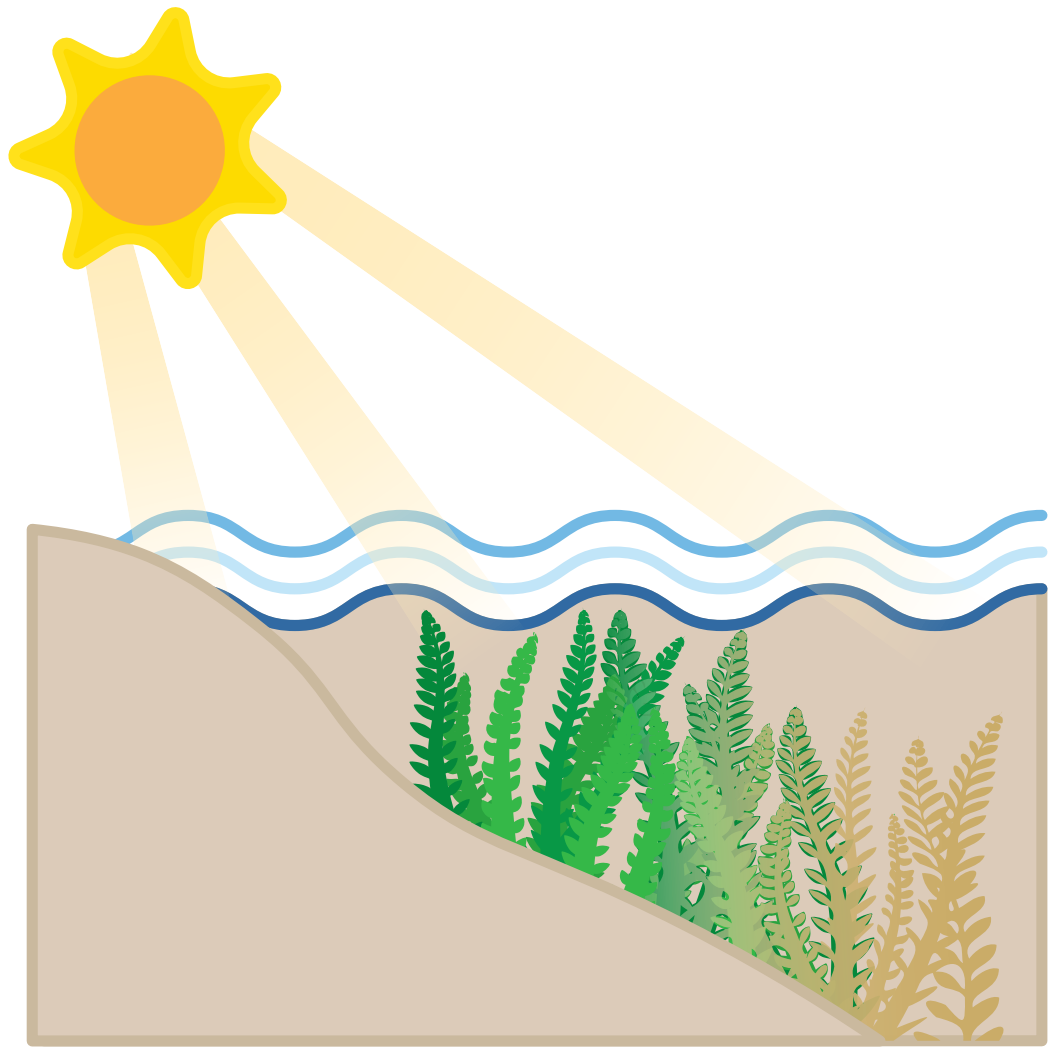
**Sea ice loss is now posing serious threats to the Arctic's indigenous species – its seals, fish, wolves, foxes and polar bears.**

**“The Arctic food chain relies on a stable sea ice platform that is now disappearing, putting the region's wildlife at risk”, said marine ecologist Tom Brown of the Scottish Association for Marine Science in Oban, United Kingdom.**

Source: The Guardian



## Rising Sea Levels Will Have Serious Impacts On Marine Ecosystems.



The amount of light reaching underwater plants and algae dependent on photosynthesis could be reduced, while coastal habitats could become flooded.

Source: WWF

## A Small Rise In Sea Level Can Have Devastating Effects On Coastal Habitat Further Inland



1. Loss of habitats for fish, birds and plants



2. Wetland flooding



3. Destructive erosion



4. Salt contamination of aquifer and agricultural soil

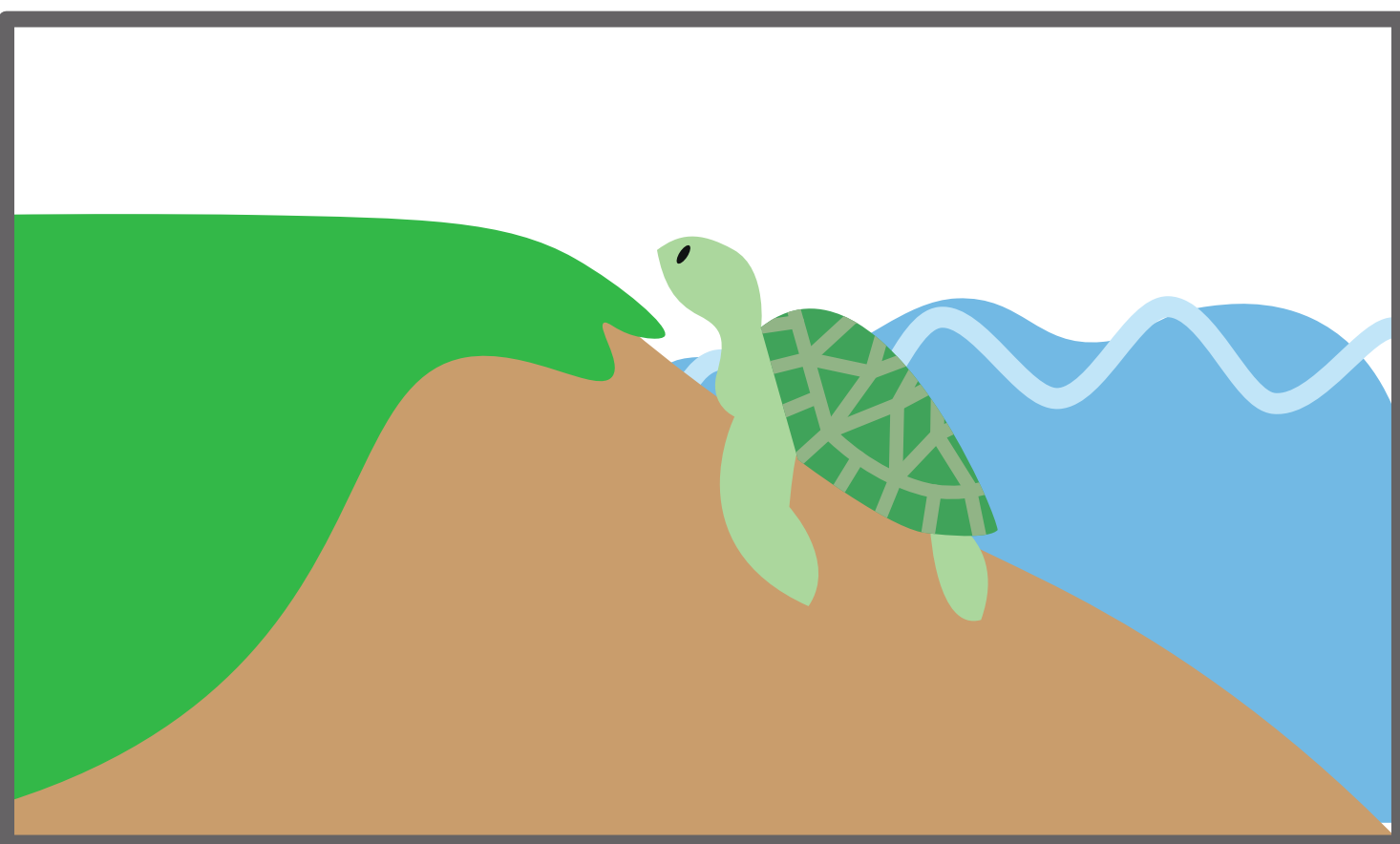
Source: Pixabay, Unsplash



# HOW IS COASTAL WILDLIFE AFFECTED?

## 1. Sea Turtles And Freshwater Turtles

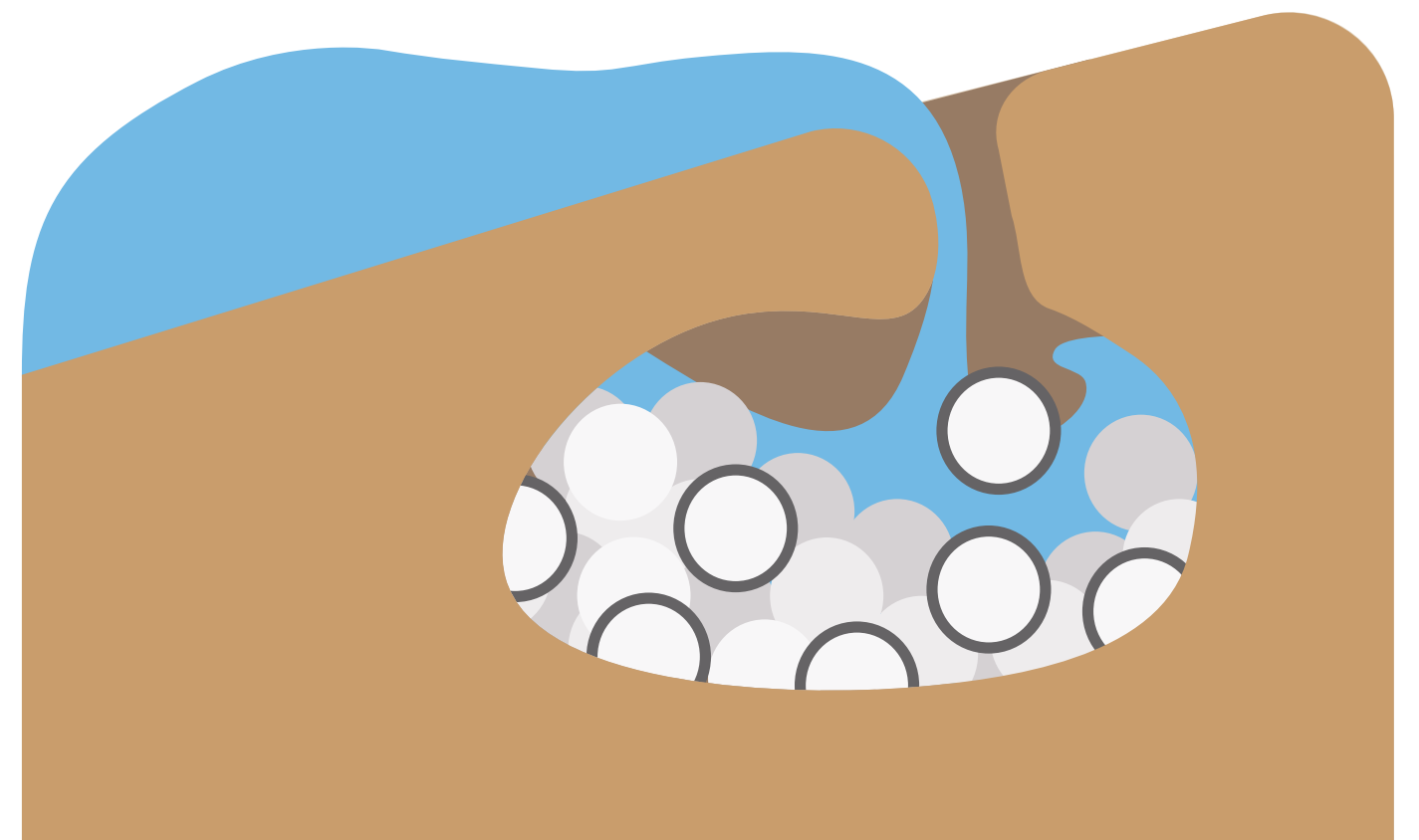
Endangered animals' habitats are being destroyed



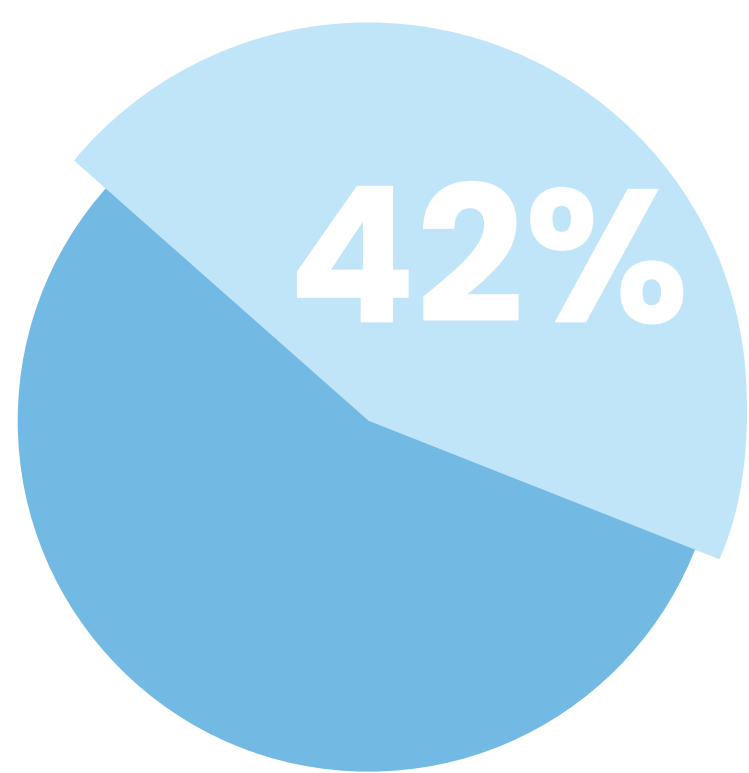
**Sea Level Rise will threaten wildlife populations**

Many forms of wildlife have their homes in coastal areas. As the rising sea level erodes the shoreline and floods the areas in which coastal animals live, animals like shorebirds and sea turtles will suffer.

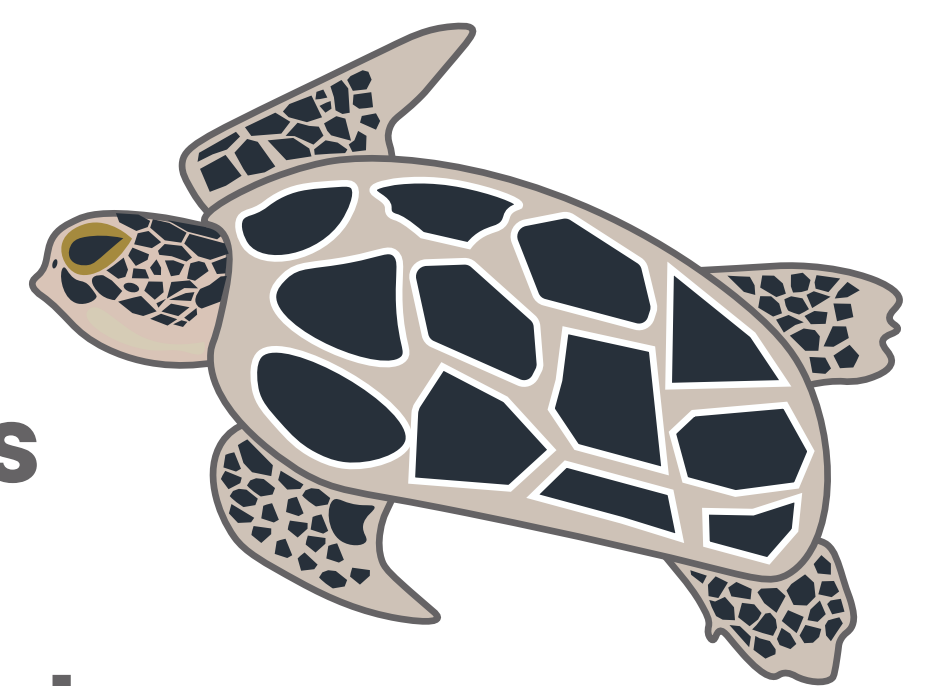
Their delicate nests may be swept away by floods, which poses an especially big problem for endangered animals like sea turtles that cannot afford to lose their offspring. Their habitats may be so badly affected by the floods or changes in the surrounding plant life that they can no longer survive in the environment.



Source: Business Insider



**At Florida's Archie Carr National Wildlife Refuge, 42% of Loggerhead Sea Turtles' nesting beaches are expected to disappear if sea levels rose by just 1.5 feet.**



Loggerhead Sea Turtle

Source: EcoWatch



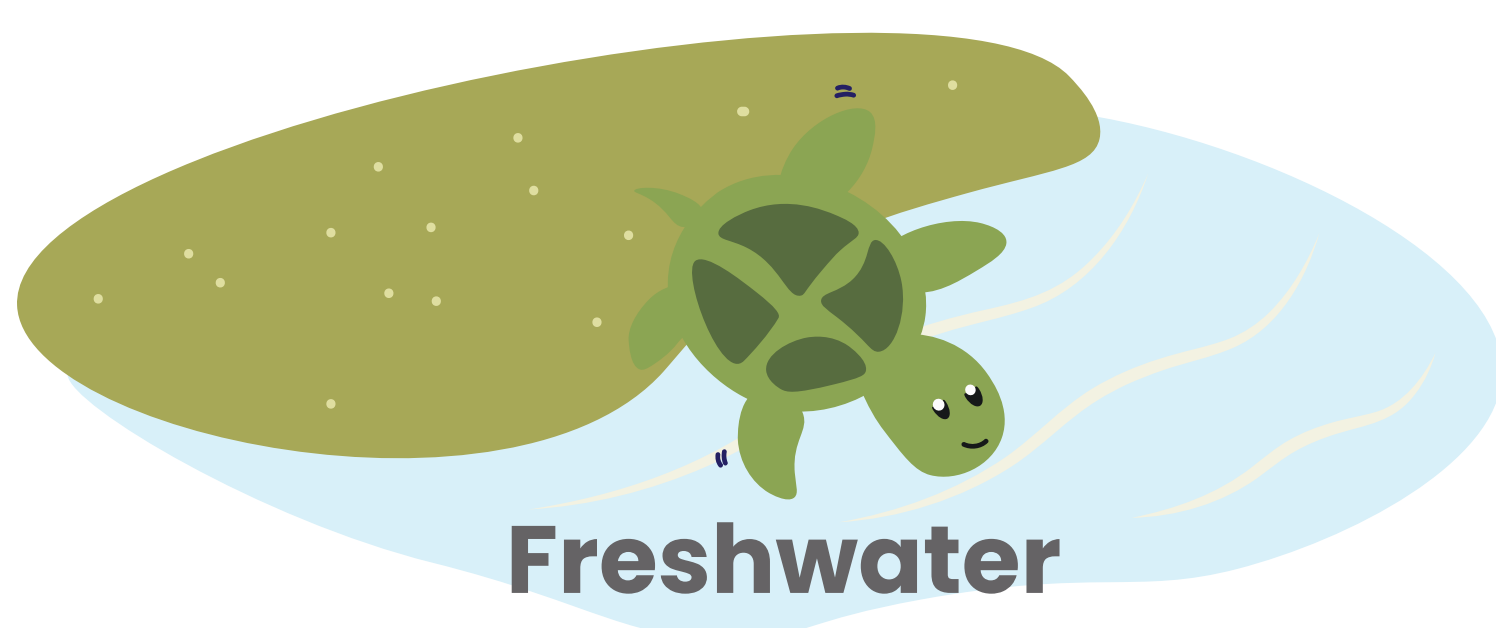
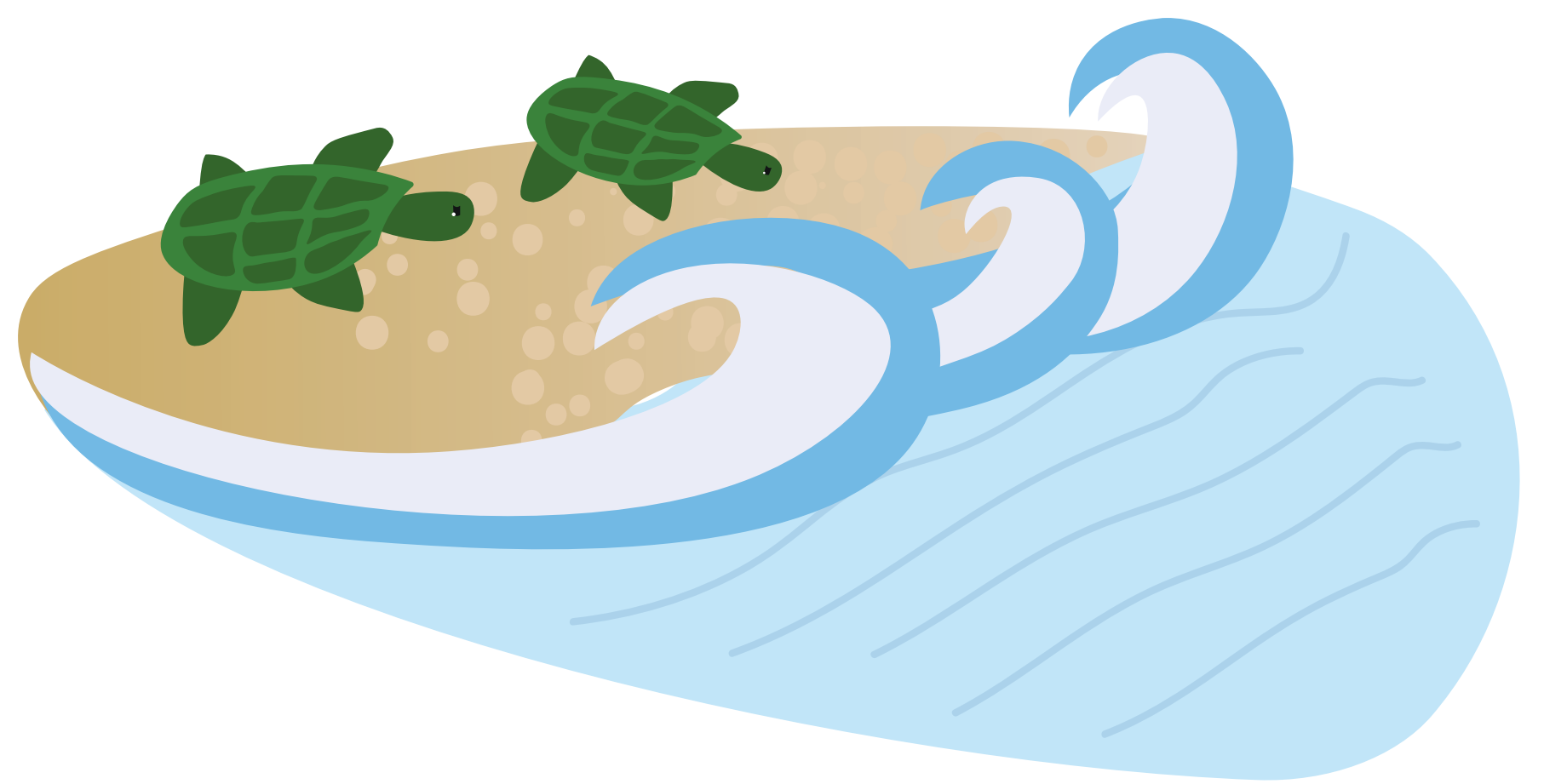
## The intrusion of seawater into freshwater habitats will affect more species.

If the sea level were to rise just a metre by 2100, the intrusion of seawater is likely to inundate many of the habitats that freshwater turtles need.



Many freshwater turtles live adjacent to brackish ponds where, during periods of high water, the brackish pools can overflow into the freshwater and increase the salinity.

Droughts and water diversions can also increase salinity levels of water bodies. While turtles can live in brackish areas, many do not cope well with high levels of salinity.



Coastal freshwater turtles that live in brackish water are in poorer condition than those in freshwater.

Salt is an irritant to the eyes and respiratory system of the turtles. Hence, freshwater turtles often get out of the water to prevent too much salt from getting into their body.

Source: Yale Climate Connection

## 2. Hawaiian Monk Seals

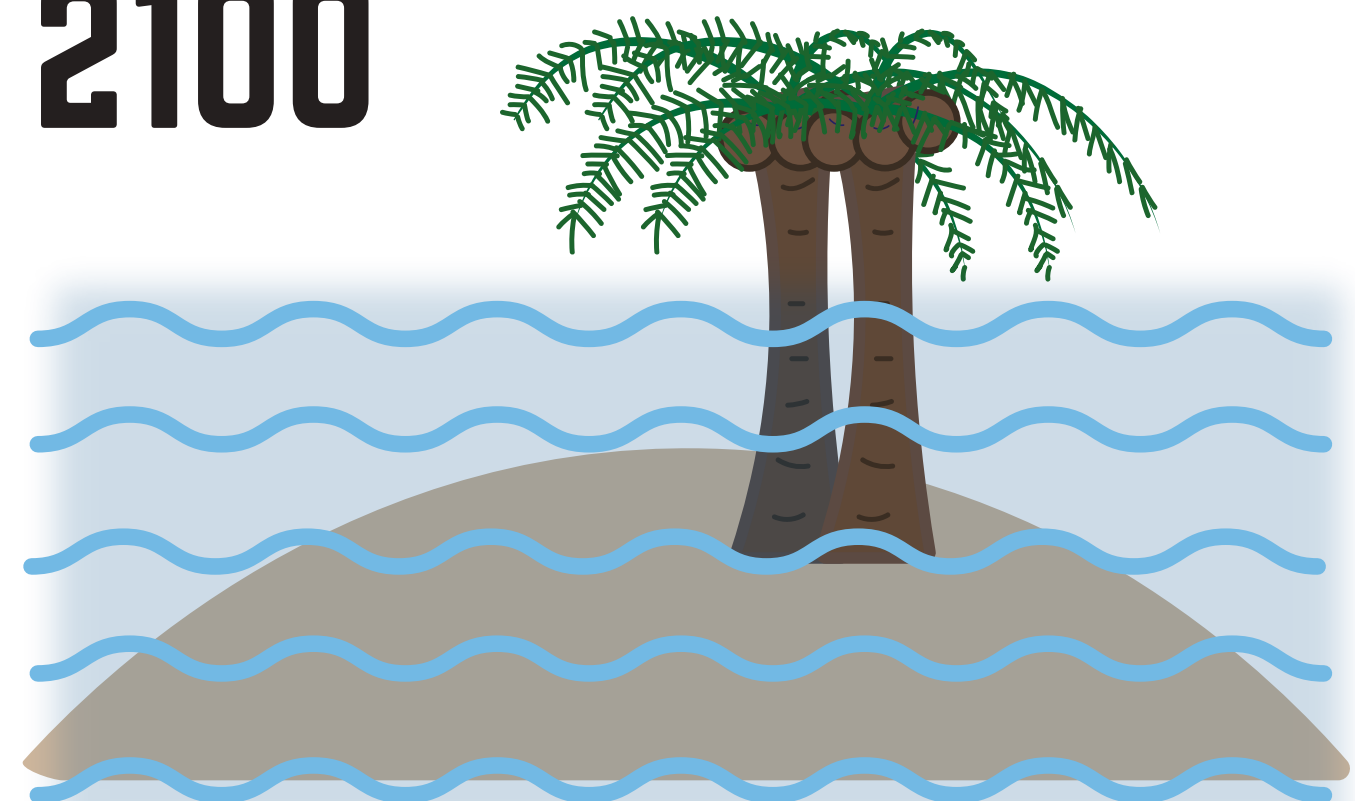


Most Hawaiian monk seals live in the northwestern Hawaiian islands. Females give birth, nest and nurse their pups on the islands' sandy beaches. In addition to pupping, the seals also use the islands to moult their fur and skin for a few weeks annually.

The Hawaiian monk seal is **endangered and very rare, with only around 1,400 of them in the world.**

A one-metre sea level rise by 2100 could submerge huge swaths of these low-lying Hawaiian islands under the ocean.

YEAR  
**2100**



Hawaiian monk seals may be able to find higher elevation islands for their pups to moult their fur and skin. However, with habitat loss, these animals will likely be forced into closer quarters, as there would be less space for them to carry out these activities after a large portion of the island has been submerged.

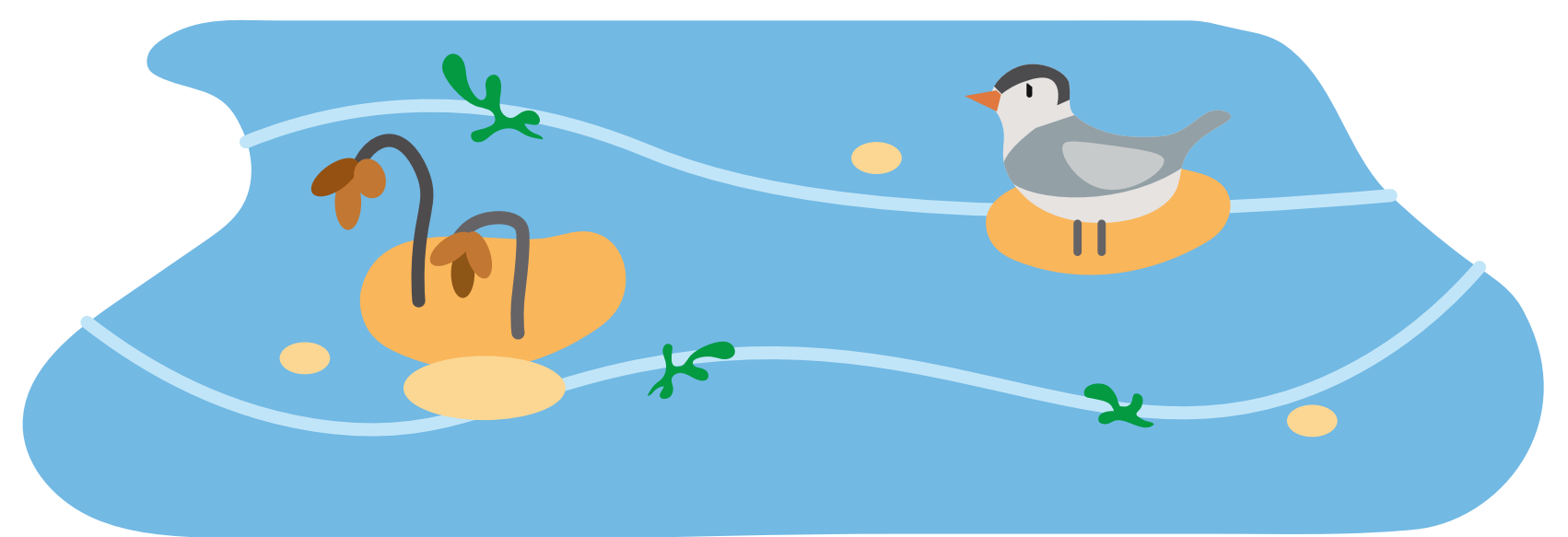
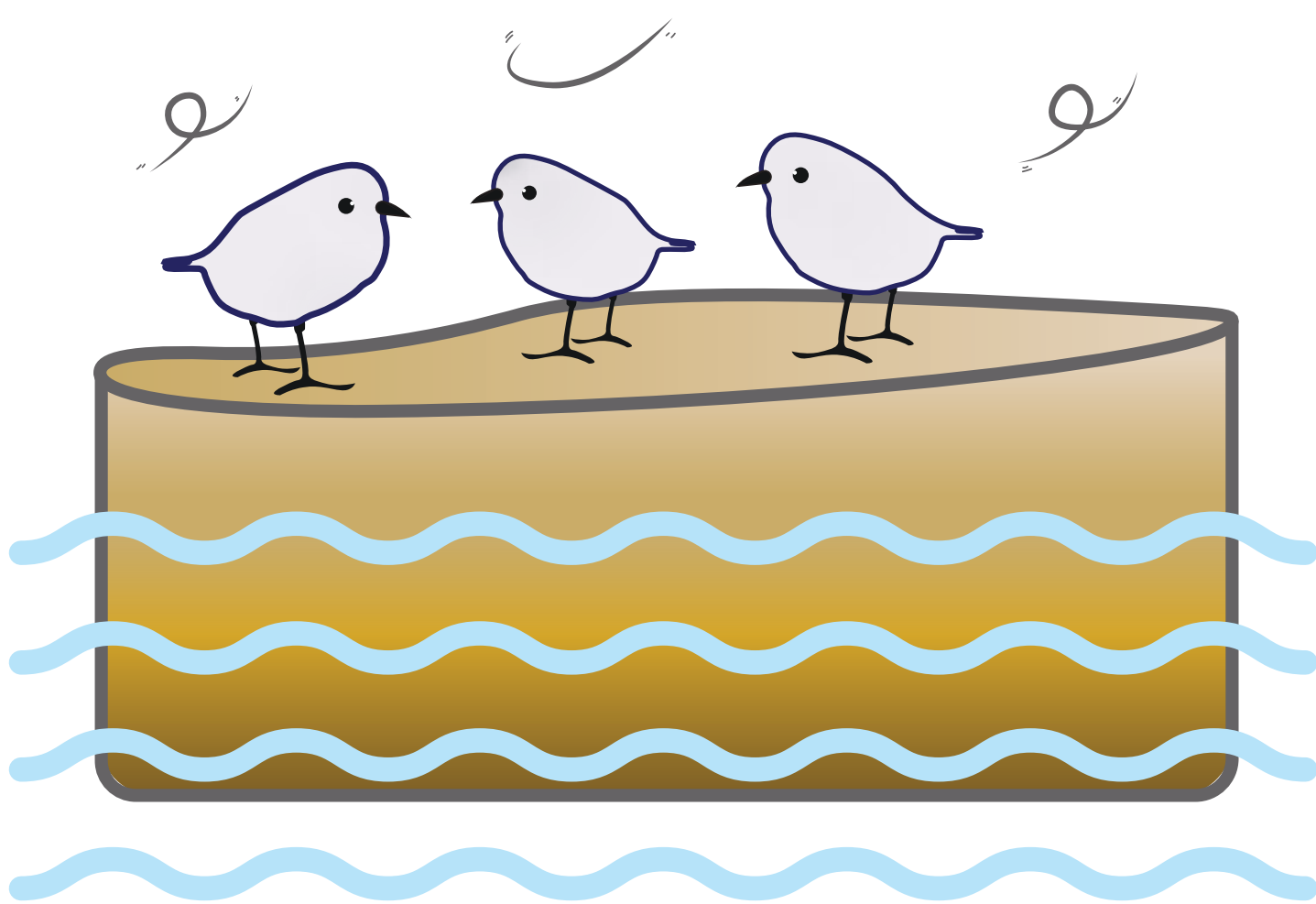


### 3. Western Snowy Plovers

**Rising sea levels and more frequent flooding may drive coastal nesting birds around the world into extinction.**



**1 of the main reasons** is that even though tidal floods are predicted to become more frequent and severe due to climate change, these birds have not responded to tidal floods, such as increasing the elevation of their nests, even among those that have lost their nests in these floods. Some attributable factors include the presence of predators or unsuitable vegetation, which might discourage birds from nesting higher.



**A third of the American West Coast beach habitat area used by the western snowy plovers is less than 1 metre above sea level! This makes them especially vulnerable to rising sea levels.**

Source: Yale Climate Connection, Australian National University & EcoWatch  
Image Source: Unsplash

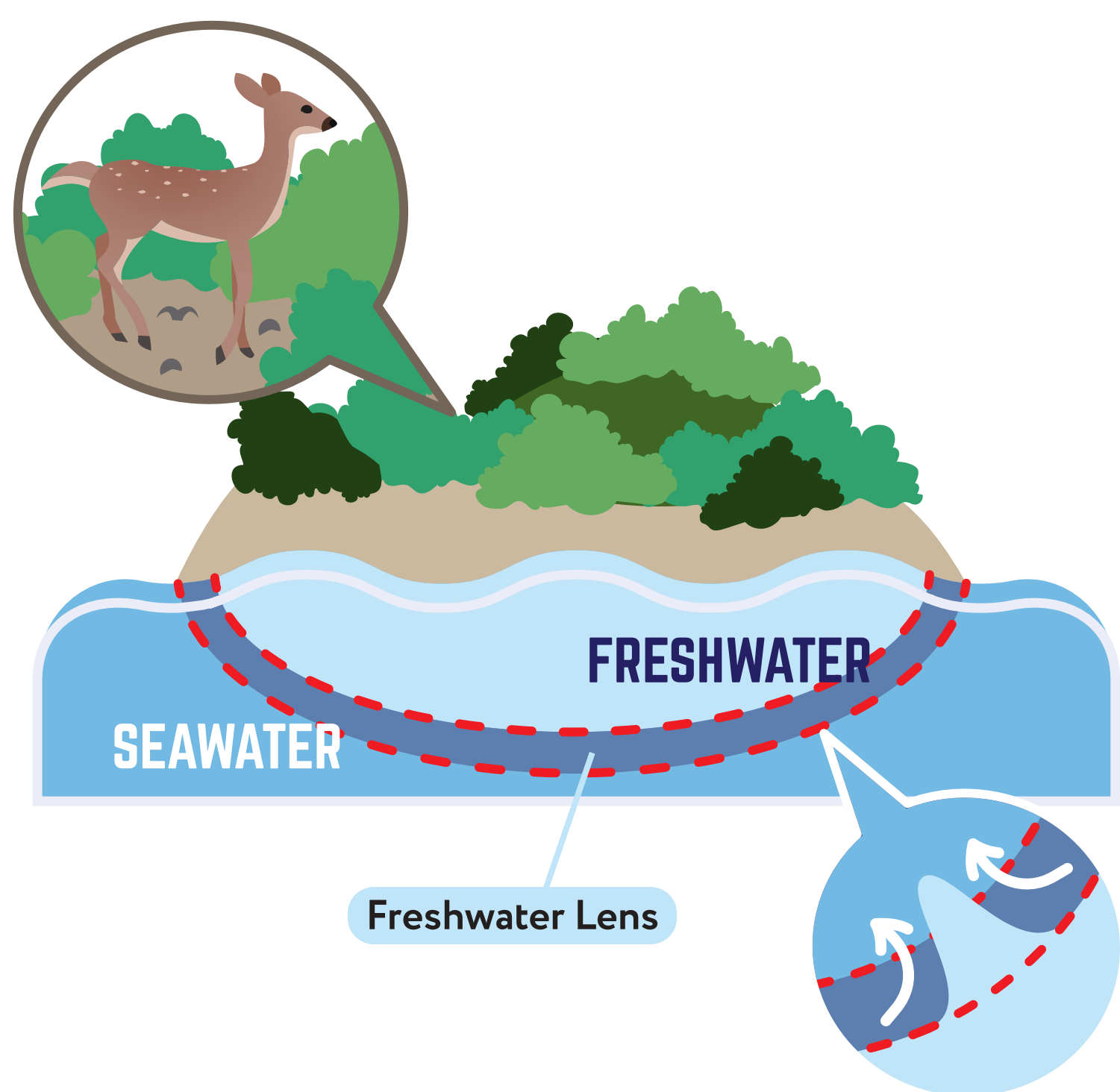
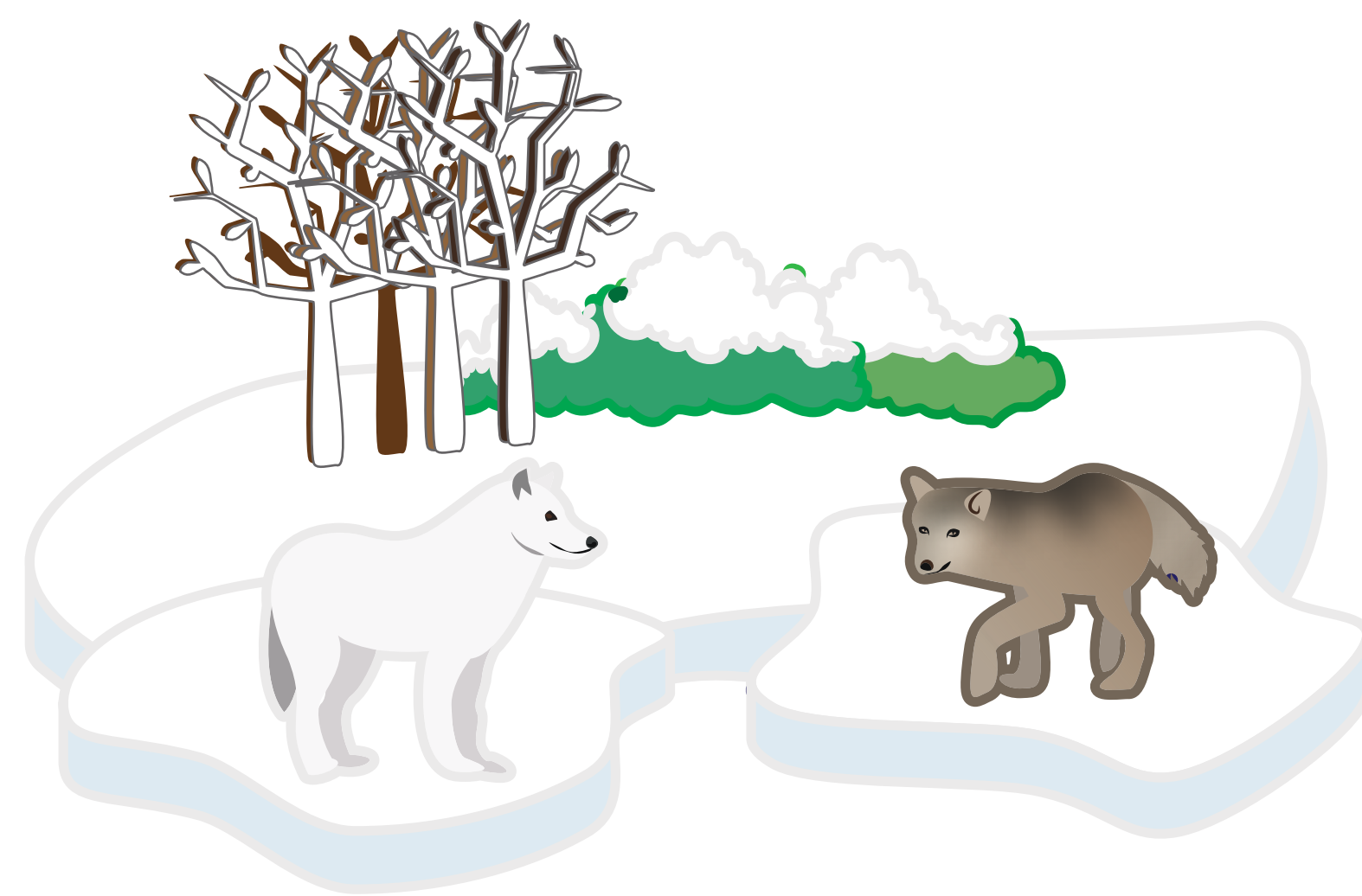
# HOW IS TERRESTRIAL LIFE AFFECTED?

## 1. Wolves and Foxes

Populations of wolves and foxes are currently isolated only in summer.

For most of the year, these groups are connected by sea ice. But as sea ice coverage declines over the years, packs are being kept away from each other for an extended length of time, reducing cross-breeding which is important for genetic well-being.

Source: The Guardian



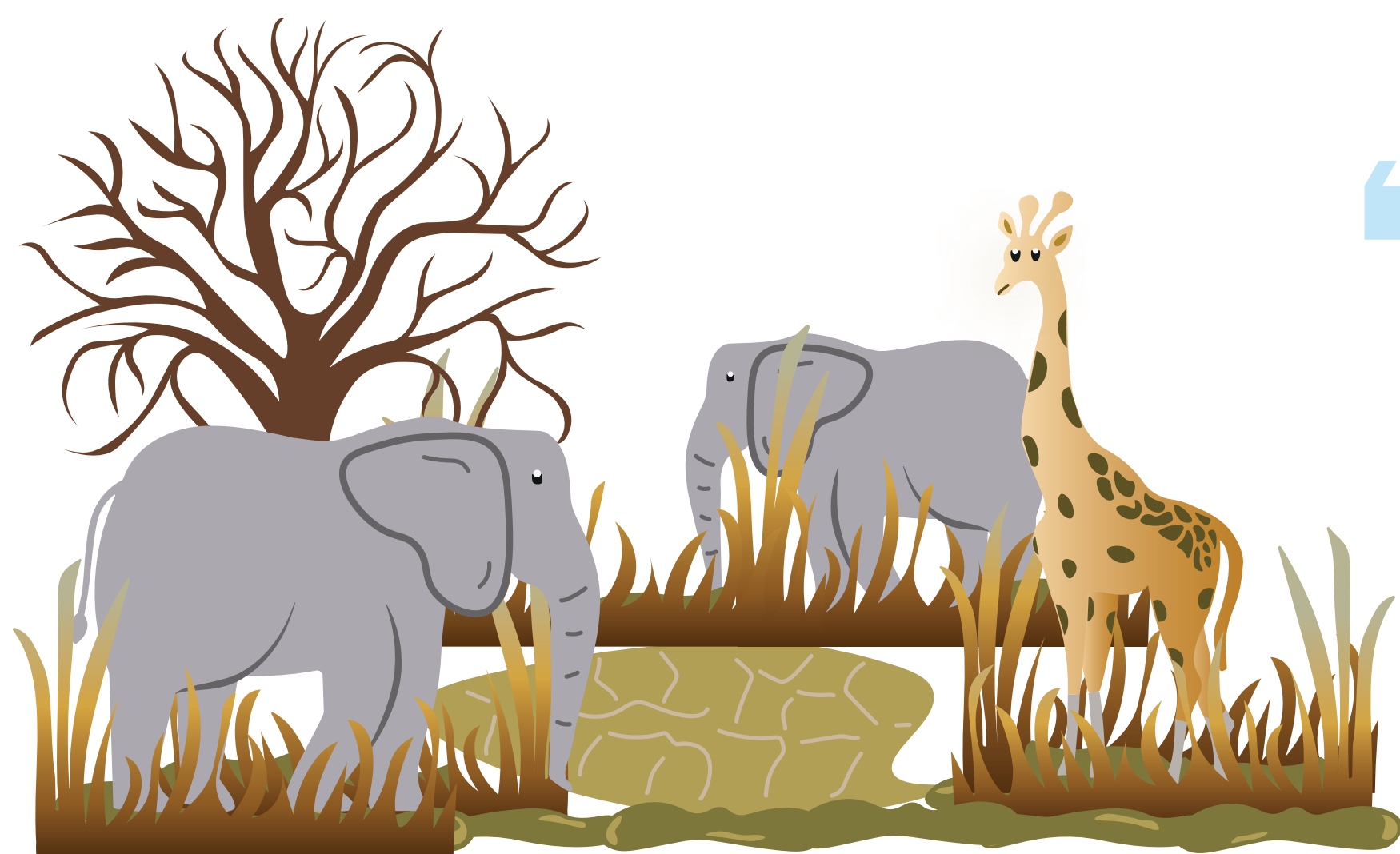
## 2. Florida Key Deer

In Florida, the Florida Key Deer population is estimated to be roughly 1,000. However, their low-lying habitat is in grave danger of being flooded by seawater.

The primary concern is the “freshwater lens” which allows freshwater to pool on the island. If the sea level rises even minimally, this lens could be breached, causing saltwater inundation, and making the water on the islands non-potable.

## 3. Wildlife

There are many species in the ecosystem that are at risk of extinction, such as the Lower Key March rabbits, snakes, butterflies and many others. This is only one part of the larger ecosystem. If more species become extinct, our ecosystem will slowly be destroyed.



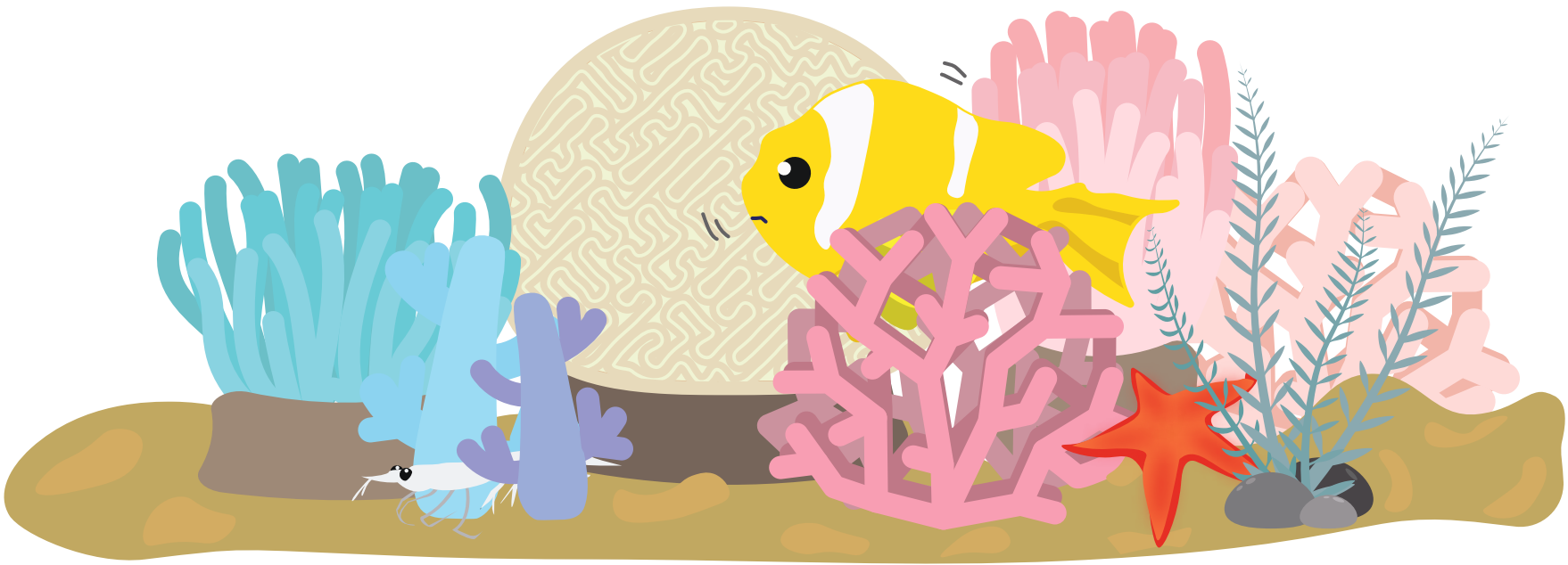
“It’s not the species so much as the ecosystem that’s being altered and lost and there’s a lot of other species that are directly impacted (as well as) the ecosystem as a whole. It’s a symbol of the ecosystem as a whole that’s being changed.”

Eric Hoffman, Associate Professor of Biology at the University of Central Florida



# HOW IS MARINE LIFE AFFECTED?

## 1. Survival Of Coral Reefs



The survival of coral reefs and other critical habitat-forming species hinges on their ability to move into shallower waters.

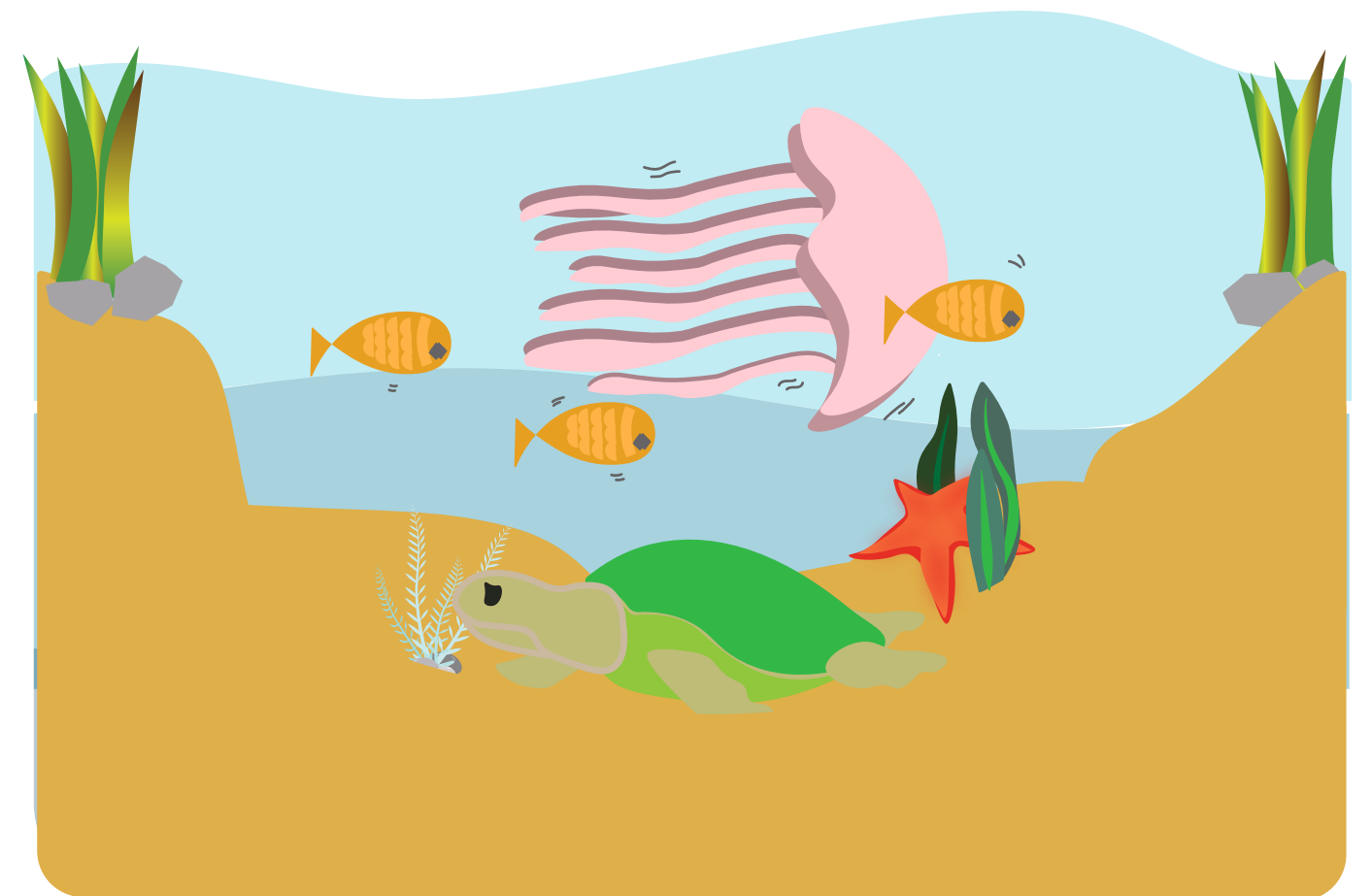
Most slow-growing species are unlikely to be able to keep pace with rising sea levels. Coral reefs, sea grass meadows, kelp beds, rocky intertidal zones and estuarine communities; all of these valuable ecosystems can be found at around sea level.

Source: Conservation International

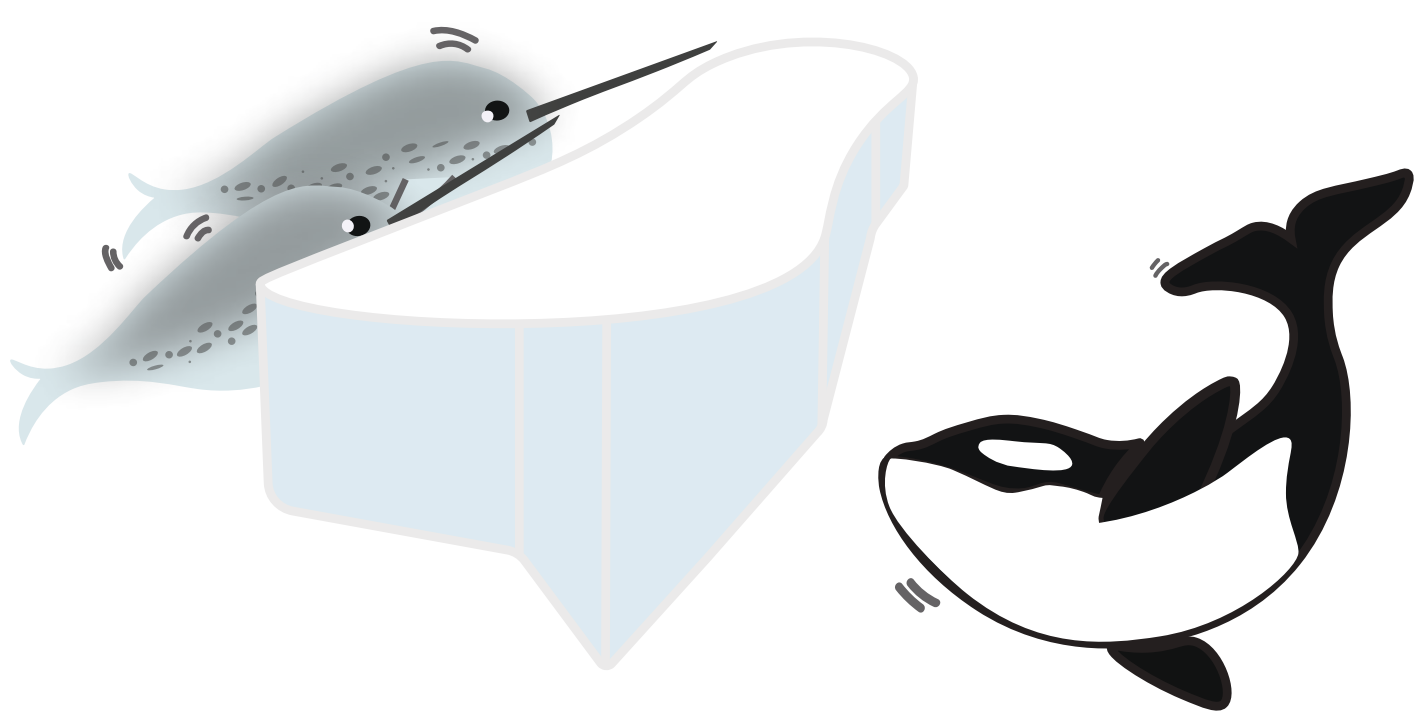
Sedimentation runoff can lead to the smothering of corals.

Sea level rise may lead to increased sedimentation at reefs located near land-based sources of sediment. This can reduce the survivability of organisms in the ecosystem, which are still trying to adapt to the changing environment.

Source: National Ocean Service



## 2. Marine Animals



Narwhals hide safely among sea ice to avoid their natural predator, the killer whale.

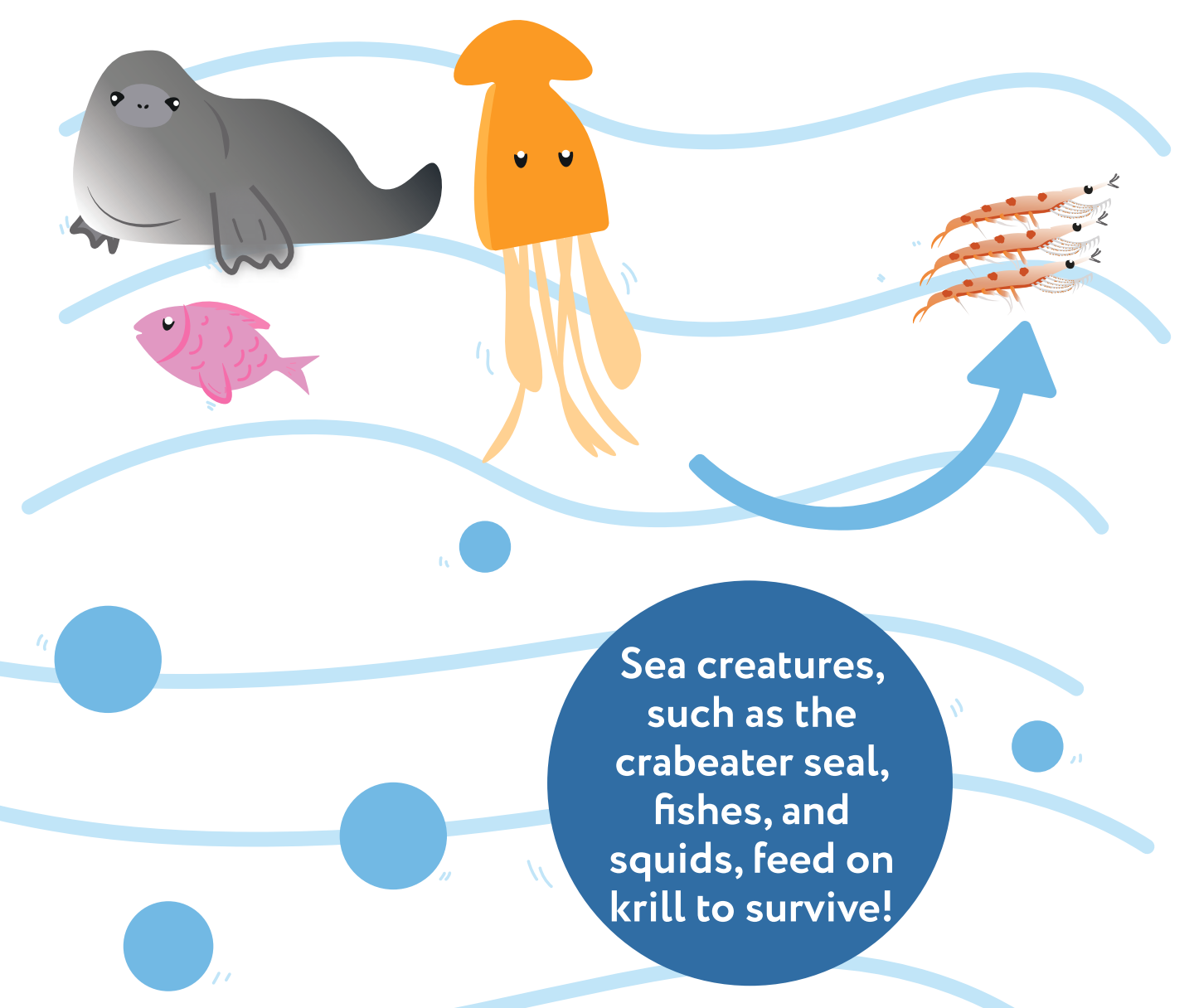
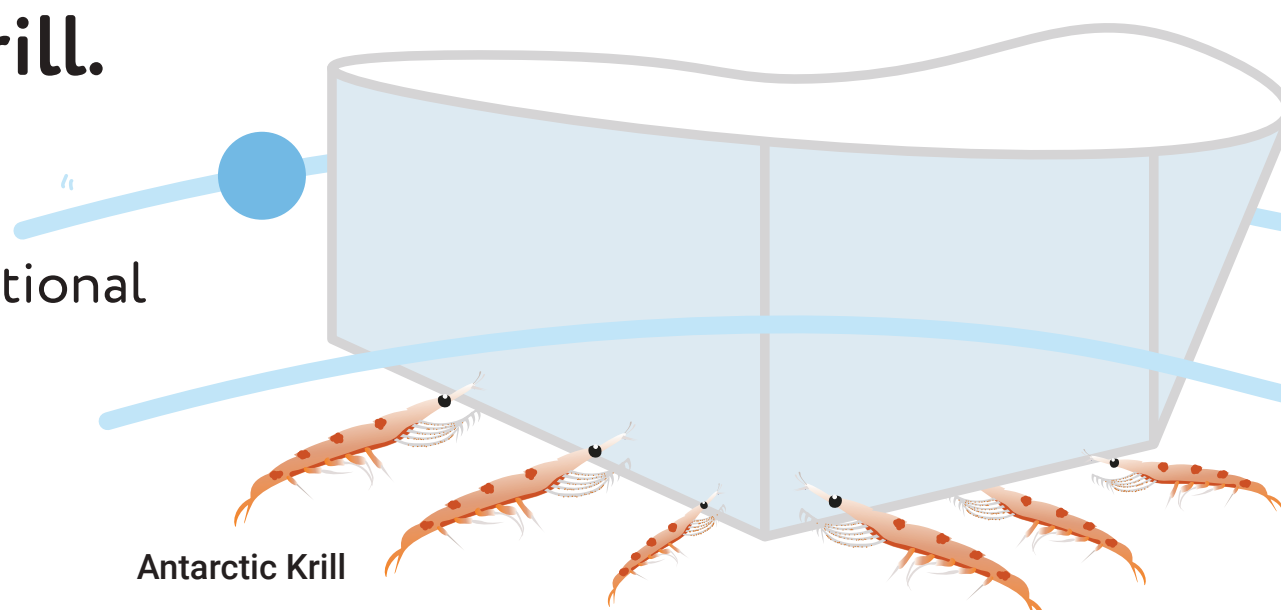
Robbed of that protection, narwhal numbers could dwindle dangerously, marine biologists warn. These tusked whales are also called the unicorns of the sea!

Source: The Guardian

Sea ice is a critical habitat for Antarctic krill, the food source for many seabirds and mammals in the southern ocean.

As sea ice diminishes, so do Antarctic krill populations, resulting in the decline of various species dependent on the krill.

Source: Conservation International



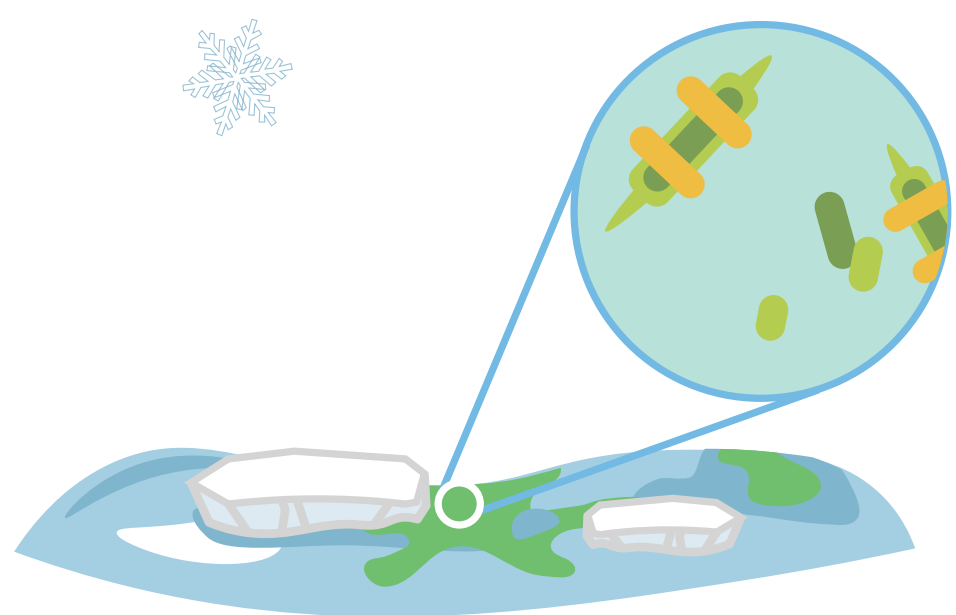
# HOW IS WILDLIFE LIVING ON ICE AFFECTED?

## 1. Ice-Dependent Seal

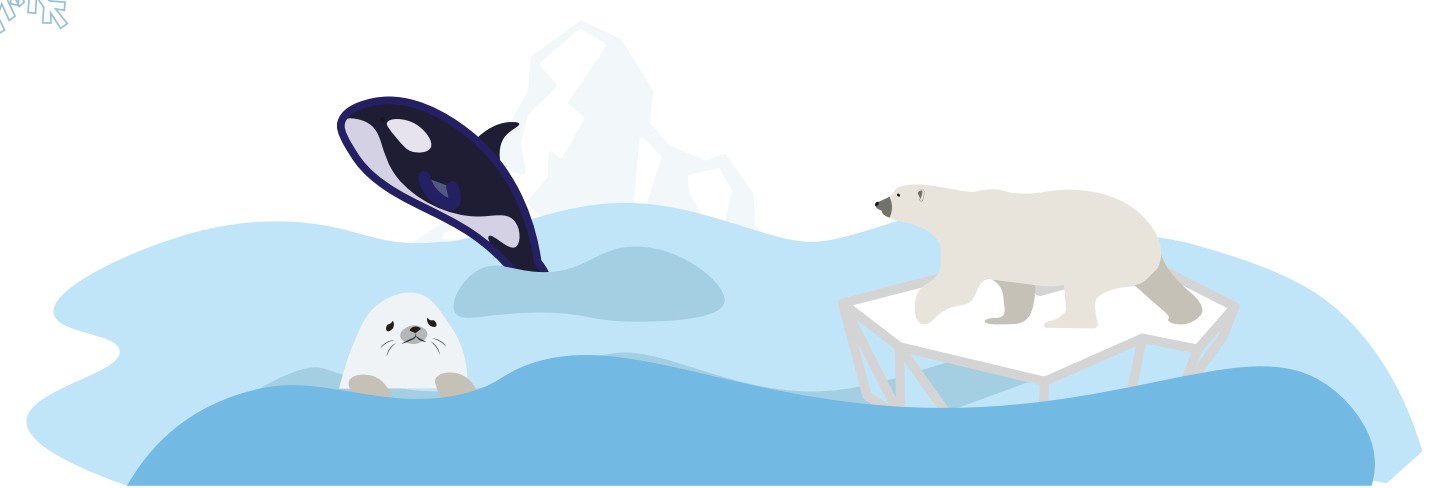
**As the temperature rises, glaciers melt faster than they accumulate new snow. As these ice sheets and glaciers melt, the water eventually runs into the ocean, causing sea levels to rise.**



Source: Jet Propulsion Laboratory

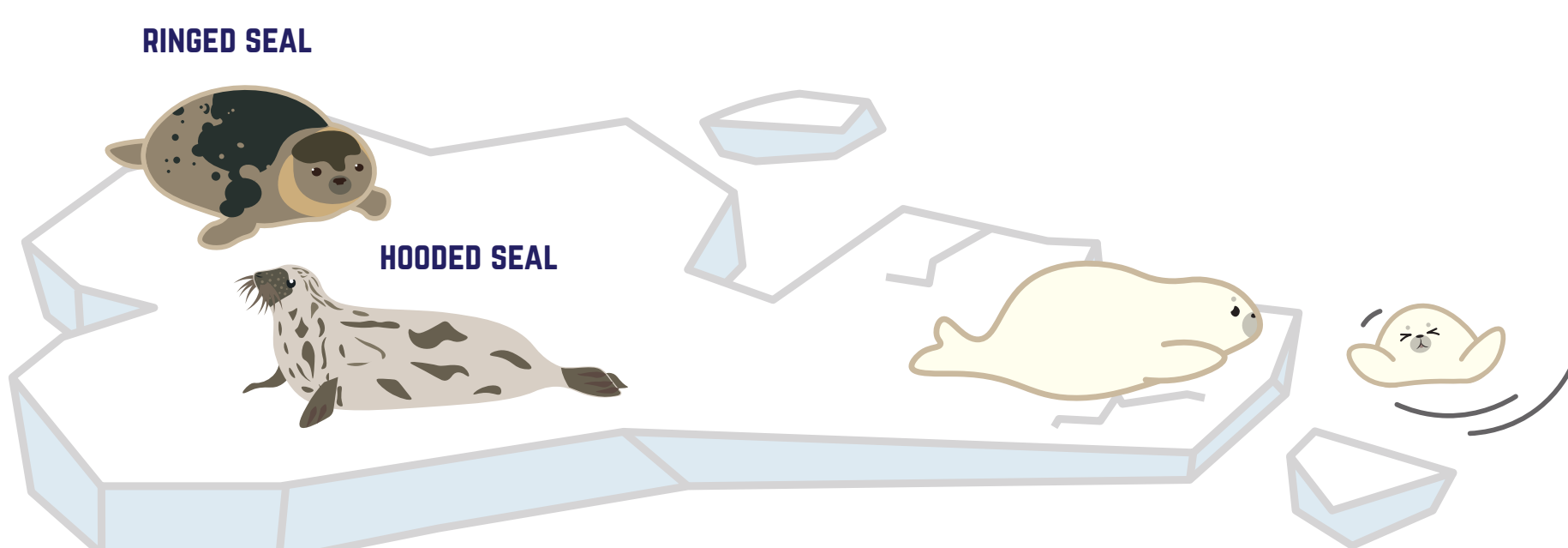


**As sea ice diminishes, algae - the primary food source of the Arctic food web that is dependent on sea ice - will consequently disappear. This will cause a ripple effect on Arctic wildlife.**



**Diminished sea ice results in the loss of vital habitats for seals, walruses, penguins, whales and other megafauna.**

**Ice-loving seals, such as harp, hooded and ringed seals, are among the many species threatened by climate change!**



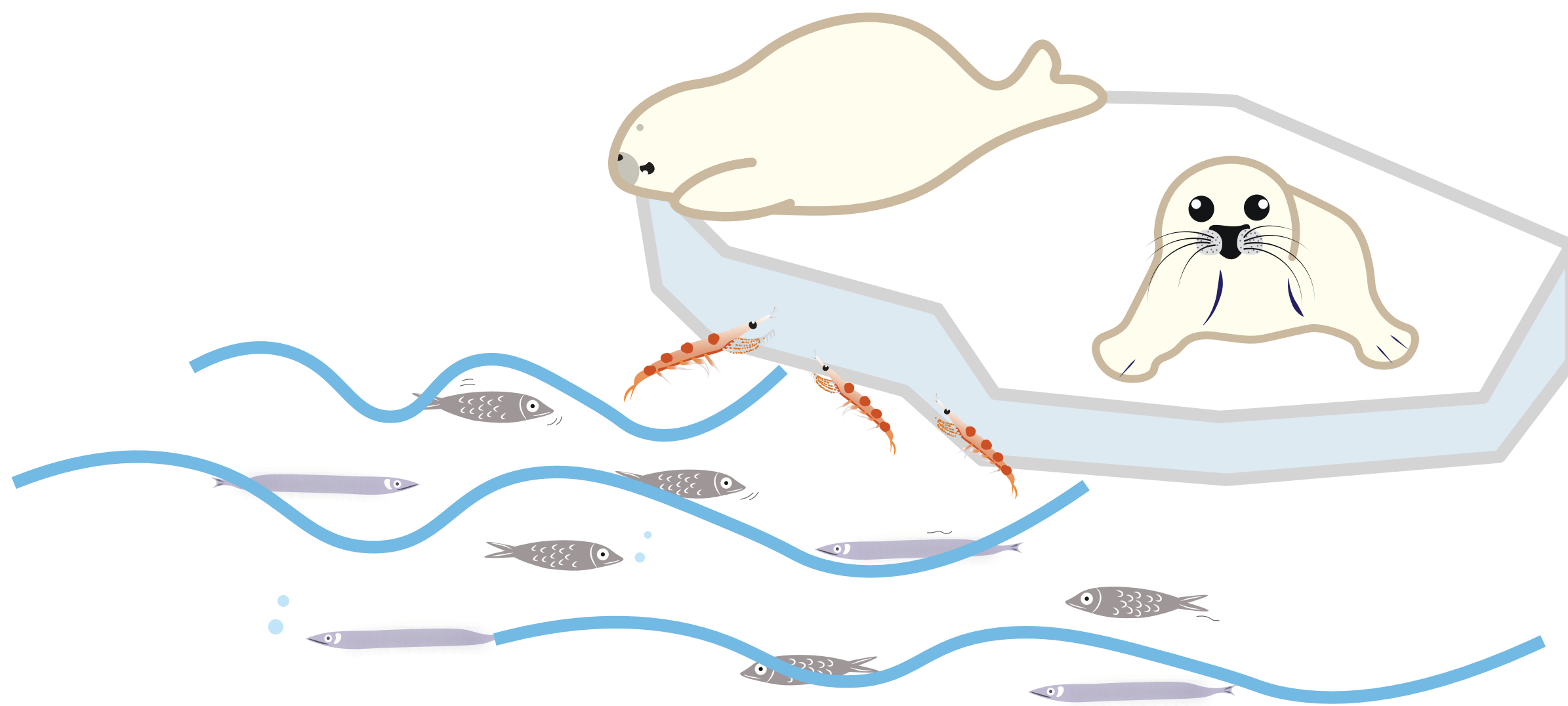
**Harp seals are a prime example of why sea ice matters. These seals give birth to pure white pups on Arctic ice floes. During their first six weeks of life, before they grow large enough to spend most of their time in the water, the pups use the ice as platforms for nursing and resting.**

**But as ice melts more quickly, pups are forced into the water before they are ready to fend for themselves. These young pups are at risk of hypothermia, starvation and being crushed by moving ice in the Arctic.**

Source: GreenFacts, Smithsonian Ocean & Phys.org



**Seal yearlings are also harmed by declining sea ice because their food is found along the edges of the ice.**



**Harp seals feed primarily on small crustaceans and fish, such as krill, capelin and sand lance. Both use the sea ice edge as shelter from their predators and feed on algae found along the edges of sea ice.**

**Given a choice between giving birth on land or sea ice, pacific walrus mothers more often choose ice.**



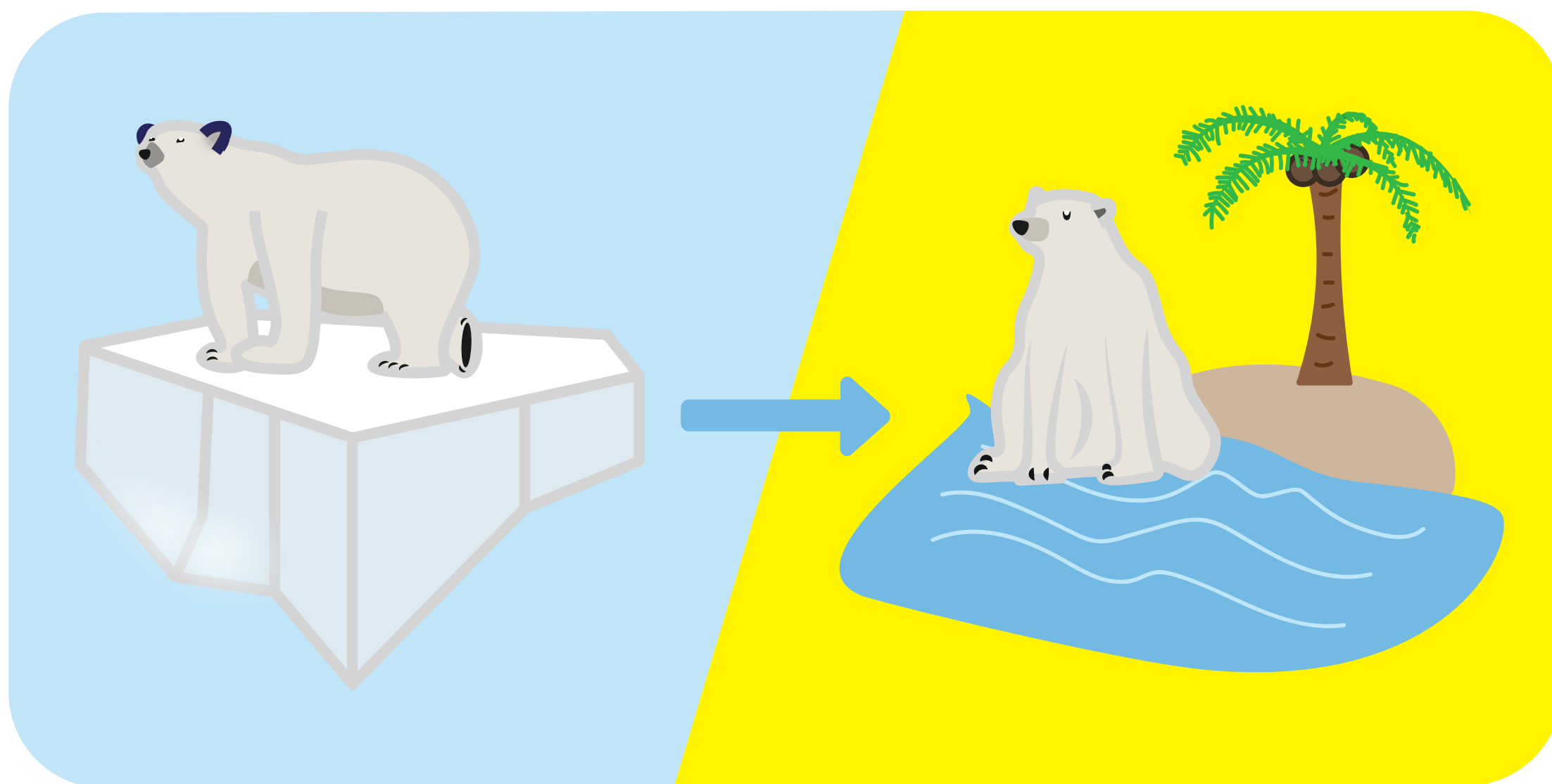
**Likewise, they prefer sea ice for moulting, mating, nursing, and resting between dives for food. The problem is, as the century progresses, there is going to be far less ice around with sea ice receding beyond the shallow continental shelf.**

**Female walruses and their calves face difficult situation: they have to swim further distances to seek refuge on shore when no ice is available, and the calves also risk getting crushed in stampedes triggered by hunters, airplanes, or bears on land. The melting of sea ice hence threatens the survival of walruses.**

Source: GreenFacts, Smithsonian Ocean & Phys.org

## 2. Polar Bears

**A dramatic decrease in sea ice pushes polar bears toward coastal communities and hunting camps to find food, making them a nuisance and danger to people living there.**

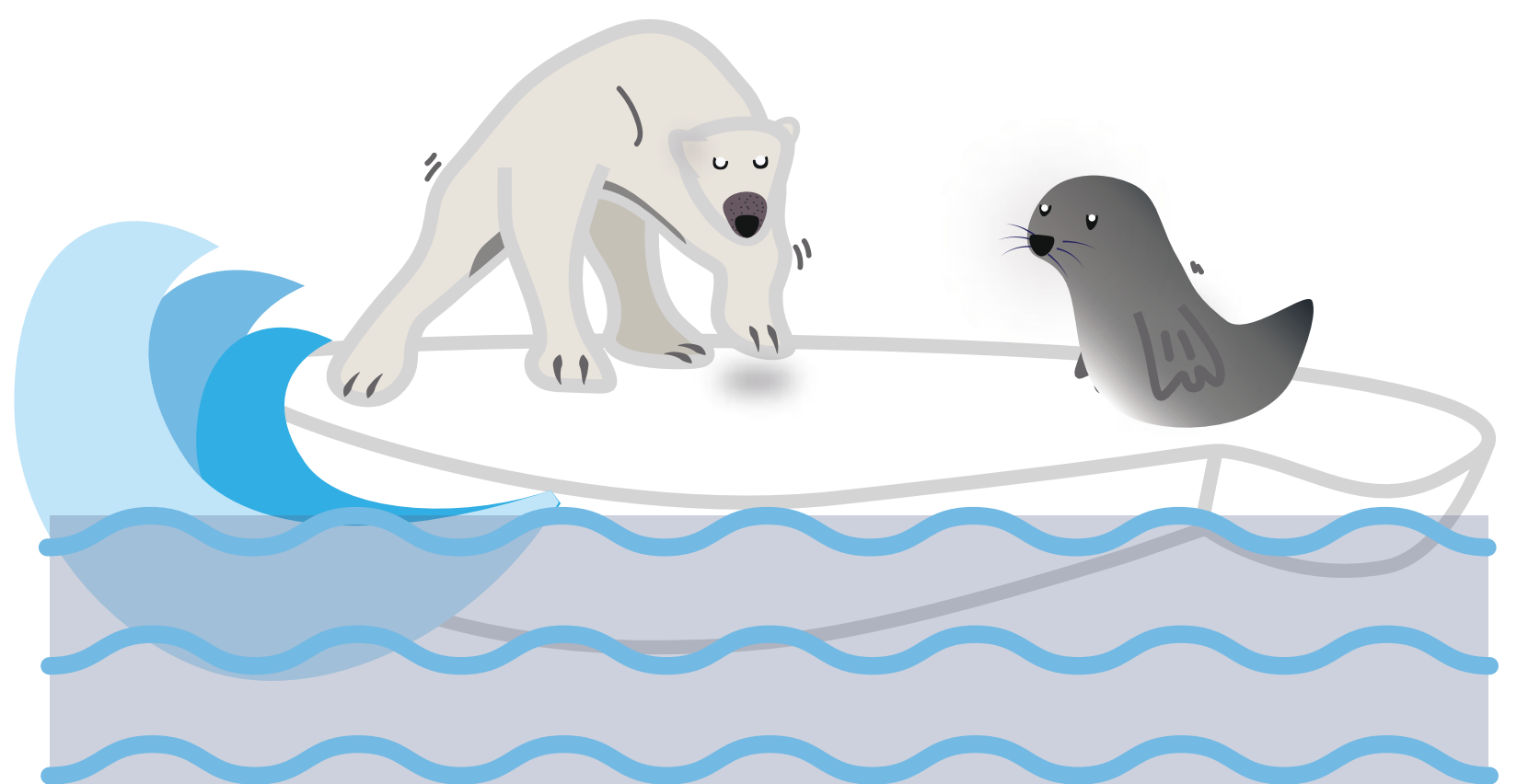


**Polar bears rely on sea ice for hunting seals, their primary food source.**



**While the bears can fast for months, their survival depends on how much energy they have managed to reserve through eating ahead of time, the energy they expend during the fast and how long a fasting period lasts.**

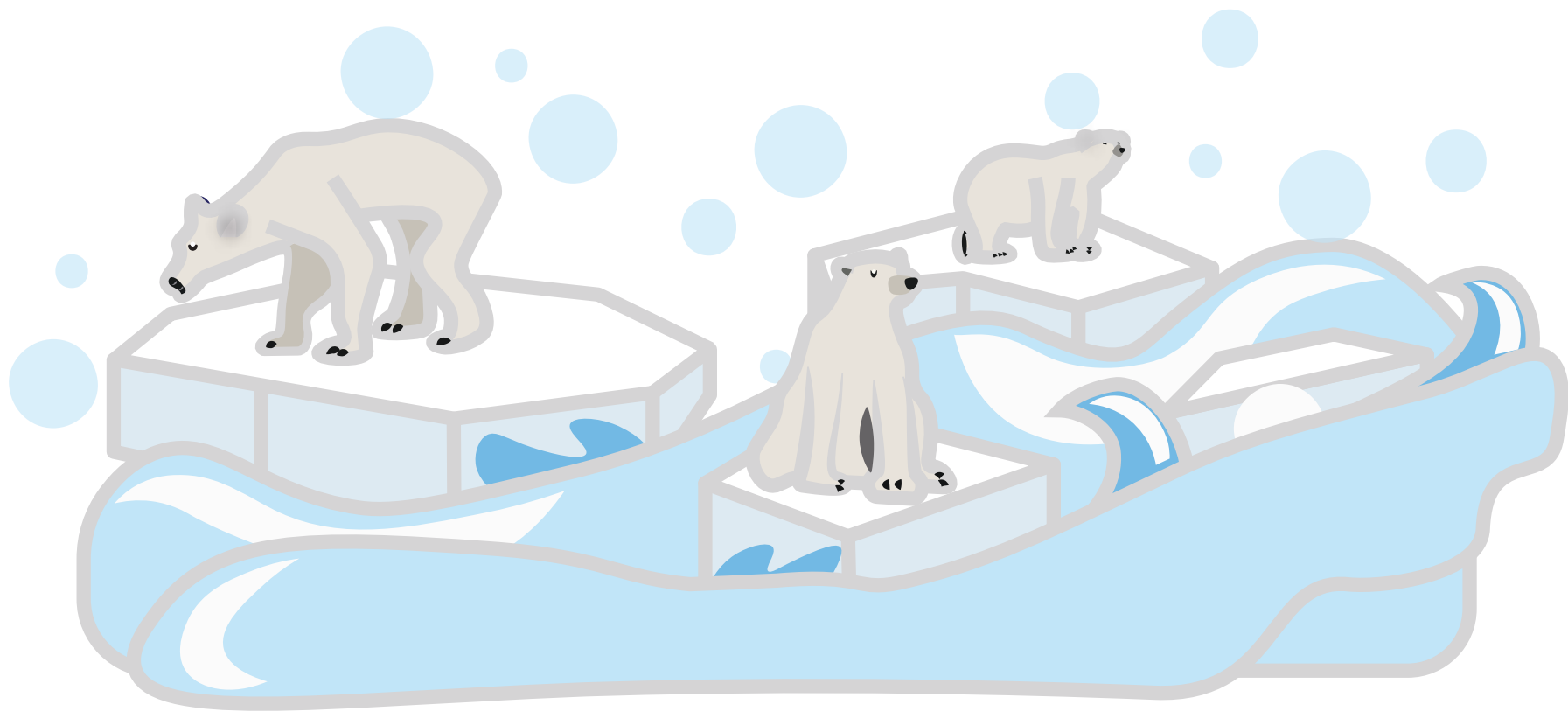
**The spread of ice has been on the decline as climate change accelerates the rise in temperatures at the poles, keeping polar bears on land where it is harder to catch seals.**



Source: Conservation International, NBC NEWS & National Geographic

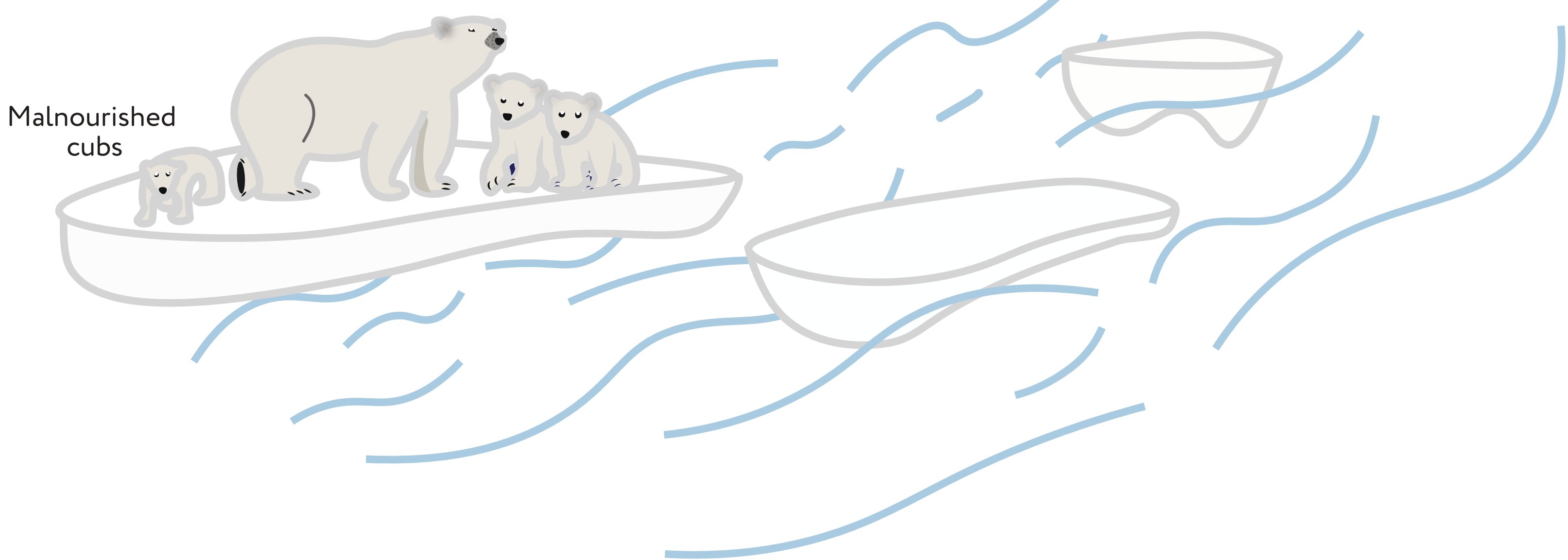
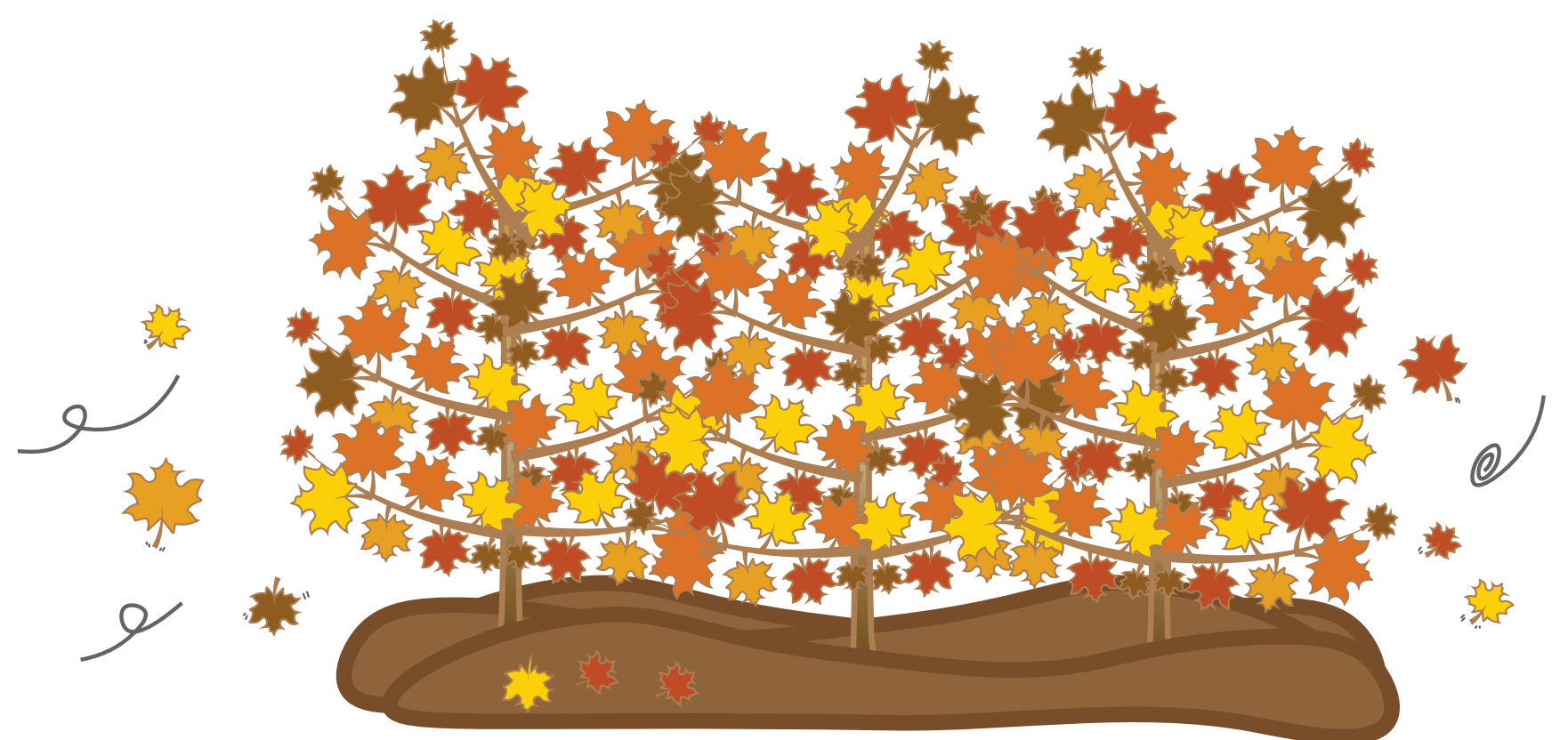


## The Ice Will Break Up Sooner In The Spring And Form Later In The Fall.

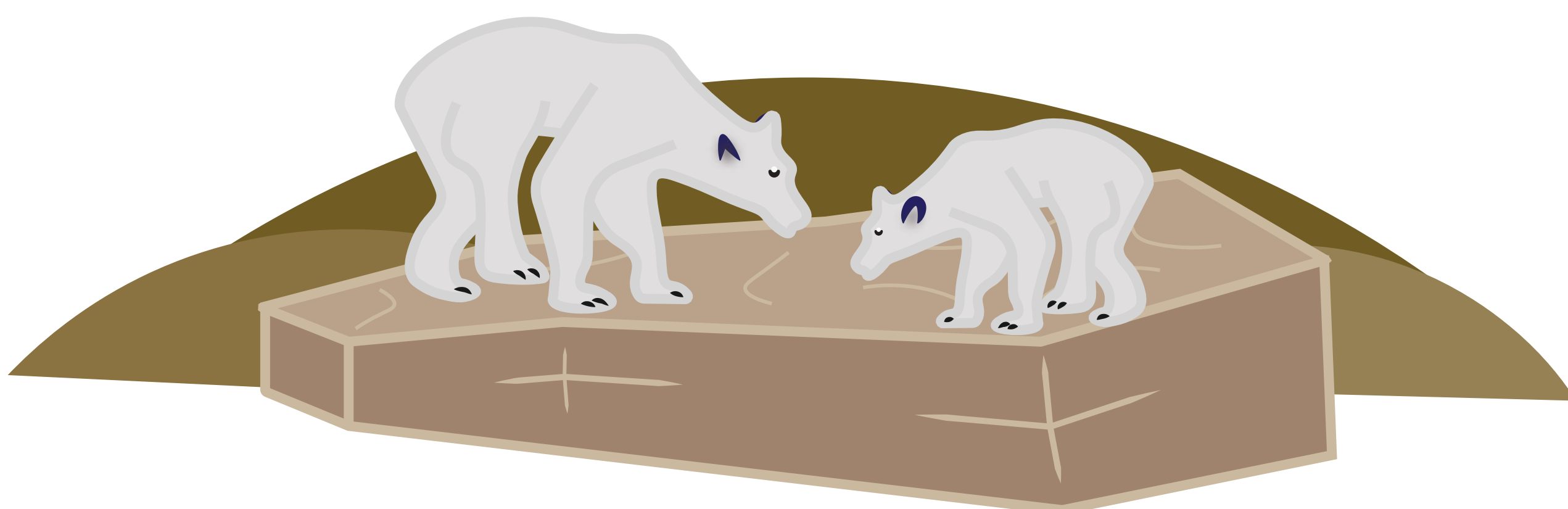


This causes the bears to burn huge amounts of energy walking or swimming long distances to get to any remaining ice.

In the worst-case scenario, they will need to stay on land longer, spending the summer -- and, increasingly, the fall -- fasting, living off their fat from the seals they caught in spring. The farther the bears have to travel to get on the ice to hunt, the more weight they lose.

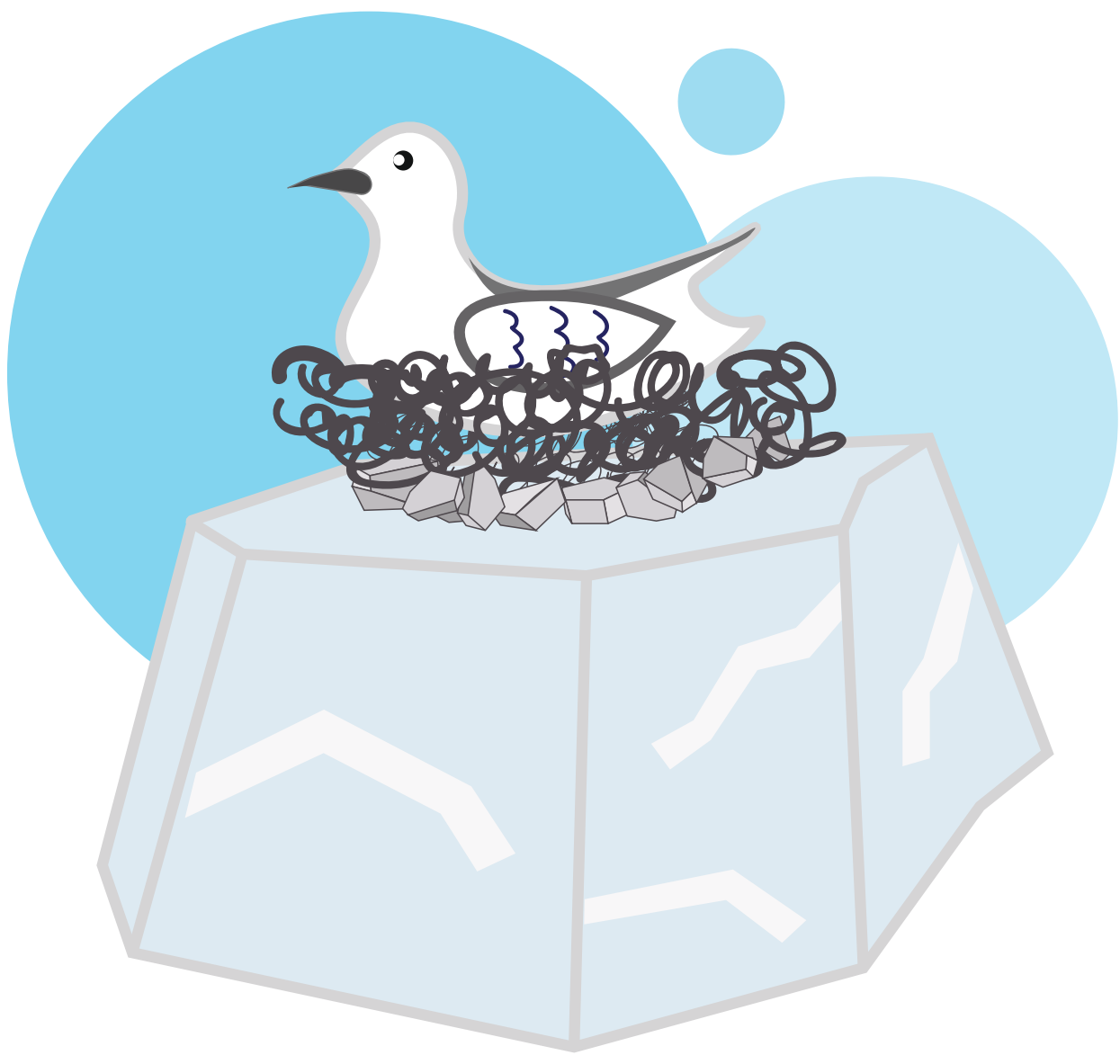


Eventually they will start losing muscle, hurting their success at hunting, which can affect their ability to survive.



Source: Conservation International, NBC NEWS & National Geographic

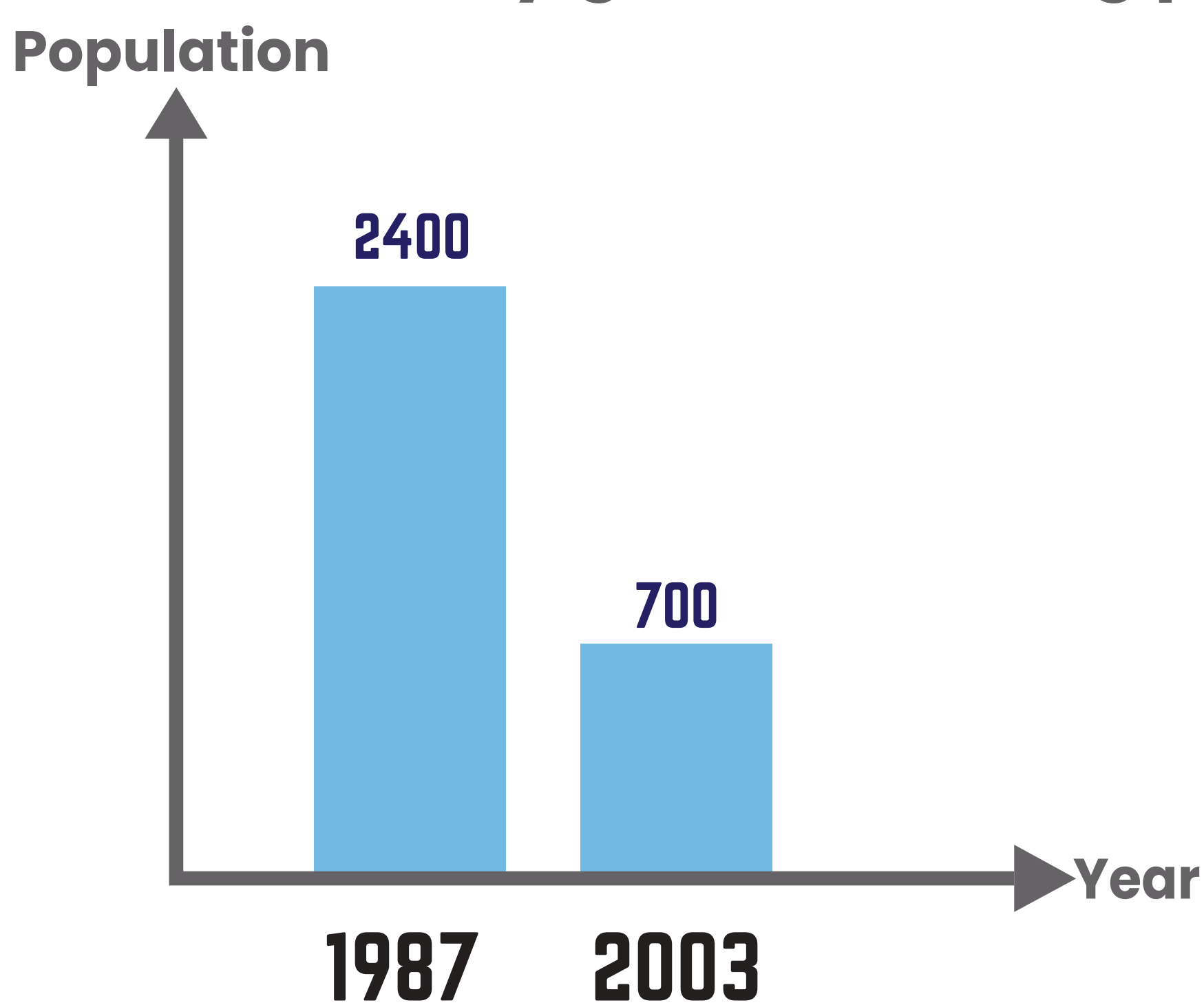
### 3. Ivory Gulls



Ivory gulls are the most northerly breeding birds in the world. They are also the ones known to nest directly on sea ice, including icebergs.

As sea ice declines, ivory gulls seem to be declining in numbers too.

#### Ivory gulls' breeding population in Canada



The population of ivory gulls has been decreasing in the past few decades in Canada.

The ivory gull is listed as endangered in Canada and near threatened on the International Union for Conservation of Nature Red List.



“Ivory gulls are so highly specialised that it's hard to see what they would do to survive in ice-free Arctic. They're now dealing with an ice environment that's very atypical compared to what they've had to deal with for the last 10,000 years or so.”

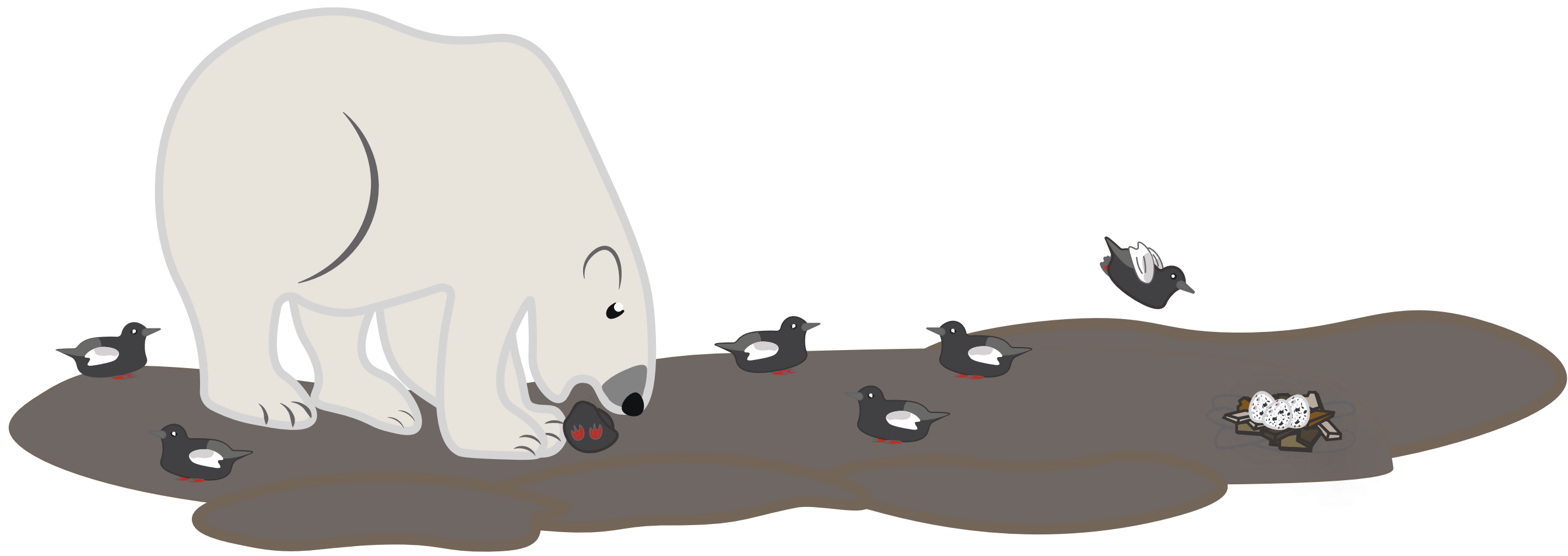
George Divoky, Director and Founder of Friends of Cooper Island

Source: Audubon



# HOW IS WILDLIFE ADAPTING TO RISING SEA LEVELS?

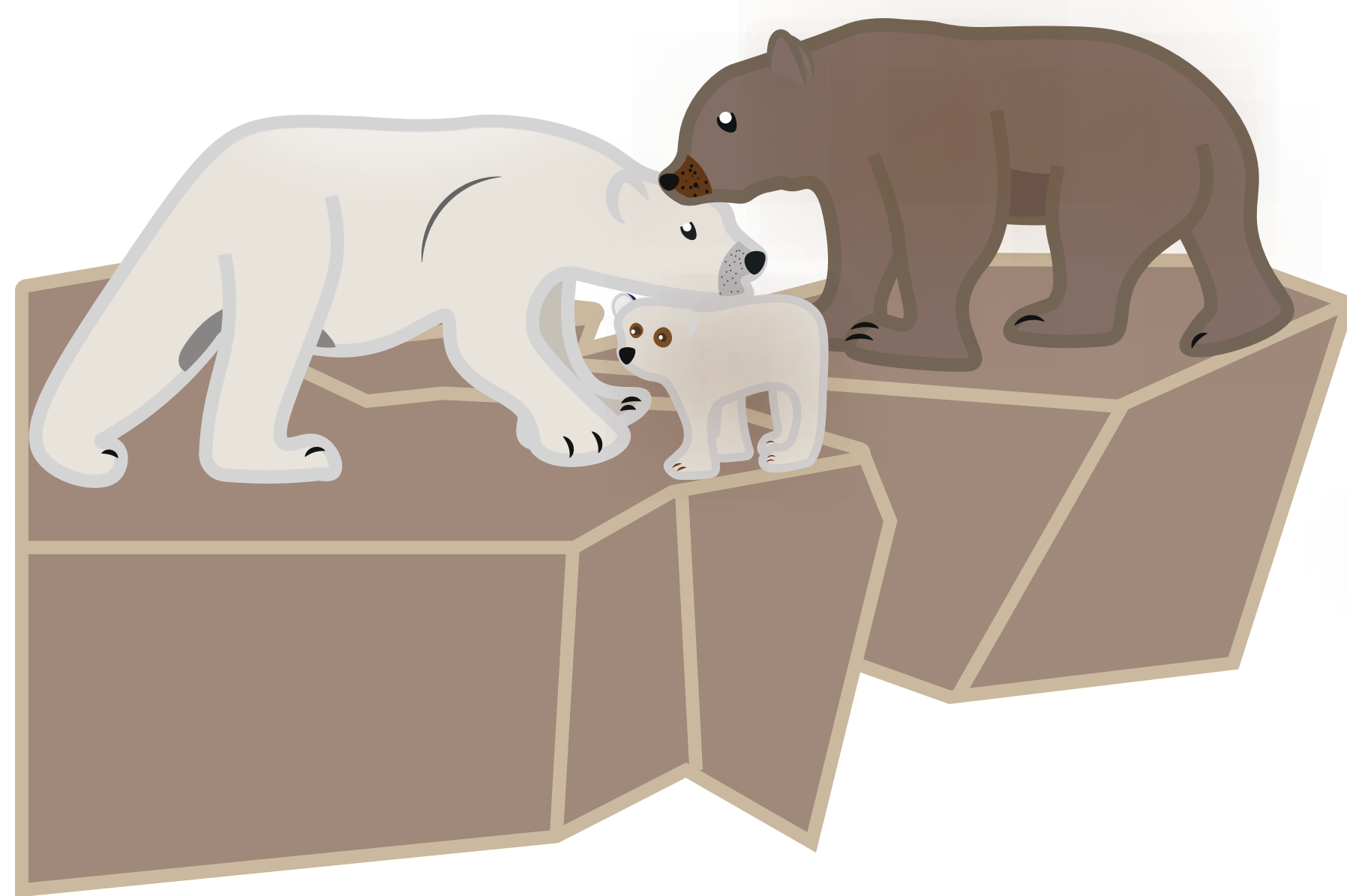
## Mandt's Black Guillemots



On a small sandbar island in the Arctic, Mandt's black guillemots are laying their eggs earlier than usual to try to keep up with the pace of melting ice.

In addition to this, they have to worry about the threat of polar bears visiting the sandbar and eating the small guillemots.

## Polar Bears And Brown Bears

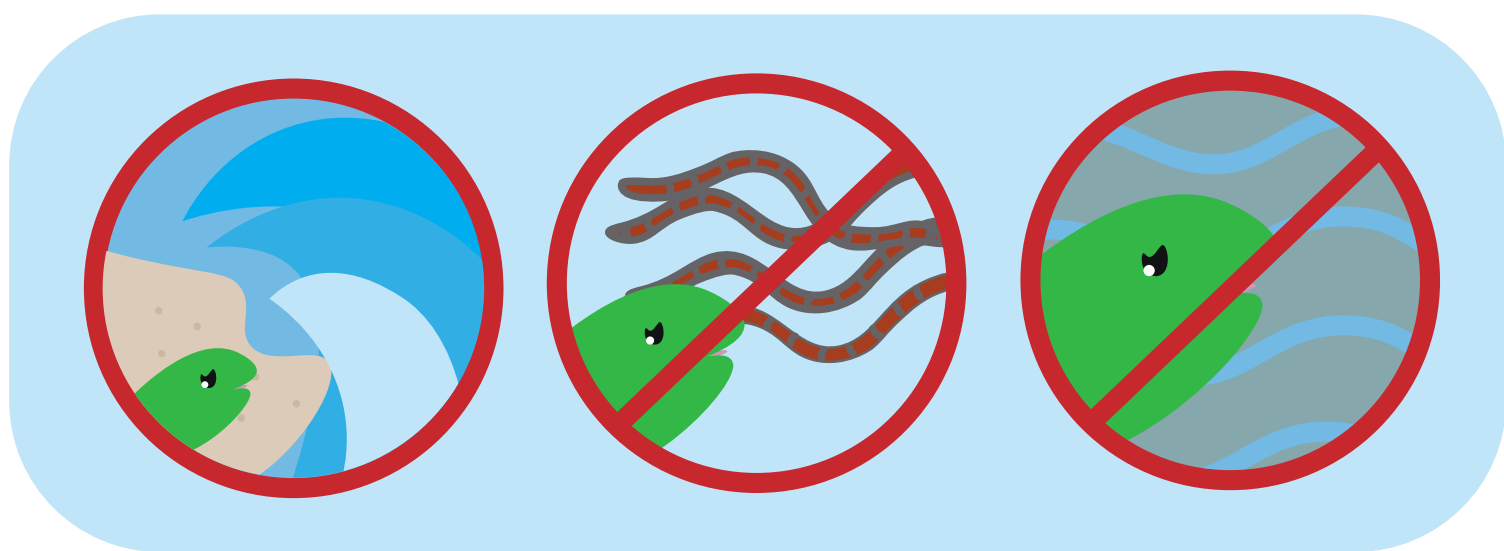


Rapidly melting Arctic sea ice imperils species through interbreeding as well as through habitat loss. With a loss of habitat, animals of the same species are kept separated from one other and are prevented from mating.

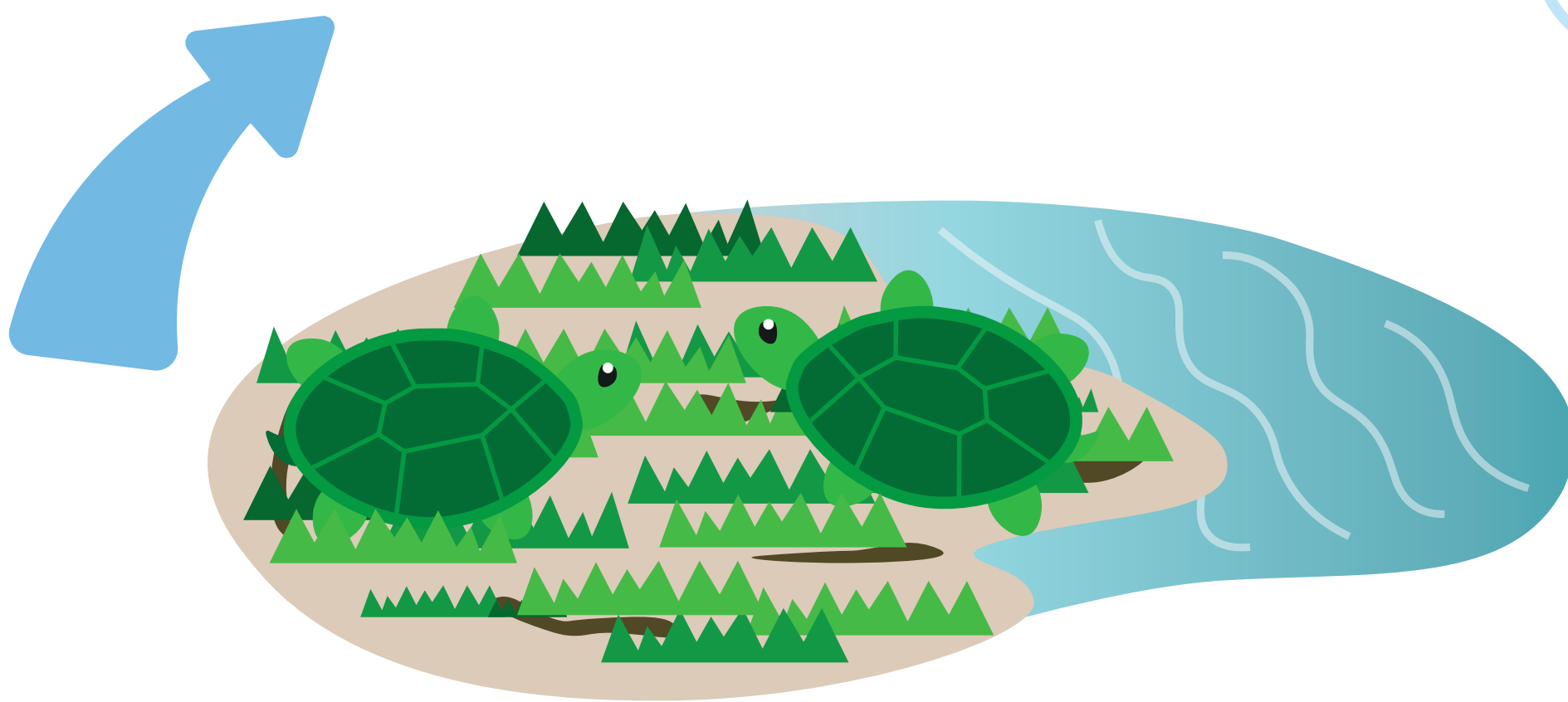
When more isolated populations and species come into contact, they are more inclined to mate, forming hybrids, and increasing the likelihood of rare species going extinct. As the genomes of species become mixed, adaptive gene combination will be lost.

# Sea Turtles

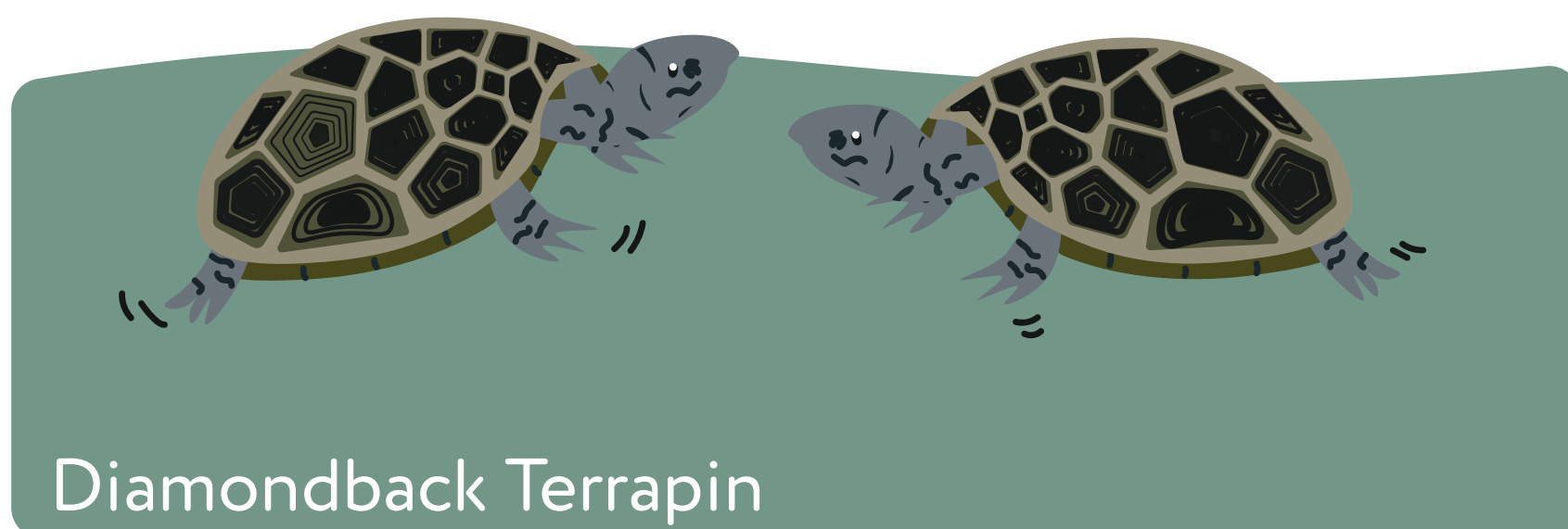
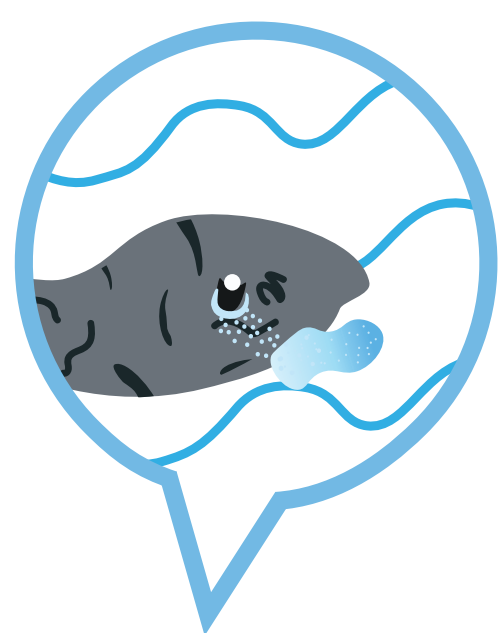
Sea turtles and birds with high fertility and dispersal rates may be able to adapt by expanding or contracting their home range sizes at current rates of sea level rise.



Turtles' bodies cannot process water with high salinity. As such, they refrain from eating or drinking when in these salty waters.



Many turtles will lose body mass over time.



Diamondback Terrapin



However, some species have adapted to survive in more saline water

The diamondback terrapin, which lives on the eastern coast of the United States, is able to live in brackish water by excreting salt from glands near its eyes.

Source: National Geographic, Nature.com, The Wildlife Society & Yale Climate Connection



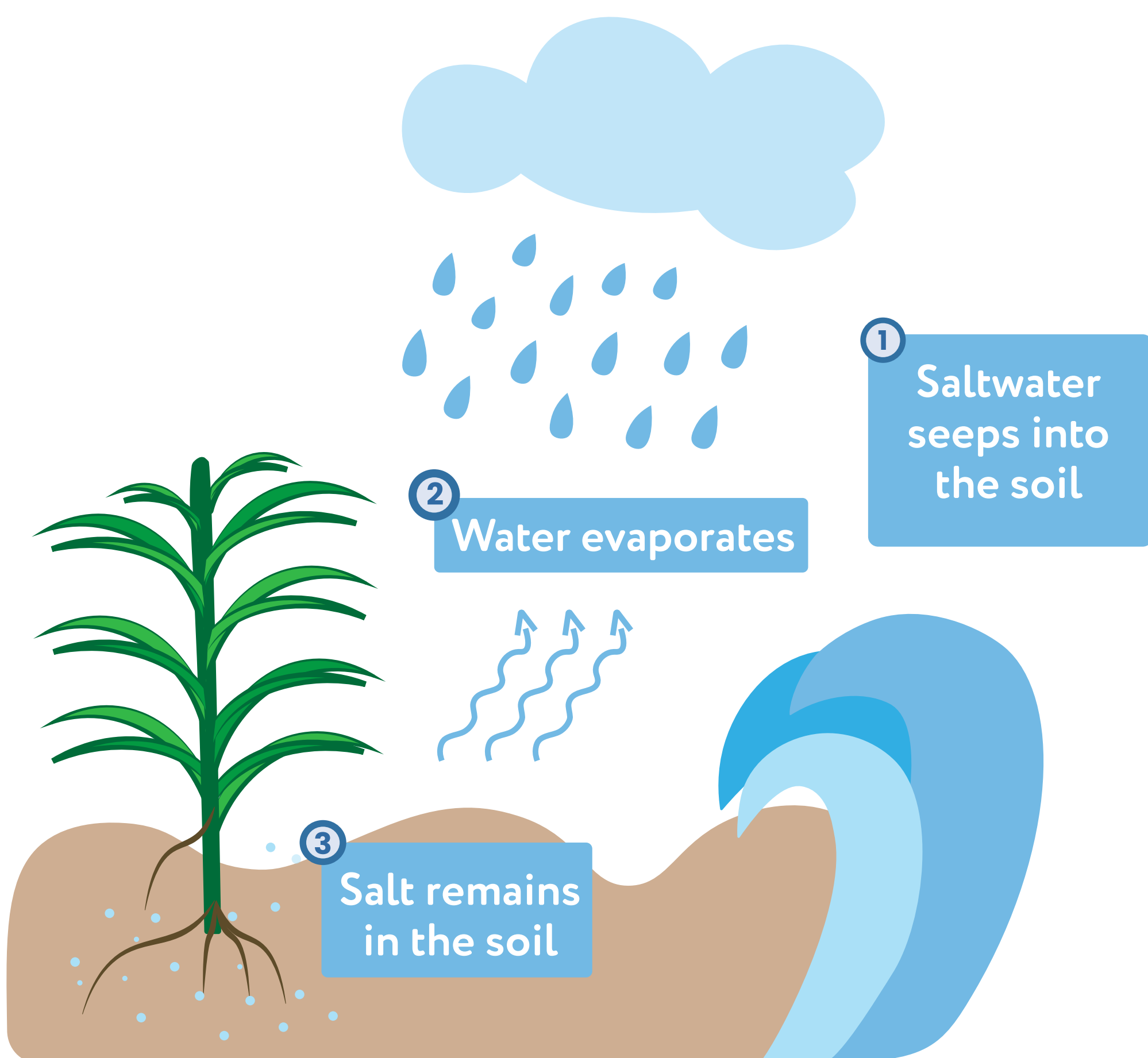
## CHAPTER 4: Feeling salty

In the fourth chapter of this series, we examine the effects of rising sea levels on low-lying coastal areas as they become increasingly inundated with saltwater, which gradually contaminates the soil.



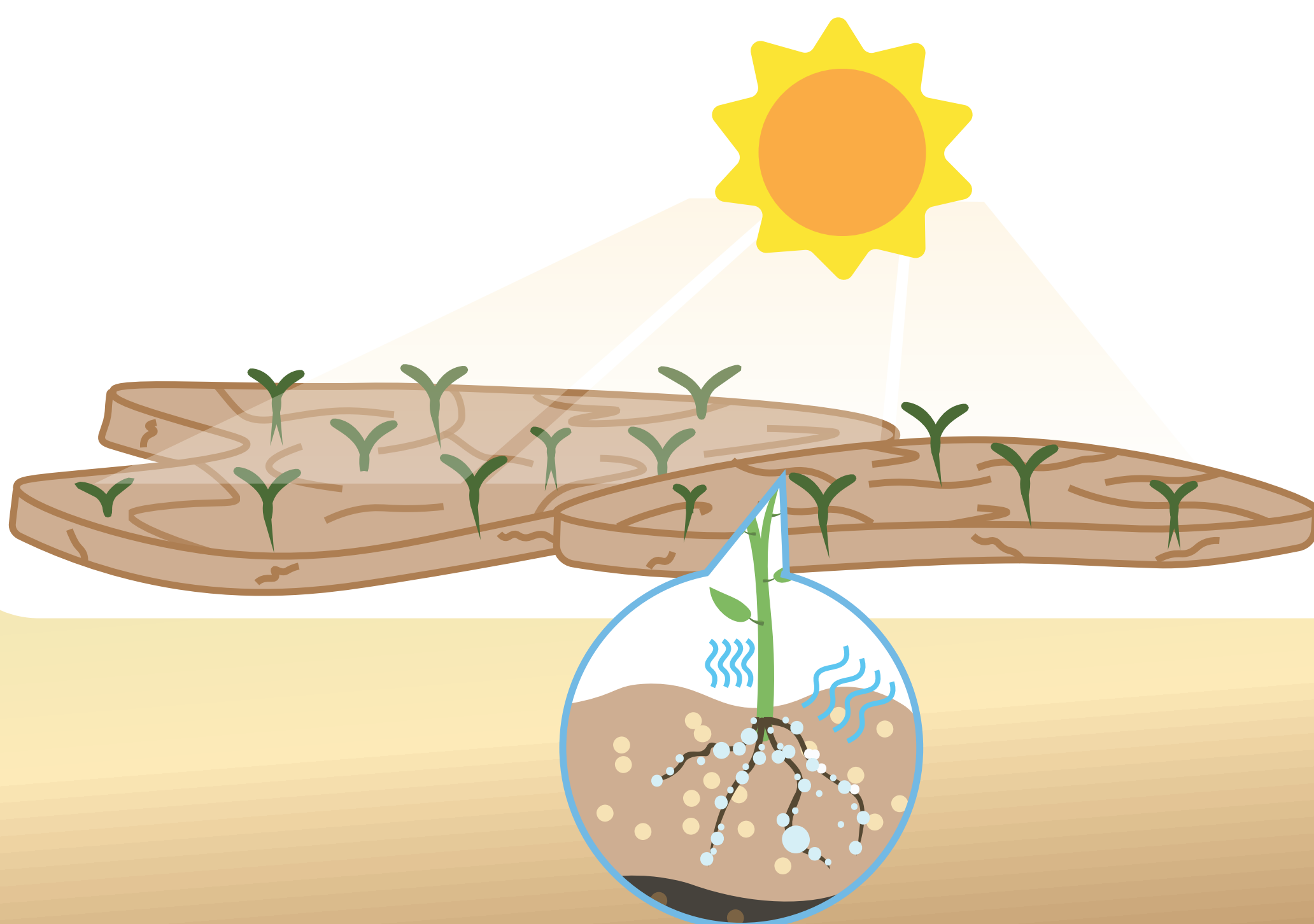
# HOW DO RISING SEA LEVELS AND HIGHER SOIL SALINITY AFFECT CROPS?

**As Sea Levels Rise, Low-lying Coastal Areas Are Increasingly Being Inundated With Saltwater, Which Gradually Contaminate The Soil**



While salt can be dissipated by rainfall, climate change is increasing the frequency and severity of extreme weather events, including droughts and heat waves. This leads to more intensive use of groundwater for drinking and irrigation, which further depletes the water table and allows even more salt to leach into soil.

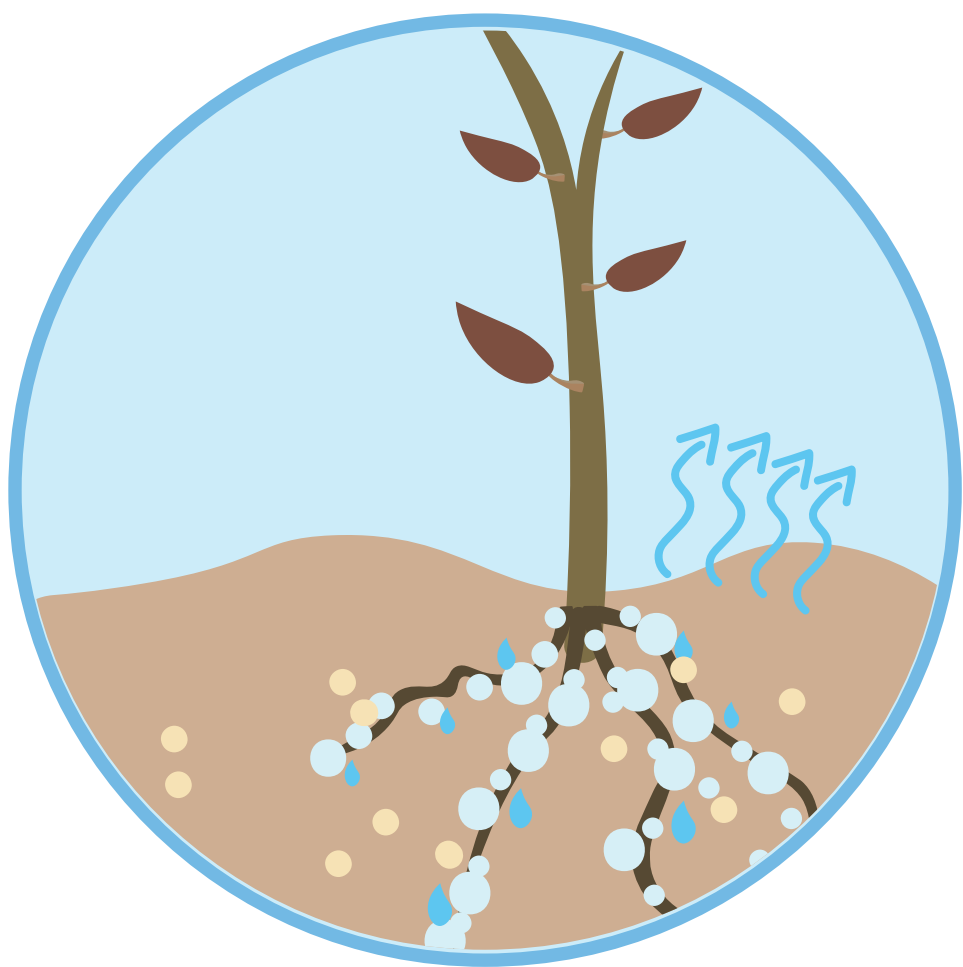
**As Saltwater Increasingly Floods Our Lands, Soil Salinity Increases**



This directly impacts the fertility of the soil for crop production. Essentially, having too much salt present in the soil is harmful for crops.



## When Water Evaporates, Salt Is Left Around The Roots Of Plants. Here Are Some Effects Caused By Soil Salinity:



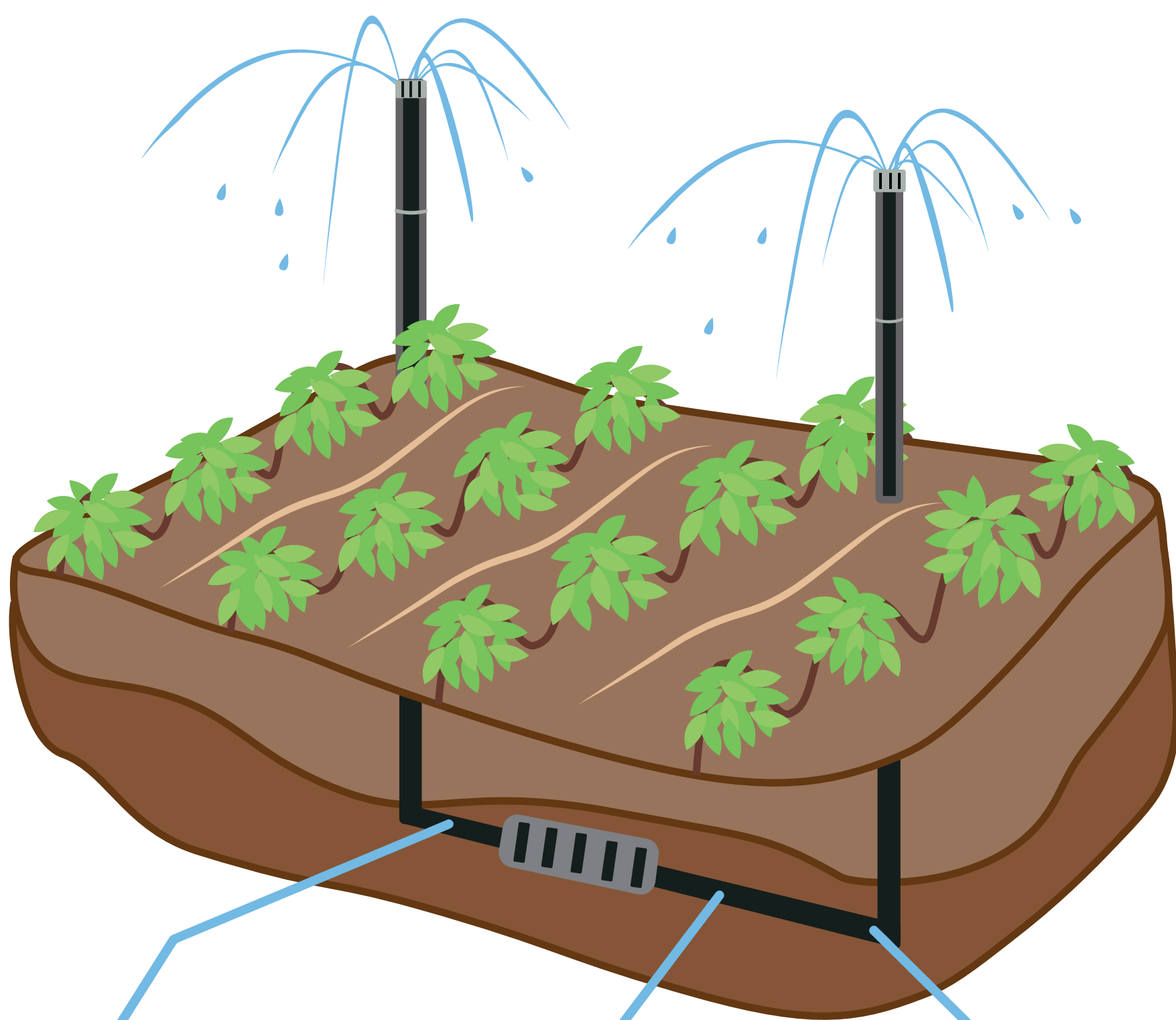
Preventing plants from absorbing water



Stunting growth of crops



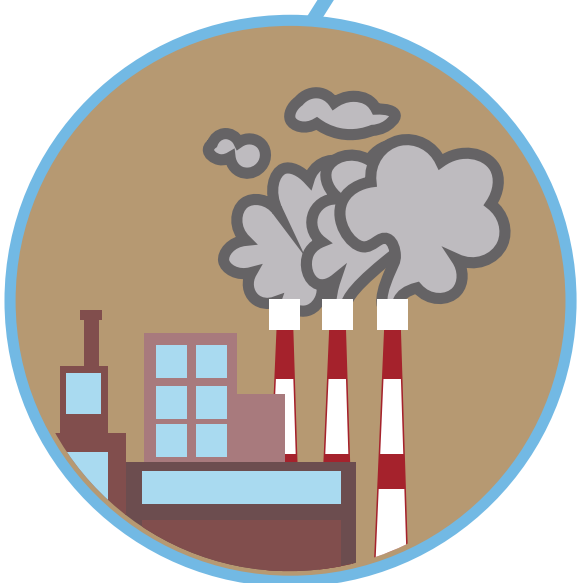
Contaminating natural water resources, causing the depletion of drinking water supplies



**Soil salinity is an enormous problem for agriculture under irrigation.**

In the hot and dry regions of the world, the soil has high salinity and low agricultural potential. In these areas, most crops are grown under irrigation.

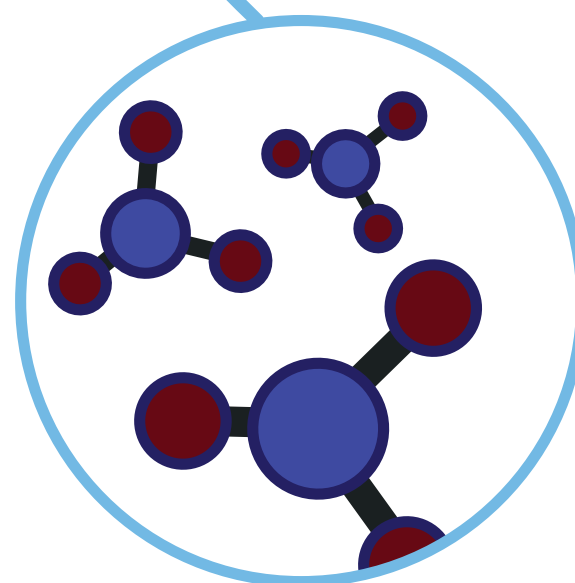
To exacerbate the problem, **inadequate irrigation management** leads to secondary salinisation that affects 20% of irrigated land worldwide.



Industrial Pollutants



Agricultural Pollutants

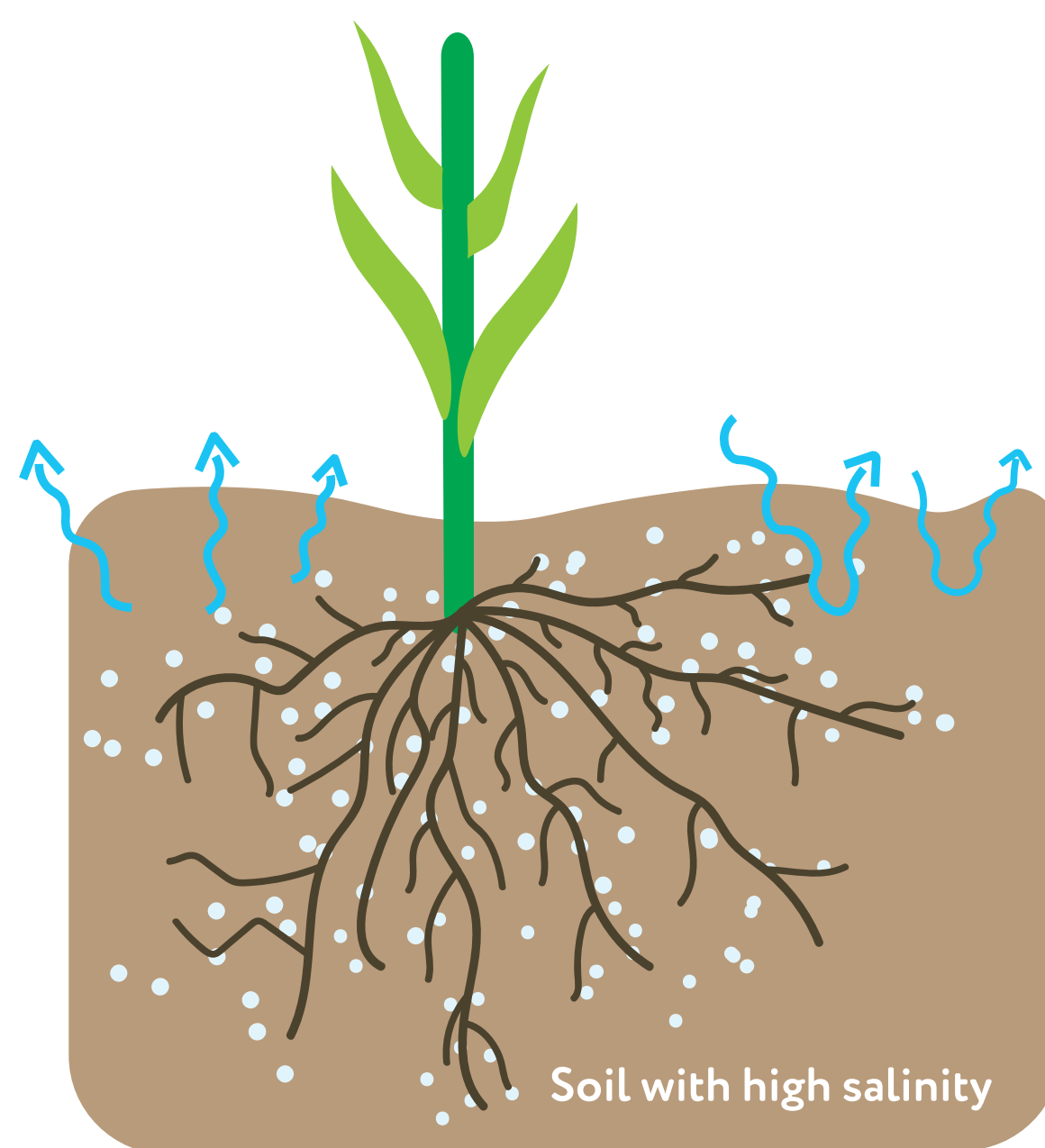


Chemical Composition

**Increased soil salinity will lead to low crop production and the loss of wide varieties of microbes and plant species.**

## 1. Decreased Water Uptake

When soil salinity is too high, water in the roots is pulled back into the soil.



As the level of salinity in the soil nears that of the roots, water becomes less and less likely to enter the roots.

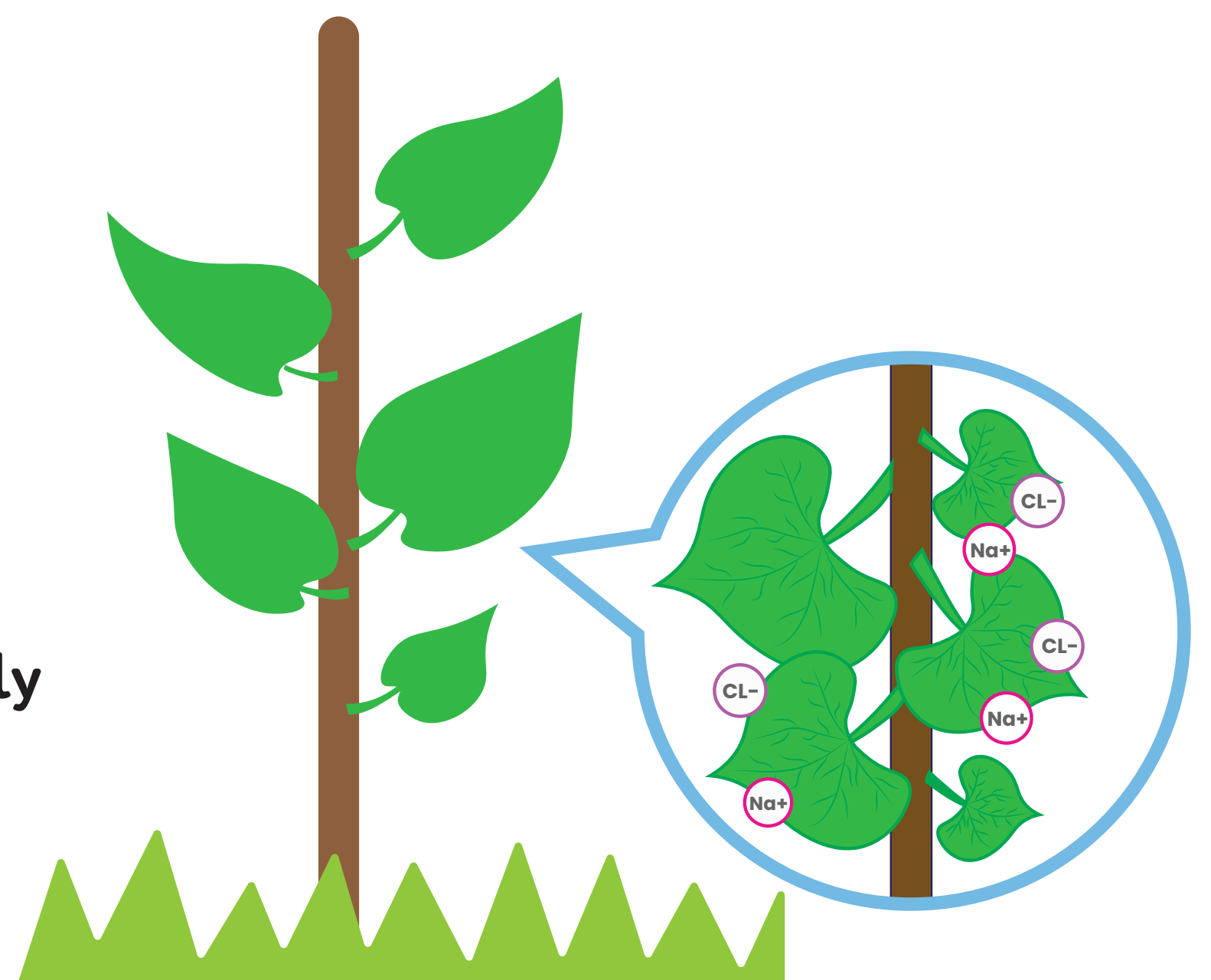
As the soil becomes more saline, plants are unable to draw as much water from the soil. This is because plant roots naturally contain varying concentrations of ions, or salts, that facilitate the flow of water from the soil to the roots.

In saline soil, salinity levels are close to that of the roots, which hinders this natural flow of water. The plant is thus unable to take in enough water to grow. If the salinity concentration in the soil is too high, the plant will wilt and die, regardless of the amount of water applied.

## 2. Ion-Specific Toxicity

Excessive accumulation of salts in the root growing solution and irrigation with saline water alters water movement in the plant. This leads to excessive and damaging accumulation of salts within the plant.

As a consequence, ion toxicity often induces necrosis or chlorosis in the plant tissues, frequently due to sodium but also chloride accumulation that interferes with a range of physiological processes in the plant.



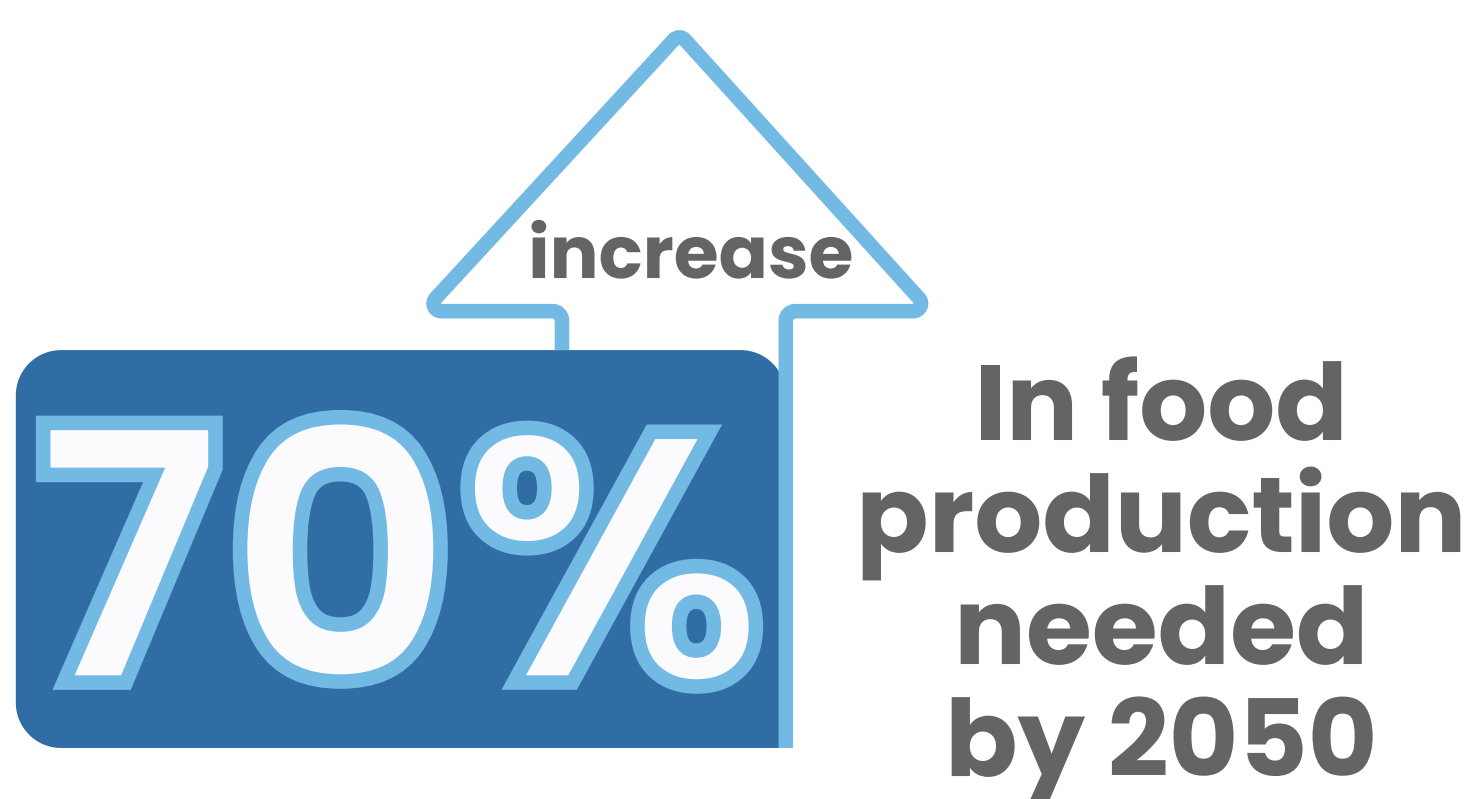
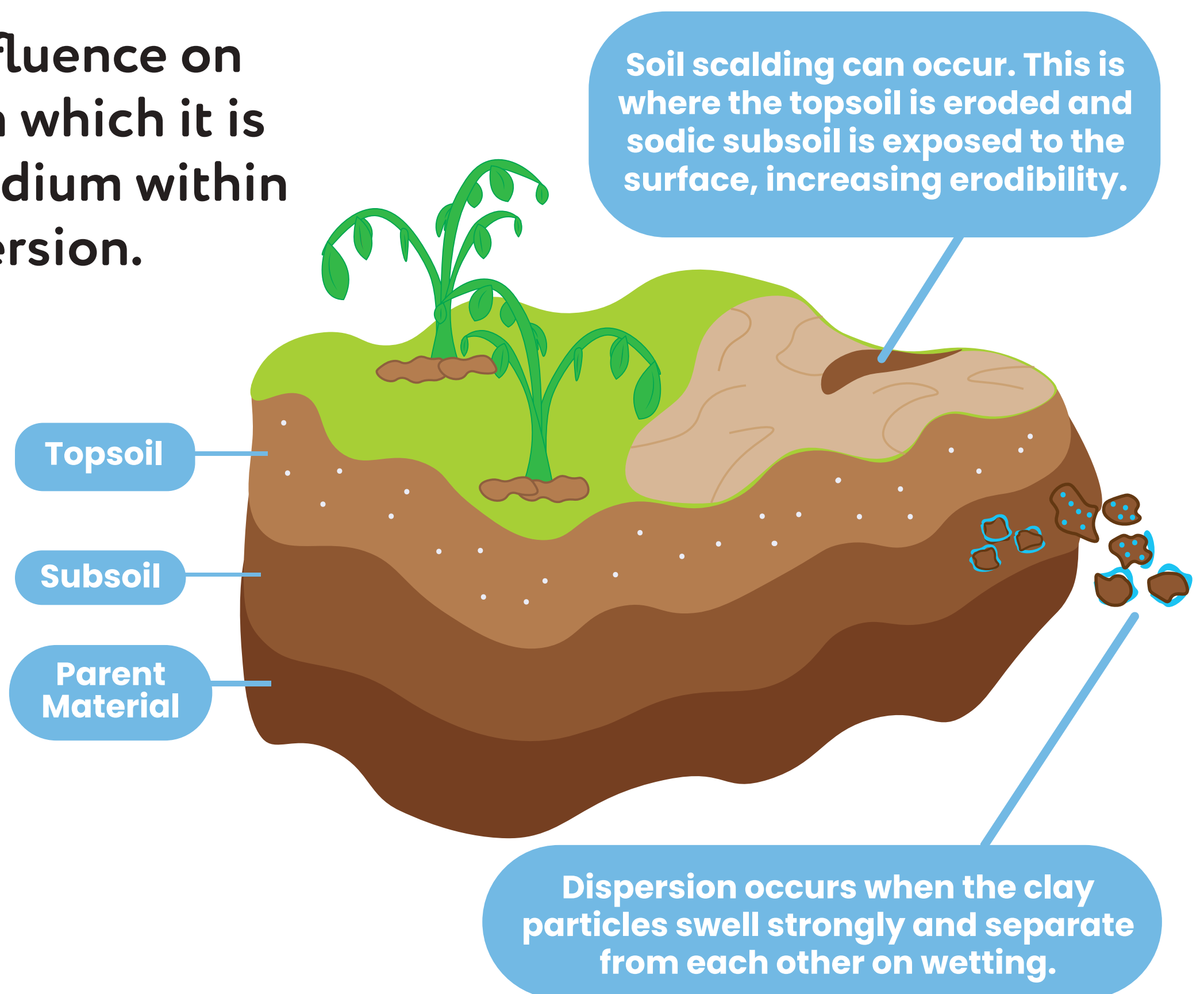
Source: Texas A&M AgriLife Extension, ScienceDirect, Eco-Business & Magazin MN



### 3. Sodium Effect On Soil Structure

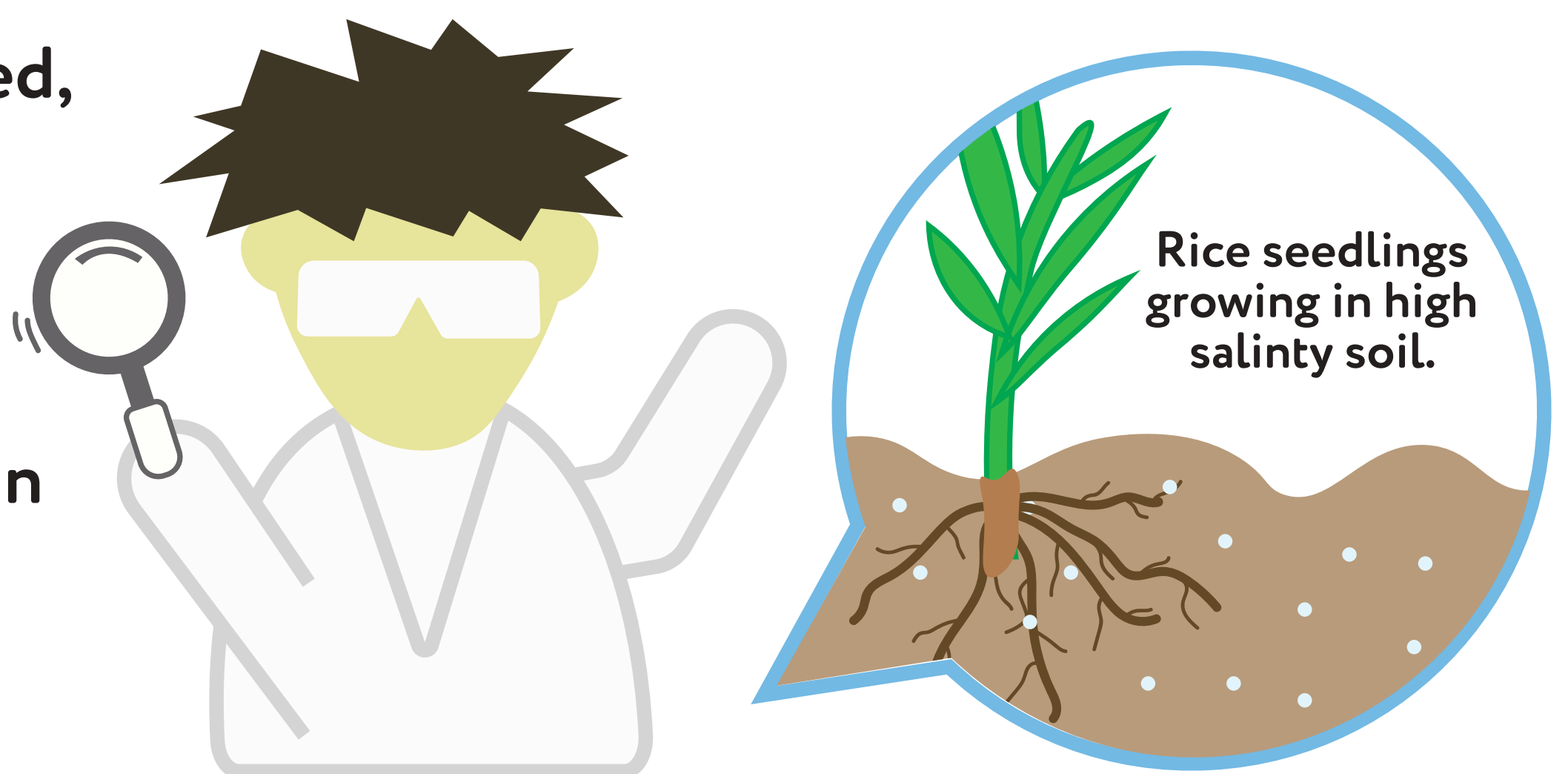
Sodicity in soil has a strong influence on the soil structure of the layer in which it is present. A high proportion of sodium within the soil can result in dispersion.

On drying, the soil becomes dense, cloddy and without structure. This dense layer is often impermeable to water and plant roots. This is how sodic soil can adversely affect the plants' growth.



As the United Nations has projected, particularly in irrigated areas where large-scale salinisation occurs.

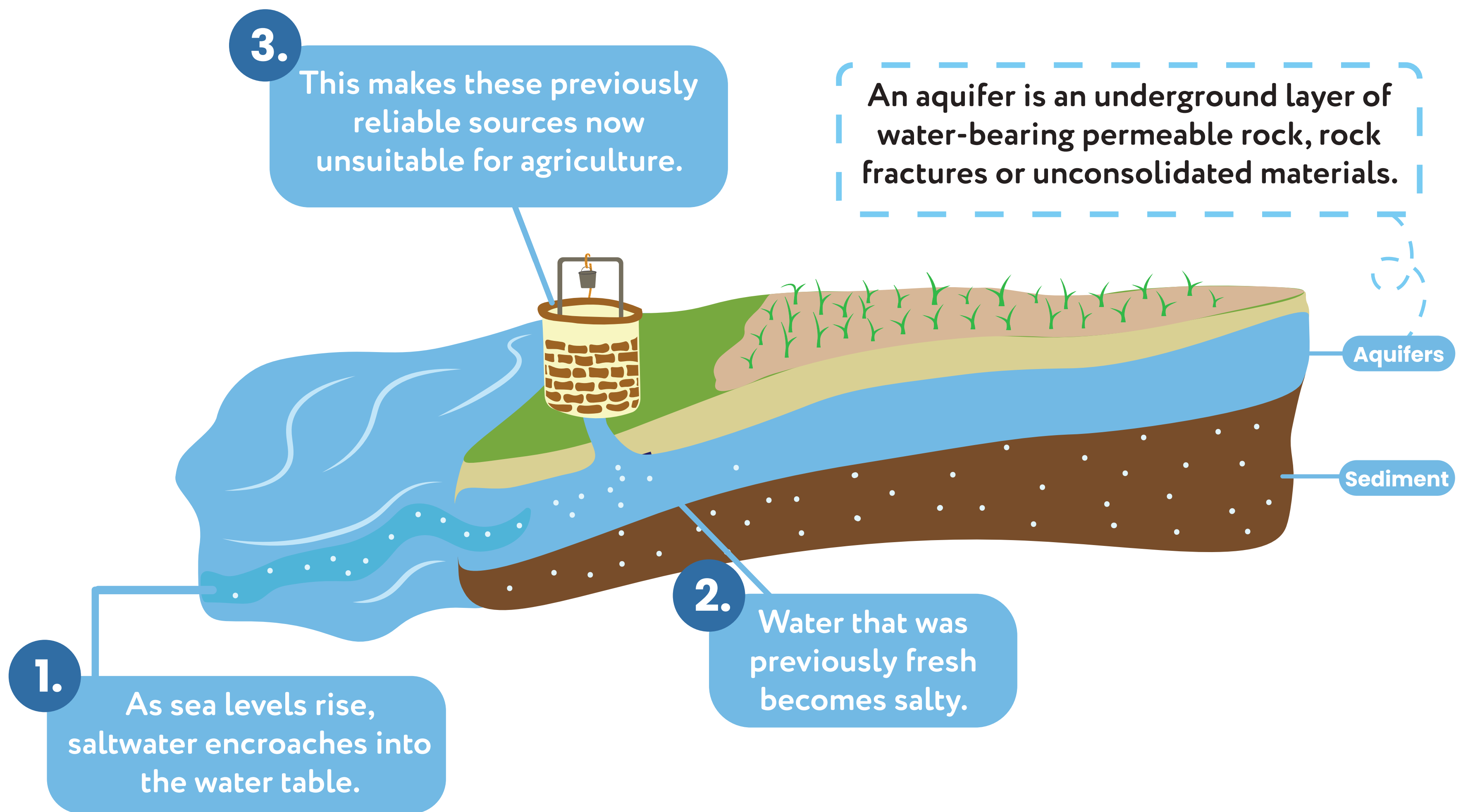
Rice farms are frequently flooded, and the crop itself is especially sensitive to salt. In response to these new pressures of rising sea levels, researchers are developing rice varieties that can handle higher salinity and other environmental stresses.



Source: Texas A&M AgriLife Extension, ScienceDirect, Eco-Business & Magazine MN

# HOW DOES GROUNDWATER CONTAMINATION AFFECT CROPS?

In many areas of the world, people get their freshwater from groundwater. This water is pumped up from aquifers for human use. One of the most significant ways freshwater is used is for agriculture.



**As changes in precipitation occur and the sea level rises,**

the occurrence of saltwater infiltrating groundwater resources may increase and reduce the availability of freshwater for coastal communities.



Source: Magazine MN, NEEF & The Washington Post



### Rising Seas



### Extreme Weather



### Sinking Land



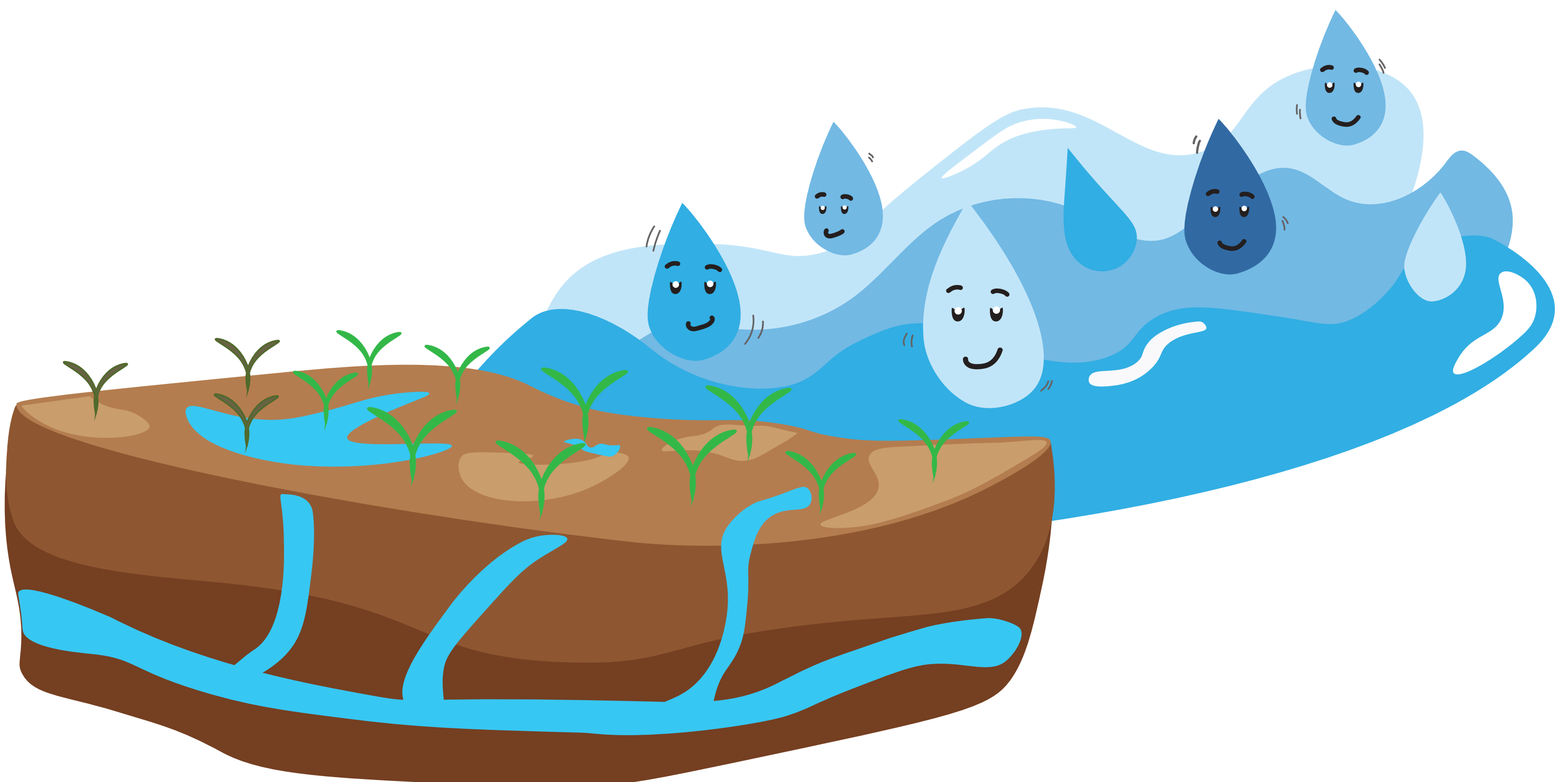
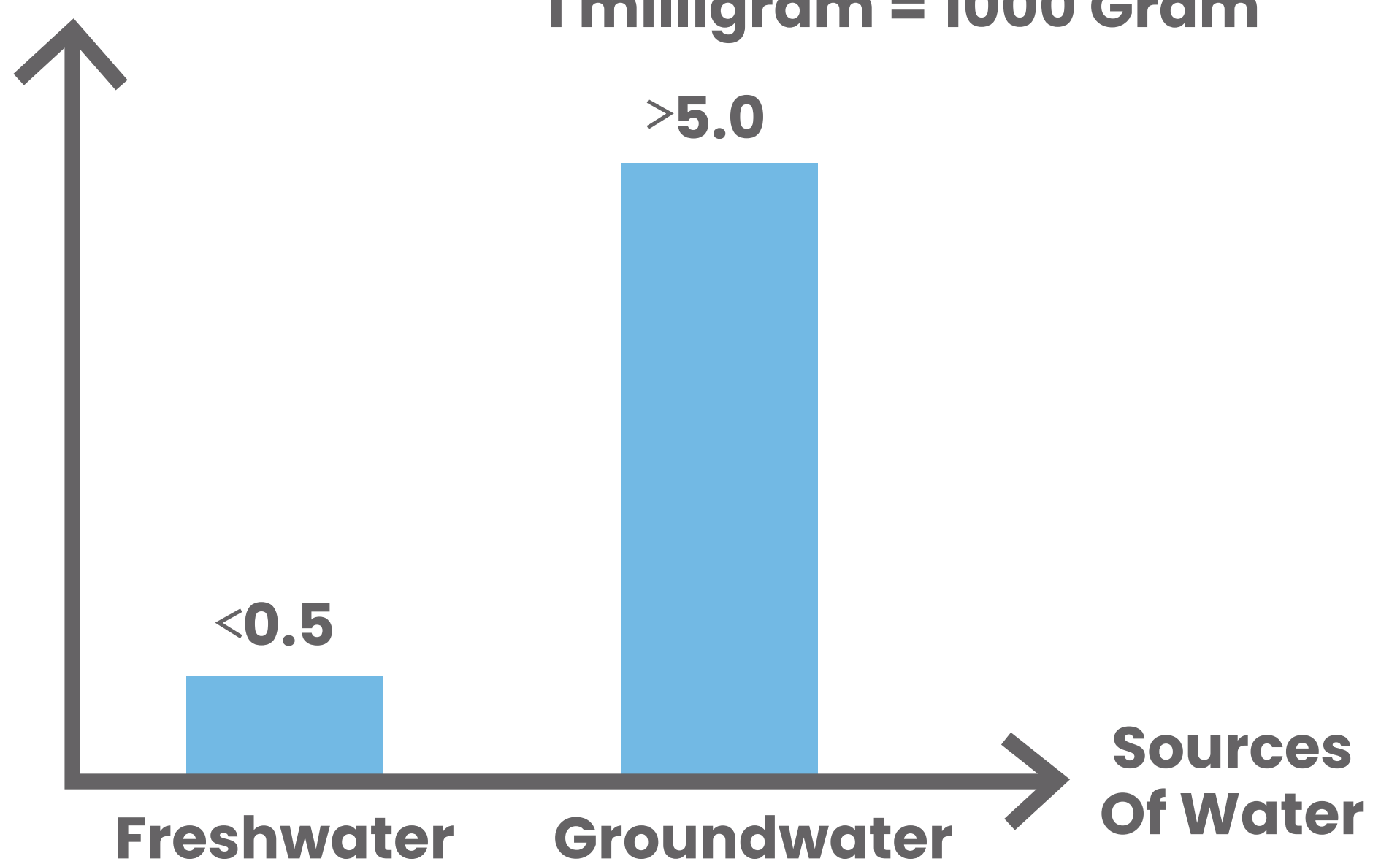
These are causing salt from the ocean to contaminate aquifers and turn fertile fields barren.

## Salinity Level Of Groundwater

In a study by researchers from North Carolina, the salinity of groundwater at a farmland located in Engelhard, North Carolina was found to be between five to nine parts per thousand - far above typical salinity levels of 0.5 parts per thousand, which is the recommended salinity level for agriculture.

Salinity Level

unit: parts per thousand  
1 milligram = 1000 Gram



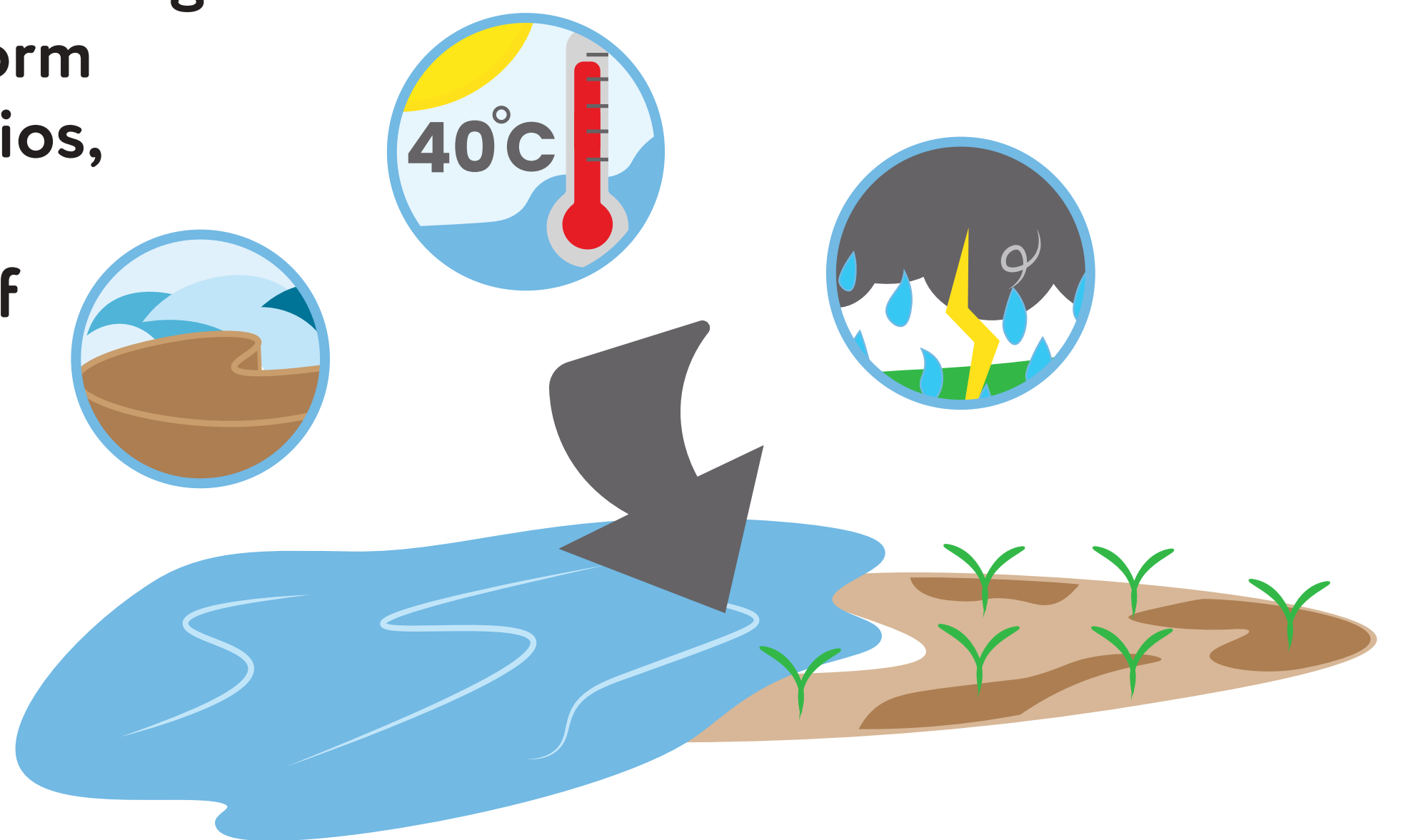
Source: Magazine MN, NEEF & The Washington Post

# HOW DOES AN INCREASE IN FLOODS AFFECT CROPS?

## Warmer Temperatures Are Also Resulting In Stronger And Wetter Storms

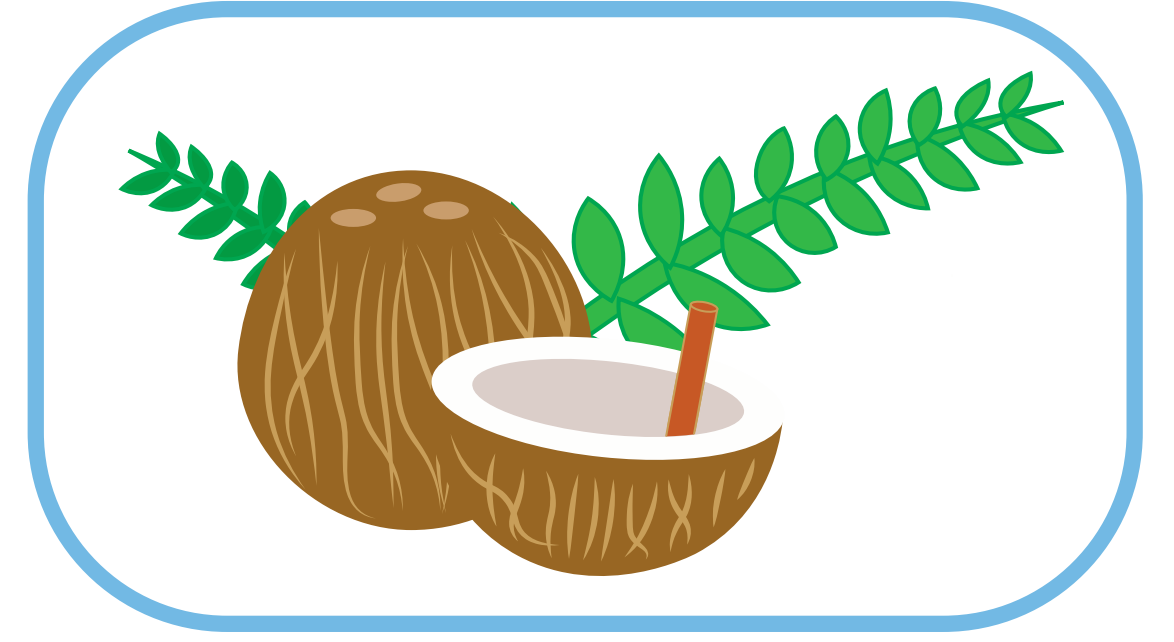
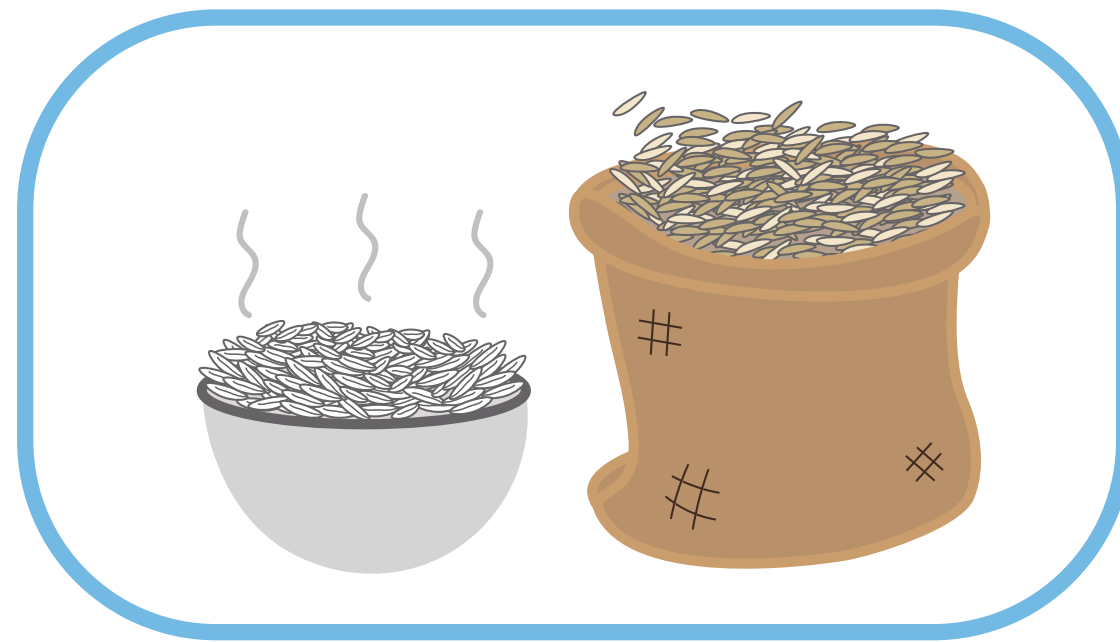
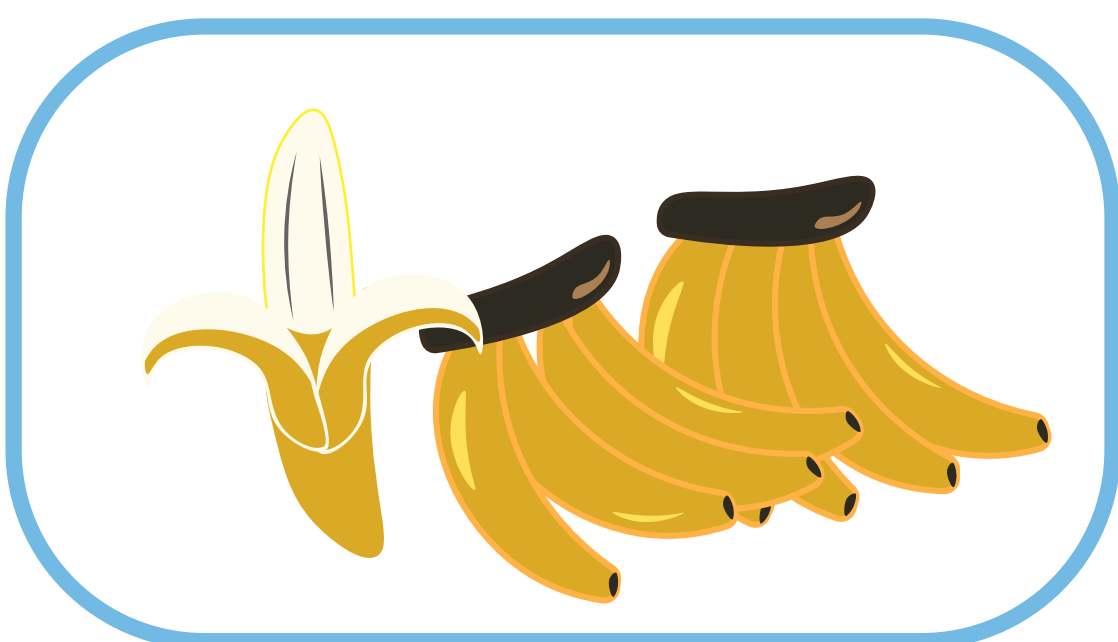
Warmer temperature combined with rising sea levels create more damaging storm surges. Under future climate scenarios, including sea level rise and greater storm surge frequency, the extent of coastal flooding is set to increase.

With rising sea levels, storm surges become more widespread and catastrophic. This leads to greater amounts of land being exposed to saltwater flooding.



## Coastal Flooding Of Farmland Can Lead To Immediate And Long-Term Crop Losses

Even after floodwater recedes, salt deposition from seawater establishes a legacy of soil salinity, negatively affecting the growth of many crops with a long-term impact on soil structure.



Flooding makes growing crops like rice, bananas and coconuts more difficult as these crops are mostly grown in low-level coastal areas. Flooding in these areas can kill these crops. This will likely heavily impact coastal countries.



## Rice Is Grown In Vast Low-Lying Deltas And Coastal Areas In Asia

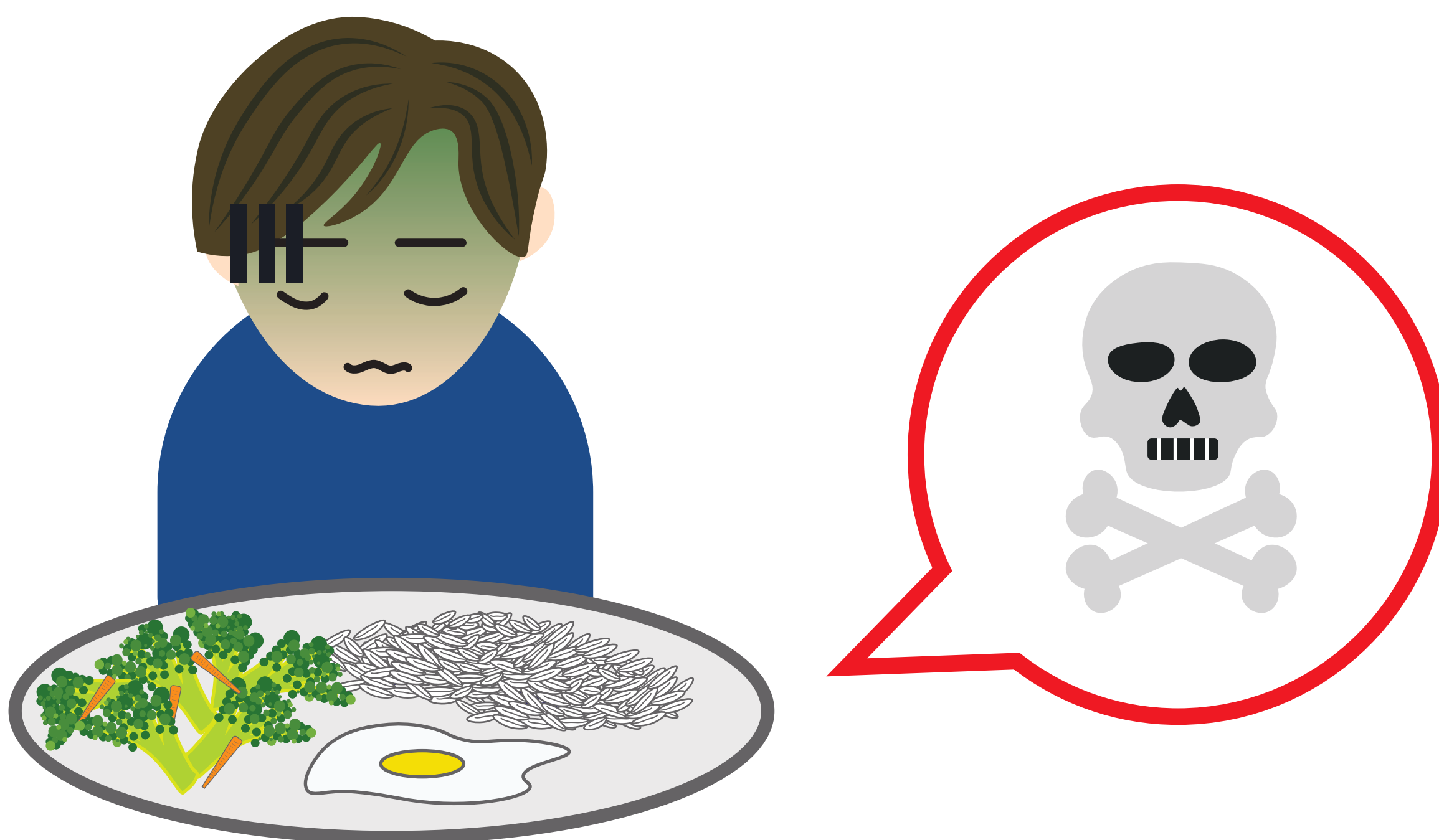
More than half of Vietnam's rice produce, for instance, is grown in the Mekong River delta—all of which are vulnerable to sea level rise.



Predicting the precise effect of sea level rise on rice production in vulnerable areas is complicated as the entire hydrology of the delta would be affected; sediment discharge and shoreline gradients would also change.

## The Growing Intensity Of Tropical Storms May Result In More Flooding

Sea level rise is also likely to increase with climate change, and can lead to the drowning of crops. Floodwater can also transport sewage, manure or pollutants from roads, farms and lawns. As a result, more pathogens and toxins could find their way into our food.



Physical damage caused by a coastal flood will not only affect the farmland but also the entire agricultural pipeline, from fertiliser and machinery suppliers to processing plants and distributors.

Source: MarshMclennan, Wiley Online Library, Magazine MN, Ricepedia & Comlumbia Climate School

# HOW DOES EROSION DESTROY AGRICULTURE?

**Soil Erosion Is A Gradual Process Of Movement And Transport Of The Upper Layer Of Soil (Topsoil) By Different Agents**

**Water, wind and mass movement can cause the topsoil to deteriorate in the long term.**



**As Flooding Becomes More Frequent And Far-Reaching, Erosion Will Also Become More Widespread**

When floodwater recedes, it can sweep away soil and land. This can deteriorate agricultural lands, which previously did not flood or only flooded infrequently.



Unfortunately, erosion control measures are often costly and ineffective. This makes them particularly problematic in developing countries with limited financial resources. Often enough, agricultural land heavily impacted by erosion will become permanently unusable.

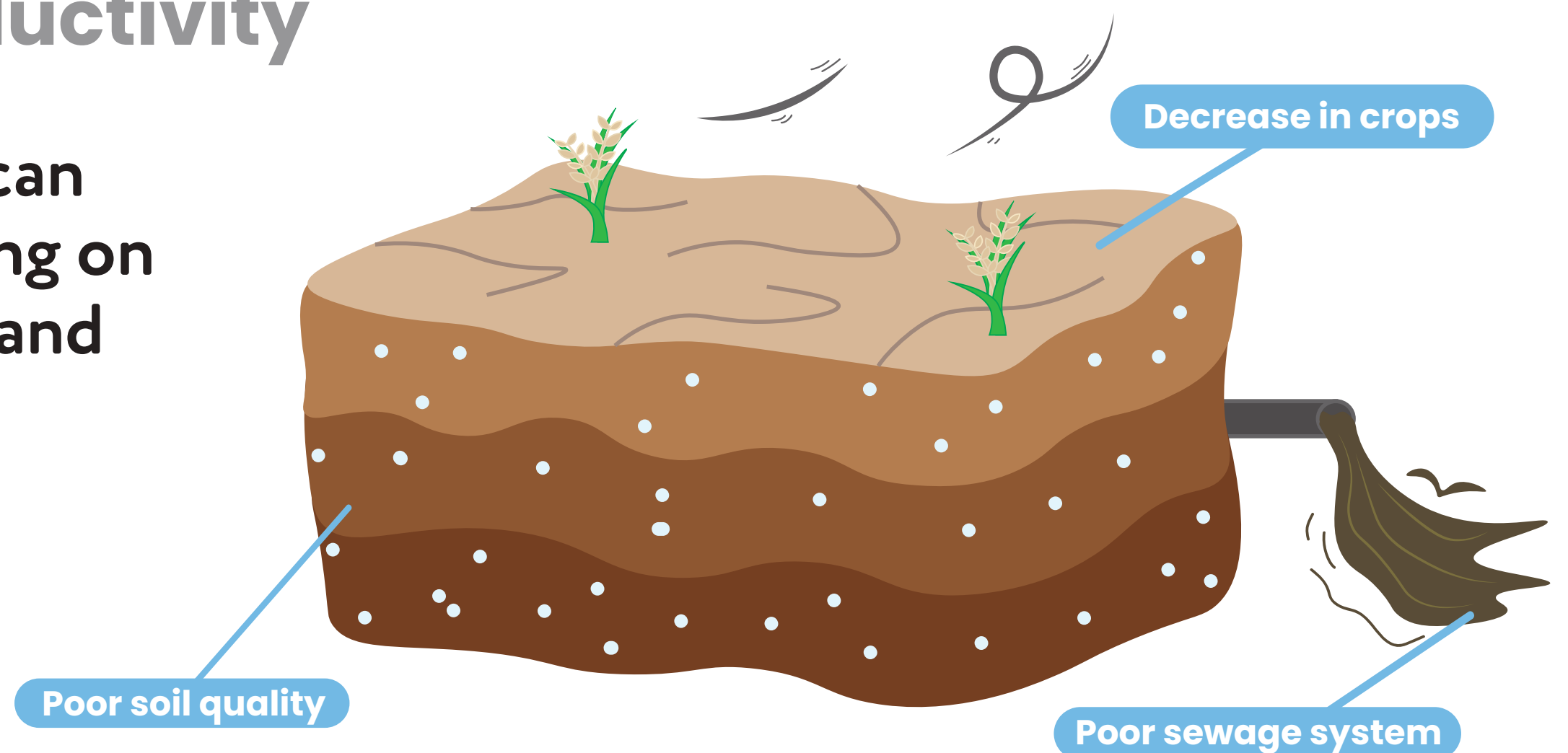
Images source: Unsplash



## Effects Of Erosion:

### 1. Reduced Crop Productivity

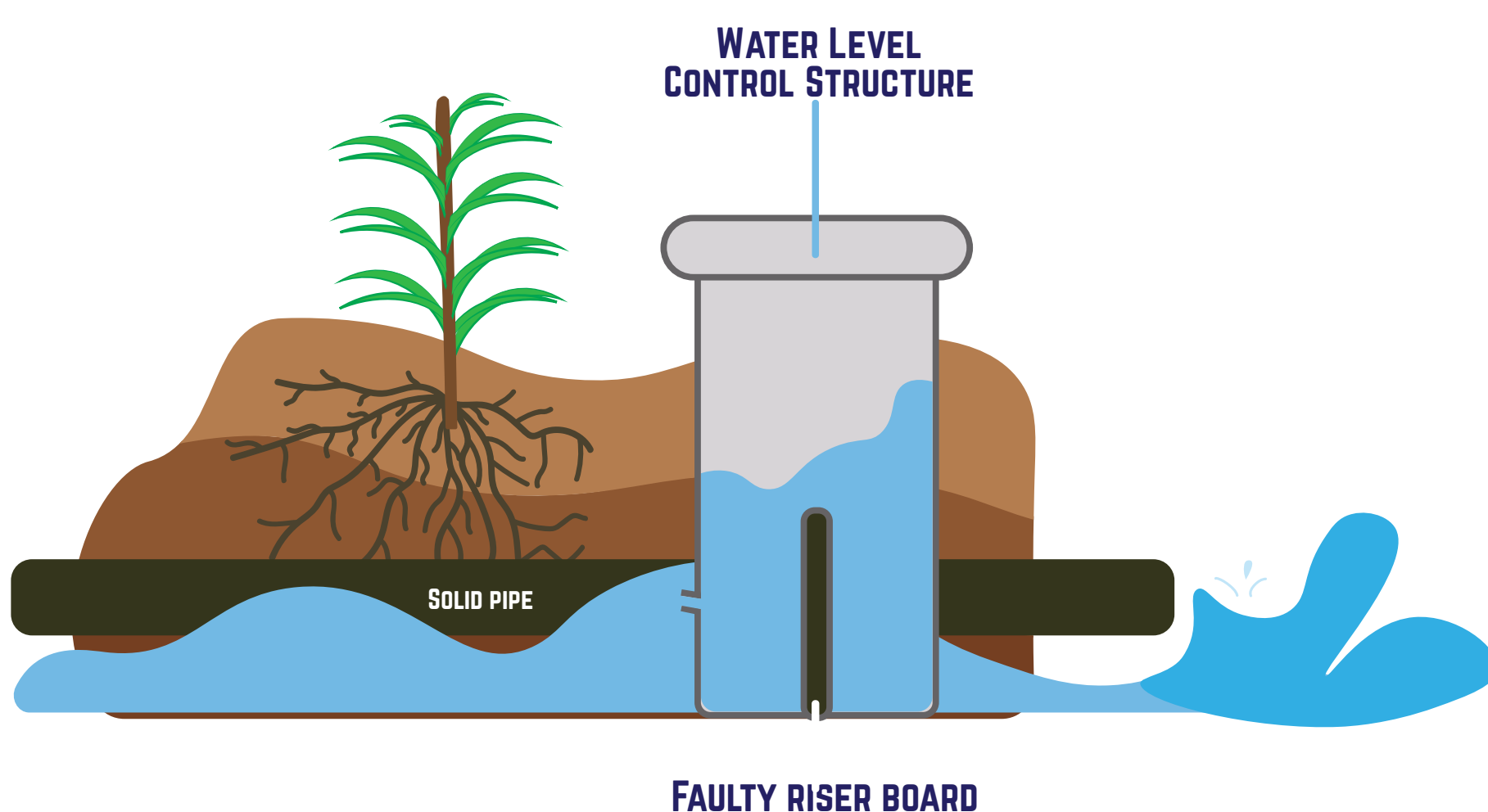
The development of erosion can take a different pace depending on the circumstances. It affects land productivity and soil fertility, degrades water quality, and affects water drainage.



### 2. Lack Of Moisture

Moisture is known as an important factor for soil all over the world. Erosion results in groundwater pollution, and the stiffened structure of soil, caused by lack of moisture, impedes the flow of water in deeper layers.

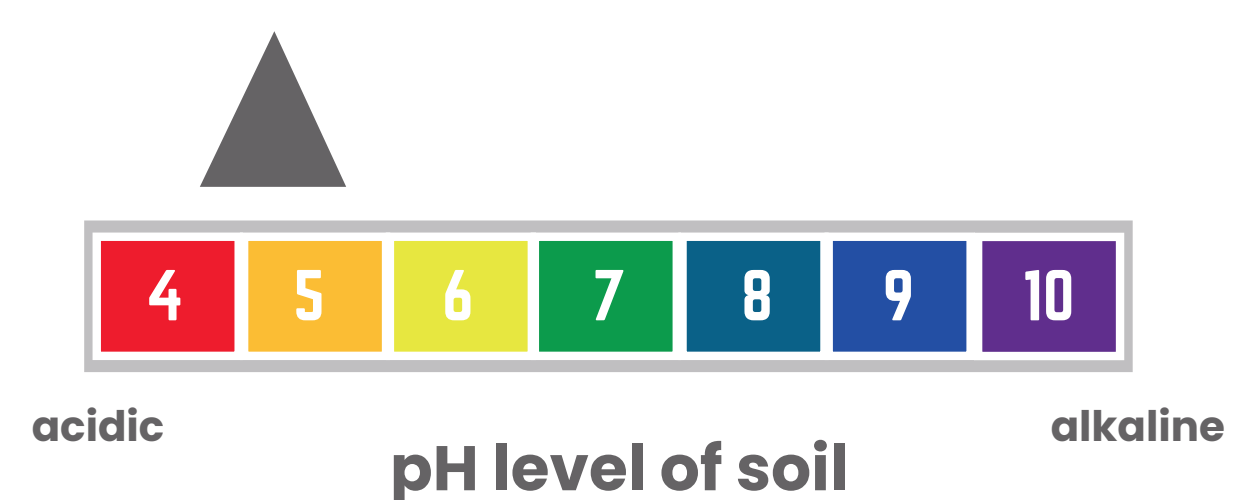
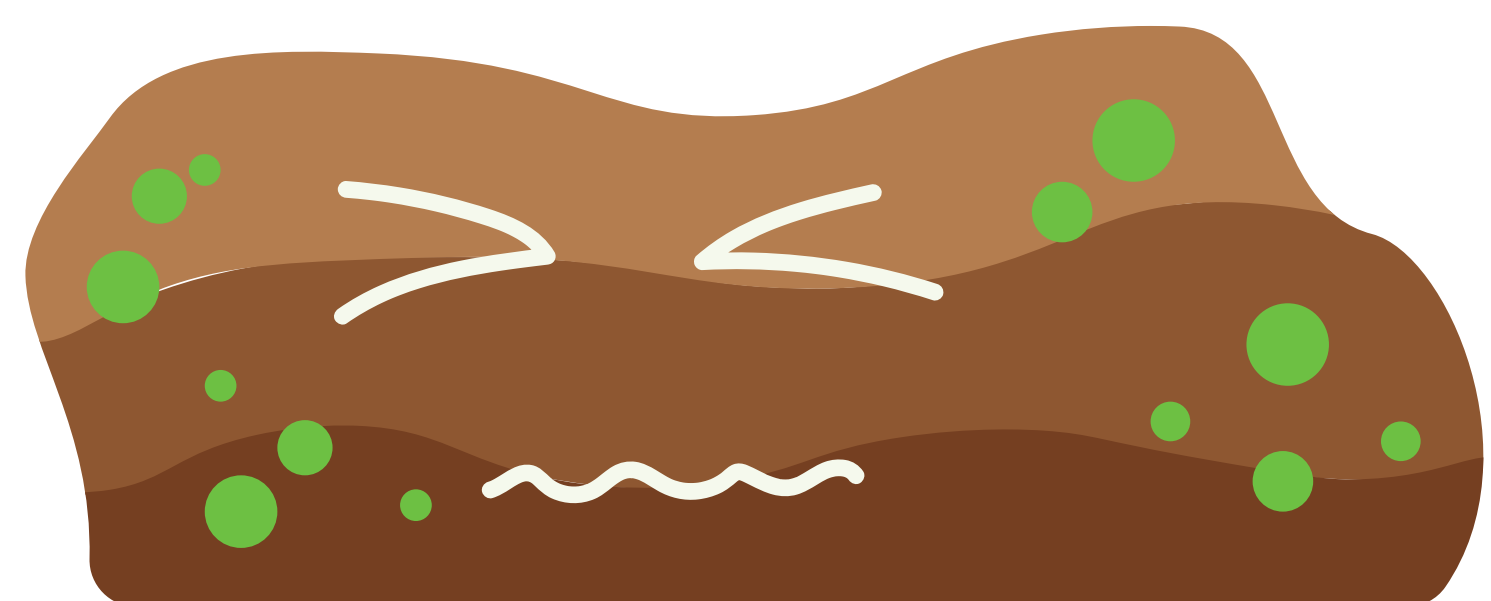
Poor drainage speeds up erosion due to densely-packed soil. This leads to insufficient levels of soil moisture, which may decrease field productivity.



### 3. High Soil Acidity

Another detrimental effect of erosion is the increased level of acids in soil as the biological structure is impaired. Once organic masses are thinned out from the topsoil layers, the soil is no longer able to maintain an acceptable pH level. pH values above or below the desired range undermine the ability of plants and crops to grow.

Soil with a pH level of 4.0 to 5.0 is extremely acidic!



Source: Youmatter, Magazine MN & Earth Observing System

# HOW DO RISING SEA LEVELS AFFECT CROP YIELD?

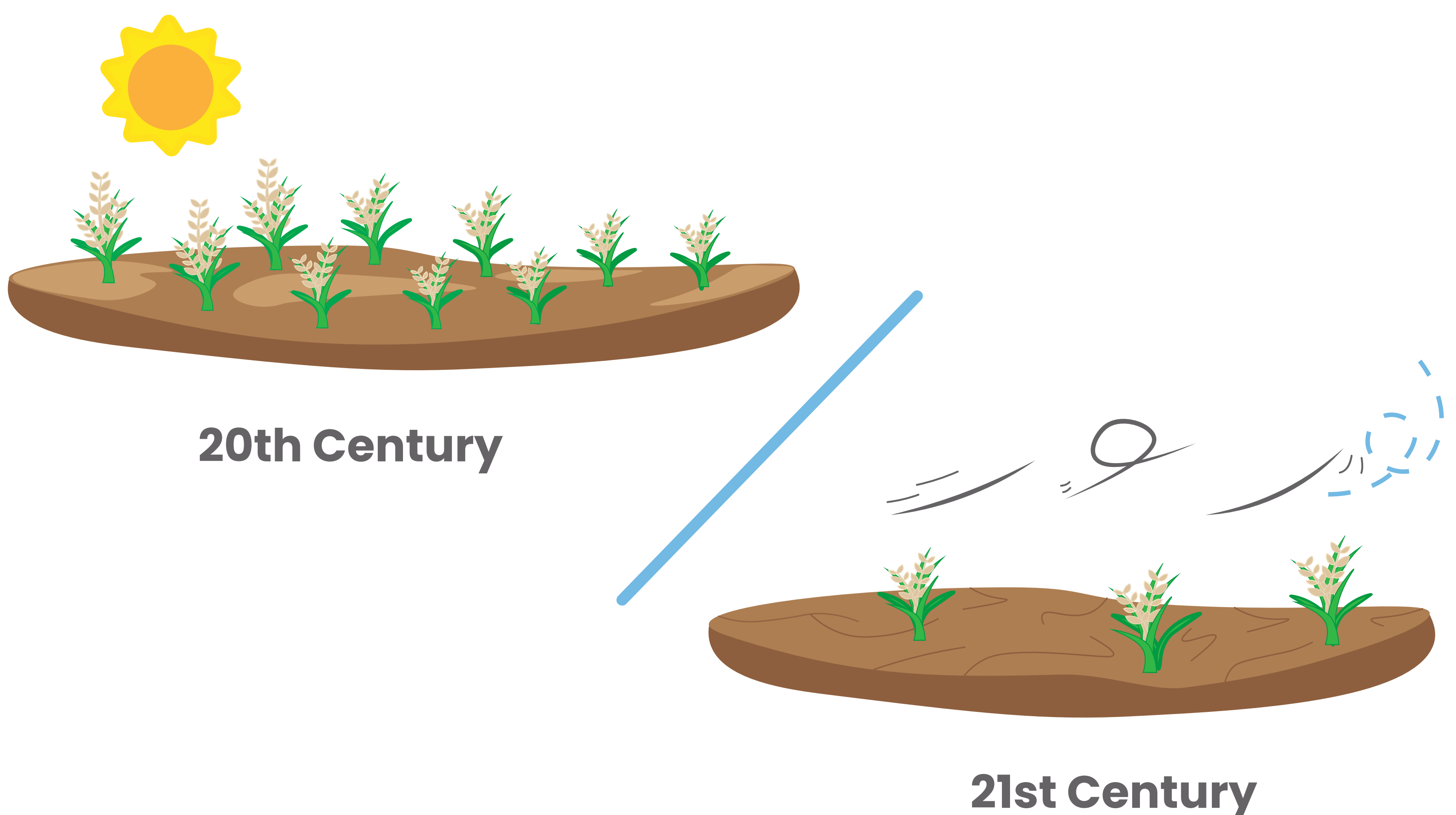
According To A Food & Agriculture Organisation Report:



Image Source: Pixabay & Unsplash

Increasing temperatures, rising sea levels and changes in rain patterns because of global climate change will make water and land resources scarce. This will then substantially impact rice cultivation.

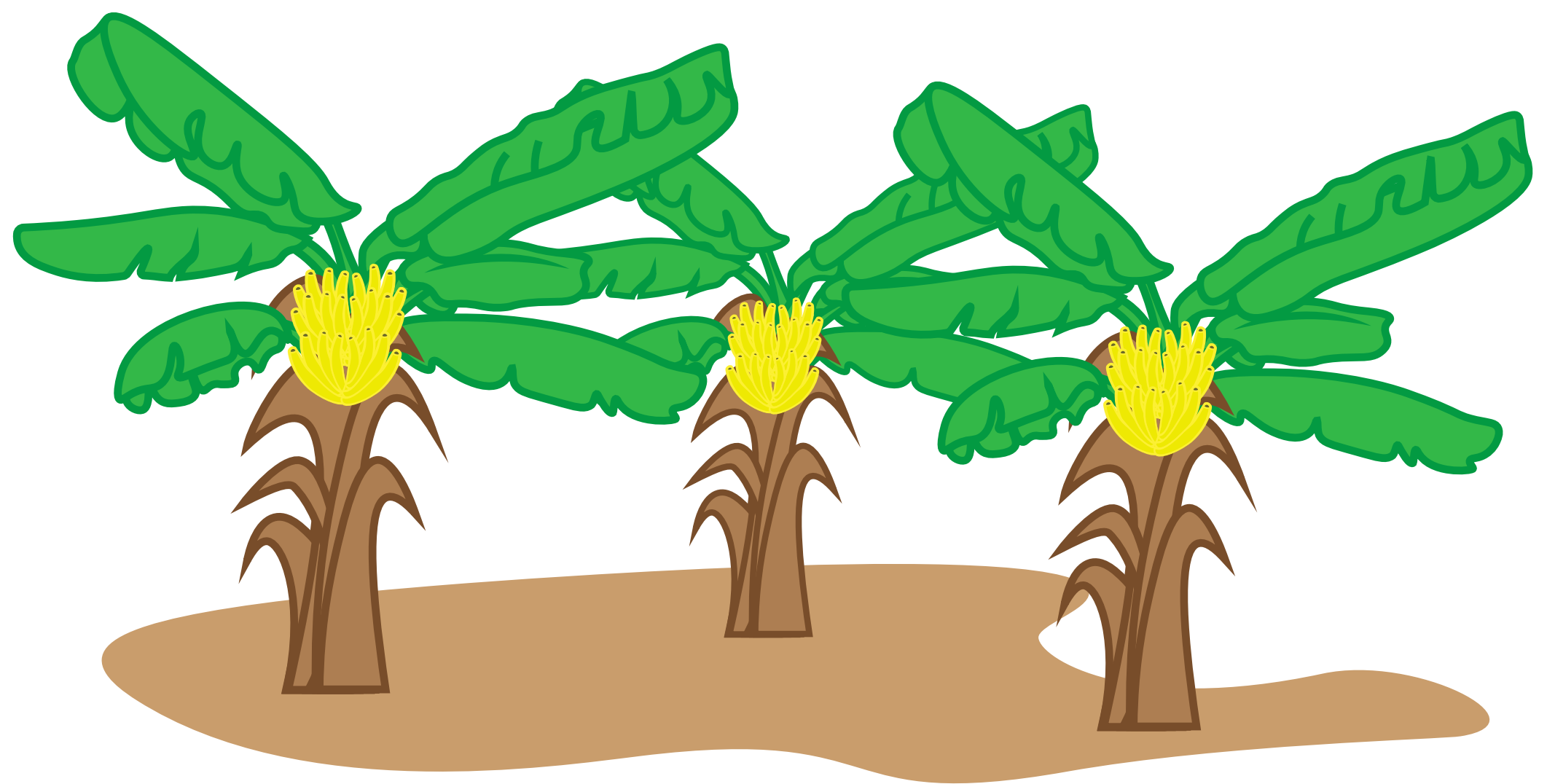
This will especially impact Asia, where the viability of land to grow rice crops decline by more than 50% within the next century. In Asia, where much of the rice is grown in coastal areas and low-lying deltas, rising sea levels will likely disrupt rice production, and saltwater that moves further inland can reduce yields.





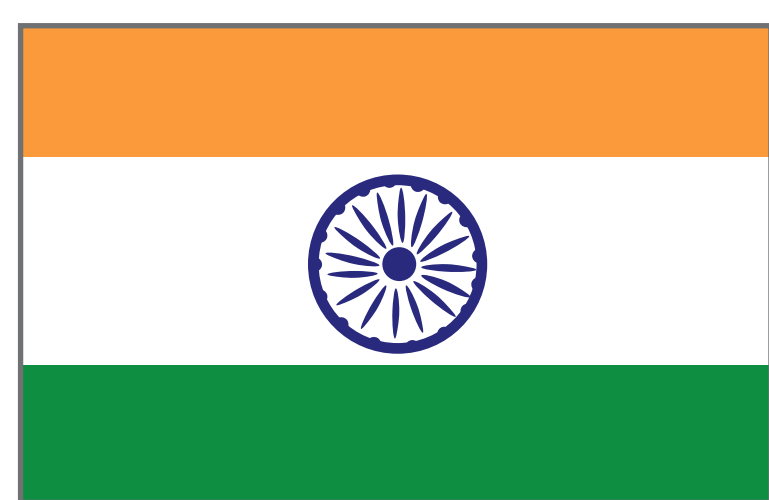
**In a recent study by the University of Exeter, banana production could be wiped out by adverse climate conditions in 10 countries by 2050!**

Although crop yields have increased since 1961 due to higher temperatures and better production methods, global warming and frequent floods and droughts will still threaten banana production.

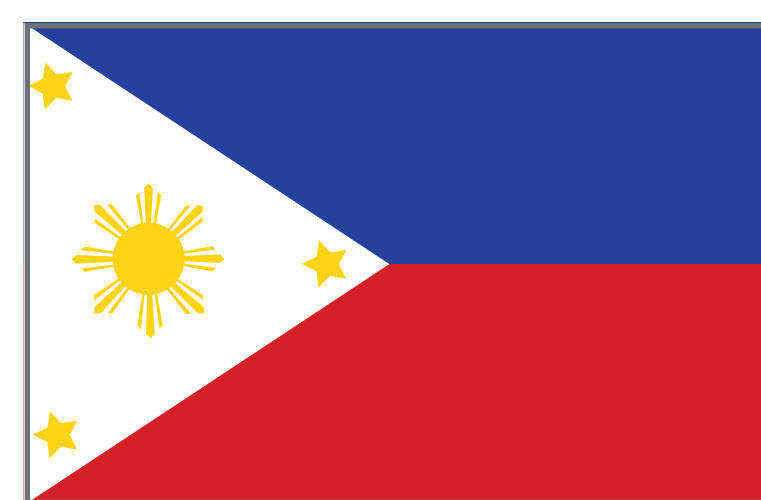


**Banana production won't just be threatened in South America but also at our doorstep in Asia:**

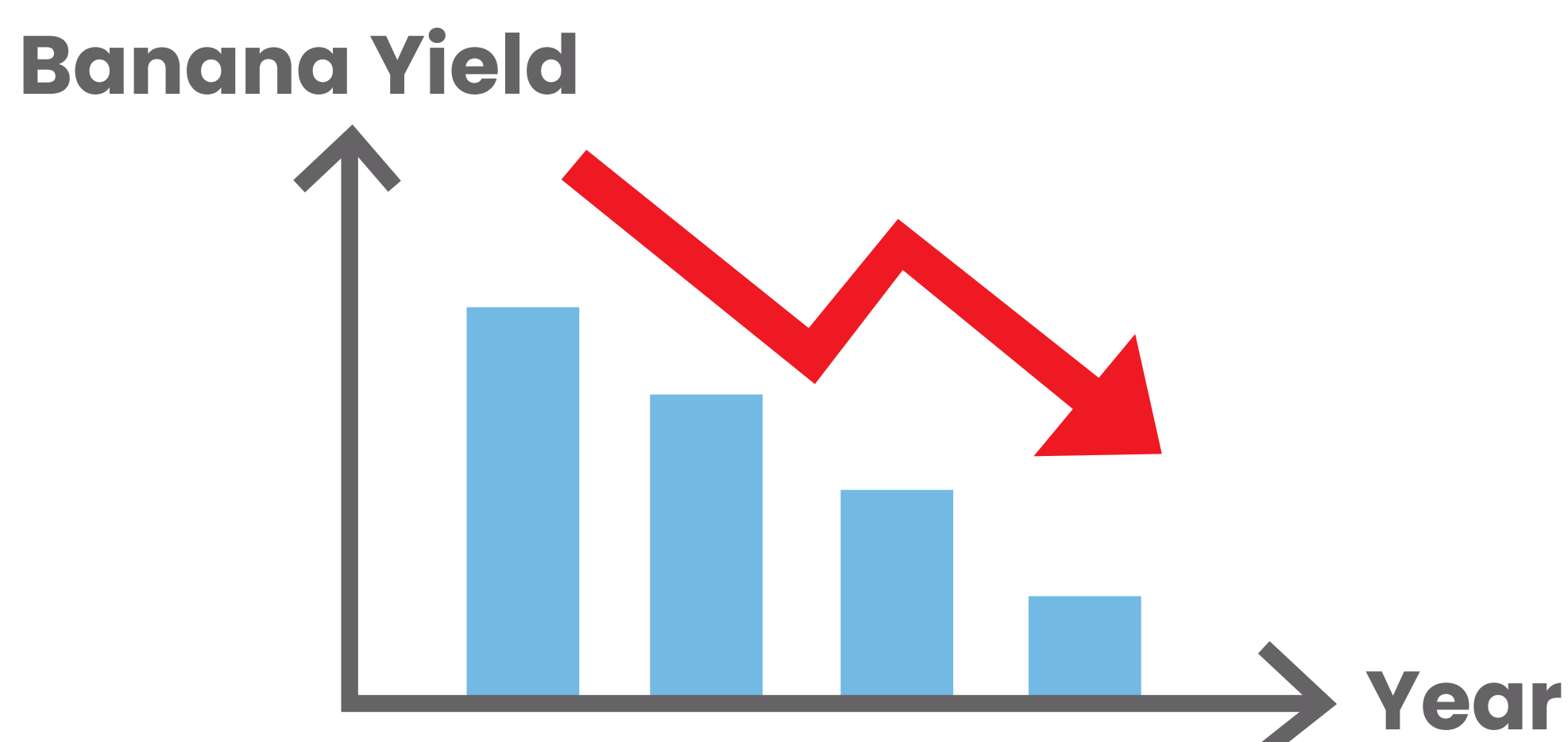
**India**



**The Philippines**



**The world's 2 largest producers and consumers are projected to suffer marked drops in banana yields in the coming decades.**



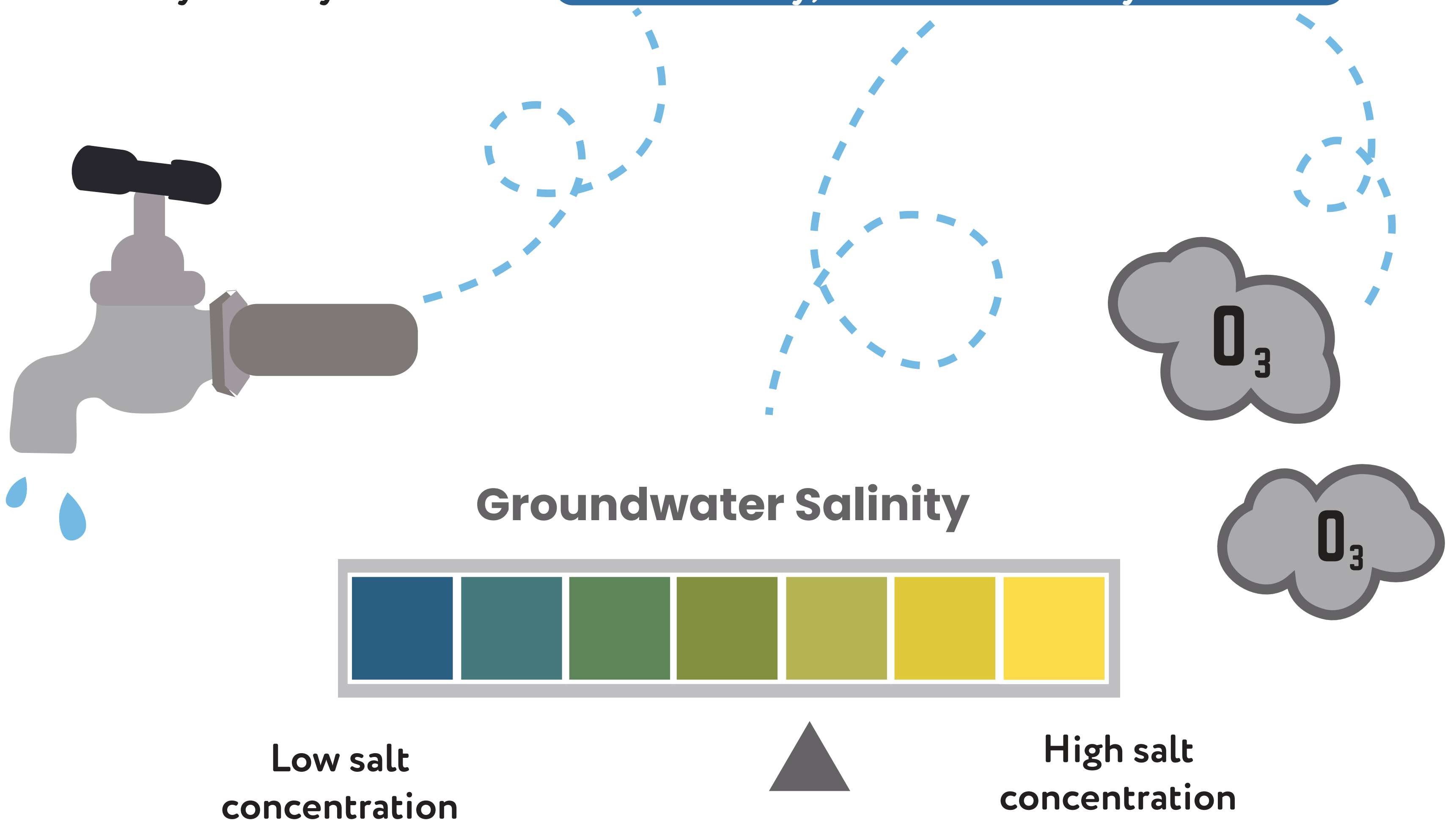
**Coffee is set to disappear as 50% of the land used to grow coffee will not be arable by 2100.**



Arabica Coffee Plant

A landmark Intergovernmental Panel on Climate Change report warned of the urgent need to tackle land management, with topsoil erosion happening at faster rates than ever before, threatening irreversible ecosystem loss. A study published in the journal Science Advances stated that popular coffee species, such as Arabica which makes up 60% of global production, are under threat.

A recent study of global vegetable and legume production concluded that if greenhouse gas emissions continue on their current trajectory, yields could fall by 35% by 2100 due to **water scarcity, increased salinity and ozone.**



Source: Green Queen Media & Columbia Climate School

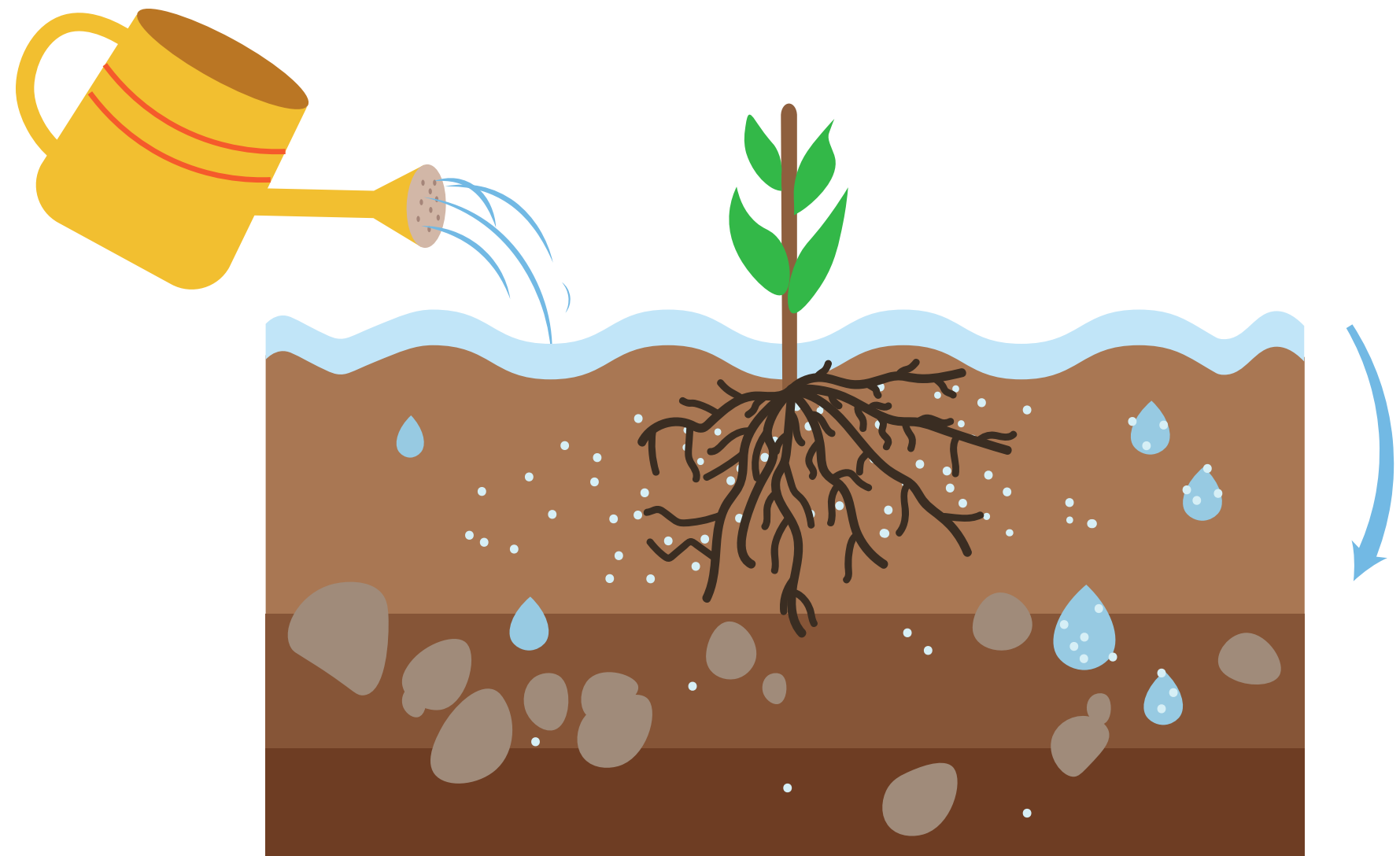


# HOW TO MANAGE HIGHER SALT CONTENT IN FARMLANDS?

## There Are Three Ways To Manage Saline Soils:

### 1. Leaching Requirement Method

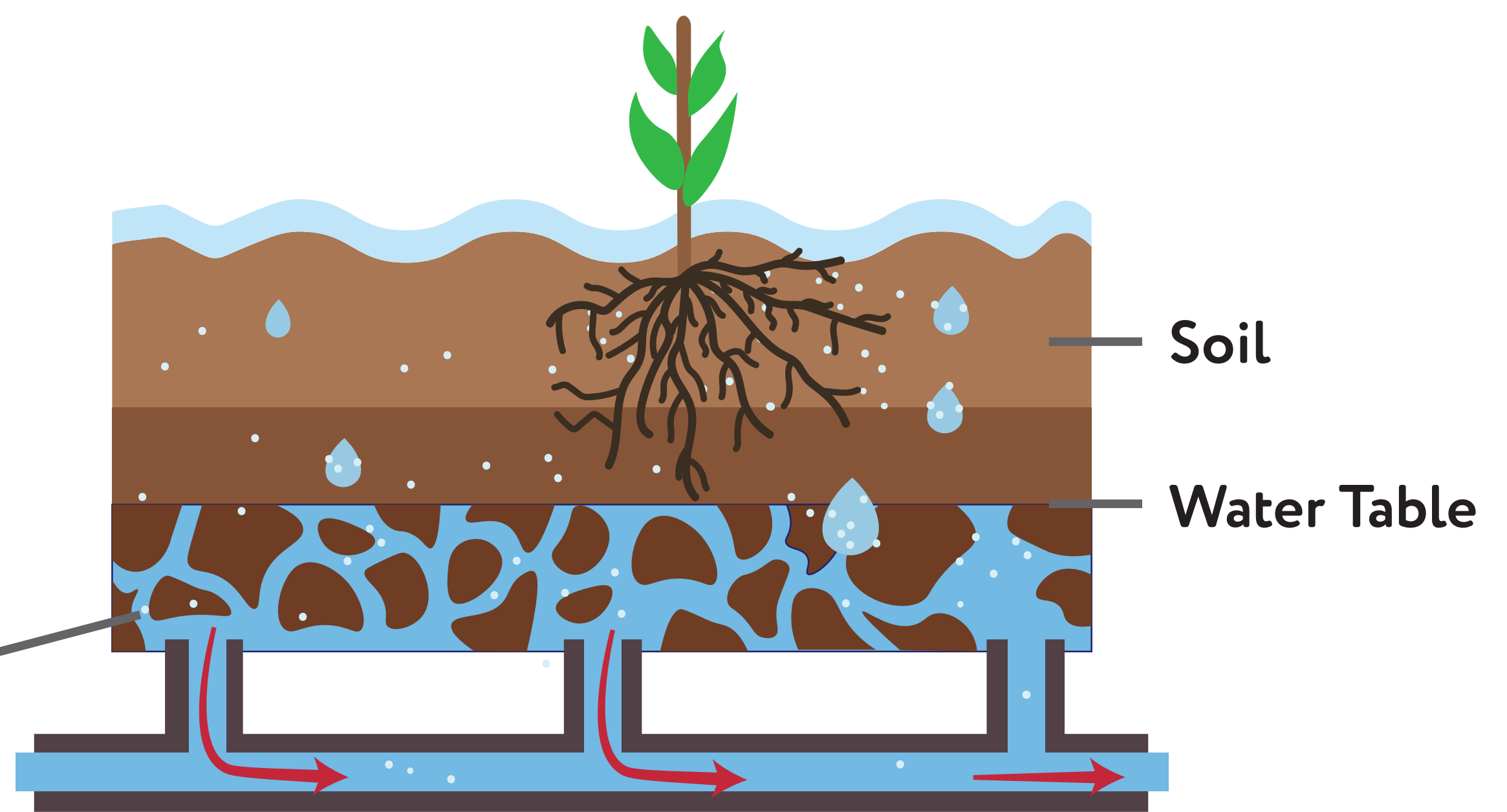
Salts can be moved below the root zone by applying more water than the plant needs.



Once the soil is saturated with water, the water begins to leak deeper into the layers of rock and subsoil beneath. When this happens, the water-soluble salts are also carried further down into the soil.

### 2. Leaching + Artificial Drainage

**Zone of saturation** refers to the area where the pores and fractures in the ground are saturated with water.



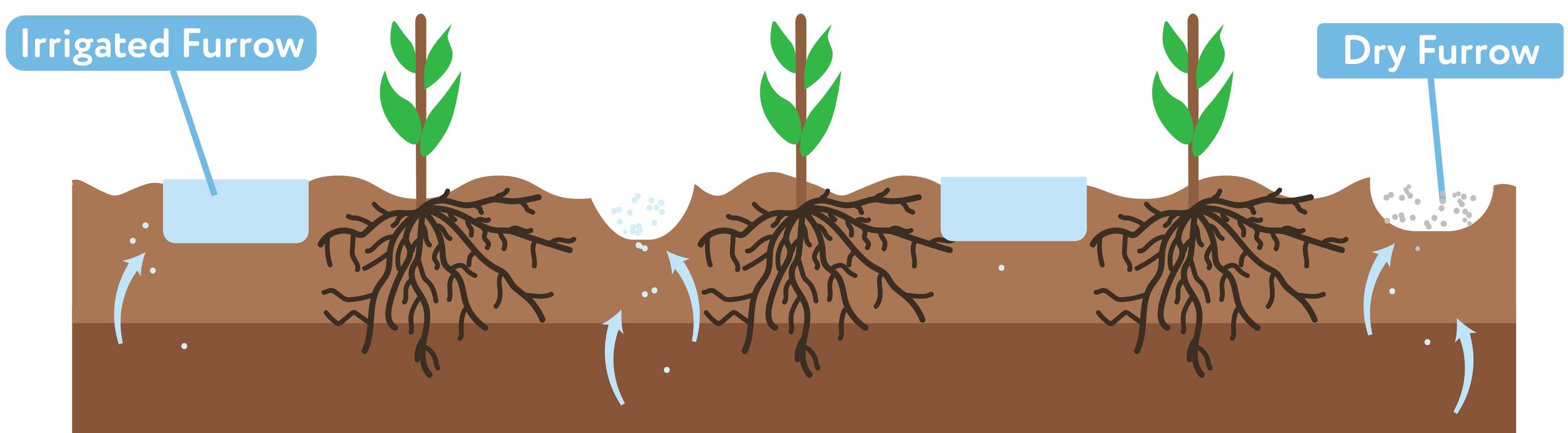
If the water table, or the surface of the zone of saturation in the ground, is shallow, a drainage system is used alongside the leaching requirement method.

The drainage ditches are dug beneath the water table level to help channel away the drainage water and allow the salts to leach out.

### 3. Managed Accumulation

Salts can be moved away from the root zone to locations in the soil, other than below the root zone, where they are not harmful.

One way to achieve this is to irrigate every other furrow while leaving alternate furrows dry. This pushes the salts from the irrigated side of the furrow to the dry side.



**Soil salinity can be reversed, but it takes time and is expensive.**

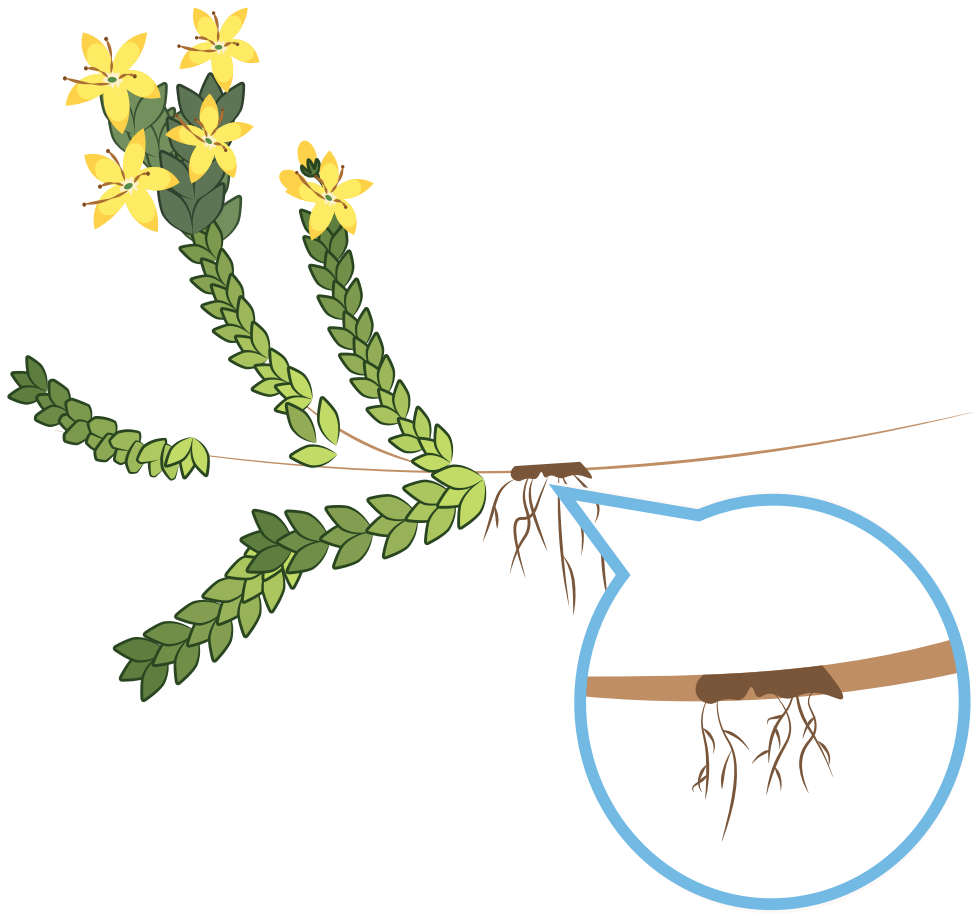
**Solutions include improving the efficiency of irrigation channels, capturing and treating salty drainage water, setting up desalting plants and increasing the amount of water that gets into aquifers. Mulches to save water can also be applied to crops.**

Mulch is any material that is spread or laid over the surface of the soil as a covering.

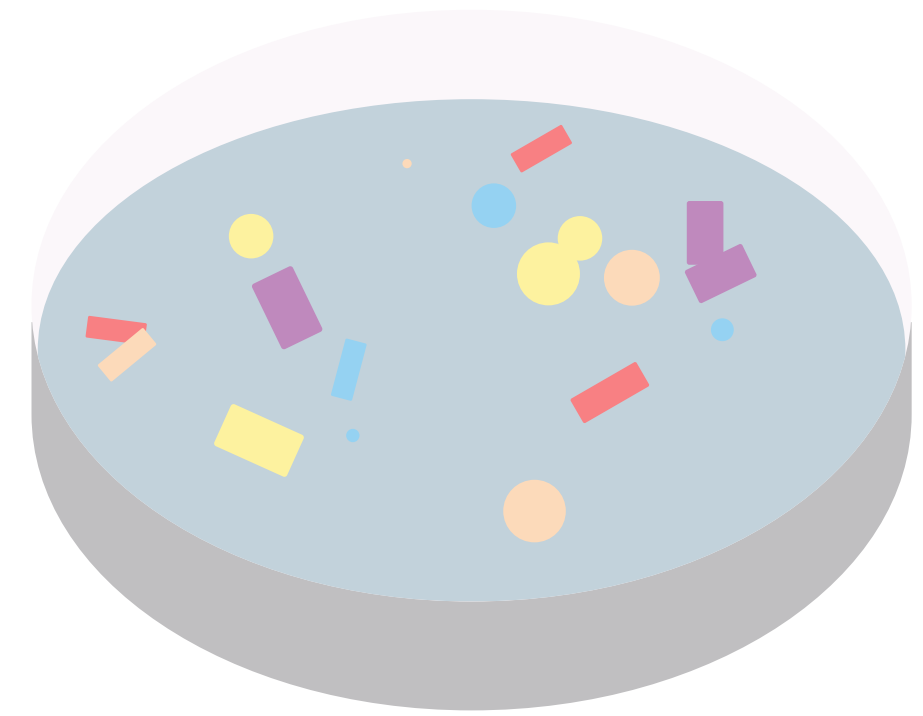
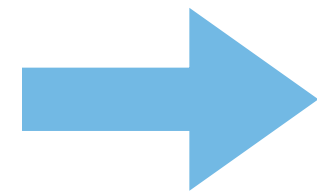
Source: Colorado State University & Eco-Business



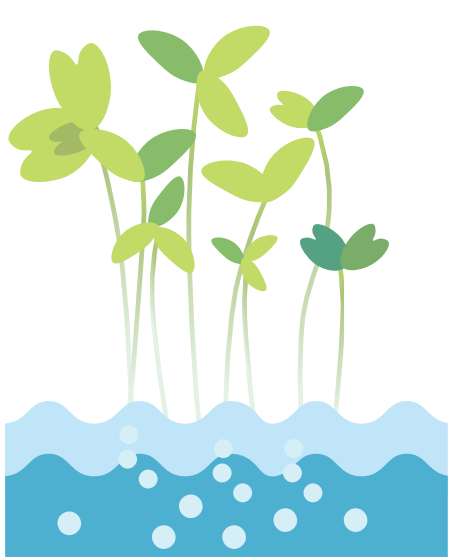
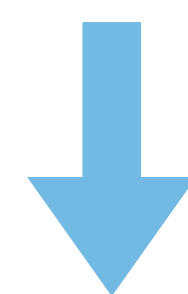
**Developing salt-tolerant crop varieties and farming methods, as well as funding infrastructure projects to prevent saltwater flooding, can help coastal farms remain viable as sea levels rise.**



Scientists from Brigham Young University took the roots of salt-tolerant plants (called halophytes), grounded them up and grew the bacteria in a petri dish in the lab.



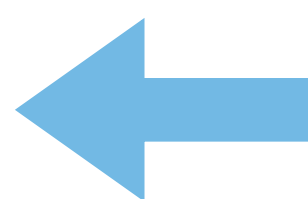
They isolated over 40 different bacterial isolates, some of which can tolerate ocean-level salt content.



**Alfalfa**

Alfalfa is typically consumed by humans as a herbal supplement or in the form of alfalfa sprouts.

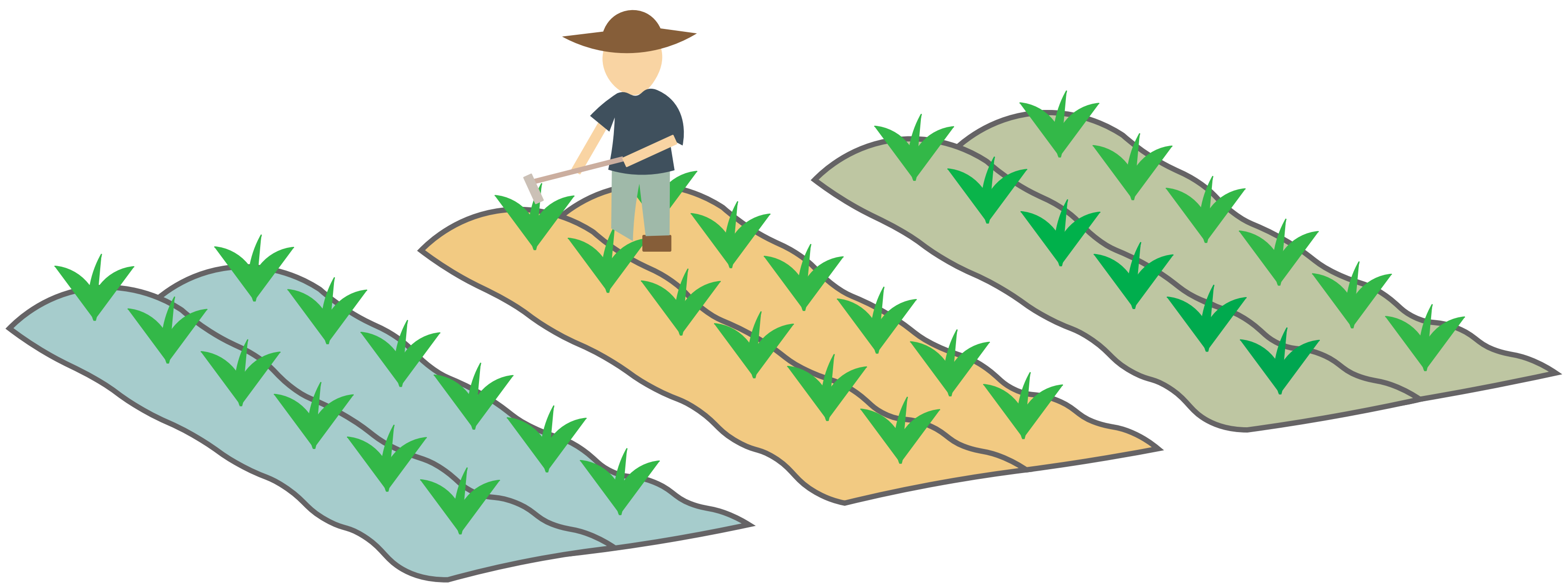
They saw significant growth of the alfalfa both in their lab and in greenhouse experiments carried out by collaborators at the Institute for Advanced Learning and Research in Virginia.



The team then applied the bacterial isolates to alfalfa seeds through a solution and tested the alfalfa's ability to grow in high-saline conditions.



**With these discoveries, they learnt that lands that are unable to sustain plant life due to high salinity can once again be used for crops.**



**Farmland testing of salt-tolerant rice varieties under different soil and water regimes, training and raising awareness among farmers, as well as developing policy guidelines, have also been important aspects of developing new crops and farming methods.**

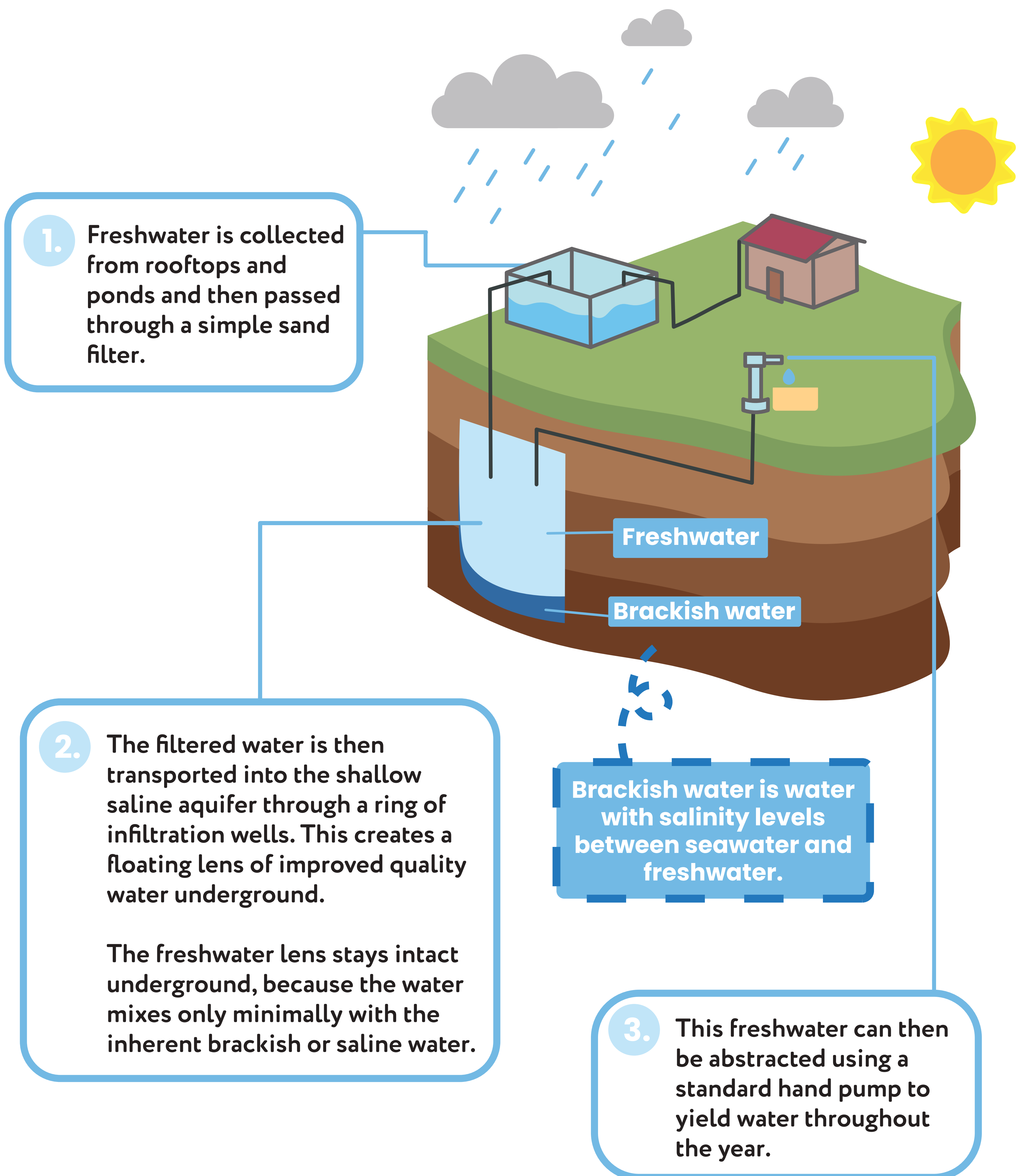


**In addition to developing new rice varieties, other measures that can be carried out include the implementation of crop rotation systems, soil salinity management using raised seabeds and changing the date of sowing.**

**In Bangladesh, one successful measure was an aquifer recharge which collects freshwater during the rainy season for use in the dry season. This, combined with improved soil management, can greatly benefit agricultural land vulnerable to saltwater intrusion.**



## Application Of Managed Aquifer Recharge:



Source: International Water Management Institute (WMI)

# WHAT CHANGES WILL BE INTRODUCED WITH THE SINGAPORE GREEN PLAN 2030?

## What Is The Singapore Green Plan 2030 All About?

In February 2021, the Government unveiled the Singapore Green Plan 2030, a whole-of-nation movement to advance Singapore's national agenda on sustainable development.

The Green Plan charts ambitious and concrete targets over the next 10 years, strengthening Singapore's commitments under the United Nations 2030 Sustainable Development Agenda and Paris Agreement, and positioning Singapore to achieve its long-term net-zero emissions aspiration as soon as viable.

## The 5 Pillars

### 1. City In Nature

- Add 1,000 more hectares (ha) of green spaces by 2035, and increase nature parks' land area by over 50% from 2020 baseline.
- Every household will live just a 10-minute walk from a park.

### 2. Sustainable Living

- 75% of all trips to be on mass public transport by 2030, up from 64% in the present.

### 3. Energy Reset

- Existing HDB towns will use 15% less energy through measures like the widespread use of smart LED lights and solar energy by 2030.
- 80% of new developments to be Super Low Energy buildings from 2030.

### 4. Green Economy

- Develop Singapore to be a carbon services hub, and a leading centre for green finance in Asia and globally.
- Leverage opportunities in sustainable industries to create good jobs for Singaporeans.

### 5. Resilient Future

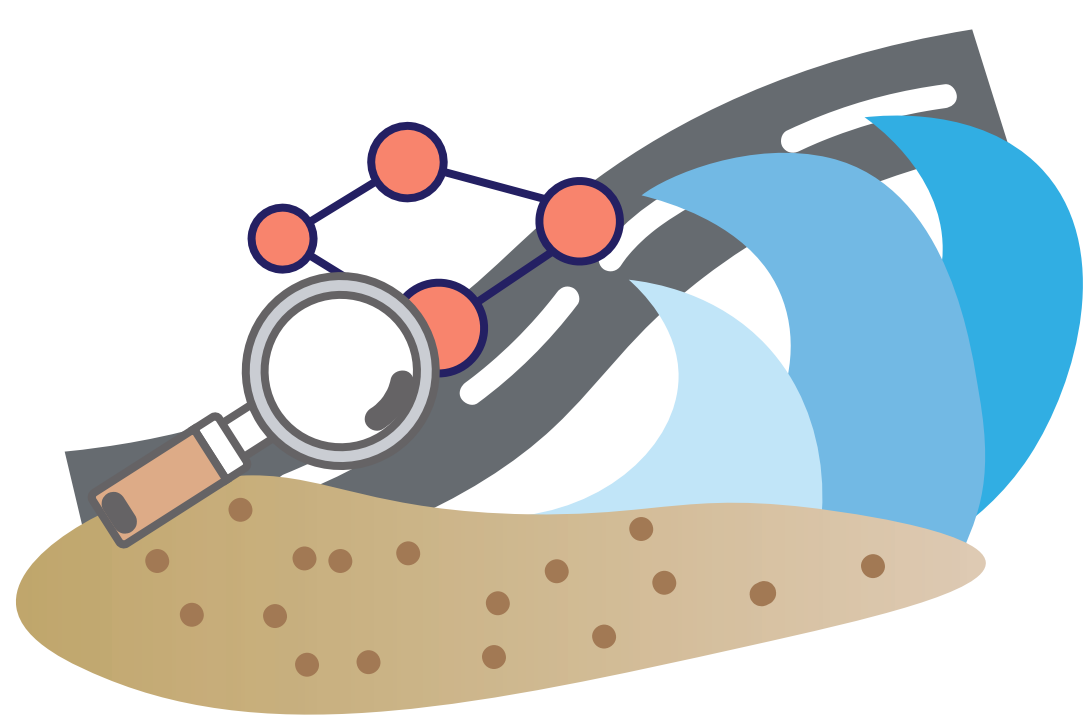
- Moderate the rise in urban heat, such as with cool paint and by increasing greenery.



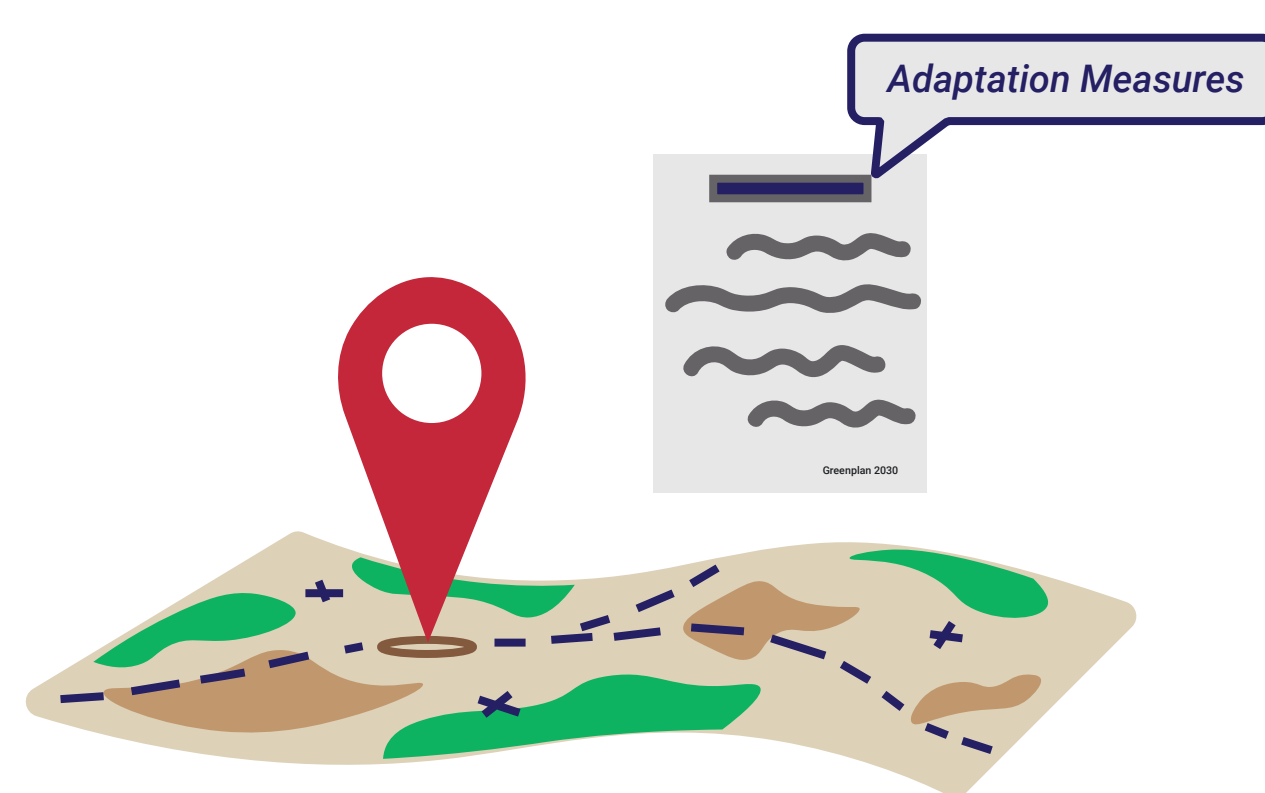


## With Regard To Rising Sea Levels, One Of The Green Plan's Five Key Pillars Includes:

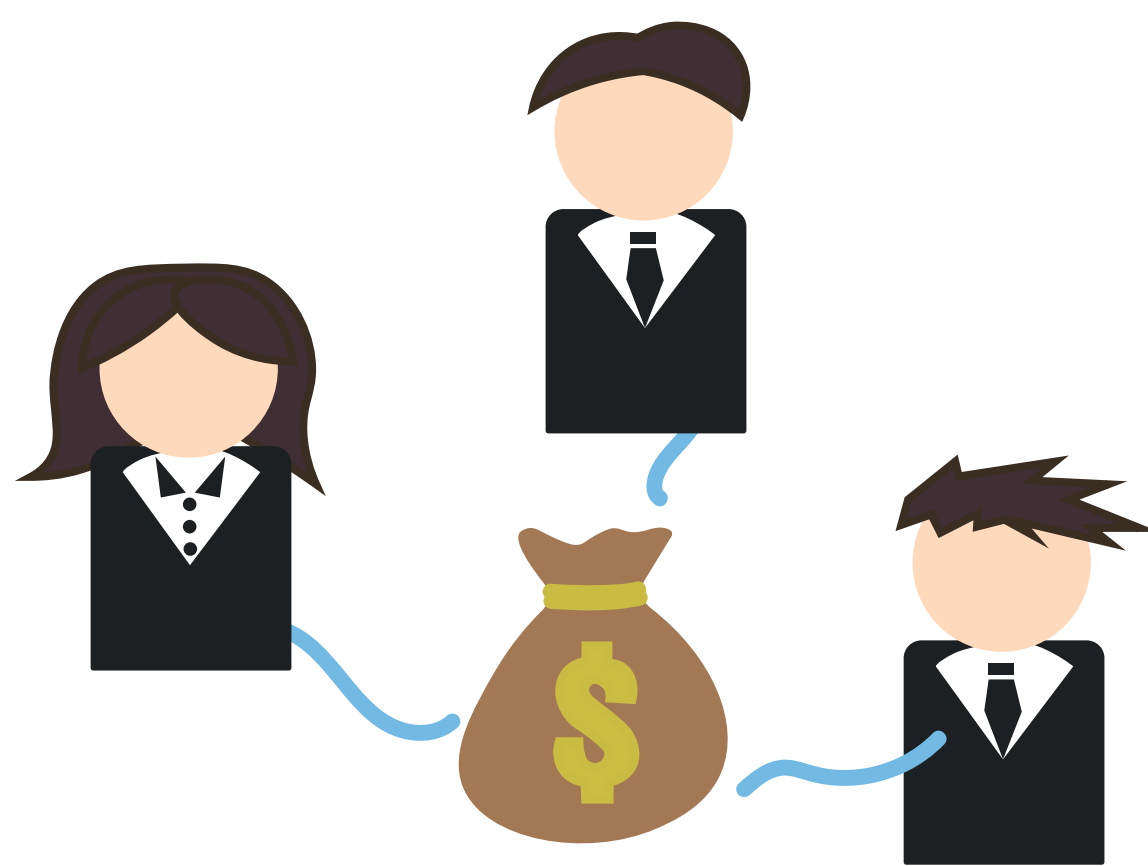
**Resilient Future:** To build up Singapore's climate resilience and enhance our food security. This pillar includes ways in which Singapore plans to adapt to sea level rise and enhance flood resilience, such as:



**Research and development** to better understand sea level rise projections and technology/modelling to manage inland and coastal flood risks holistically.



**Site-specific studies** to assess and provide details of coastal adaptation measures to be implemented.



A sustainable and **reliable funding pool** to be set aside for coastal and flood protection.



**Target For 2030:**

**Complete formulation of engineering design and implementation plans for coastal adaptation measures at City-East Coast, Northwestern Coast (Lim Chu Kang and Sungei Kadut) and Jurong Island.**

Source: Singapore Green Plan 2030

The background of the page is a stylized illustration of a beach. At the top, there's a solid blue sky with some light blue, wavy shapes representing clouds or water reflections. Below that, a horizontal line separates the sky from a layer of white, fluffy clouds. Underneath the clouds is a dark blue horizontal line representing the horizon. Below the horizon, there are several layers of wavy lines in various shades of blue and teal, representing ocean waves. At the bottom, there's a wide, sandy beach in a light orange-brown color. The beach has some darker orange-brown shapes scattered across it, representing rocks or pebbles.

## **CHAPTER 5:** Breaking the banks

In the fifth chapter of this series, we examine the solutions to combat climate changes in various countries all around the world. We also look at the actions taken by industries and businesses that are affected by rising sea levels.



# WHO ARE ENVIRONMENTAL REFUGEES?

In The Mid-1980s

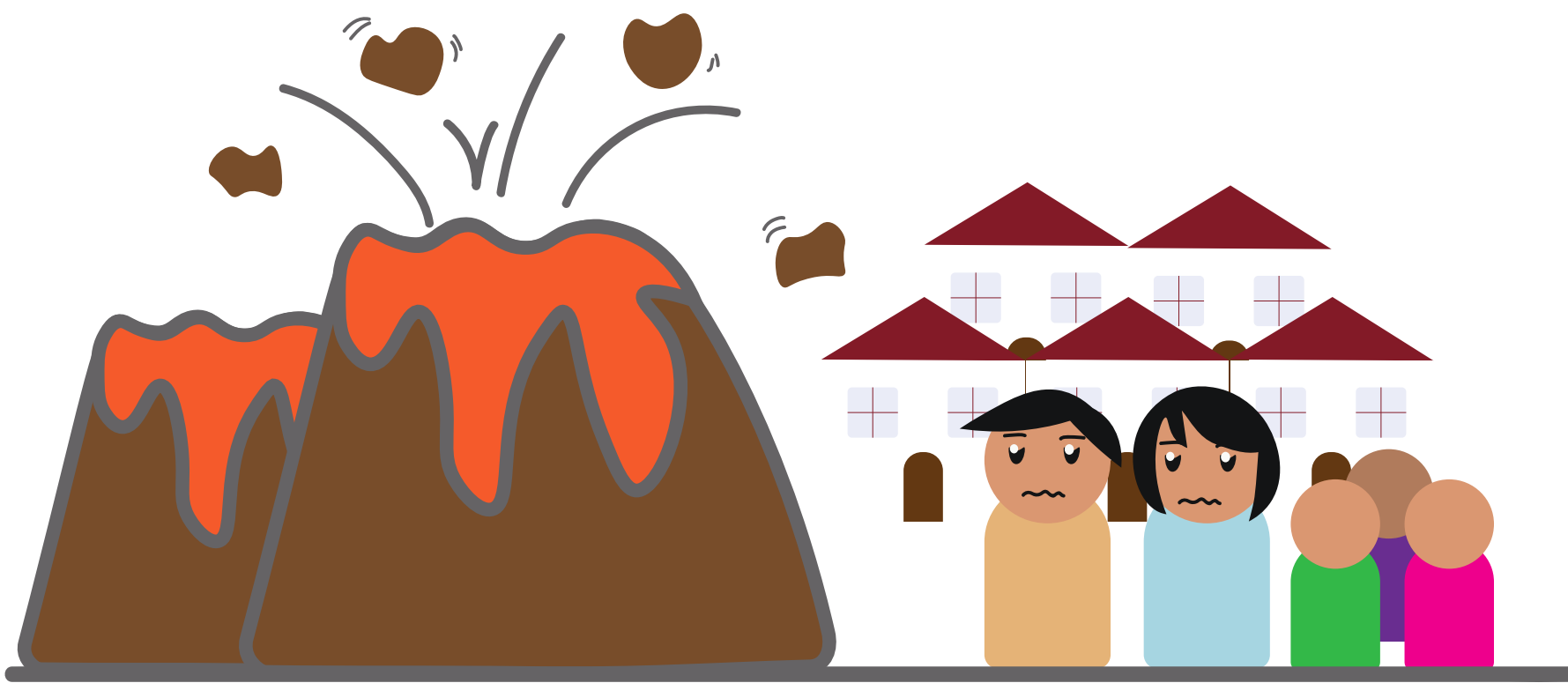
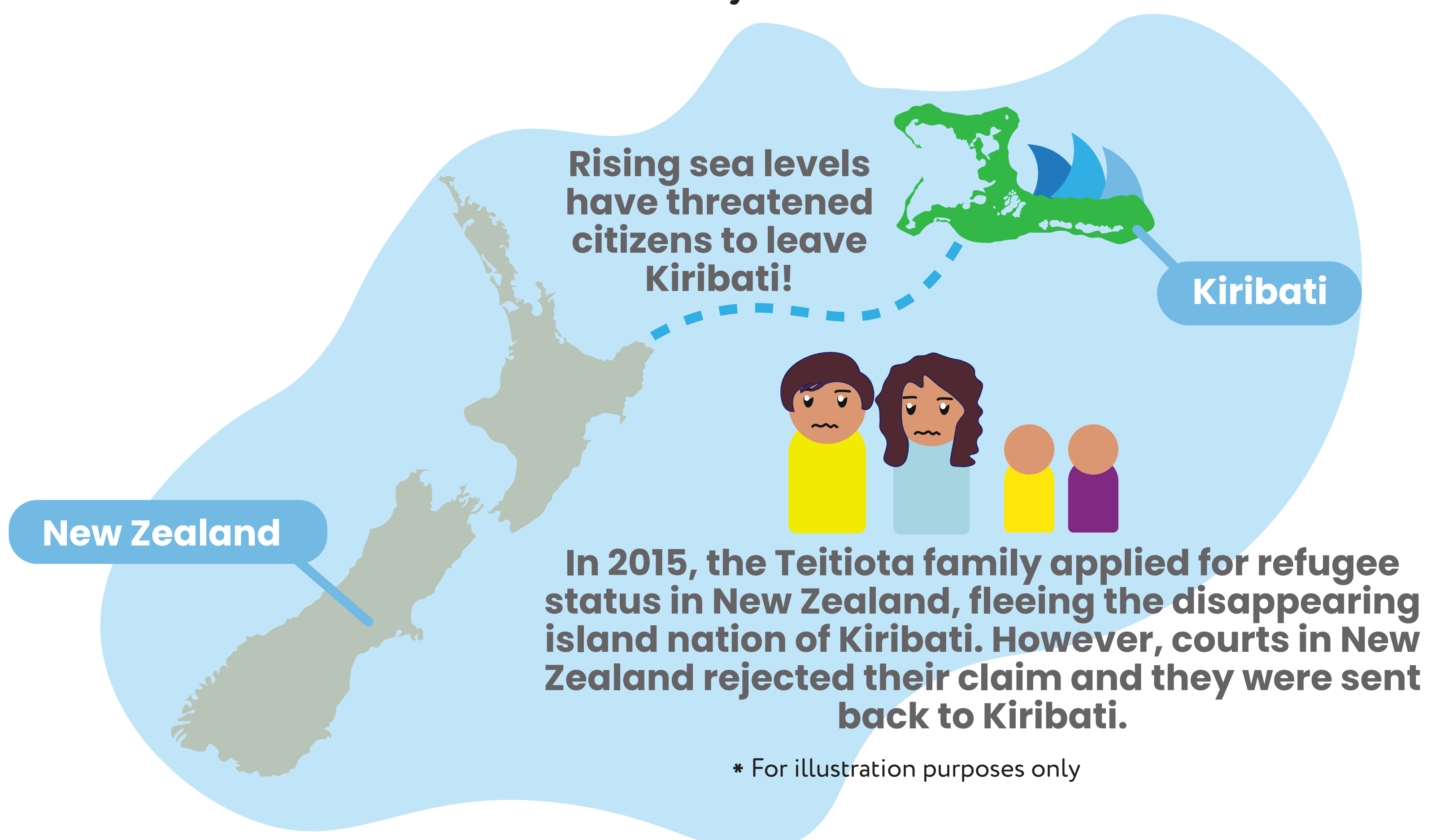


Image source: Julie Recard via Unsplash

United Nations Environment Programme researcher El-Hinnawi, defined environmental refugees as "people who have been forced to leave their traditional habitat because of a marked environmental disruption (natural and/or man-made) that gravely affected the quality of their life".

Forecasts By The UN International Organisation For Migration That There Could Be Between 25 Million To 1 Billion Environmental Refugees By 2050.

They are moving either within their countries or across borders, on a permanent or temporary basis, with 200 million being the most widely cited estimate.

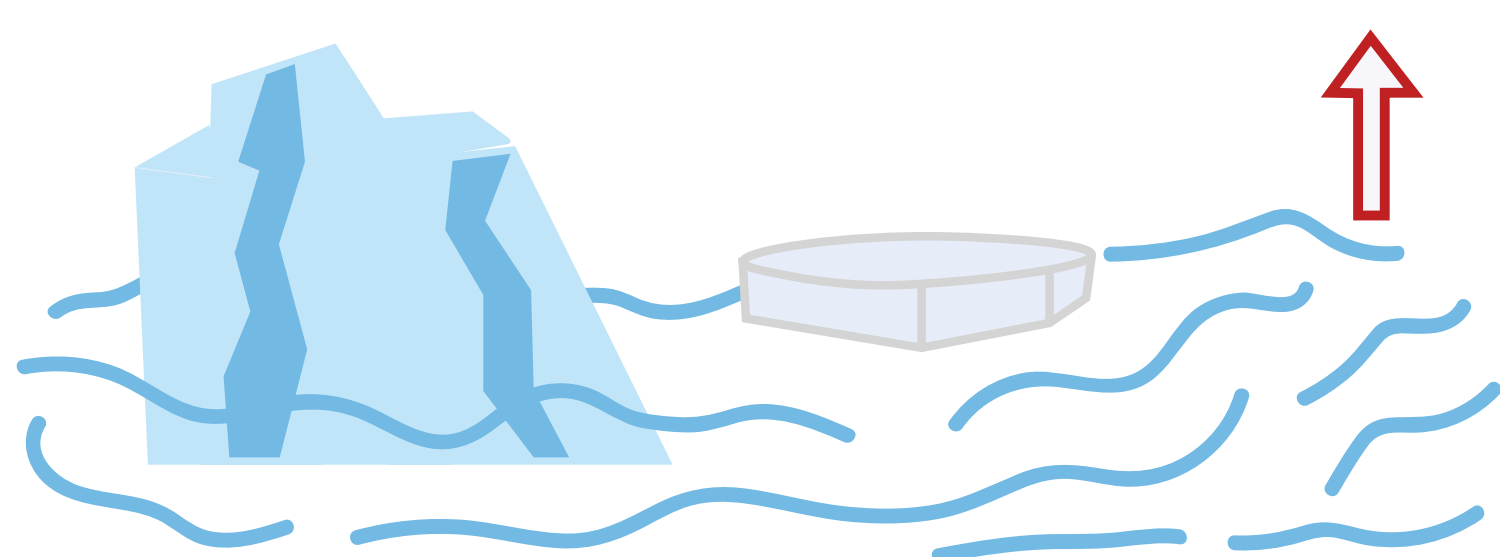


Source: BBC News

# A Study Published In The Journal Proceedings Of The National Academy Of Sciences Reports That Sea Level Rise From Accelerated Melting Could "Have Profound Consequences For Humanity."

In total, up to 2.5% of the world's current population could be displaced from their homes by 2100.

Researchers found that:

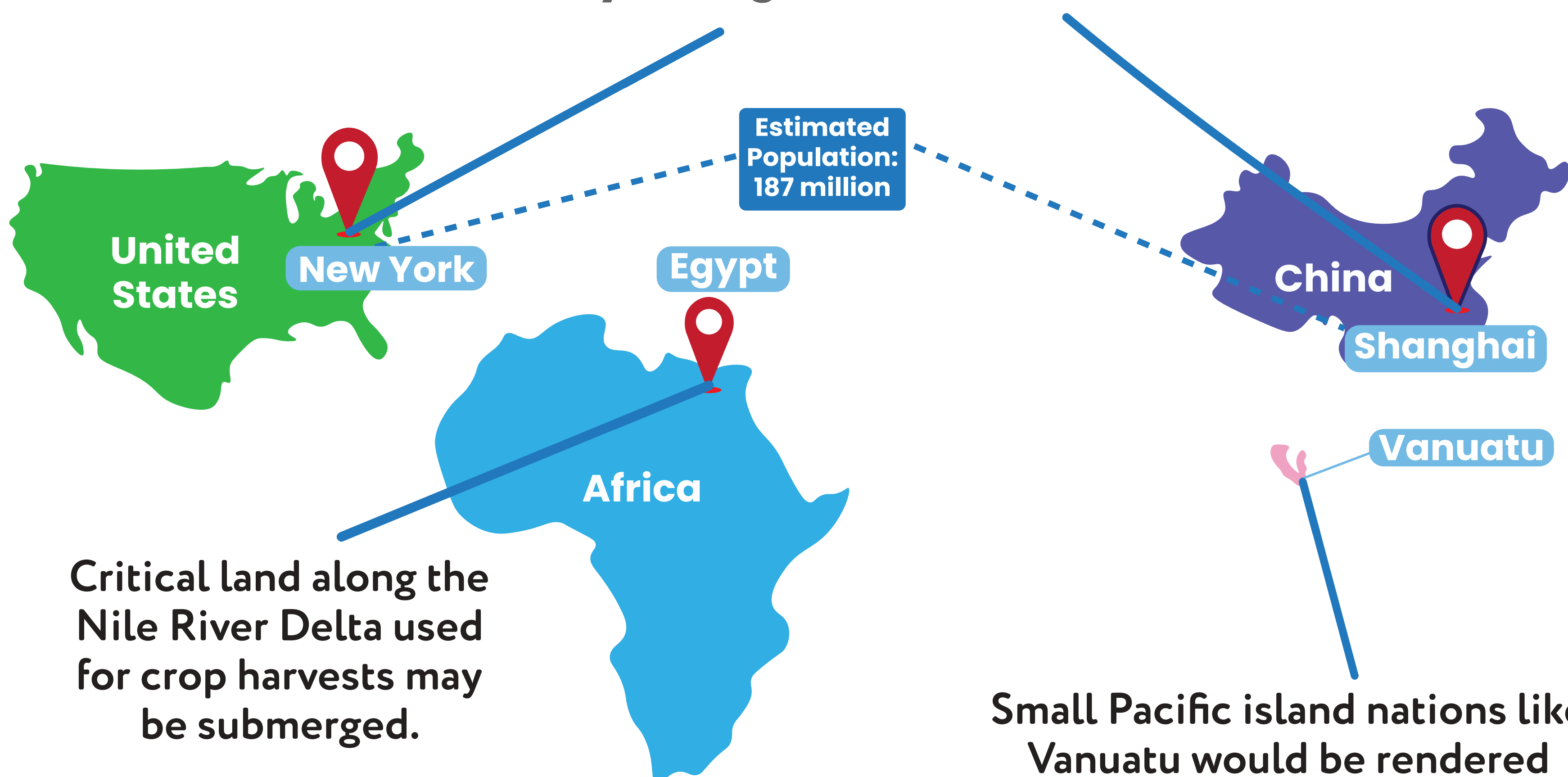


The earth could heat up by 5°C in the next 80 years!



Melted ice could raise sea levels worldwide by more than 2m!

These cities have a higher chance of being swamped by rising sea levels!



Critical land along the Nile River Delta used for crop harvests may be submerged.

Small Pacific island nations like Vanuatu would be rendered uninhabitable or disappear entirely.

\*For illustration purposes only

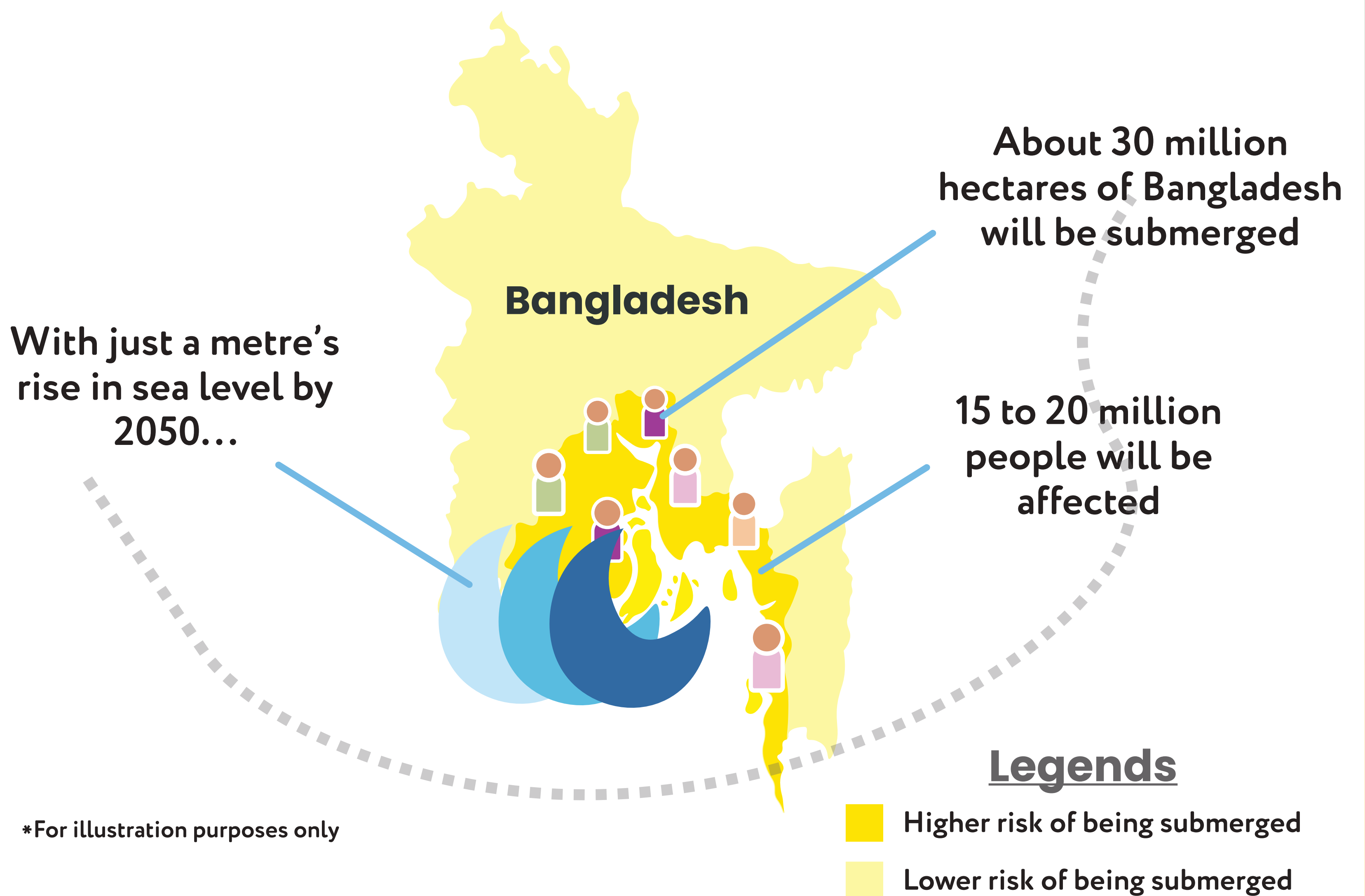


# The Poorest Populations Are At Risk Because They Often Live In Disaster-Prone Places Such As Steep Hillsides, Coasts Or Low-Lying Floodplains.



Experts predict the hardest hit populations will likely be in Africa, Asia, Latin America and the Small Island Developing States, an alliance of low-lying coastal countries around the world.

It's estimated that nearly 100 million people live in regions that are below sea level.



Source: HowStuffWorks, Business Insider & Climate Foresight

# WHAT ARE THE IMPACTS OF RISING SEA LEVELS ON THE GLOBAL POPULATION?

**Anthropogenic<sup>1</sup> Sea Level Rise Is Predicted To Impact, And In Many Cases, Displace A Large Proportion Of The Global Population Via Flooding And Other Related Hazards.**

A large proportion of the global population resides in coastal regions where sea level rise impacts are expected. Hence, sea level rise is potentially one of the most costly and permanent consequences of climate change.



More than 1 billion people are estimated to be living at coastal areas in this century!

Since 2008, 24 million people have been displaced by catastrophic weather disasters each year.



Hurricane

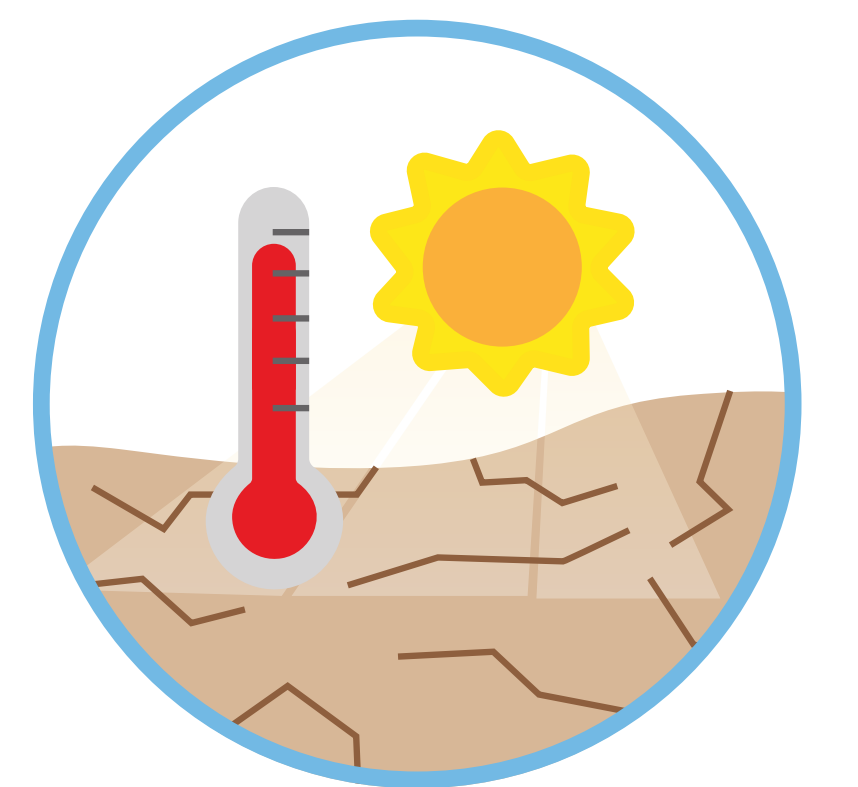


Tornado

As climate change worsens storms and droughts, climate scientists and migration experts expect the number of displaced persons to rise.



Blizzard



Drought

<sup>1</sup> Describes changes in nature made by people



**Higher sea levels are coinciding with more dangerous hurricanes and typhoons that move more slowly and result in higher rainfall.**



**This contributes to more powerful storm surges that can strip away everything in their path. One study found that between 1963 and 2012, almost half of all deaths from Atlantic hurricanes were caused by storm surges.**



**The prospect of higher coastal water levels threatens basic services such as Internet access, since much of the underlying communications infrastructure lies in the path of rising seas.**

Source: Nature Briefing, NPR, United Nations & National Geographic

# WHAT ARE SOME SOLUTIONS TO AID ENVIRONMENTAL REFUGEES?

Many coastal cities are already planning adaptation measures to cope with the long-term impacts of higher sea levels:



Building seawalls



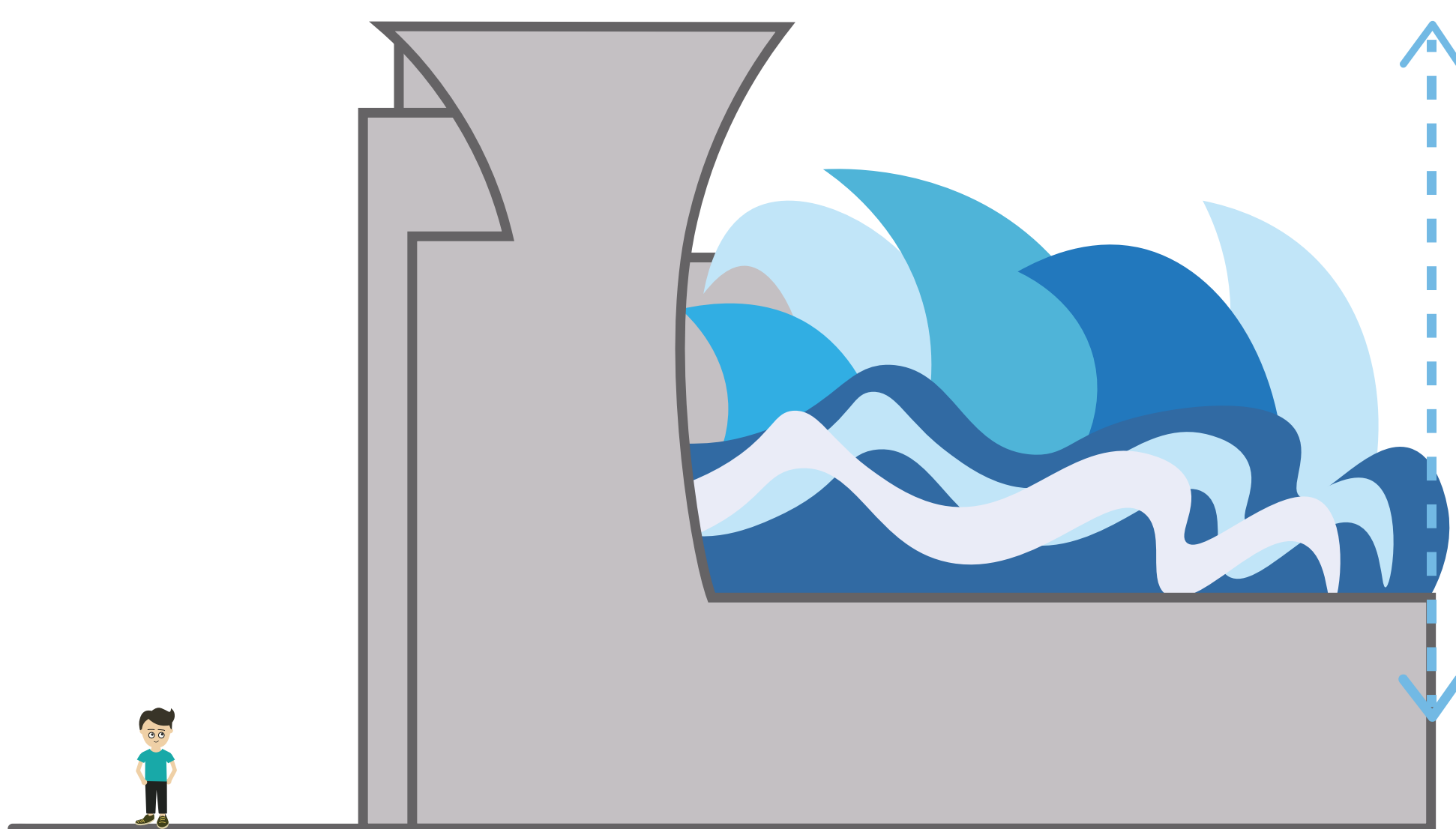
Rebuilding of roads



Planting mangroves or other vegetation to absorb water

## 1. Indonesia

### The Great Garuda Seawall

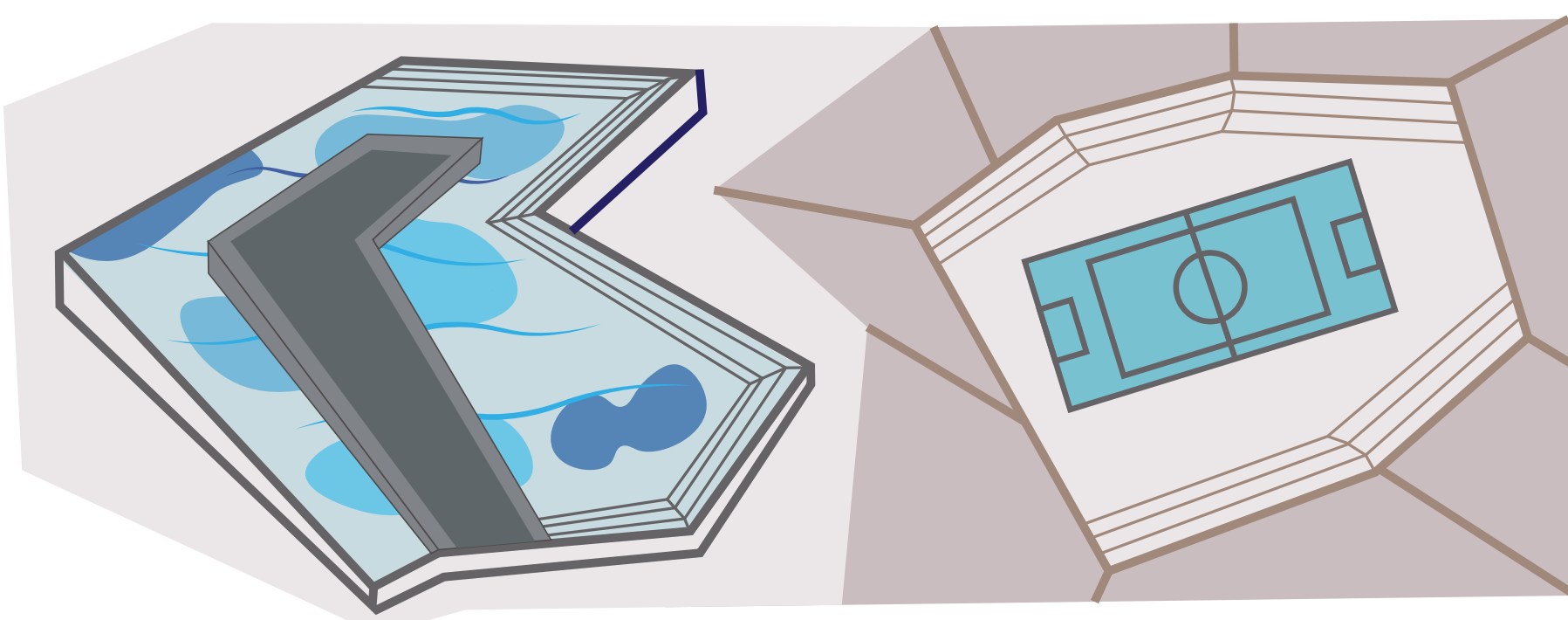


\*For illustration purposes only

The US\$40 billion project in Jakarta aims to protect the city with an 80-foot high seawall.

The Great Garuda Seawall is about 24m tall, which is 14 times taller than an average Singaporean man!

## 2. The Netherlands



Water Square in Rotterdam

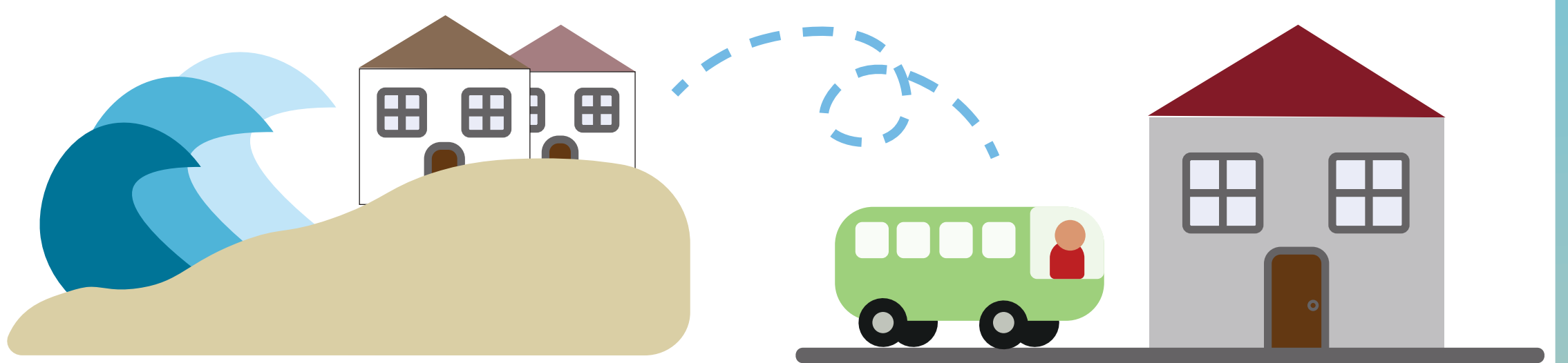
Rotterdam, home to the Global Center on Adaptation, has built barriers, drainage, and innovative architectural features such as a “water square” with temporary ponds to combat flooding and land loss.



### 3. Dhaka, Bangladesh

In a recent report, the Dhaka-based **International Centre for Climate Change and Development (ICCD)** proposed the setting up of climate funds in order to support resettlement practices and strategies.

ICCD estimates that over the next 10 years, millions of Bangladeshis will move from their homes in low-lying areas to inland towns.



ICCD is making this process easier for migrants by working to create "climate-resilient, migrant-friendly" towns.

A dozen inland towns which are far away from low-lying coastal areas have been identified. These towns can accommodate populations of about 1,500,000 people.

As part of the project, a number of initiatives aim to prepare the inhabitants of the identified towns to help migrants reintegrate in their new environment and make them feel welcome.

ICCD is also encouraging and supporting students from vulnerable coastal areas to move inland for studies.

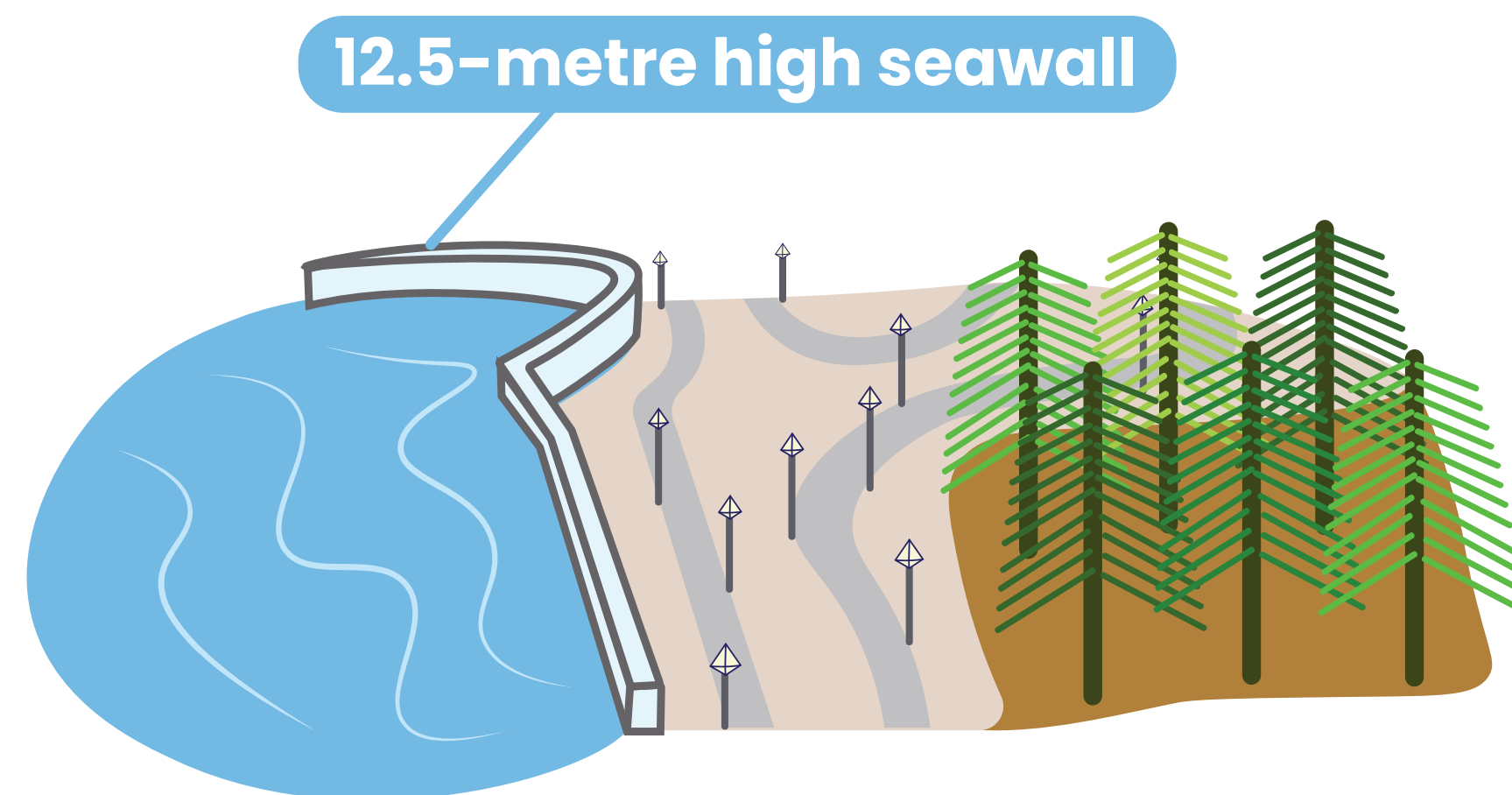
"By providing scholarships, we are encouraging students to move from low-lying coastal areas, with the hope that their parents will follow them to the climate-resilient towns".

— Saleem Huq, ICCD director



Source: National Geographic & Al Jazeera Media Network

## 4. Japan



After the destruction caused by the 2011 Tohoku earthquake and tsunami, the coastal city of Rikuzentakata, located in Iwate Prefecture, Japan, built a 12.5m high seawall surrounding the bay and elevated the city centre, among other initiatives, to make it more resilient against future flooding.



New businesses have sprung up on the elevated areas as work still continues on certain areas of the city.

**Authorities are also introducing counselling and support programmes to help people affected by past climate crises and those who may be affected by them in the future.**

Rikuzentakata will also provide different levels of disaster prevention training programmes and development schemes for students and professionals.

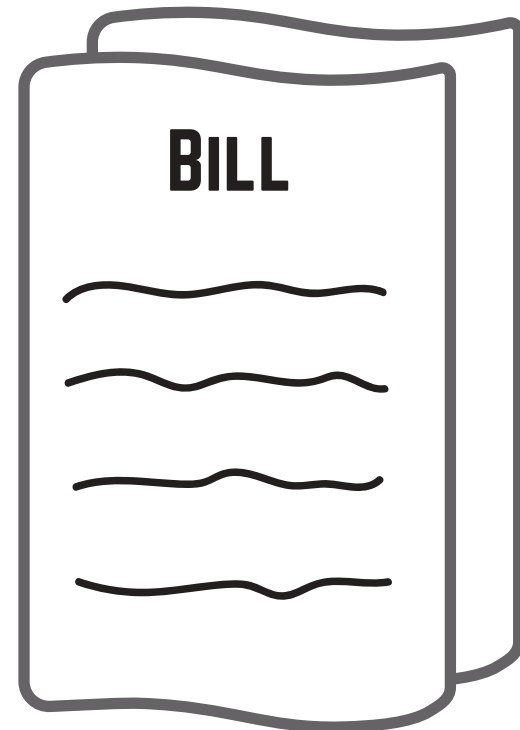




## 5. United States



U.S. Senator  
Edward Markey



In 2019, U.S. Senator Edward Markey introduced a Bill to recognise “climate-displaced persons” that would welcome up to 50,000 people in an individual fiscal year to resettle in the United States.

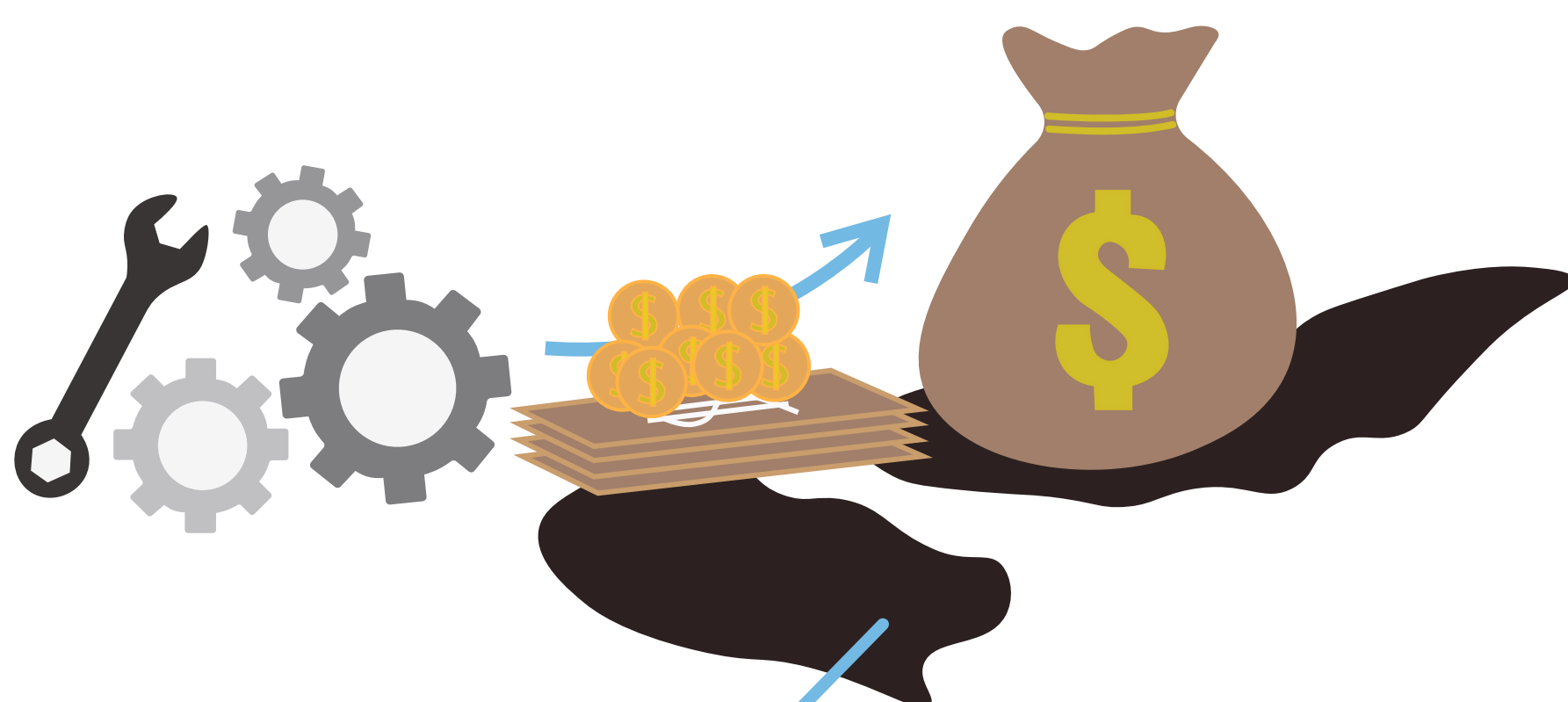
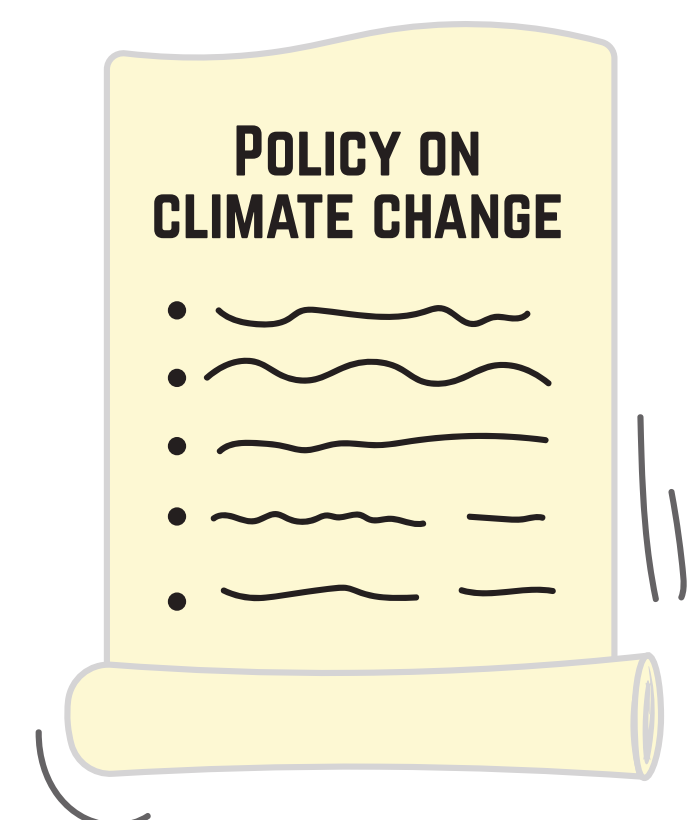
The Bill aims to establish a **Global Climate Change Resilience Strategy**, to authorise the admission of climate-displaced persons, and for other purposes.

**Given pending catastrophic climate impacts, policymakers need to seriously consider planned relocation. The Pacific Islands have been leading the way in planning relocation for their citizens.**



Vanuatu

For example, Vanuatu has created a comprehensive policy on climate change and disaster-induced displacement, which includes developing safeguards and standard operating procedures for planned relocation.



Fiji

The plan also outlines the need for technical expertise and financing. With this in mind, Fiji’s Climate Change Relocation and Displaced People’s Trust Fund may be used as a model to help the community with relocating. The fund will raise revenue through an innovative environment and adaptation levy.

Source: Al Jazeera Media Network & Refugees International

## Examples Of Policies That Are Developed Globally

In 2015, the United Nations Framework Convention on Climate Change

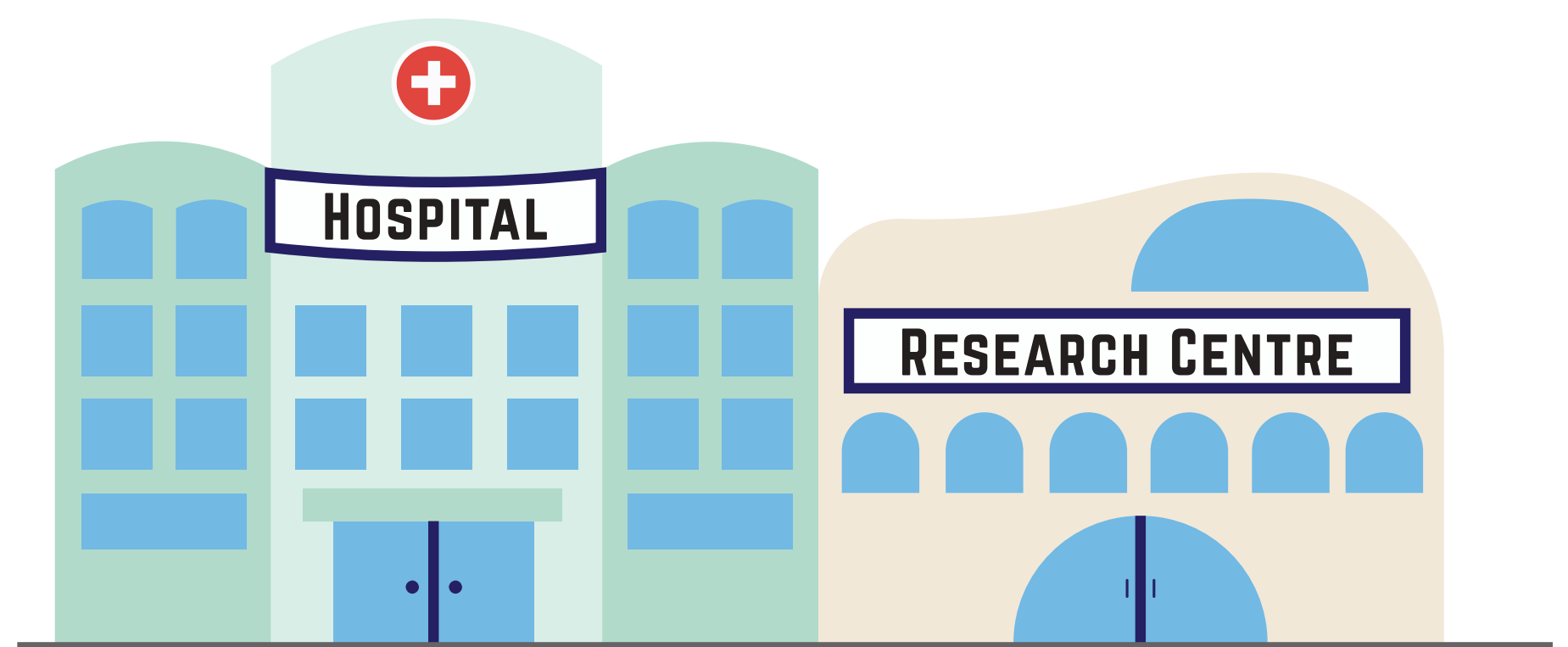
created

task force on displacement

To provide technical and policy advice on the impacts of climate change on forced displacement and migration.



Image source: Moein Rezaalizade via Unsplash



The task force will be essential in determining how displacement is factored into losses and damages, including the potential establishment of a “climate displacement facility”, where compensation for losing livelihoods or land may be negotiated.



The **Global Compact for Safe, Orderly, and Regular Migration** is the first global agreement of its kind on migration.

It refers to the need to address protection gaps for people displaced by the effects of climate change.



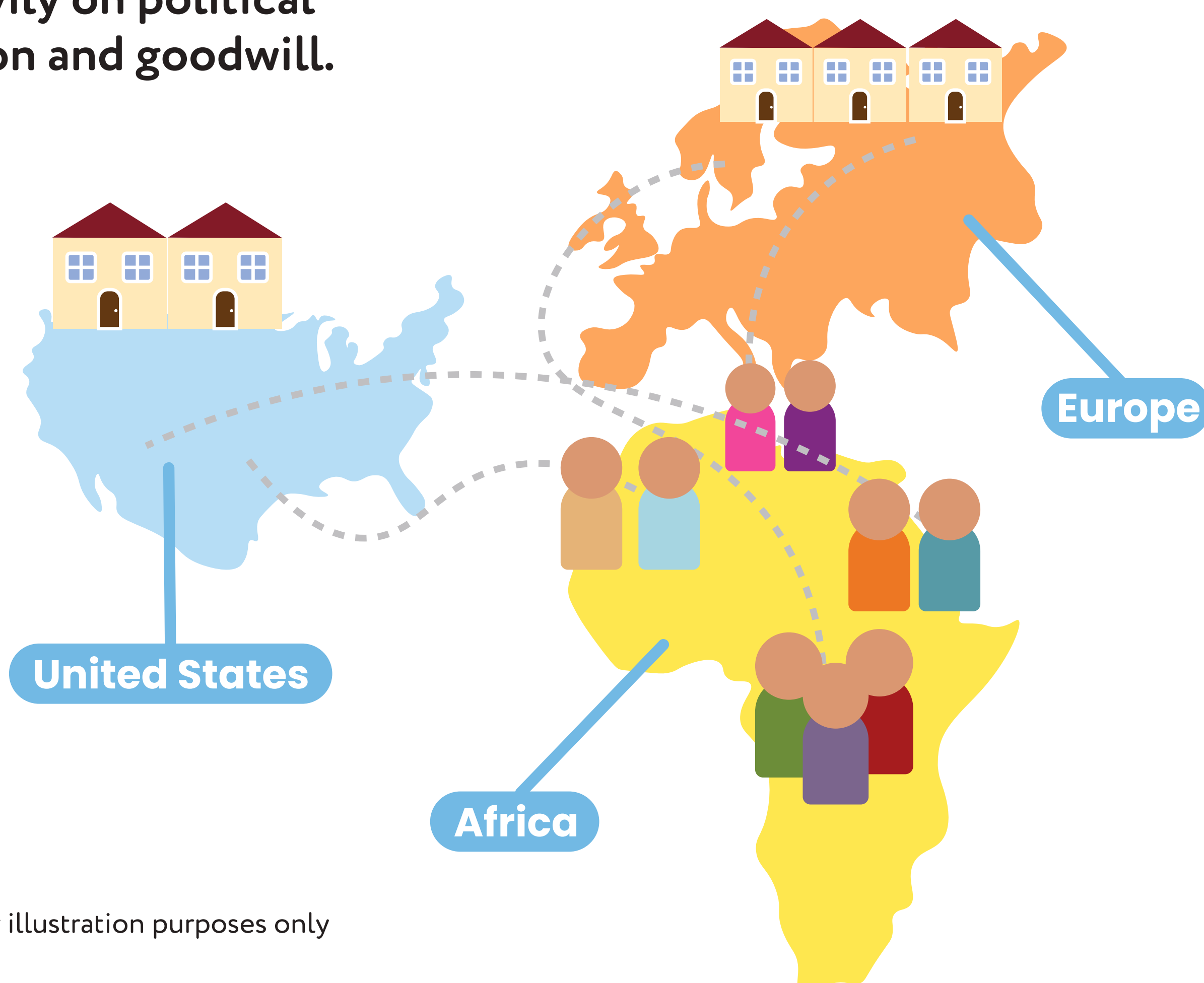
The **Platform on Disaster Displacement (PDD)** is a follow-up to the Nansen Initiative<sup>1</sup>. The PDD was put together with a Protection Agenda for people displaced across borders by disasters. The agenda leverages existing frameworks and soft laws that states can voluntarily adopt.

**PDD and other entities see great potential in creating protection mechanisms within a regional context.**

For example, the Economic Community of West African States (ECOWAS) Protocol on Free Movement allows, in principle, all ECOWAS citizens the right of admission in member states but relies heavily on political cooperation and goodwill.



Image source: Ninno Jack Jr via Unsplash



\*For illustration purposes only

Source: Refugees International

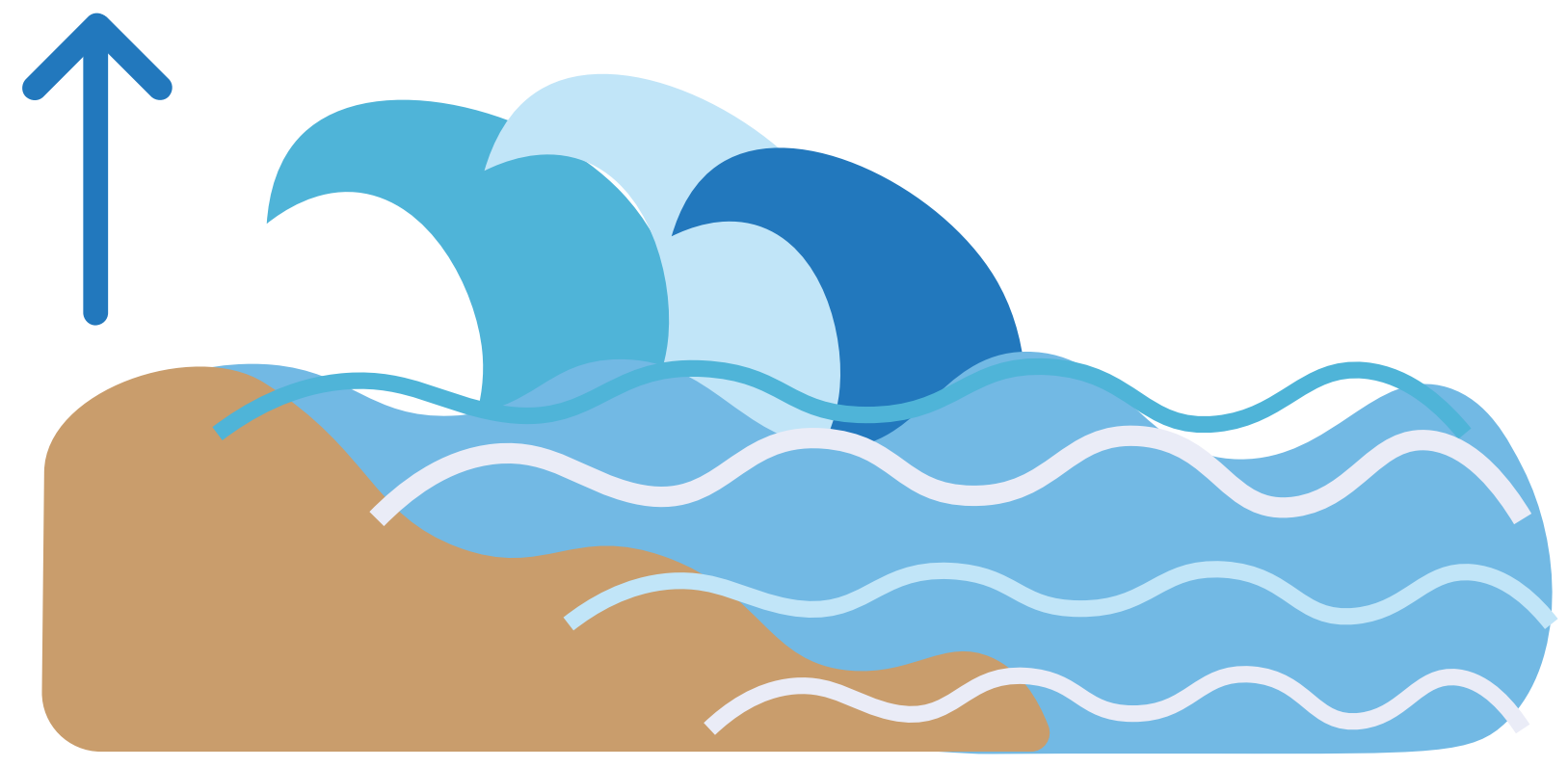
<sup>1</sup> A state-led, bottom-up consultative process intended to build consensus on the development of a protection agenda addressing the needs of people displaced across international borders in the context of disasters and the effects of climate change.



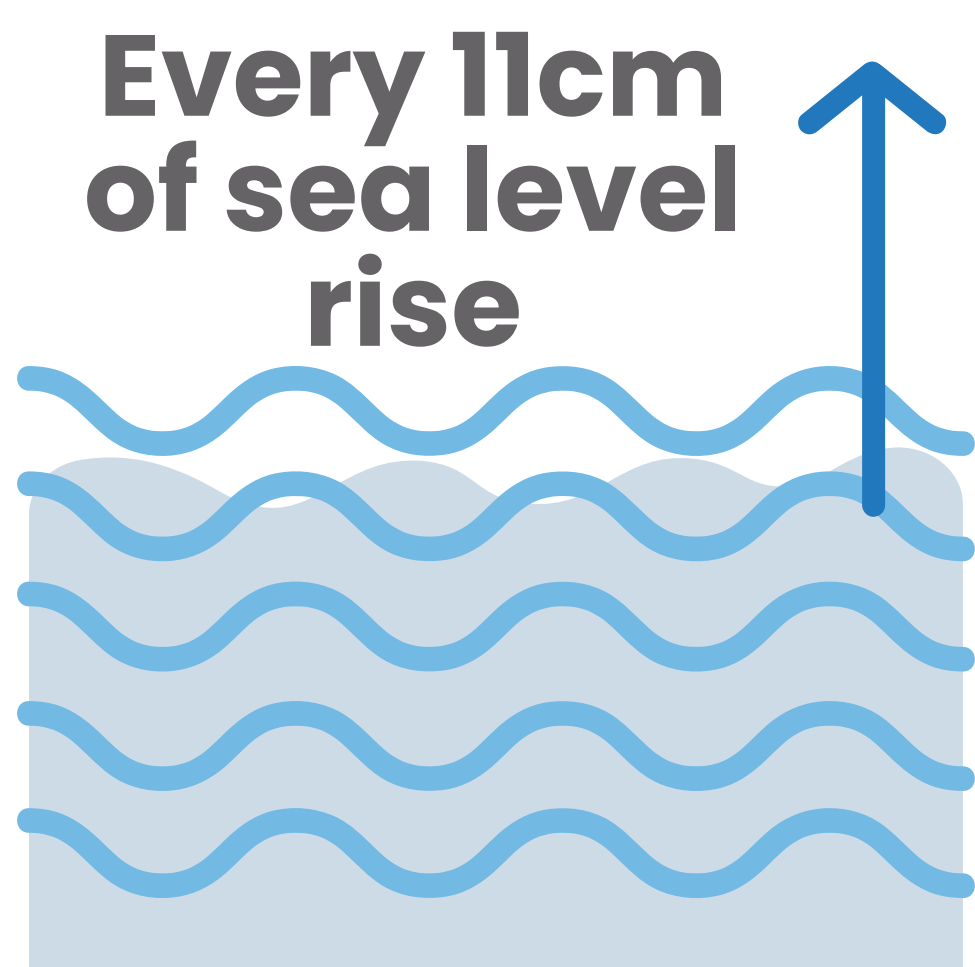
# HOW DO RISING SEA LEVELS AFFECT THE WORLD ECONOMICALLY?

According to recent research, the world's oceans rose by 14cm in the last century.

If we're lucky, this number will merely double during the course of this century. If not, an almost tenfold increase could be inevitable.



By the end of the 21st century, sea levels might increase by more than 1.4m!



According to researchers in Germany, economic losses double for every 11cm increase in sea levels.

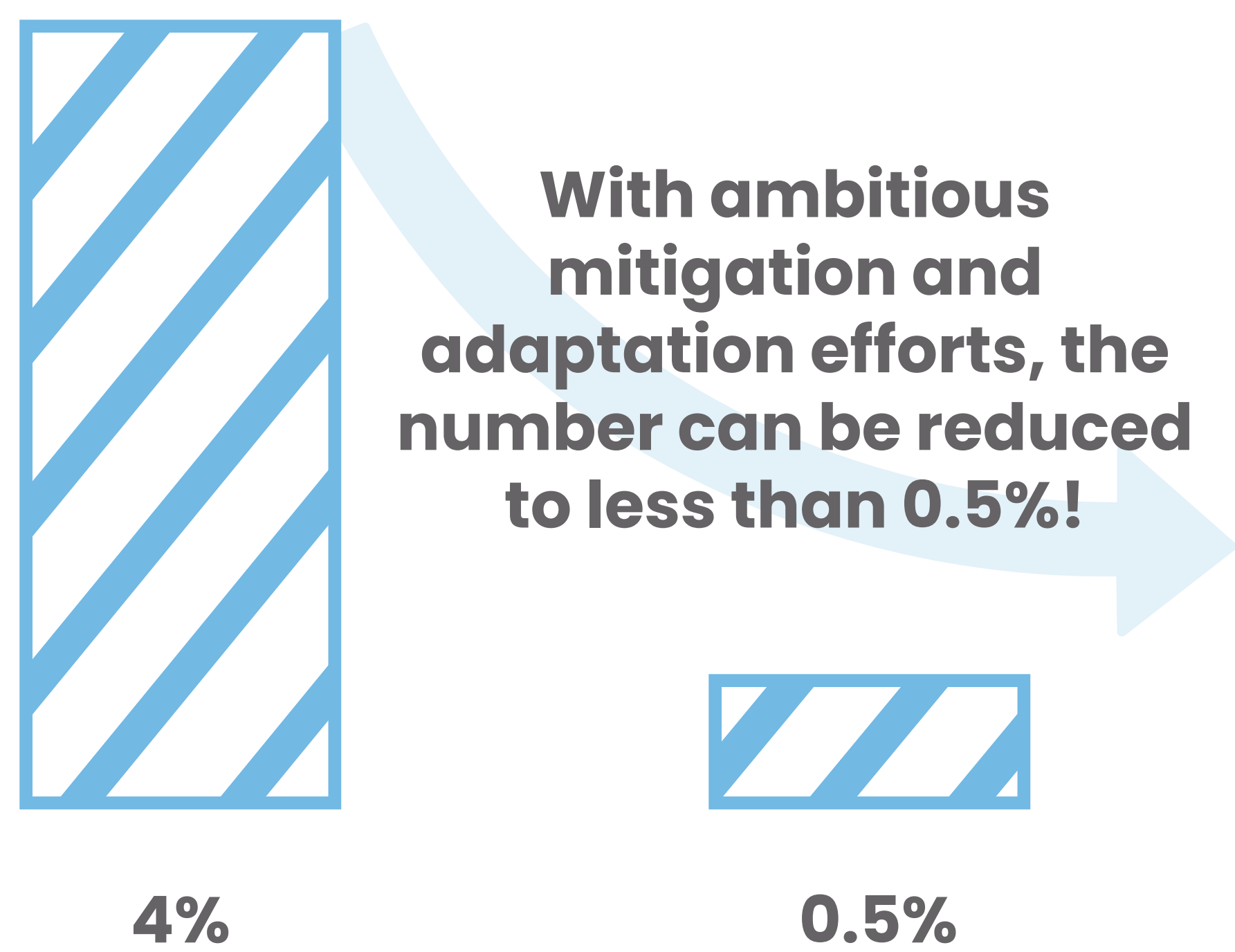
Source: The Guardian

Without further mitigation and adaptation, and assuming continued sea level rise, the projected annual global economy-wide losses can amount to more than 4% of the global gross domestic product (GDP) by 2100.

With ambitious mitigation and adaptation efforts, this number can be reduced to below 0.5% of the global GDP loss, despite the associated costs for adaptation measures and residual impacts.

This confirms the importance and economic efficiency of adapting areas for rising sea levels in the long term.

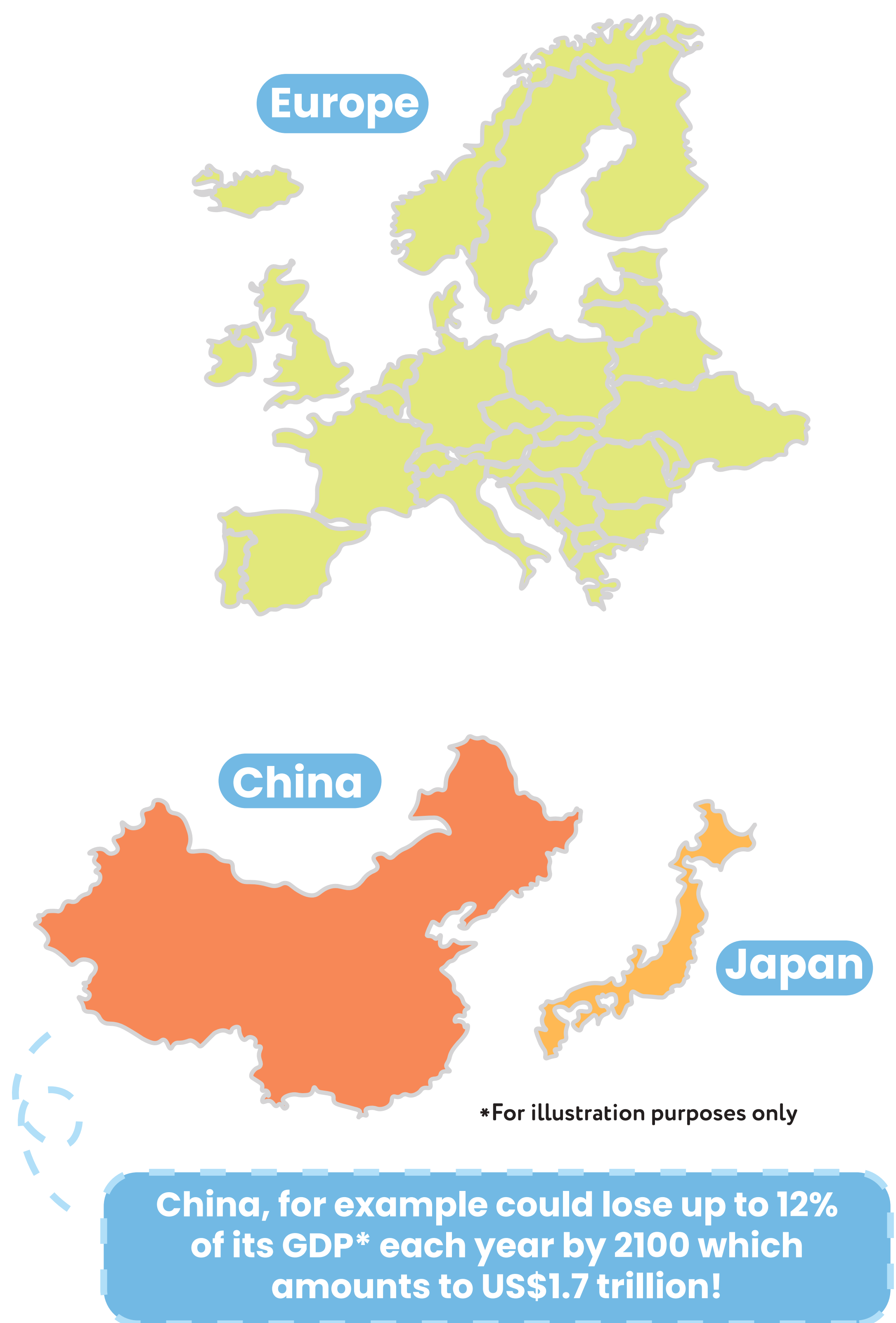
## Annual Global Economy-Wide Losses by 2100 (\$)





# Losses From Sea Level Rise Would Be Spread Unevenly Across The World

Annual GDP losses across the world due to sea level rise



\*For illustration purposes only

\*Based on China's 2019 GDP.

**GDP Loss(%)**

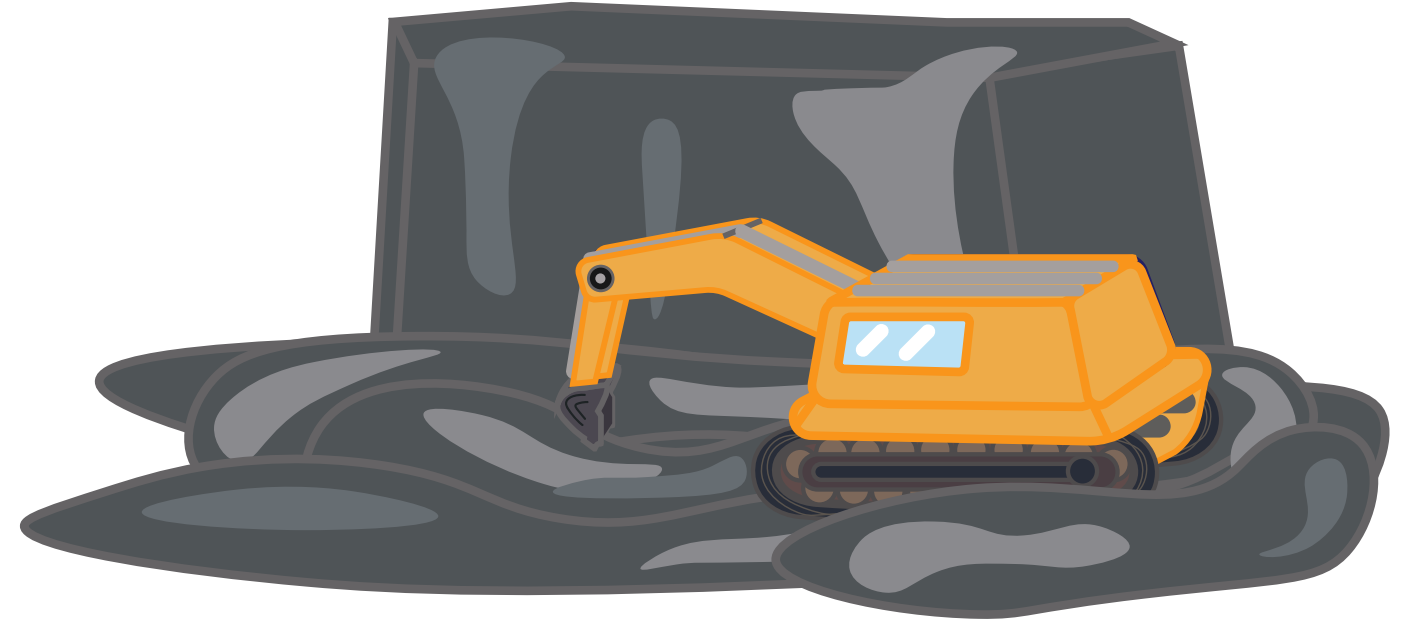


Source: The Guardian, ScienceDaily & ScienceNews

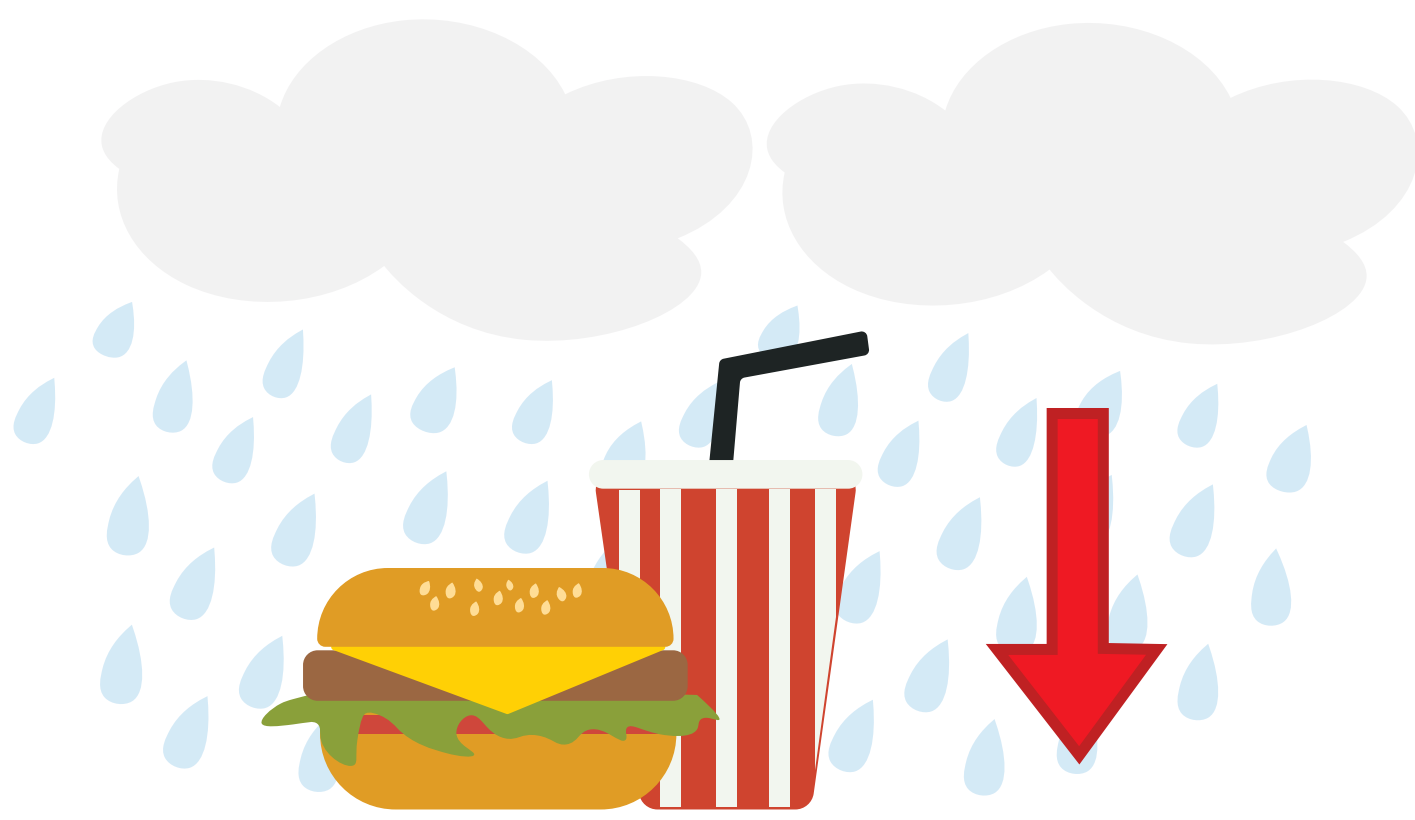
# WHAT ARE SOME INDUSTRIES AFFECTED BY RISING SEA LEVELS?

## 1. Mining

Extreme weather events such as flooding increase physical risks for mining operations.



## 2. Food & Beverage



Food supply and operations risk facing interruptions due to extreme weather events.

## 3. Agriculture



Transportation infrastructure may be damaged and services may be disrupted due to flooding. This can create problems when transporting raw materials.

Access to land can be obstructed during floods or extreme rain conditions.





## 4. Tourism

**The tourism industry in coastal areas is likely to take a hit.**

**Prime beachfront properties and recreational areas are being washed away by rising waters.**

**Flooded beaches are no attraction for tourists, who may decide to visit less vulnerable areas in the coming years.**



Source: Business Adaptation, CNBC & Business Insider

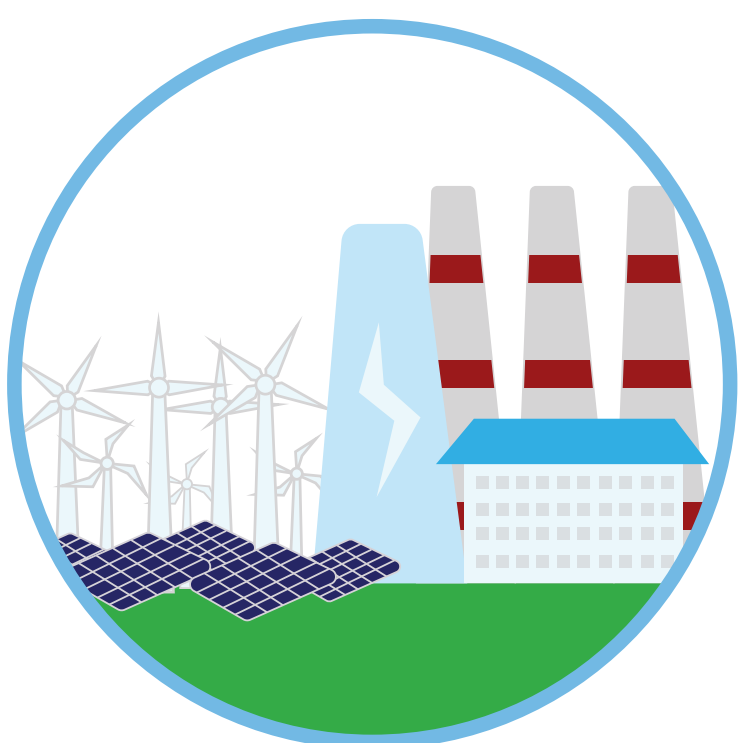
## 5. Real Estate / Building Design & Construction

### Sea level rise will cause financial risks.

Housing developers will choose to avoid flood-prone areas, causing the value of housing in these areas to fluctuate.



Apart from properties, roads, bridges, power plants, public buildings and military bases, other critical infrastructure along the coast also face the risk of chronic flooding.



Power plants



Airports



Ports

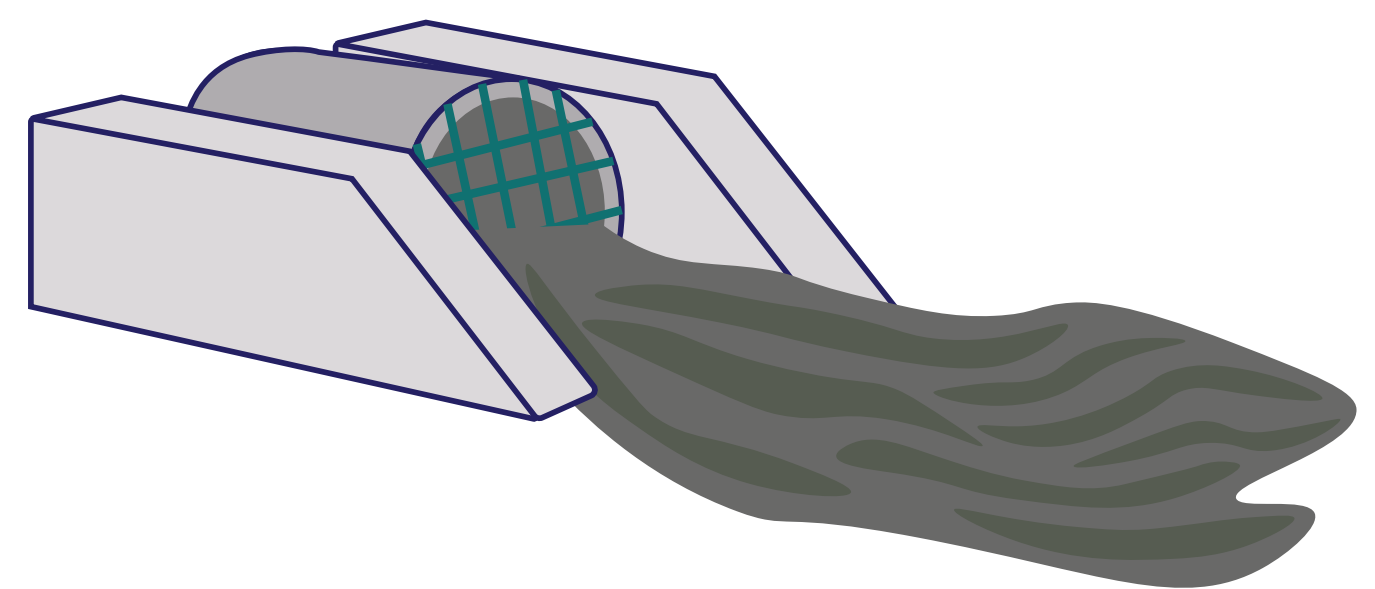


Military bases

- The costs associated with chronic flooding of our coastal built environment—both property and infrastructure—are likely to be staggering.

- Unlike the properties in previous real estate market crashes, these properties are unlikely to recover their value and will only go further underwater with time.

**Infrastructure (e.g. drainage) may be affected by extreme weather events. Design standards may need to be redefined or upgraded in response to the changing climate.**



Many urban drainage and stormwater systems are not designed well enough to handle extreme weather conditions.



## 6. Potential Financial Crisis

The impacts of climate change on the financial industry are yet to be determined, but Wall Street may find itself literally under water in the coming years.



For the financial services industry, prolonged shutdowns could lead to large losses. In the aftermath of 2012's Hurricane Sandy, Lower Manhattan was generally flooded. This resulted in losses amounting to US\$7 billion when the New York Stock Exchange was forced to close for two days.

Though Wall Street—one of the oldest streets in the city—was built mostly on old elevated land, the geography of Lower Manhattan may change drastically in the coming years.

Source: Union of Concerned Scientists, Business Adaptation & CNBC

# HOW ARE BUSINESSES ADAPTING TO RISING SEA LEVELS?

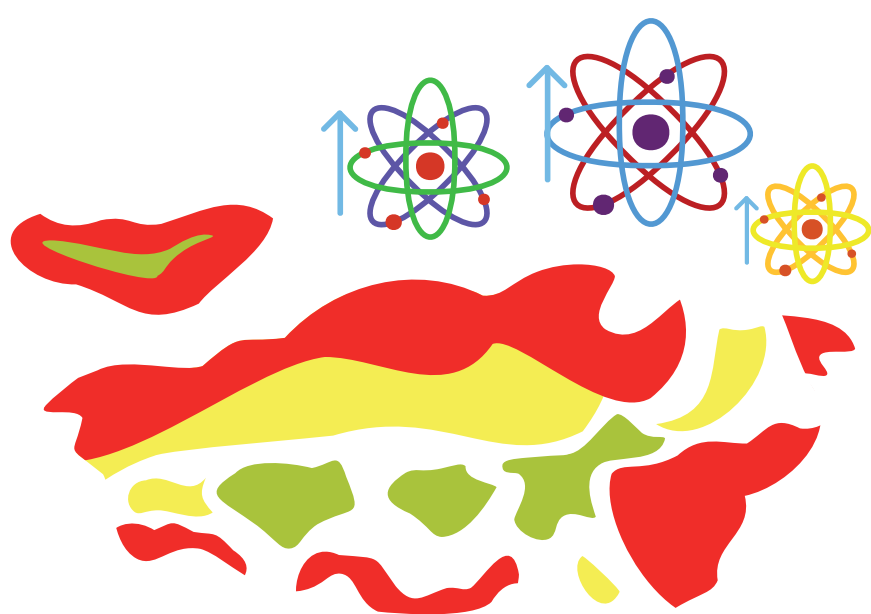
## Solutions Implemented For Different Business Sectors

① Insurance companies are actively taking steps to develop strategies to manage the risks associated with climate change.



Here are two examples of insurance companies:

- Travelers Insurance, an American insurance company, is working to develop more accurate risk assessment tools to better offer insurance rates to businesses based on exposure to effects of climate change.
- Munich Re, a multinational insurance company, has formed a global business unit that offers financial instruments that reduce the risk of weather or natural disaster-related losses.



② Investing in updated flood risk maps that reflect the latest science.

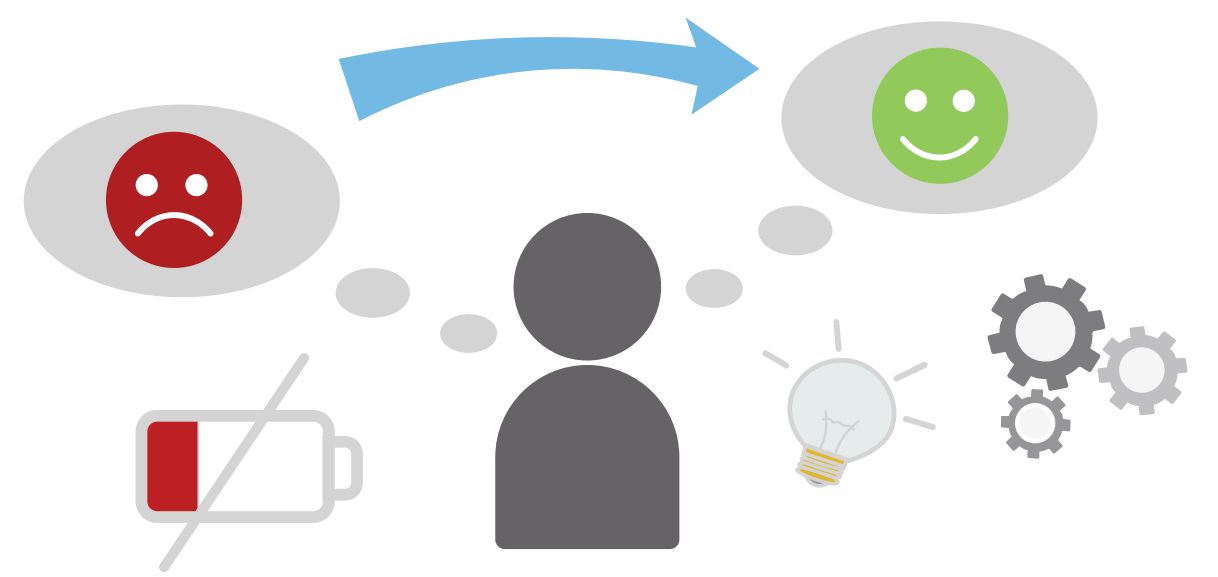
③ Ramping up investments in flood mitigation measures prior to disasters, with resources specifically targeted for disadvantaged communities.



④ Increasing funding for voluntary home buyout programmes.



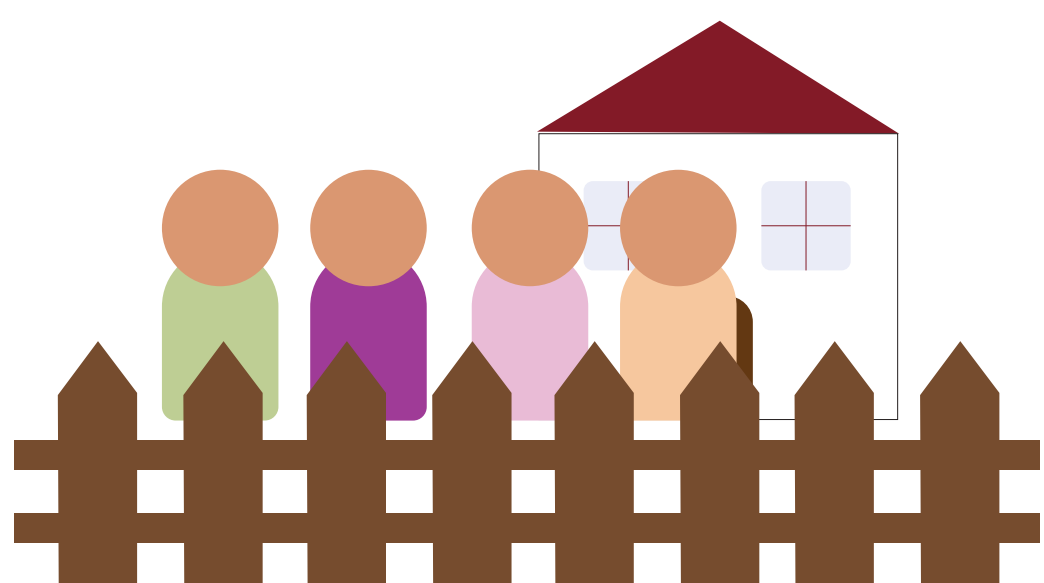
The key is to use the time we have to respond wisely and take transformative actions needed to confront these profound problems!



8 Joining the global community in making cuts in emissions in line with the long-term temperature goals of the Paris Climate Agreement.

If land-based ice loss is limited, we can limit the magnitude and pace of sea level rise, especially in the latter half of the century. Hence, we can limit the scale of harm to people and the economic losses.

7 Investing in bold, transformative policies to help protect people who have fewer resources over the long term and foster new opportunities on safer ground for those who need to relocate.



GUIDELINES	
①	_____ ✓
②	_____ ✓
③	_____ ✓
④	_____ ✓
⑤	_____ ✓



5 Implementing a flood-ready standard for central government investments.

6 Setting robust uniform standards and guidelines for flood risk disclosure including for real estate transactions.

Source: Business Adaptation & Union of Concerned Scientists

## **CHAPTER 6:** Swimming or drowning

In the sixth chapter of this series, we examine the impact of rising sea levels on tourism. Sea level rise will impact coastal tourism through inundation and erosion, damage to tourism infrastructure, (e.g., hotels/resorts, transportation) and essential coastal resources (e.g., beaches and coral reefs).

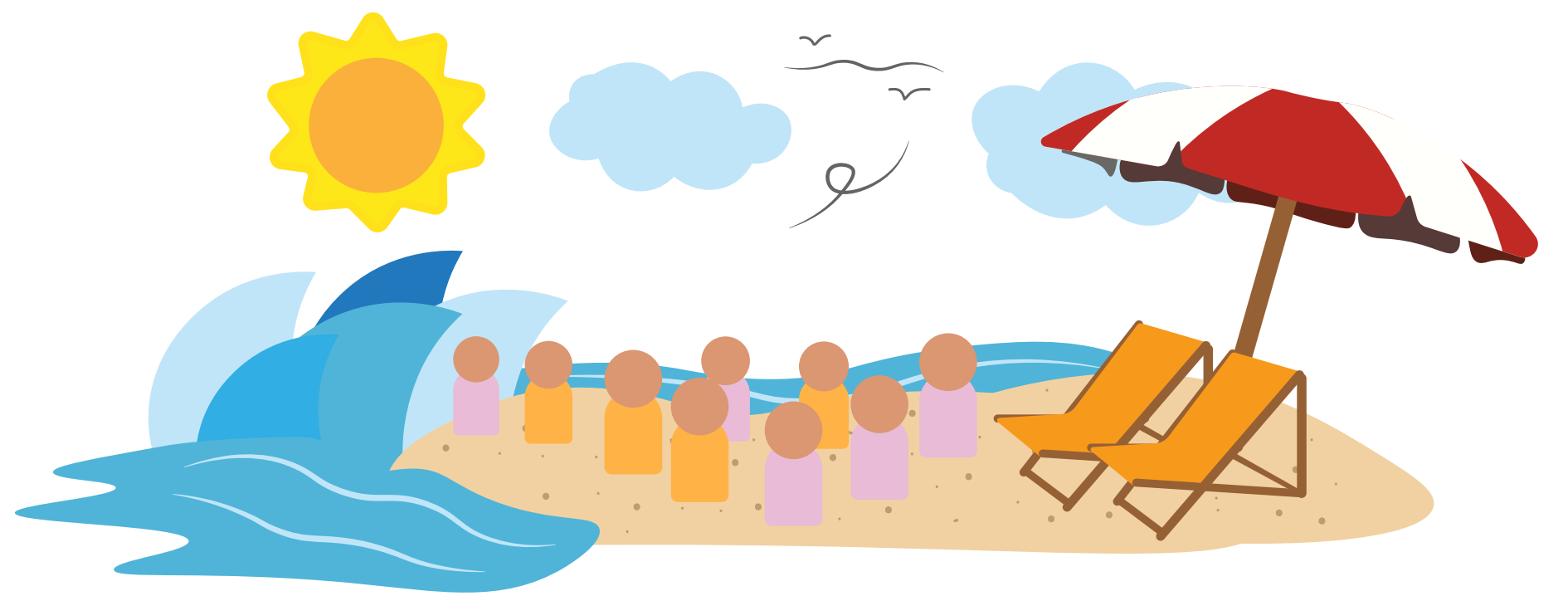




# HOW DO RISING SEA LEVELS AFFECT TOURISM?

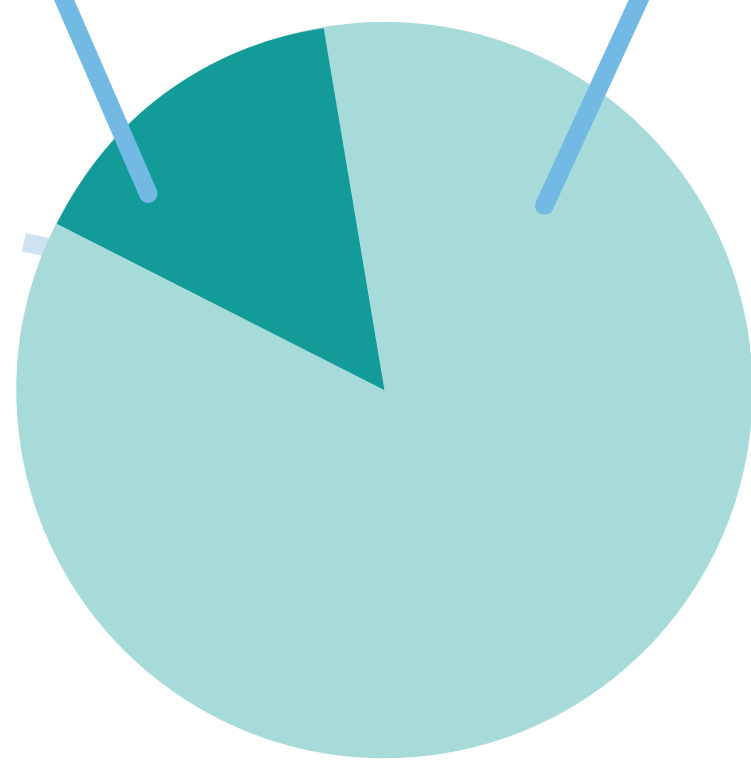
## Coastal Tourism Is Part Of the Global Tourism Industry

More than 60% of Europeans opt for beach holidays. In addition, beach tourism accounts for more than 80% of tourism earnings in the US.



### United States Tourism Earnings

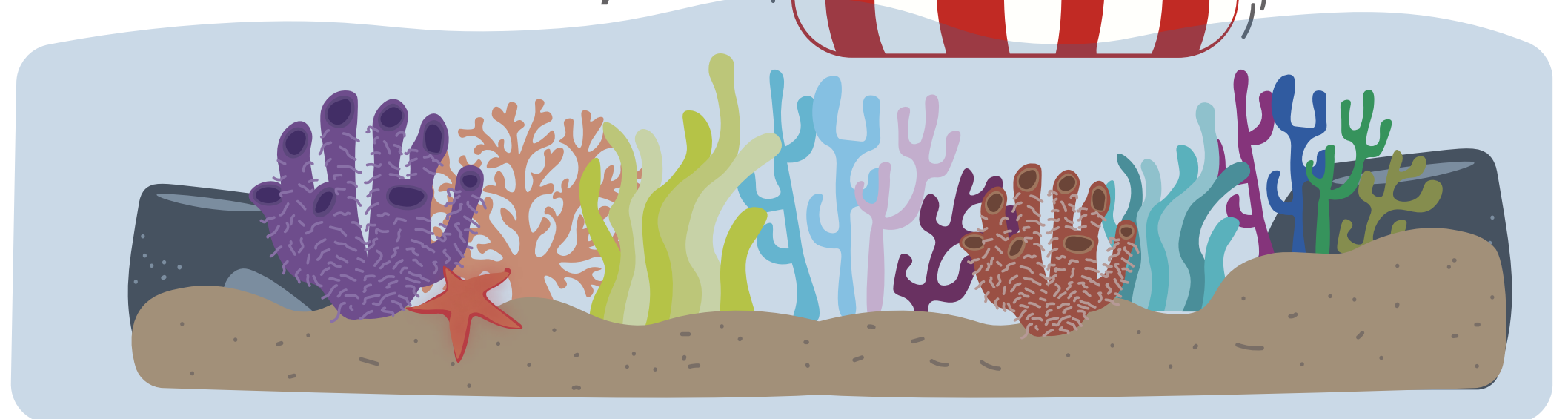
Others Beach tourism



More than 100 countries benefit from the recreational value provided by their coral reefs,



which contributed US\$11.5 billion to global tourism in 2014.



According to the World Economic Forum's Global Risk Report 2019, around 90% of coastal areas will be affected by rising sea levels to varying degrees.

Growing cities are sinking due to their sheer weight. When combined with the ongoing extraction of groundwater by city residents, it is estimated that some cities will experience sea levels rising as high as 30% above the global mean within the next 35 years.

New York



United States

These are some of the coastal areas that are at risk of being submerged underwater.



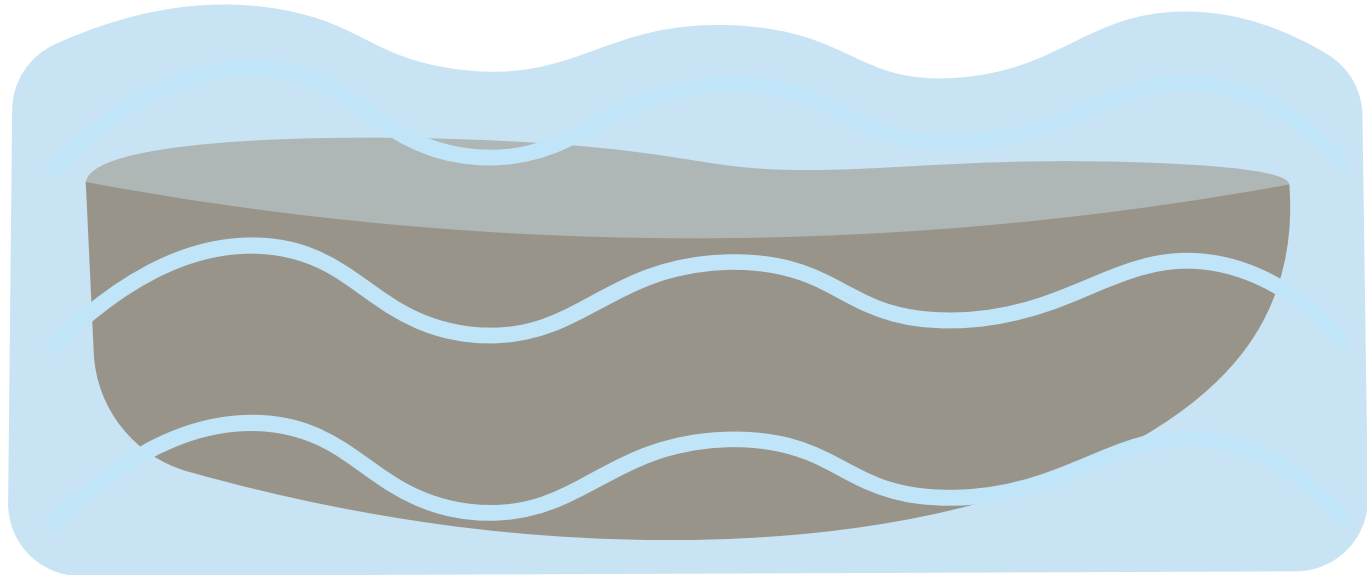
Shanghai

China

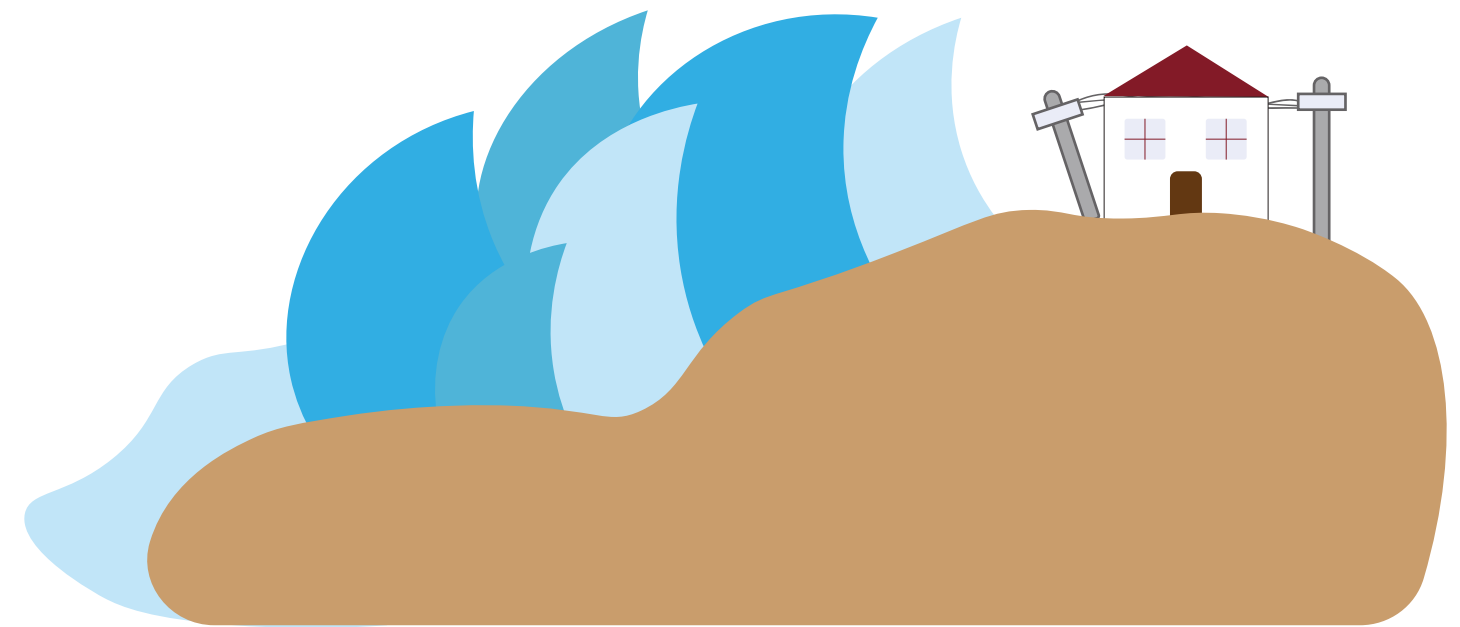


\*For illustration purposes only

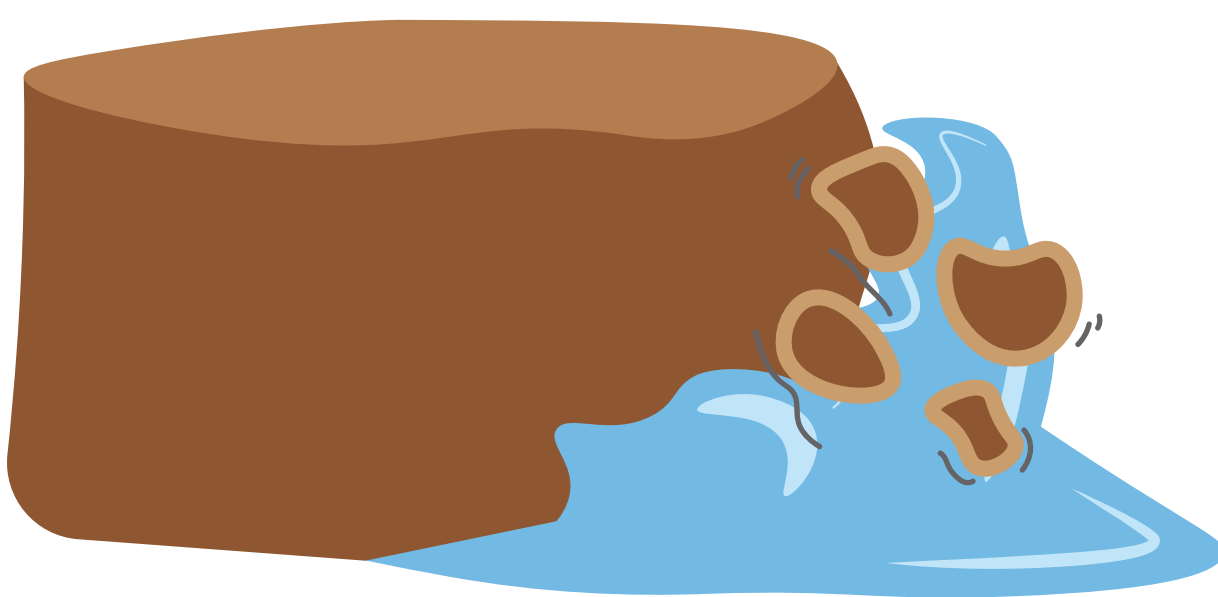
## Rising Sea Levels Pose Hazards To Coastal Zones



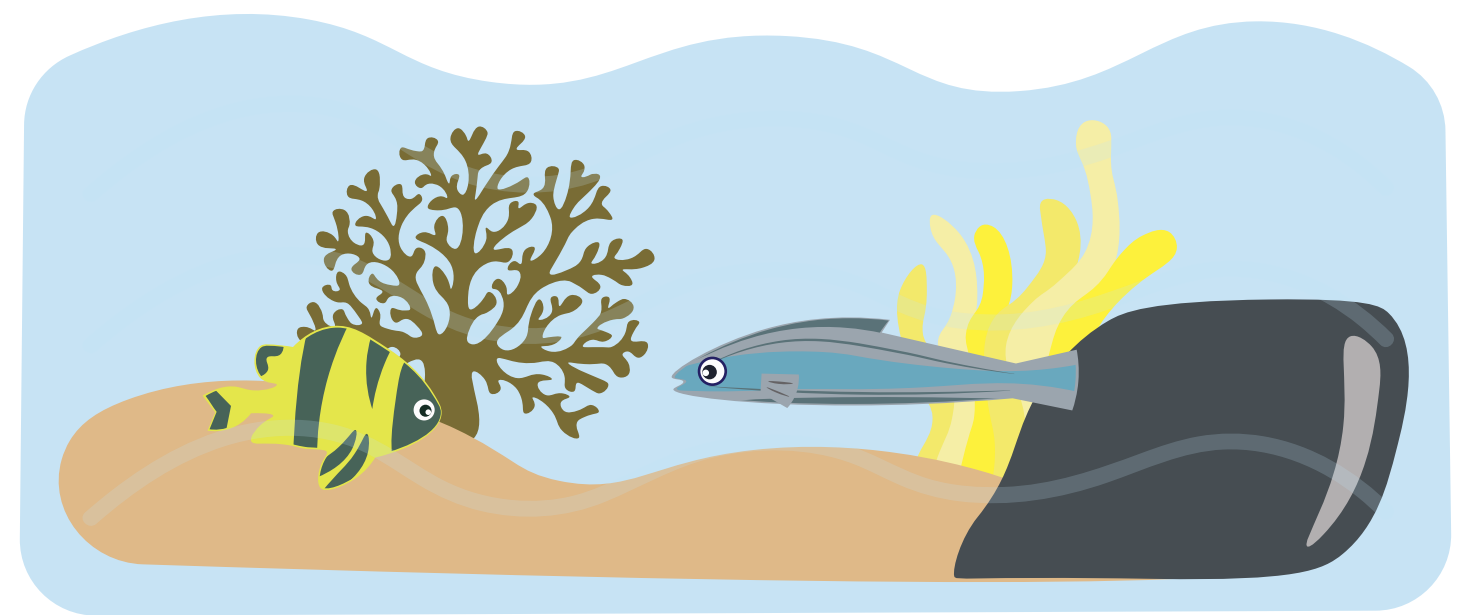
Permanent submergence of land due to higher mean sea levels or mean high tides



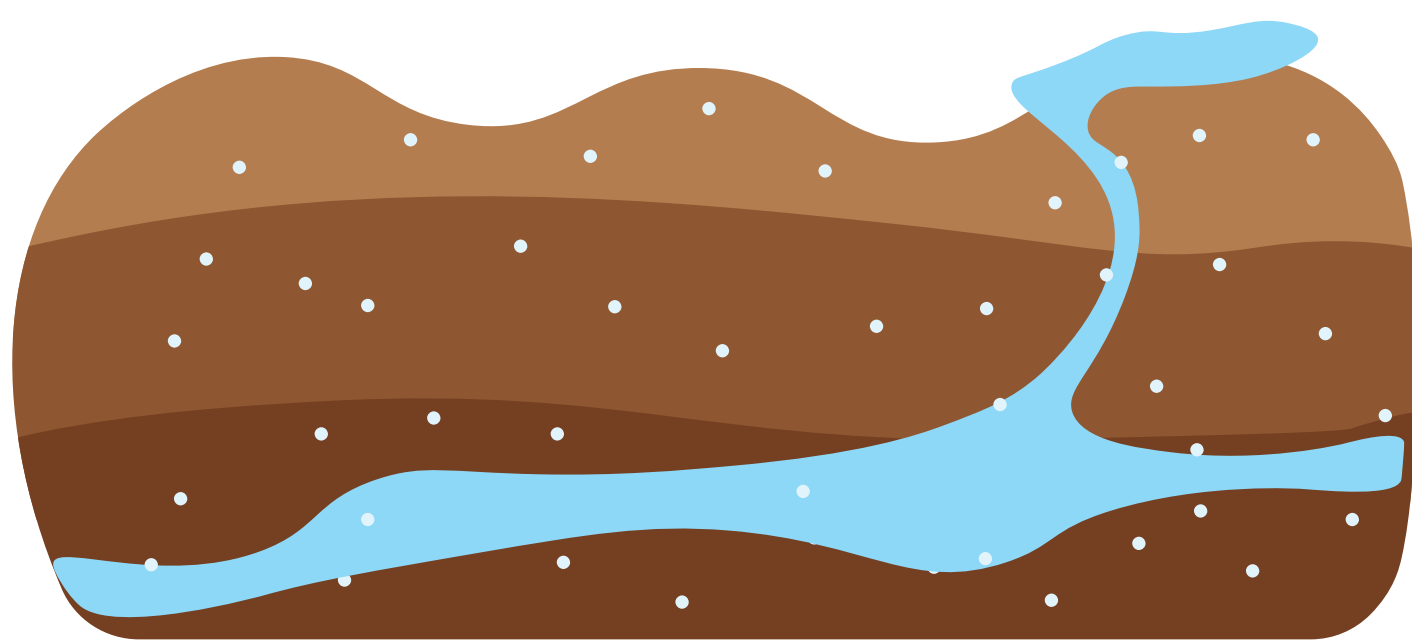
More frequent or intense coastal flooding



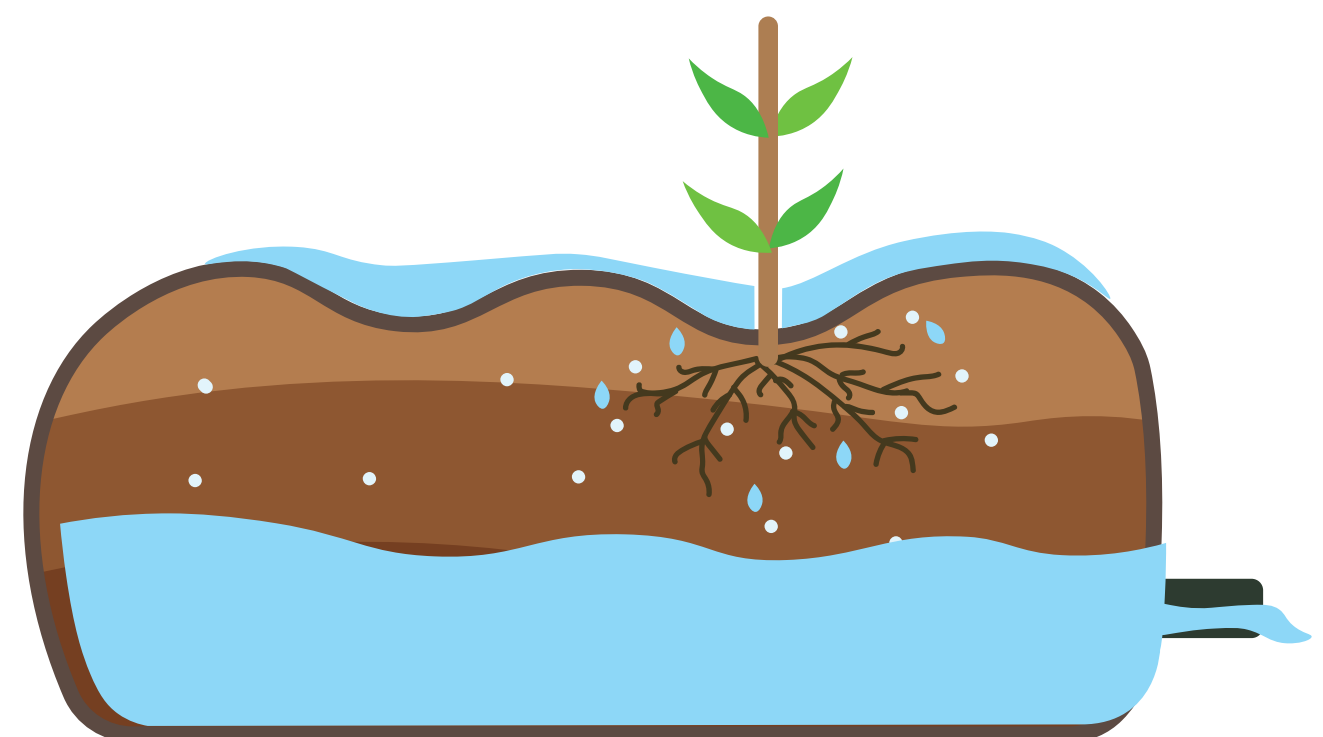
Aggravated coastal erosion



Loss of and change in coastal ecosystems



Salinisation of soils, ground and surface water



Impeded drainage

**Beaches, sand dunes and cliffs are currently eroding and will persist as long as sea levels continue to rise.**



Image source: Guillermo Alvarez via Unsplash

Source: Skift, World Economic Forum, Intergovernmental Panel on Climate Change

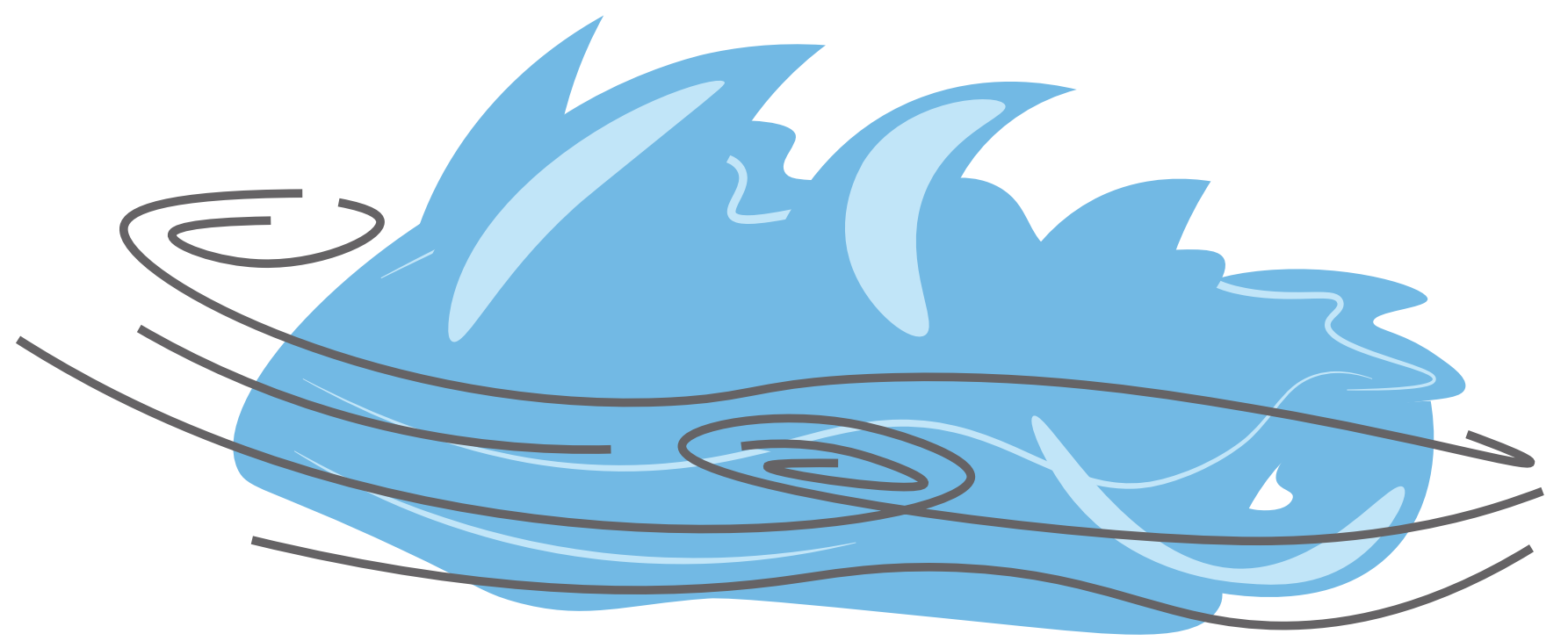


# WHAT IS THE IMPACT OF CLIMATE CHANGE ON TOURISM?

According To The Intergovernmental Panel On Climate Change, Tourism Is Considered An Industry Sensitive To Climate Change. Climate Change Has Various Impacts, Including:



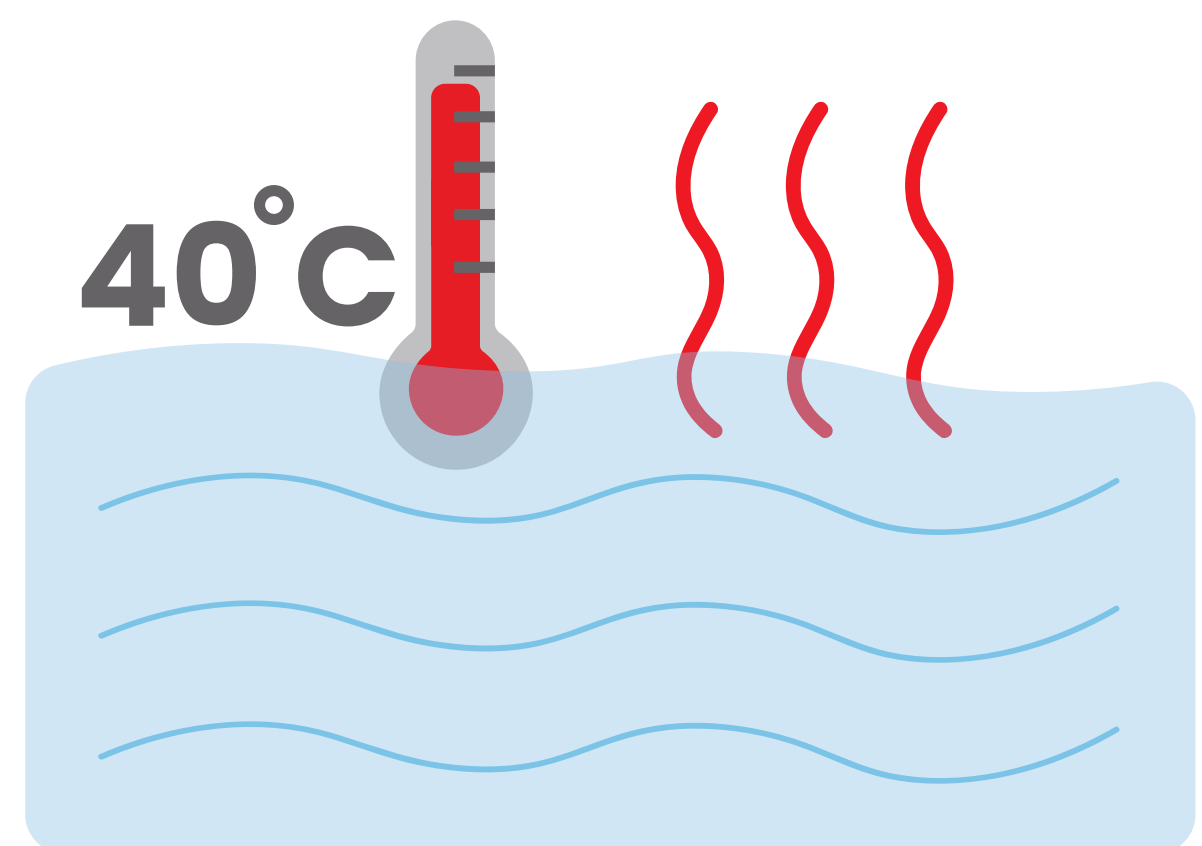
Sea level rise and beach erosion



High winds and storm surges



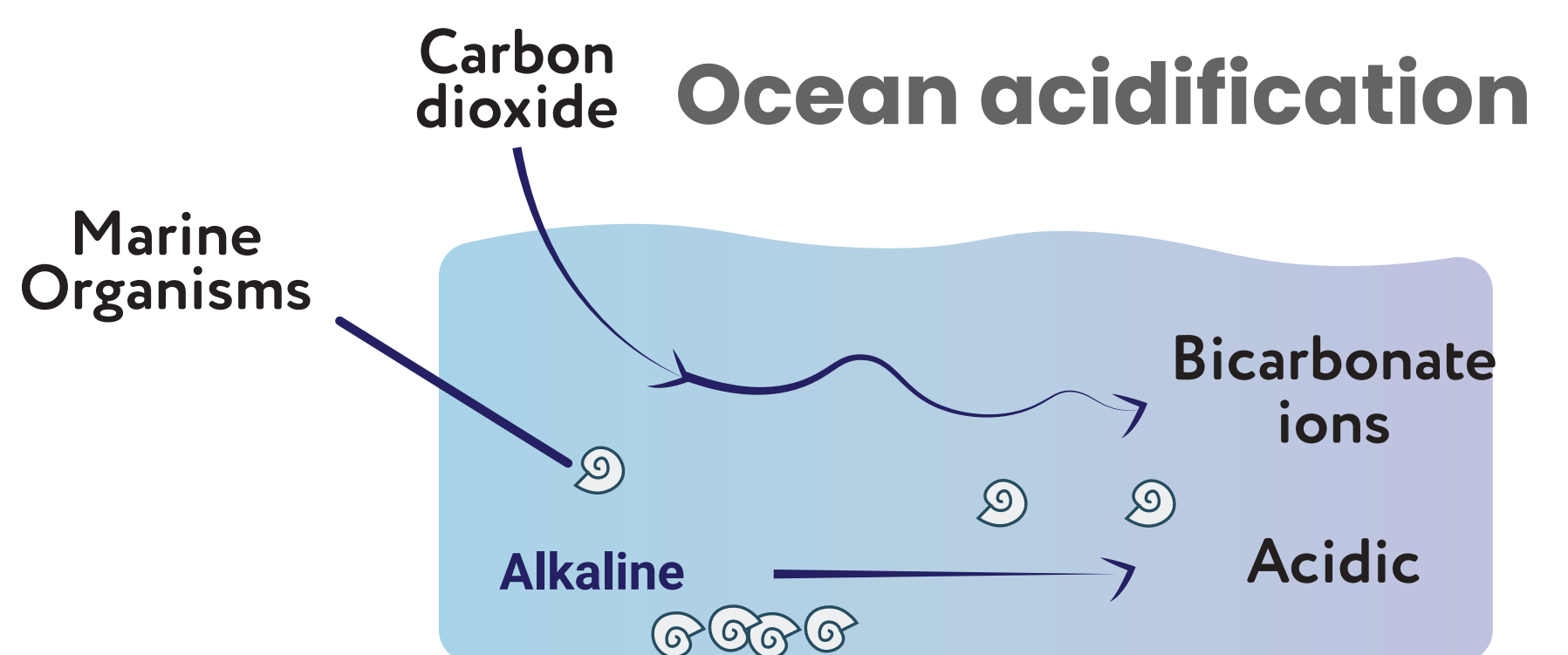
Changing rainfall patterns and amounts



Rising air and water temperatures



Extreme weather events (e.g. tropical cyclones)



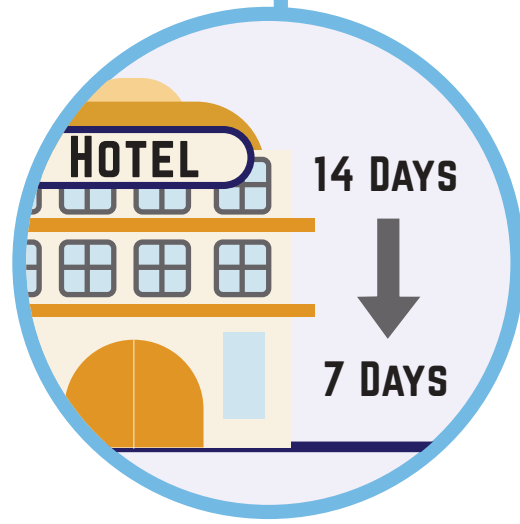
Environmental changes (e.g. ocean acidification and/or ecosystem changes)

# Impacts of Climate Change On Tourism

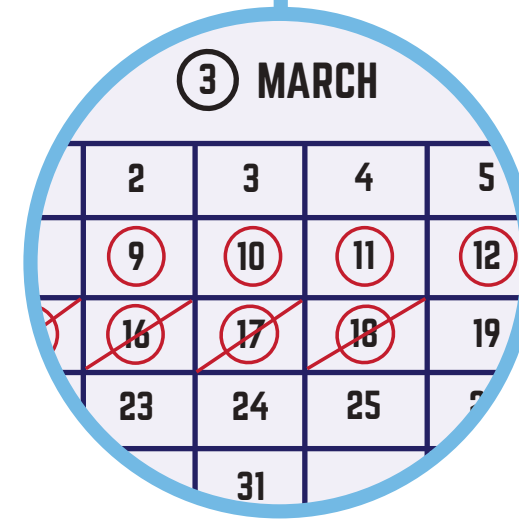
An increase in temperature creates effects such as shorter times for safe sun exposure, thermal stress and an increased risk of skin cancer. These will lead to possible consequences such as:



Redirection of demand to other potential tourism destinations



Holiday stays becoming shorter



Changes in the usual travel periods



Poor quality of experience

**Extreme weather events** cause the destruction of tourism infrastructure, road blockades and interruption of media services. Other possible consequences include:

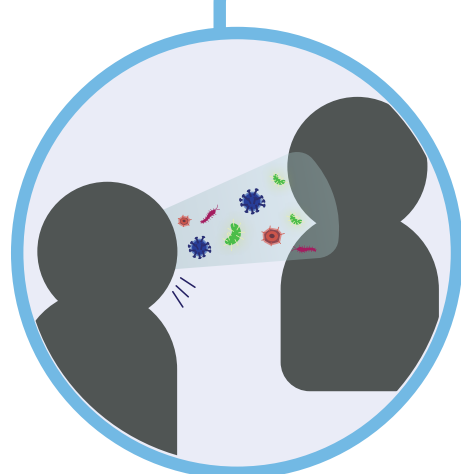
Lack of drinking water



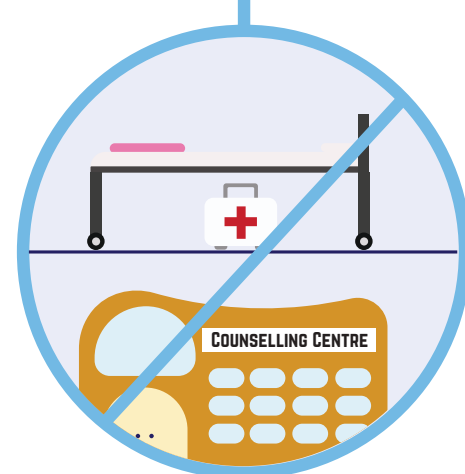
Increase in the price of travel



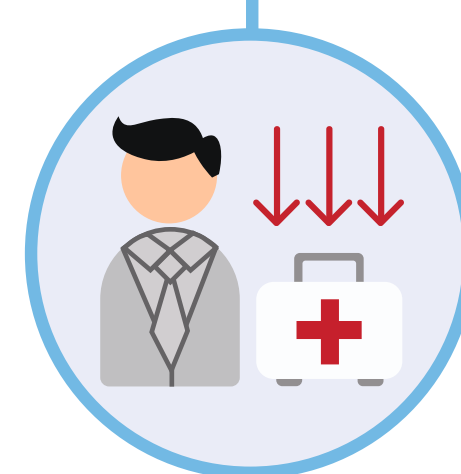
High costs of recovery



Contamination and spread of diseases



Unavailability of emergency accommodation, counselling and assistance to victims



Lower capacity for emergency care (rescue, evacuation, medical services)

Source: ResearchGate, CoastAdapt & SciELO



# WHICH TOURISM DESTINATIONS HAVE BEEN OR WILL BE IMPACTED BY RISING SEA LEVELS?

## 1. The Maldives



The Maldives is the world's lowest lying nation. On average, the islands are only 1.3m above sea level.

Should waters rise as much as 0.9m, it would submerge the Maldives' 1,200 islands enough to make them uninhabitable.

## 2. Amsterdam, The Netherlands



Parts of Amsterdam are already 4m below sea level. Should the Earth's temperatures warm by 4°C, the sea level around Amsterdam could rise by a whopping 7.6m.

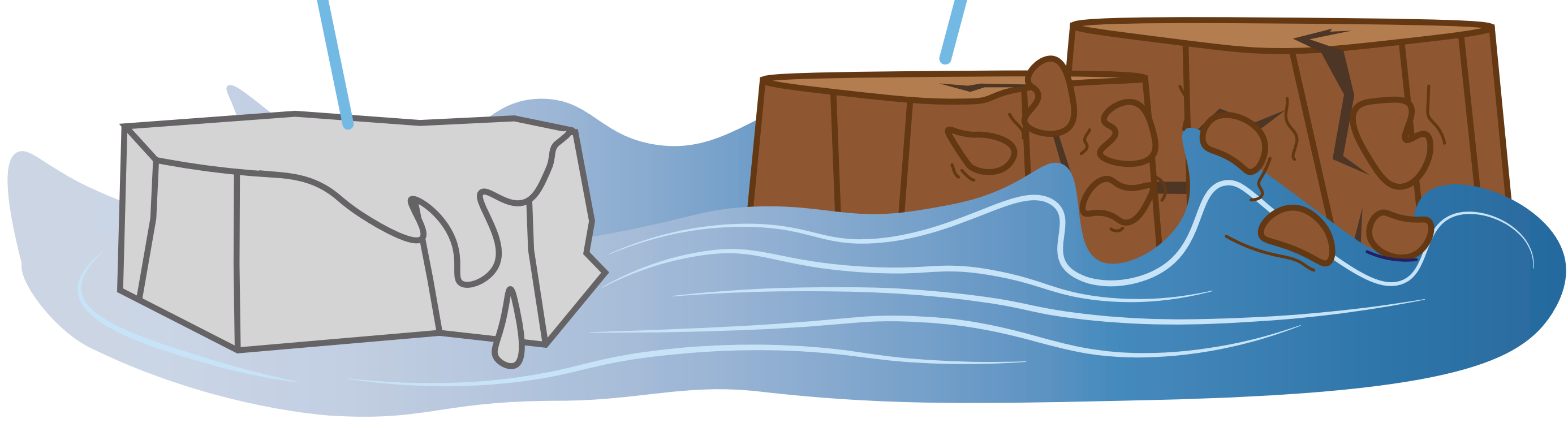
This could potentially displace as much as 98% of the city's population.

### 3. The Magdalen Islands, Canada

Located in the Gulf of St Lawrence in Quebec, the Magdalen Islands' sandstone cliffs are susceptible to erosion.

As temperatures rise, the wall of sea ice that protects the archipelago from the blustering winds and sea spray will melt rapidly.

With this last line of defence gone, it is likely that the islands will erode even faster than their current rate of loss – a massive 1m a year.

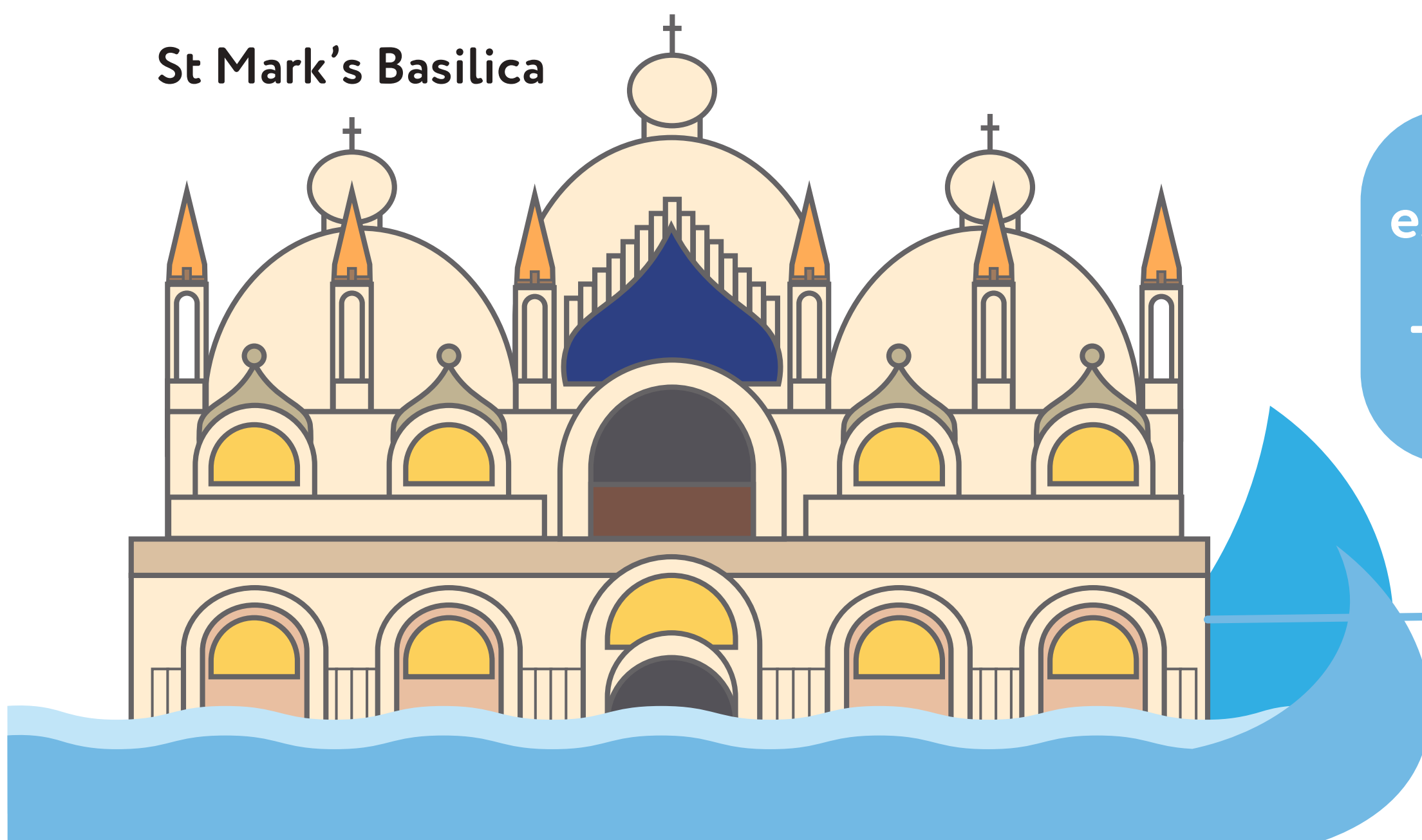


### 4. Venice, Italy

Venice's buildings have long been slowly sinking, and rising sea levels will only make things worse. Because of this, Venice is on the World Monuments Fund's list of places under threat.

In November 2019, the tide in Venice reached 1.87m - the second highest acqua alta since records began in 1923.

St Mark's Basilica

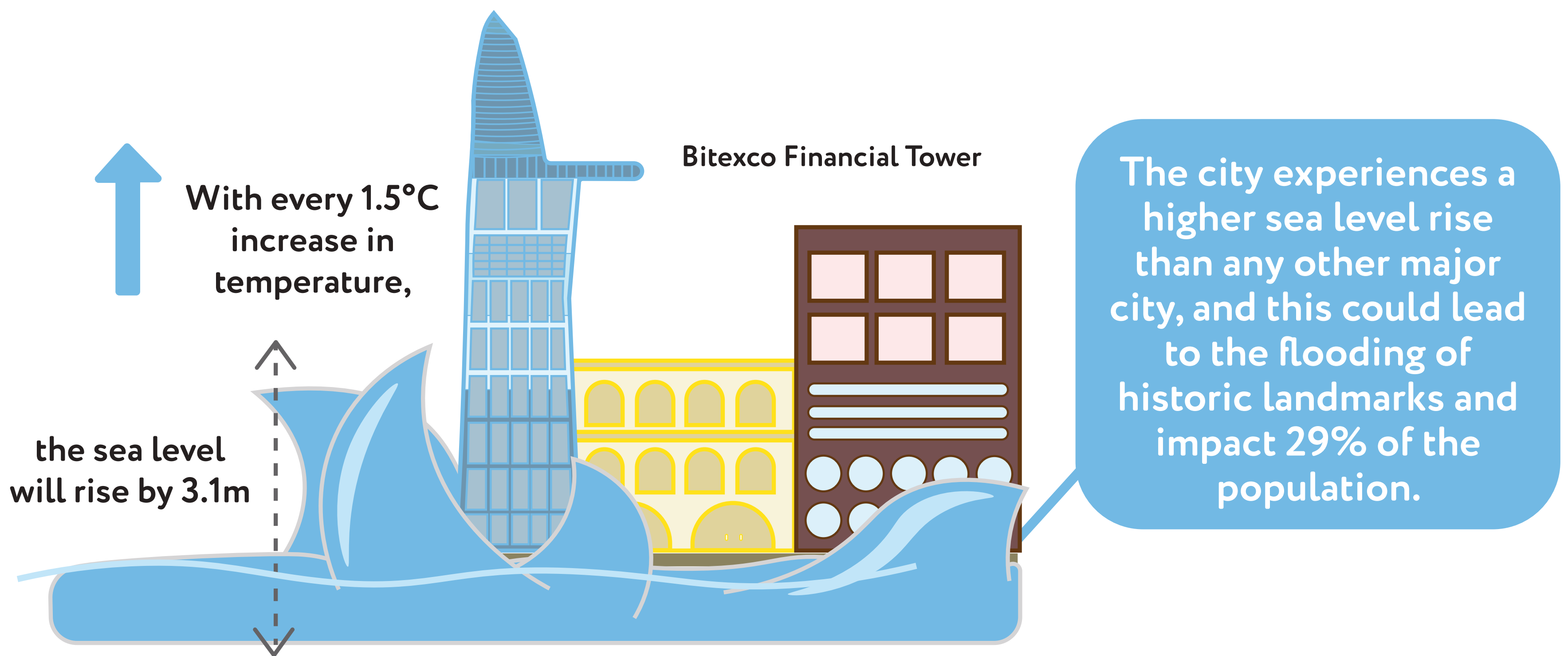


Acqua alta refers to the exceptional tide peaks that occur in the northern Adriatic sea. These tide peaks are reinforced by strong seasonal winds.

The high tide flooded the crypt of St Mark's Basilica for the 5th time in its 1,200-year history.



## 5. Ho Chi Minh City, Vietnam



## 6. Rio de Janeiro, Brazil

It has been speculated that if global warming continues at its current rate, the waters around the city could rise by up to about 0.8m by 2100. Its popular beaches could be gone, along with its airport.



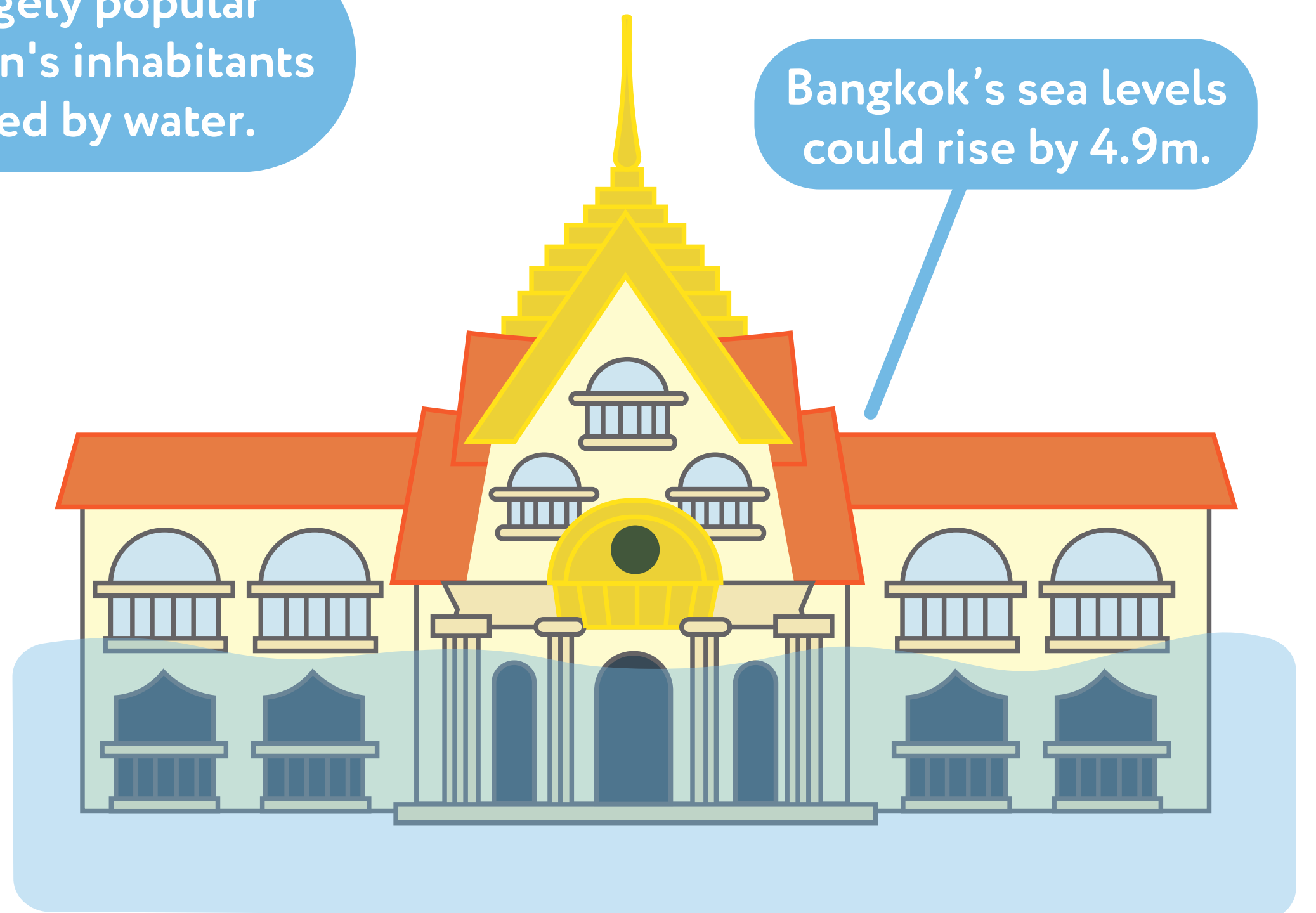
## 7. Bangkok, Thailand

If Earth  
warms by  
2°C by 2100

42% of this hugely popular  
tourist destination's inhabitants  
will be displaced by water.

The Grand Palace

Bangkok's sea levels  
could rise by 4.9m.



## 8. Bangladesh

Bangladesh is located  
downstream of three large  
river basins, and most of its  
land mass is less than 5m  
above sea level.

The precipitation from the monsoon over  
the months of June to September is  
Bangladesh's main source of water. But due  
to its low-lying land, it is periodically  
affected by floods that are accompanied by  
storm surges and cyclones.



With rising sea levels, the  
problem is set to worsen.



## 9. The Orkney Islands, Scotland

Orkney is home to an abundance of vastly important archaeological heritage sites that date back as far as 5,000 years.



Image source: Jacobite via Pixabay

As rainfall increases and sea levels rise, around half of the almost 3,000 heritage sites are under threat from coastal erosion.

Most studies show that storm activity in the area has intensified, and indicate that it will continue to increase, which may lead to further degradation of these sites.



## 10. London, United Kingdom

When the Thames Barrier was first used in 1984, it was predicted that it would only be called upon 2 to 3 times a year.

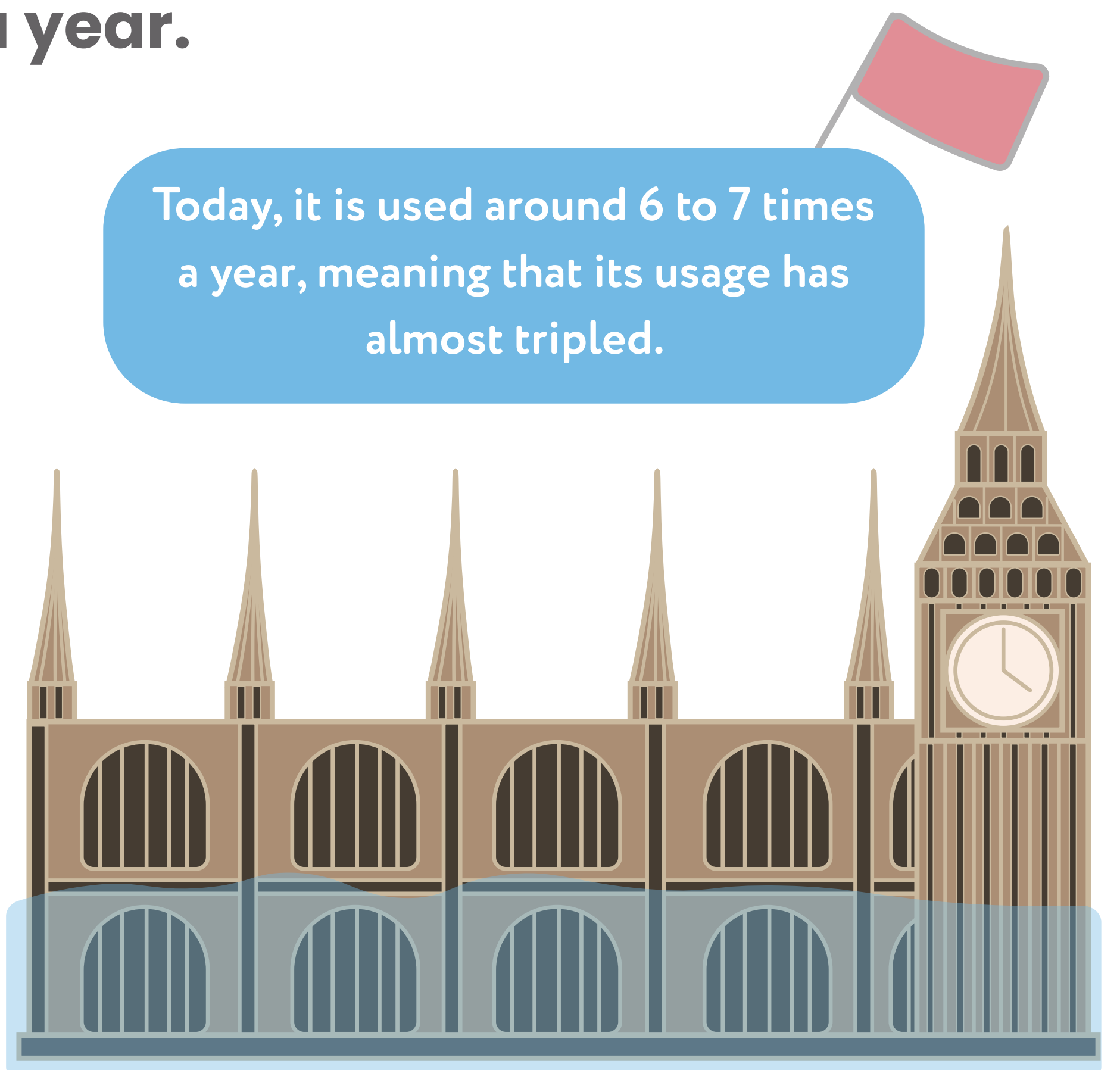
Thames Barrier



Image source: John Cameron via Unsplash

While London is fairly inland, it doesn't sit too far from the river mouth, making it vulnerable to tidal fluctuations.

Today, it is used around 6 to 7 times a year, meaning that its usage has almost tripled.

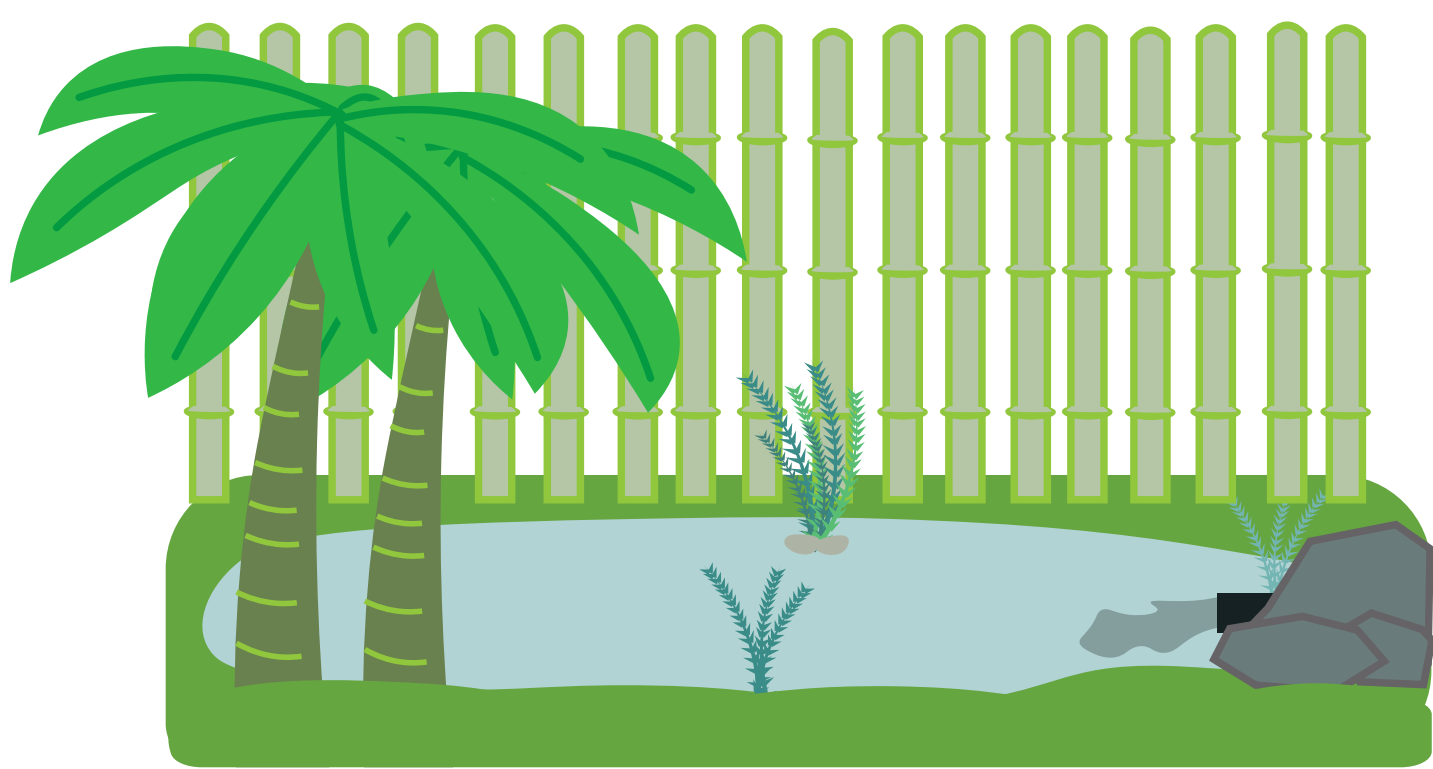


Source: The Telegraph, Yale School of the Environment, World Meteorological Organisation

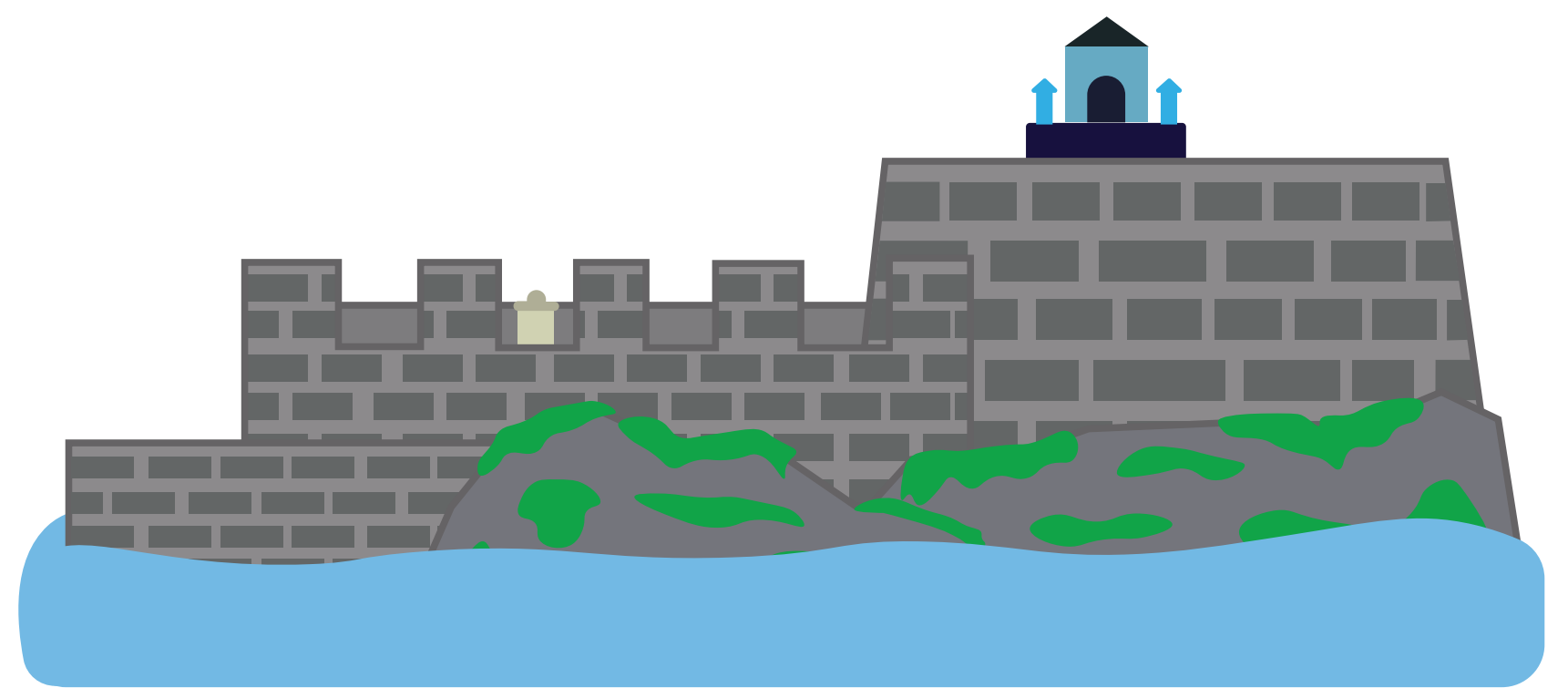


# WHAT ARE THE IMPACTS OF RISING SEA LEVELS ON TOURISM/ HOLIDAY DESTINATIONS?

**Tourism And Other Recreational Businesses That Depend On Coastal Areas May Be Severely Affected. As Such, Rising Sea Levels Can Have Both Direct And Indirect Impacts On This Sector.**



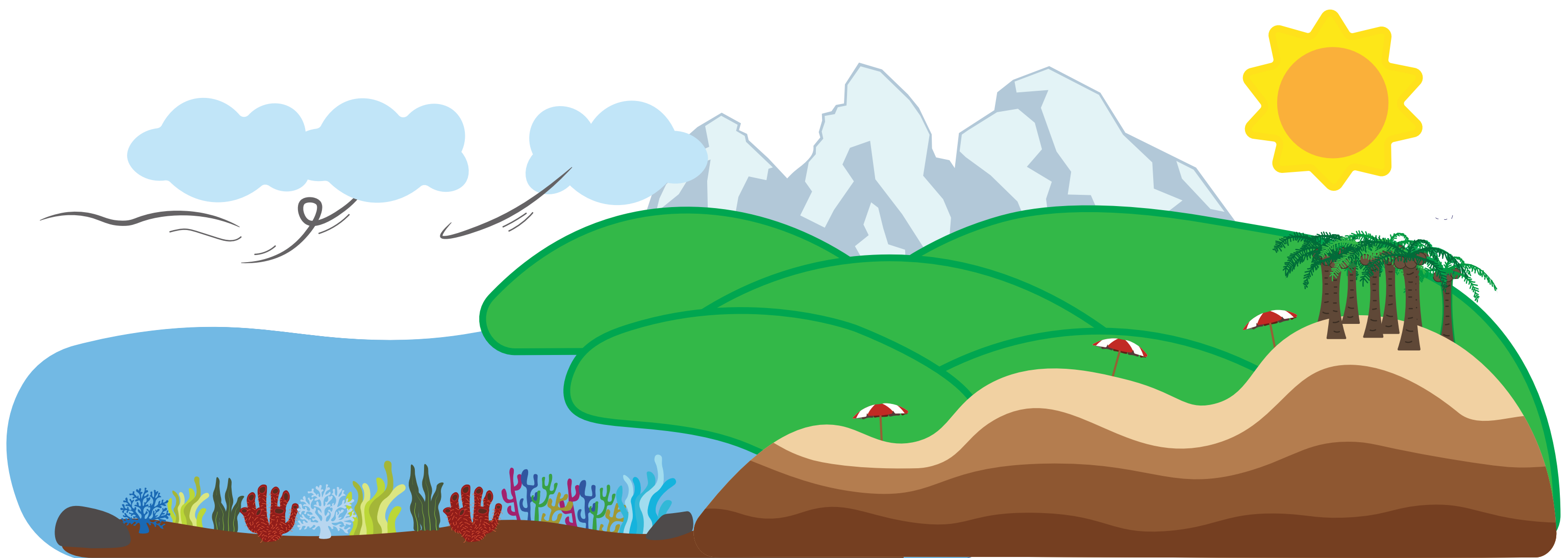
**Most prominent direct impact:**  
Potential flooding and destruction of coastal tourist and cultural sites



**Most prominent indirect impact:**  
Contamination of freshwater springs, and disruption to water supply and sewerage systems

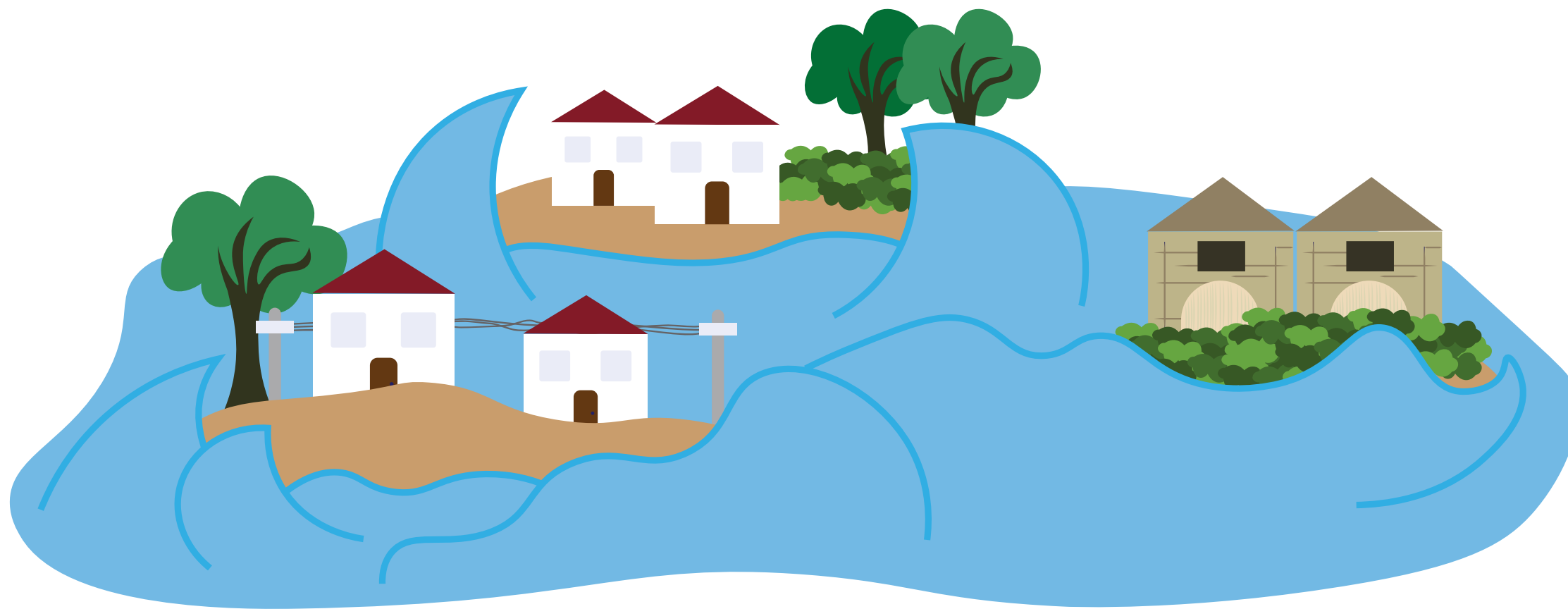
## Destruction Of Coral Reefs And Natural Coastal Areas:

Tourism in coastal areas is highly dependent on natural resources such as beaches, coral reefs and caves. Coastal erosion may destroy the beauty of these places in the next 30 years.





## Sinking Coastal Regions And Islands:

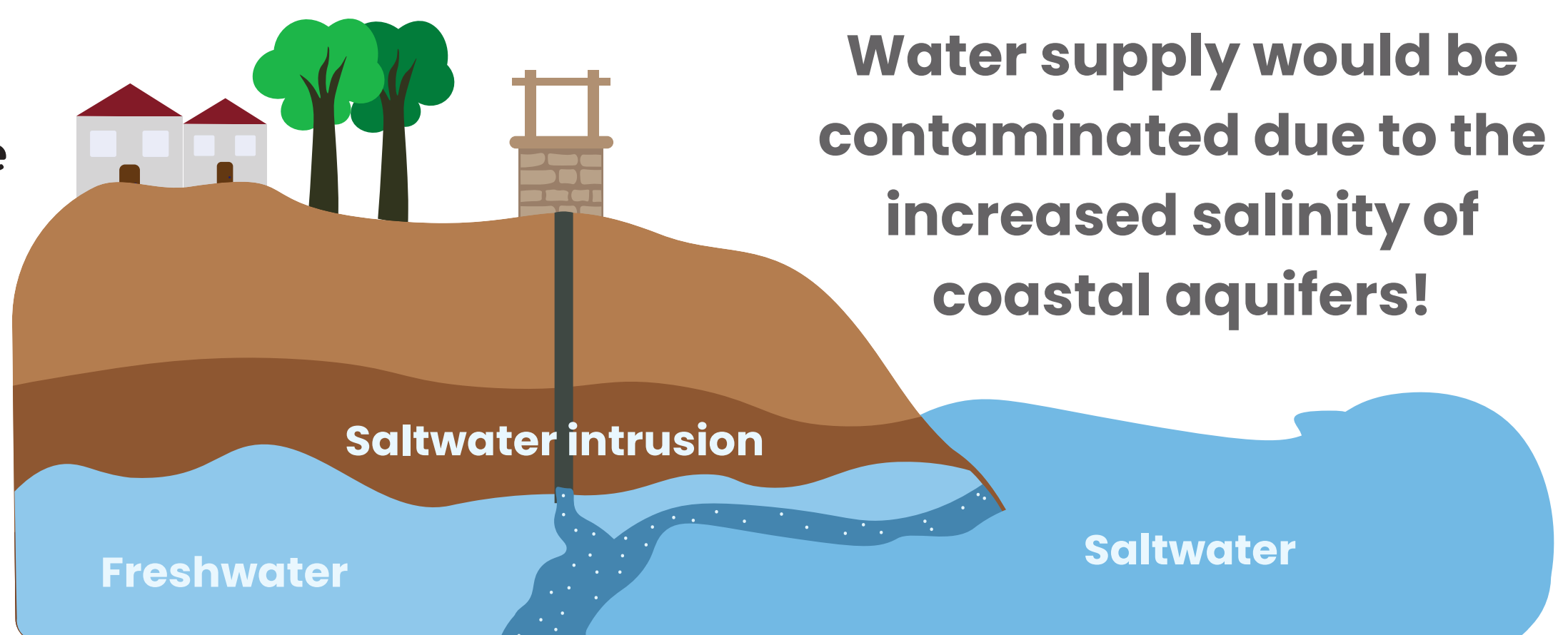


As our planet experiences rising temperatures and sea levels, small islands and parts of coastal regions may be submerged by the seas.

## Non-Economic Losses:

In Pacific Small Island Developing States (SIDS), water quality is being affected in several coastal aquifers, the rocks underground that hold water. This is due to rising sea levels increasing the salinity of the water.

This poses a serious problem for the inhabitants of these islands, whose only source of freshwater are the coastal aquifers.



Water supply would be contaminated due to the increased salinity of coastal aquifers!



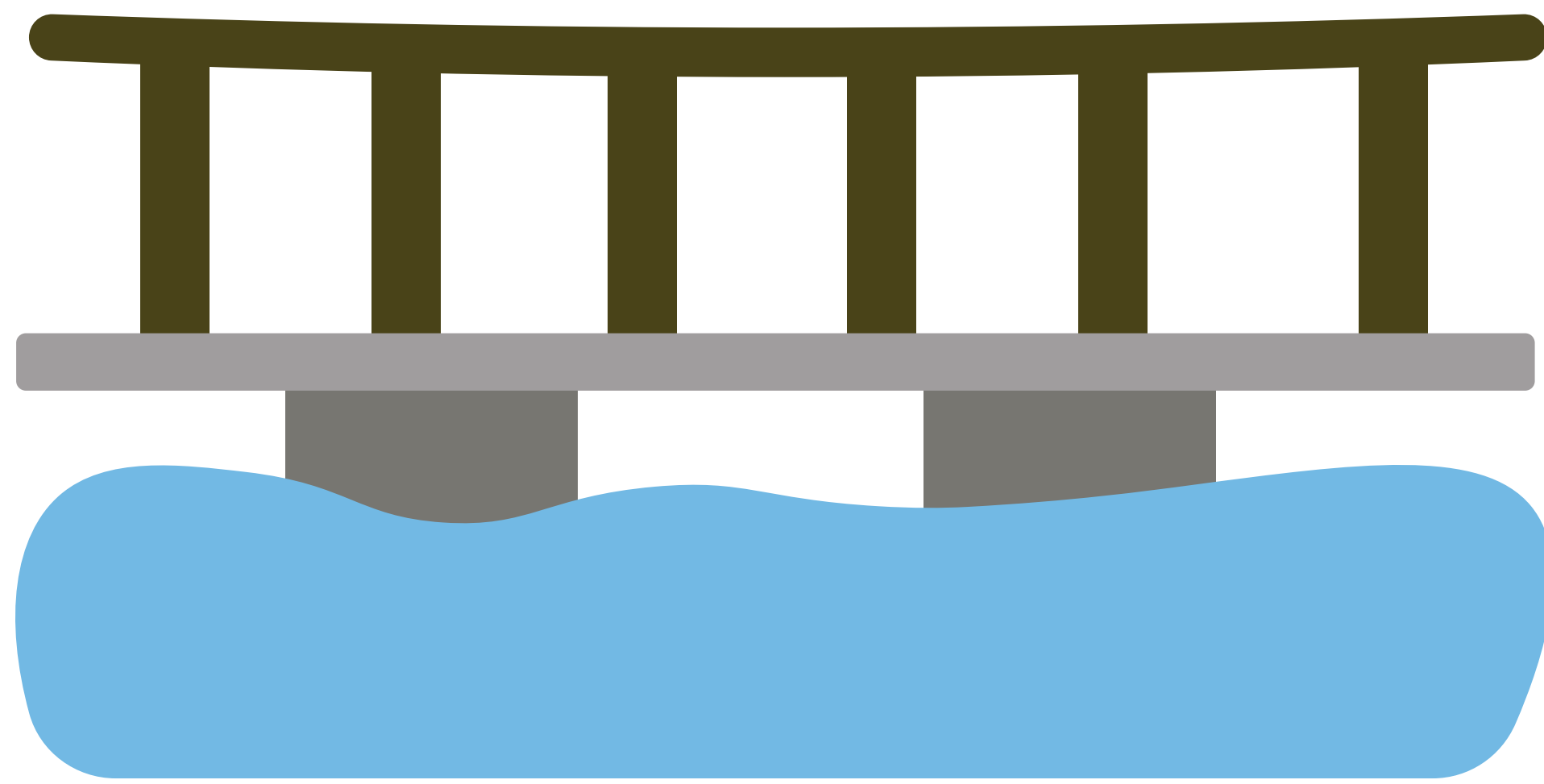
Sea level rise has severely increased the impact of tropical storms, from displacement to destruction, setting countries back in their development.

Additionally, sea level rise threatens cultural heritage and preservation in many SIDS as there are cultural and ceremonial sites found in coastal areas.

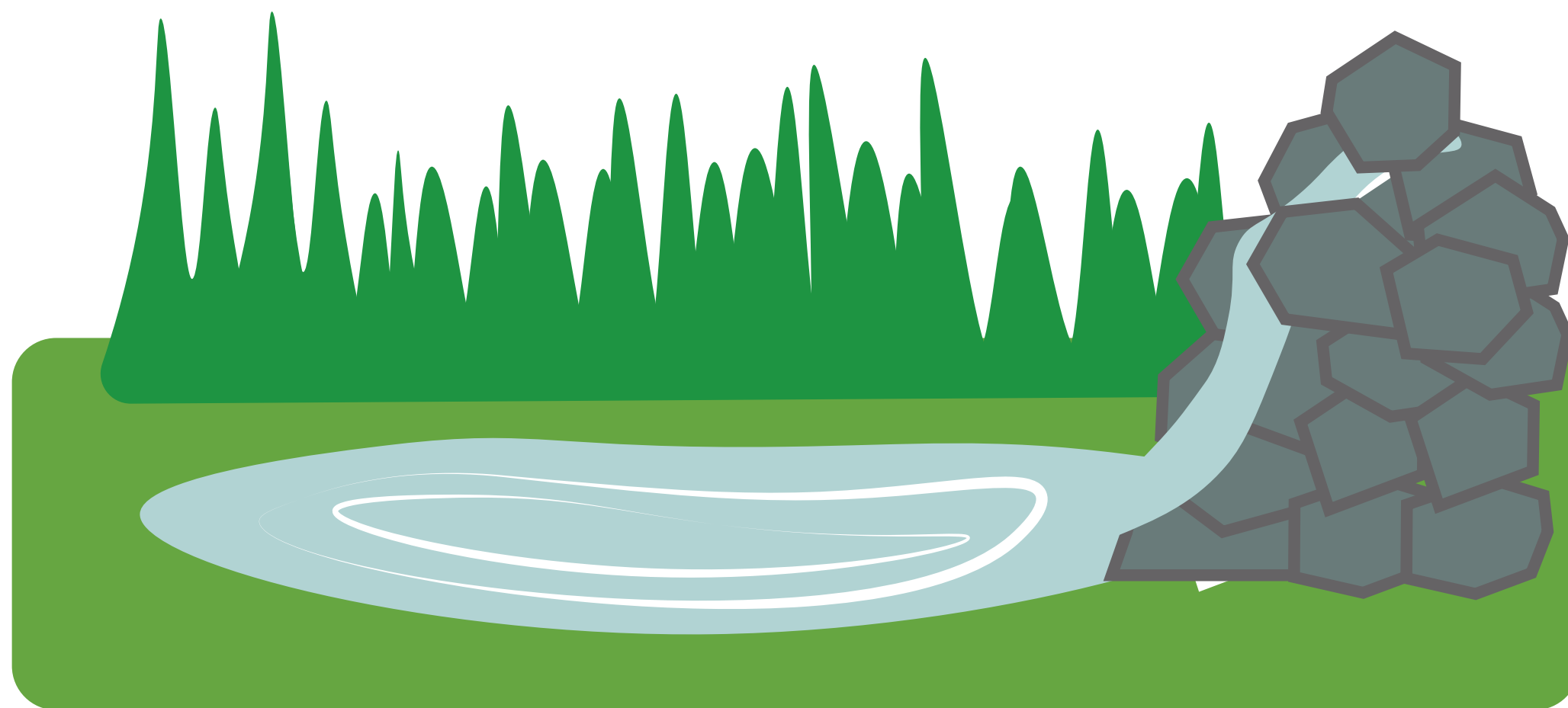
In the Pacific, sea level rise could render entire island nations uninhabitable.



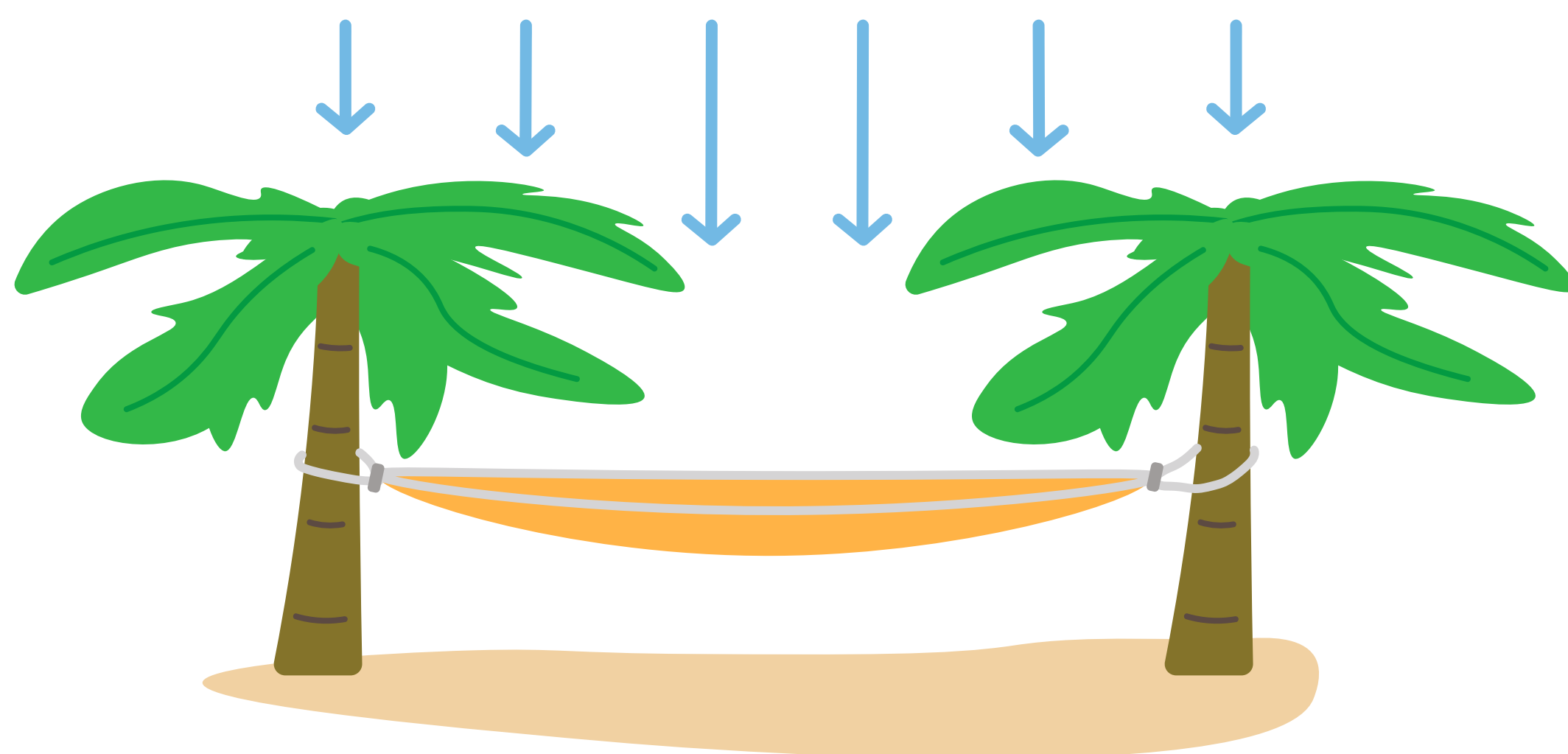
## Consequences Of Sea Level Rise



High cost of waterfront restorations



Impacts on freshwater reserves



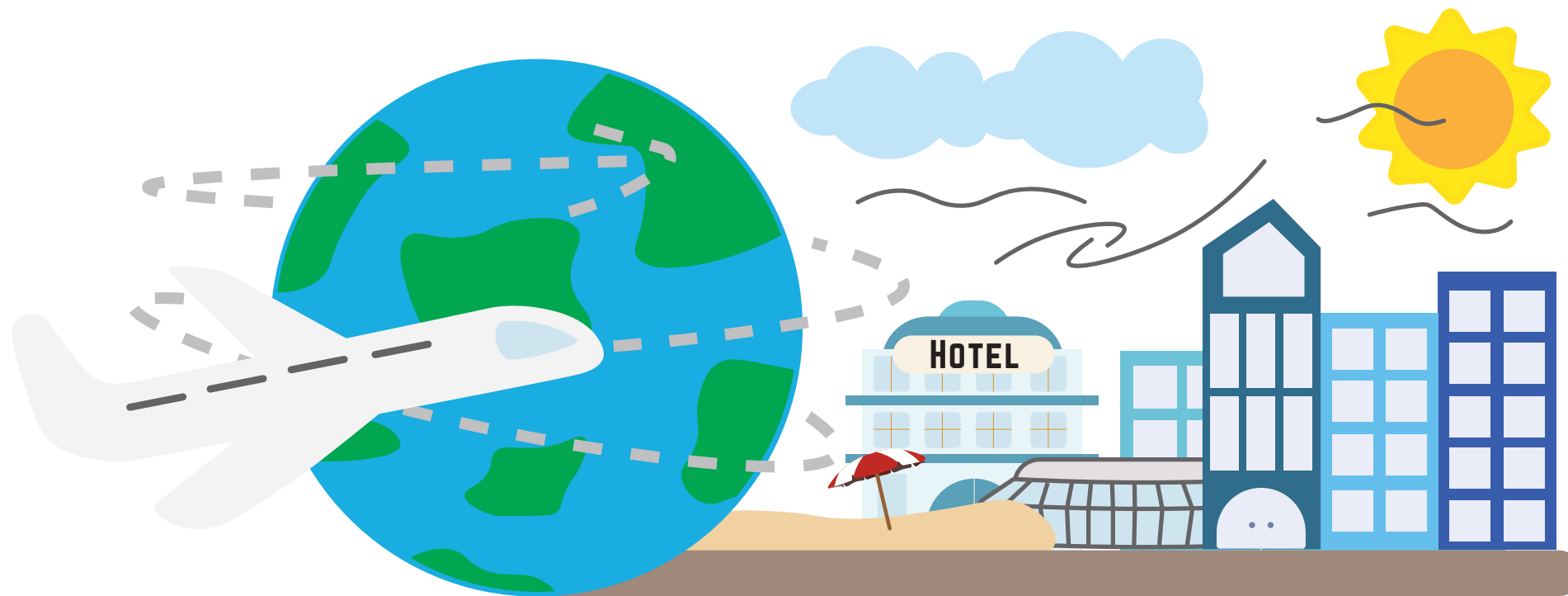
Decrease in sand space for leisure

Source: The Luxury Signature, Climate Analytics & University of Rijeka (Jože Perić, Full Professor & Zvonimira Šverko Grdić, Assistant Professor)



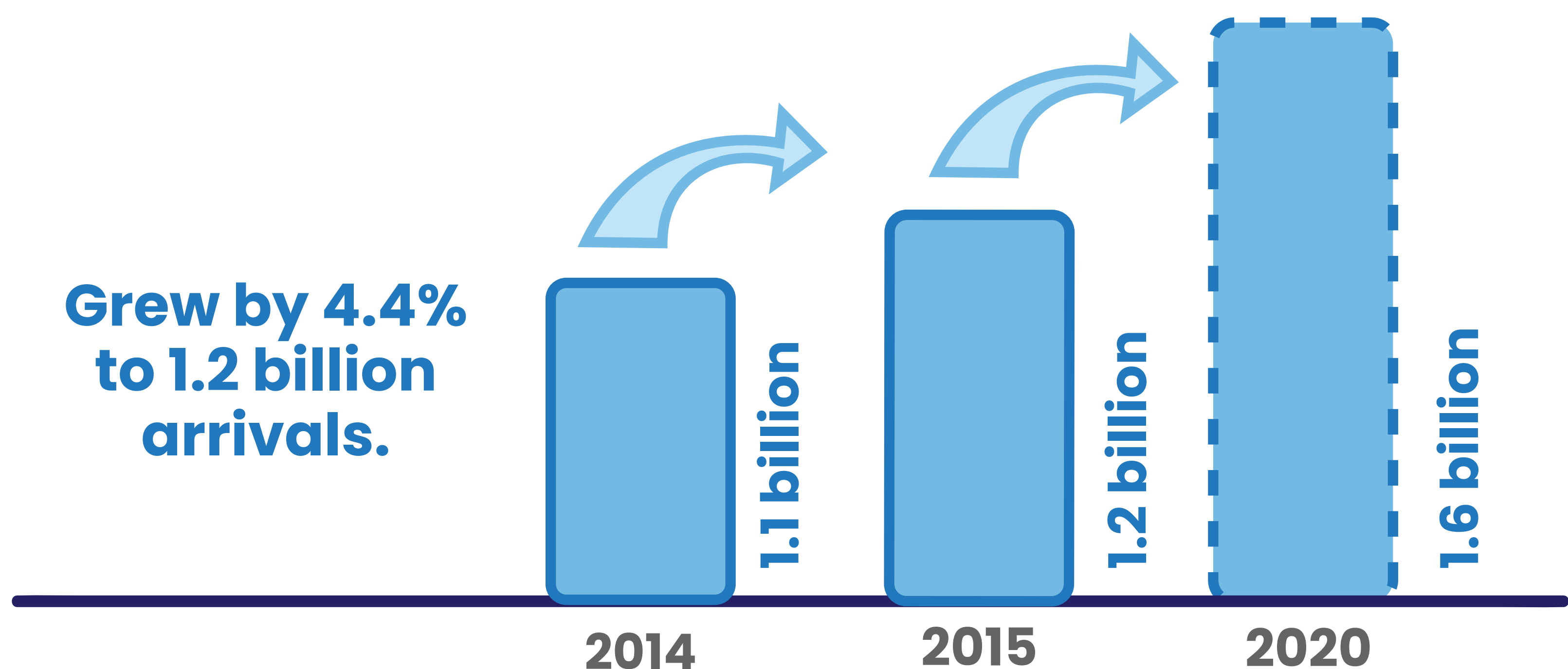
# WHAT ARE THE ECONOMIC IMPACTS OF RISING SEA LEVELS ON THE TOURISM INDUSTRY?

The tourism industry is one of the world's largest industries, accounting for about **9% of global Gross Domestic Product (GDP)** and provides jobs to people worldwide.



The sector is particularly important for some of the world's poorest countries, especially some small island states.

## 2015 International Tourist Arrivals



“

Tourism is a low-lying fruit that any coastal community can take advantage of to promote domestic jobs.

”

Impacts of Sea Level Rise on Economic Growth in Developing Asia by Ruben Carlo Asuncion and Minsoo Lee



## Many developing countries depend on tourism as a main driver of economic growth.

However, climate change poses many challenges to the development of tourism and to the gains that tourism has already garnered in many coastal scenic cities and communities. Below are some examples of coastal scenic tourist attractions:

**Cinque Terre National Park, Italy**



Image source: Mike Swigunski via Unsplash

**Helsinki Cathedral, Finland**



Image source: Tapio Haaja via Unsplash

**Blue Mosque, Turkey**



Image source: Lewis J Goetz via Unsplash

**The tourism industry in coastal areas is likely to take a hit.**



Prime beachfront properties and recreational areas are severely affected by rising waters.



Flooded beaches are no attraction for tourists who may decide to visit less vulnerable areas in the coming years.

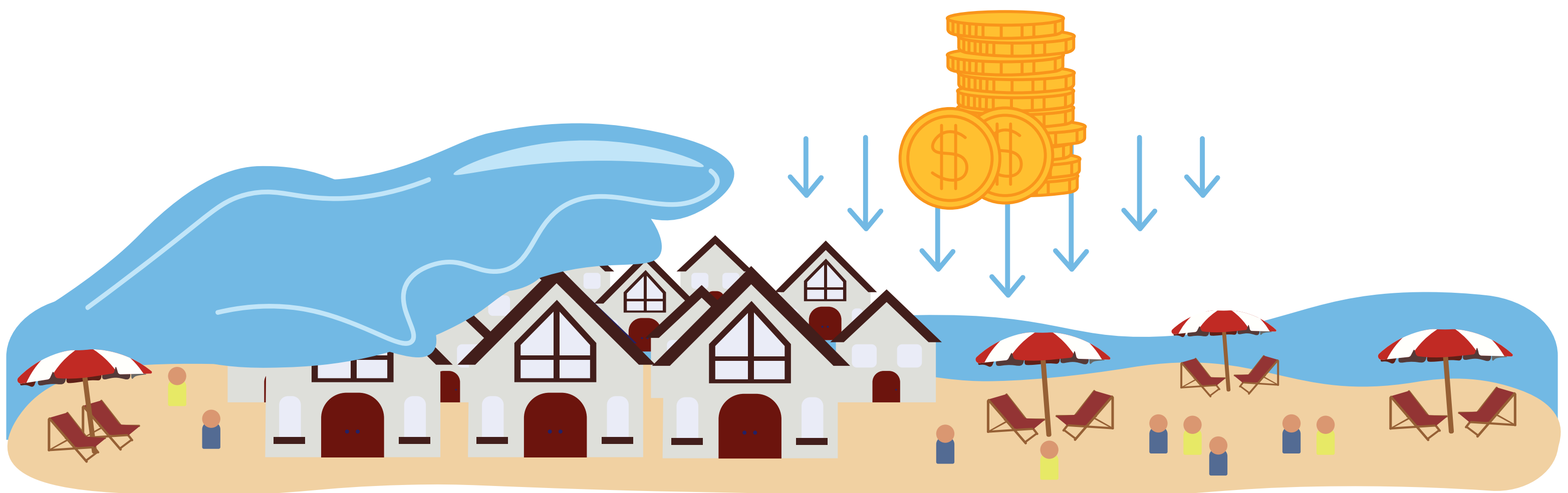
Source: Asian Development Bank & Business Insider



## Rising Sea Levels And Coastal Flooding Pose Severe Economic Risks, Affecting Major Services and Settlement And Tourism Infrastructure.

A metre's increase in sea level is projected to cause damage to at least half of the tourist resorts in the Caribbean, where tourism is a major income generator for the locals.

The tourism industry in the Bahamas alone could face annual losses of almost US\$900 million by 2050.



**The impact of sea level rise is not limited to low-lying islands and coral reefs.**



Islands on higher elevations that do not exhibit much land loss from sea level rise are also vulnerable to substantial economic losses, as many of their assets and infrastructure are located directly on the coast.



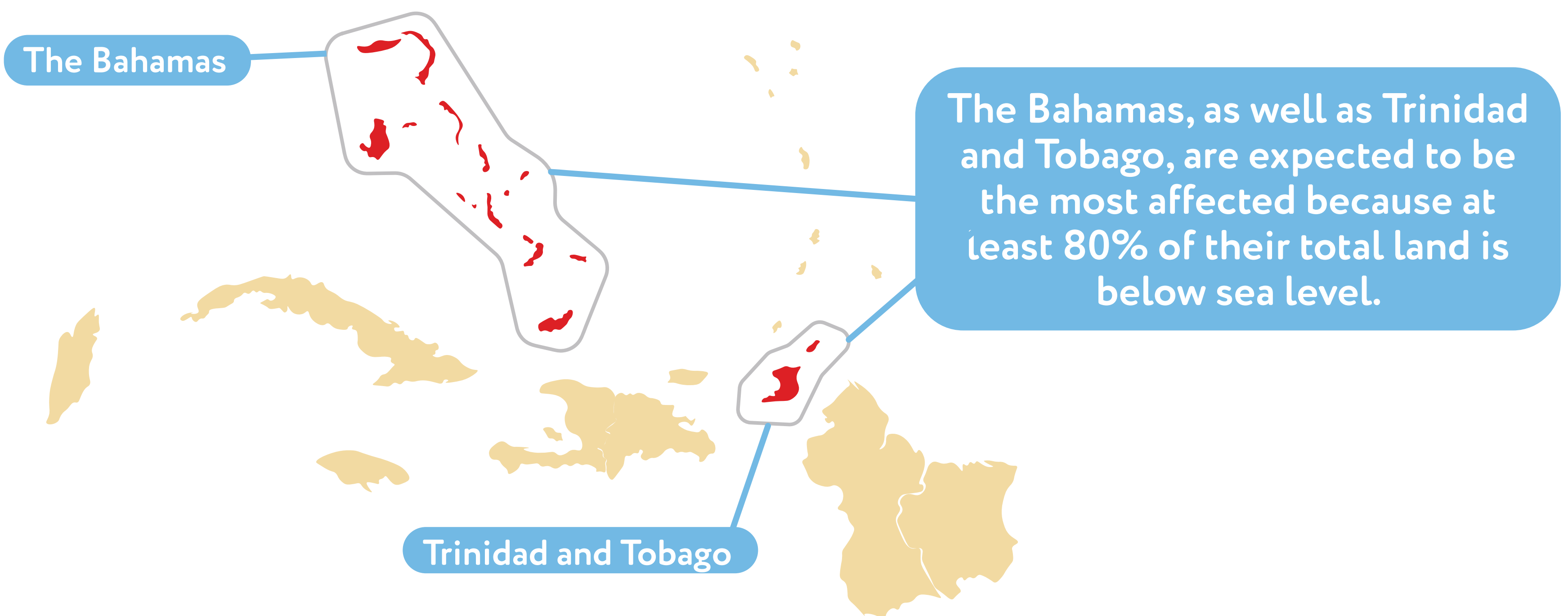
For example, 80% of hotels in Barbados are located within 250m of the high-water mark.

250m



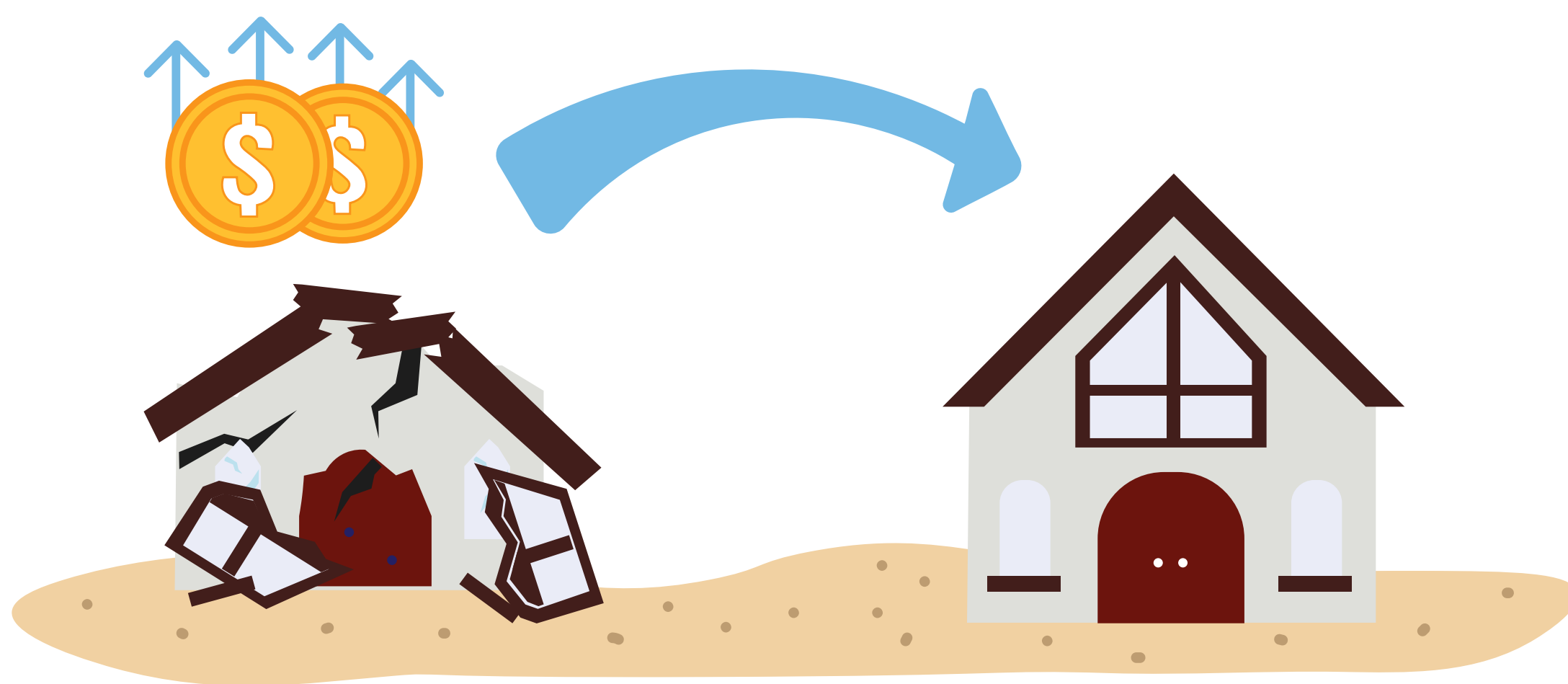
## Countries in the Caribbean Community (CARICOM)

Projections indicate that 80% of lands surrounding ports in the CARICOM could be inundated with 1m of sea level rise.



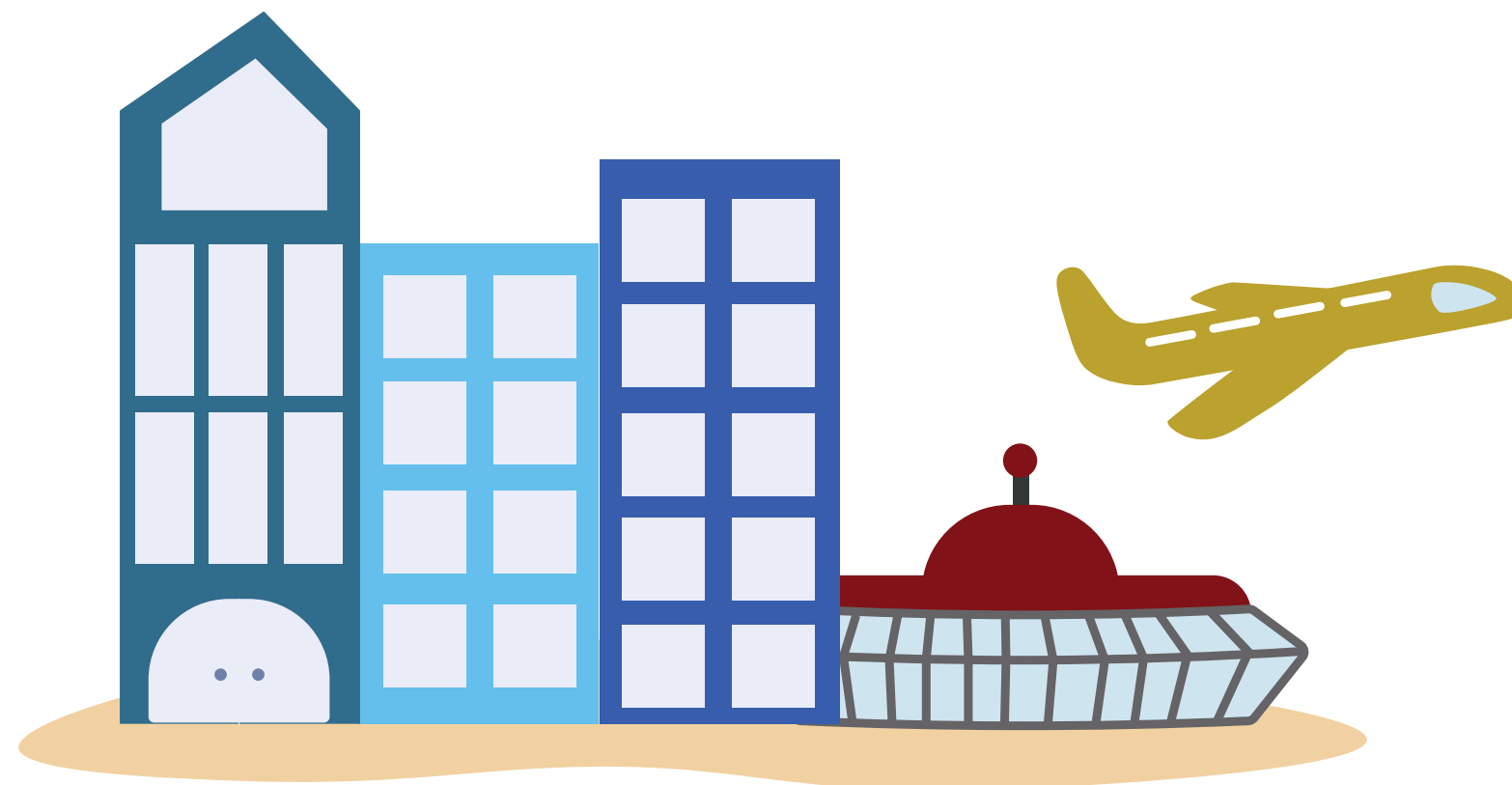
**The costs of future climate change impacts on coastal tourism are enormous.**

Rebuilding costs of tourist resorts are estimated to be about US\$10-23.3 billion in 2050.

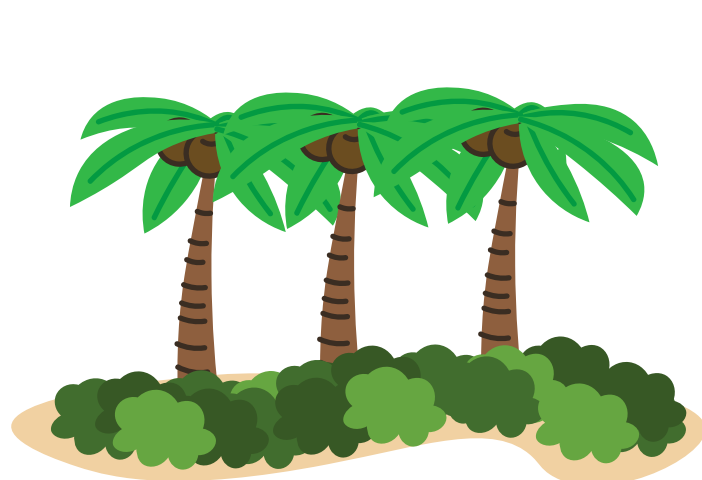




**A hypothetical 1m sea level rise would result in:**



The loss or damage of 21 airports,



the flooding of land surrounding 35 ports



and at least 149 multi-million dollar tourist resorts damaged or lost from erosion of the coastal beach areas.

Source: Climate Analytics & Skift

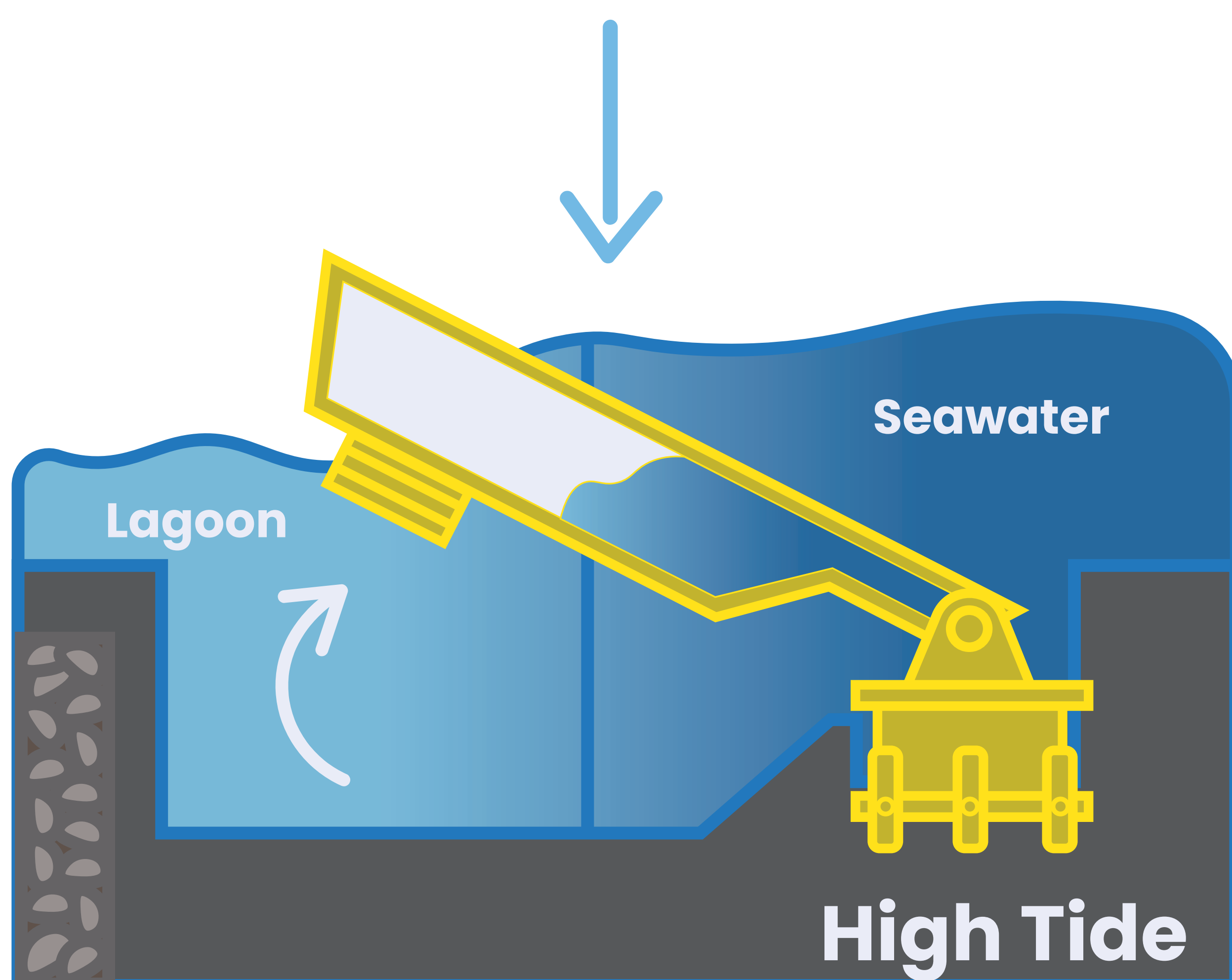
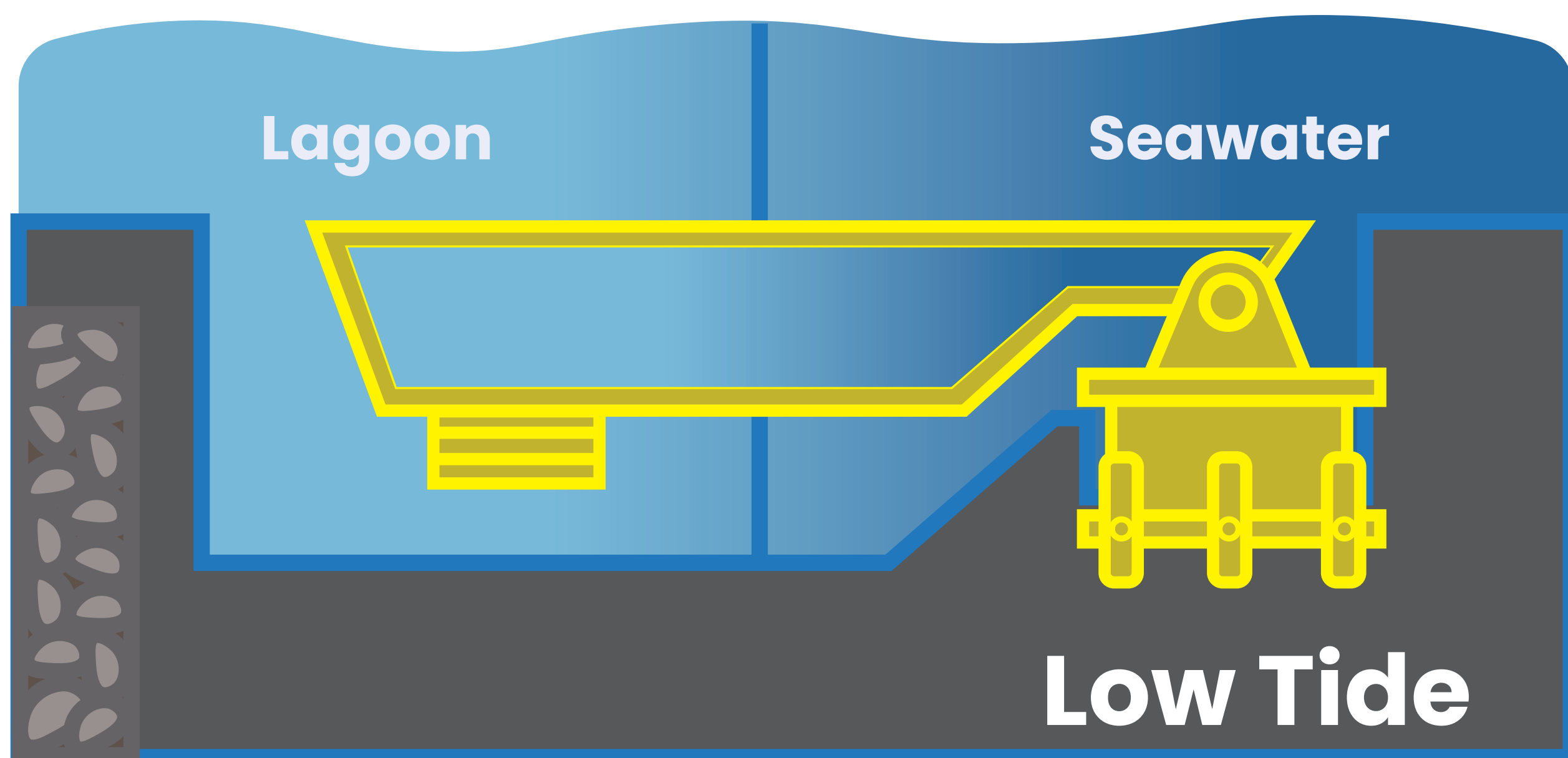
# HOW ARE HOLIDAY DESTINATIONS TACKLING CLIMATE CHANGE?

## 1. Venice, Italy

### MODULO Sperimentale Elettromeccanico (MOSE) project

MOSE is a series of mobile steel gates that are raised and lowered on command. As waters rise, engineers use air compressors to blow out seawater and fill the gates with air. This causes the gate to float and jut out over the waves, stopping rising water from entering the lagoon and thus protecting the surrounding areas from flooding.

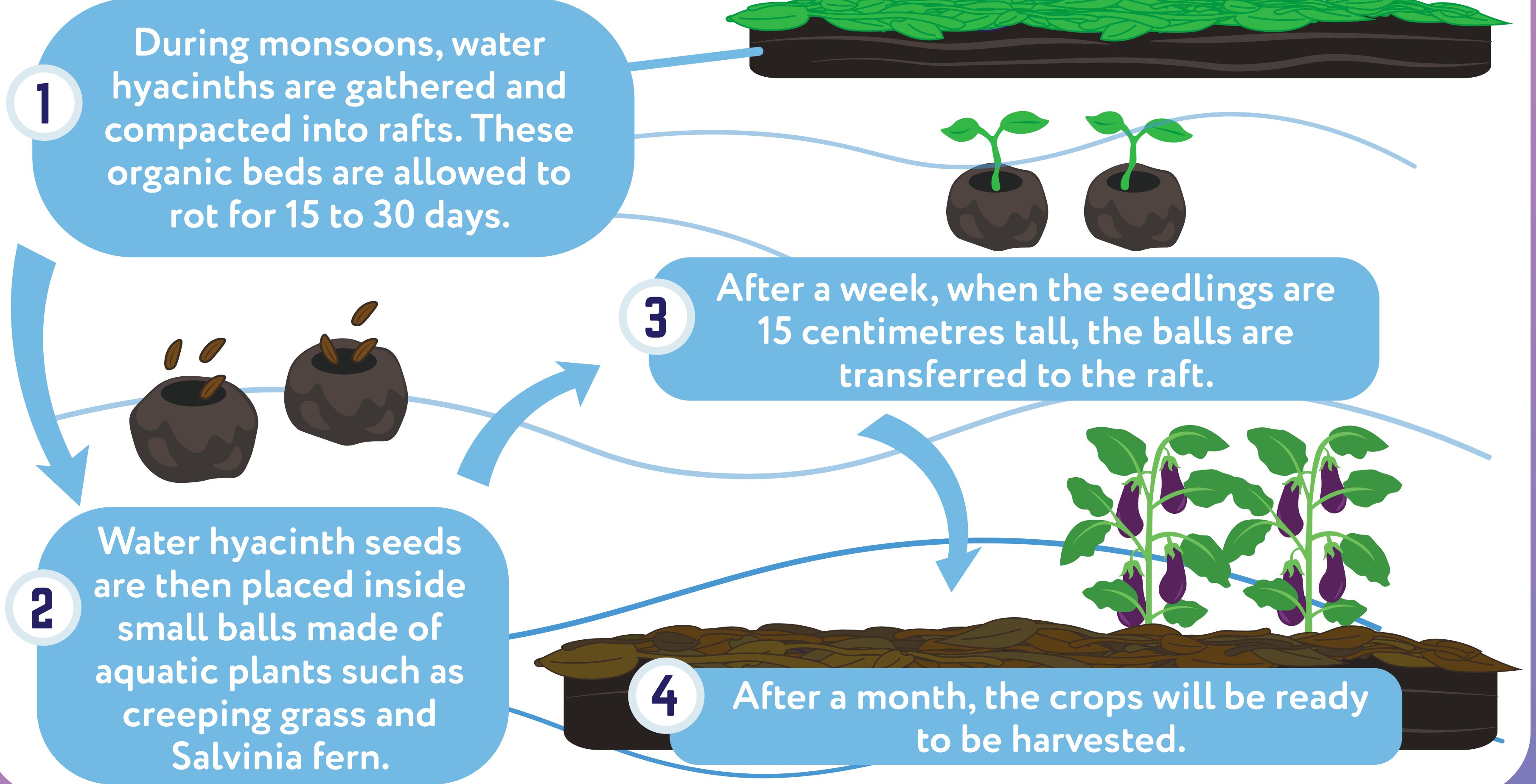
Started in 2003, the MOSE project aims to protect the Venetian lagoon from flooding, with mobile gates raised during extremely high tides





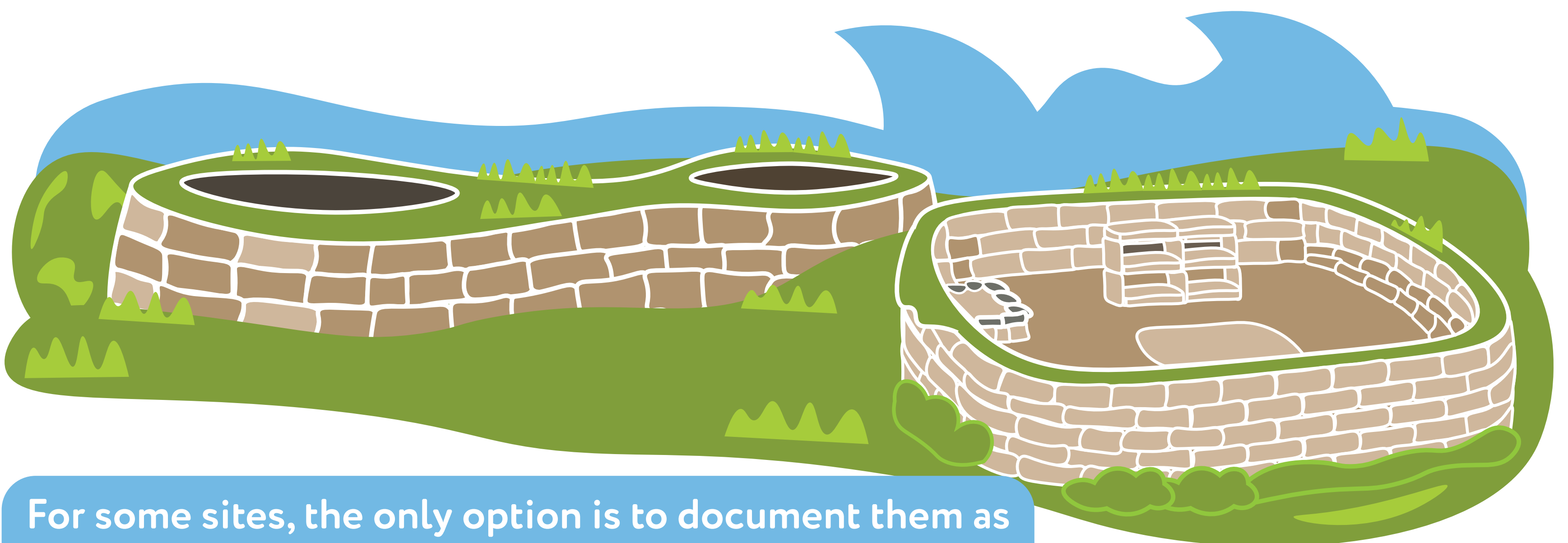
## 2. Pirojpur, Bangladesh

Farmers are using rafts to grow produce and agriculture when the waters rise.



## 3. The Orkney Islands, Scotland

The ancient Stone Age village of Skara Brae is protected by a seawall. But the surrounding beaches are shrinking and no man-made preventative methods will last forever.



For some sites, the only option is to document them as thoroughly as possible before they are lost forever.

Source: The Telegraph, Coastal Adapt, SciELO

# Risks And Adaptation Measures Taken To Tackle Climate Change

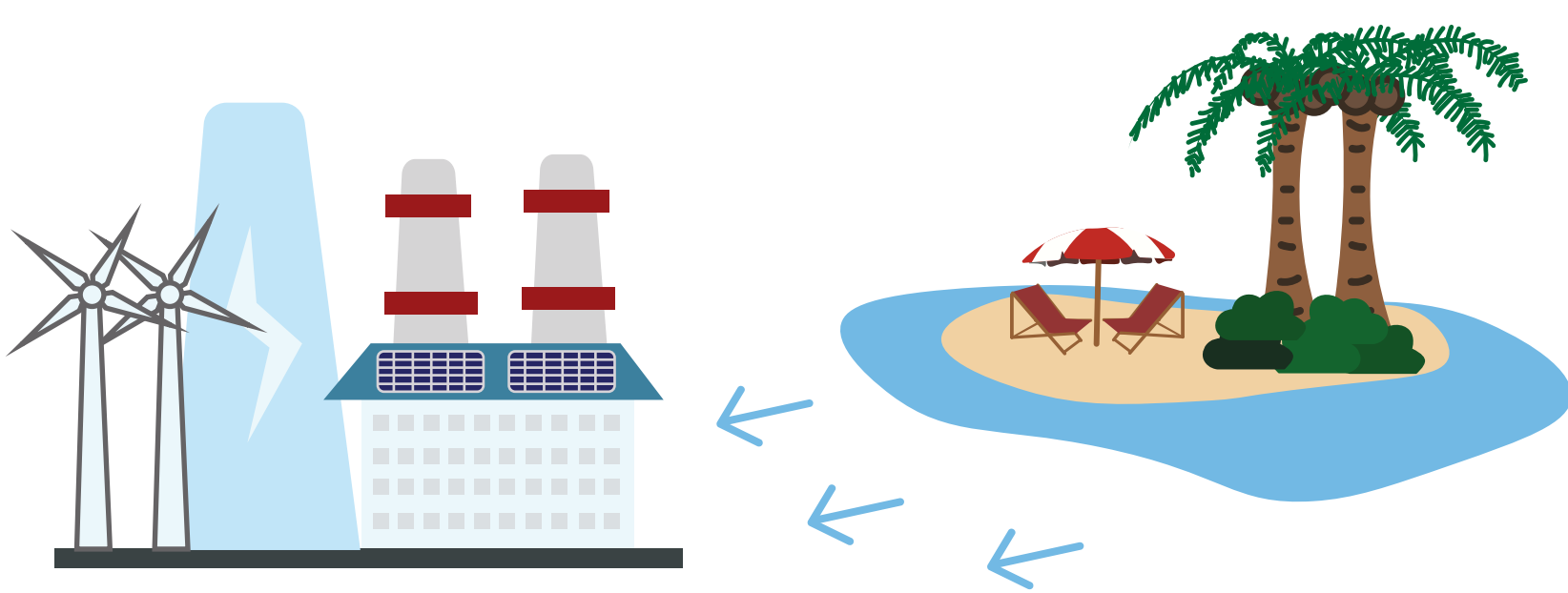
## 1. Loss Of Assets



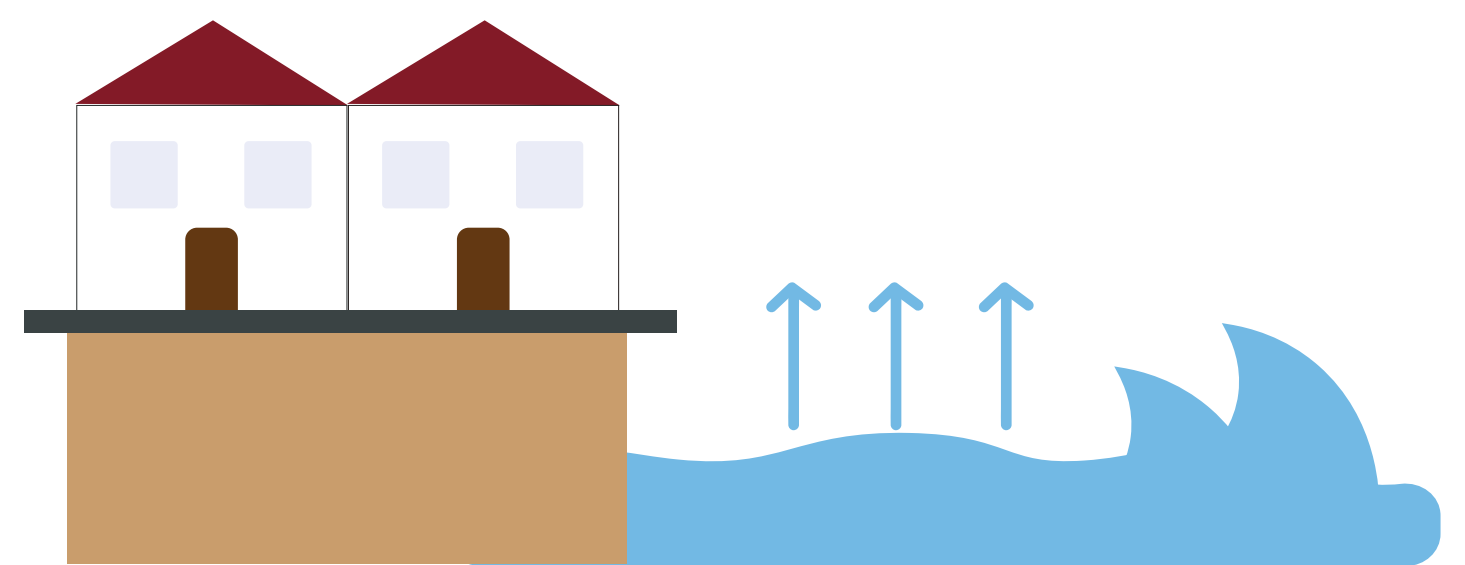
As a result of several factors including sea level rise, higher storm surges and larger spring tides will result in an increased risk of coastal erosion and flooding.

## Adaptation Measure:

Encourage developers to:



Build critical infrastructure (e.g. power houses) further from the beach



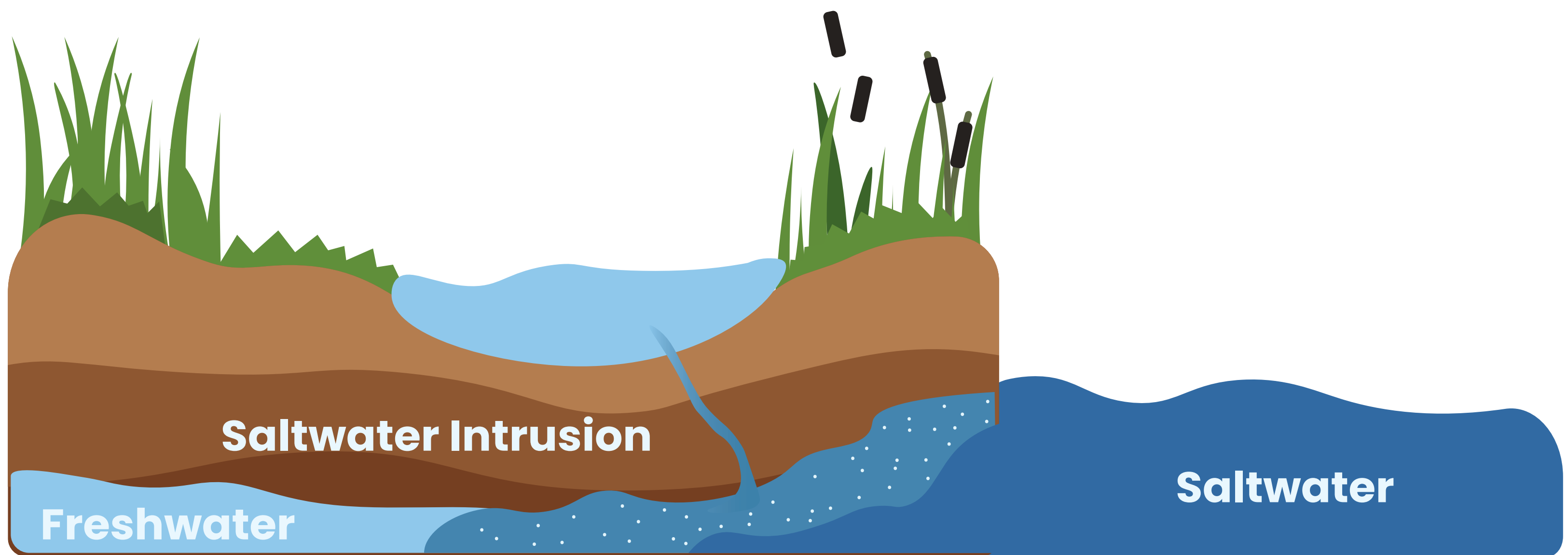
Raise structures to a minimum height



Keep buildings at a distance from the beach

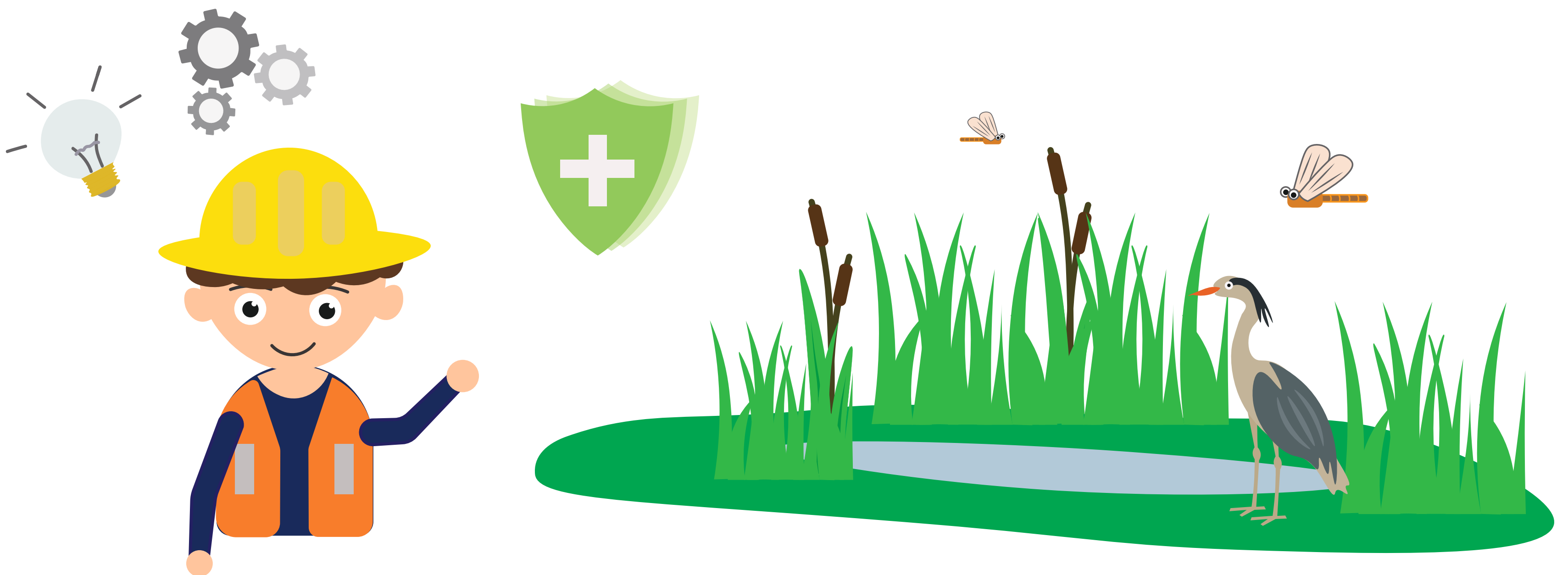


## 2. Saltwater Intrusion



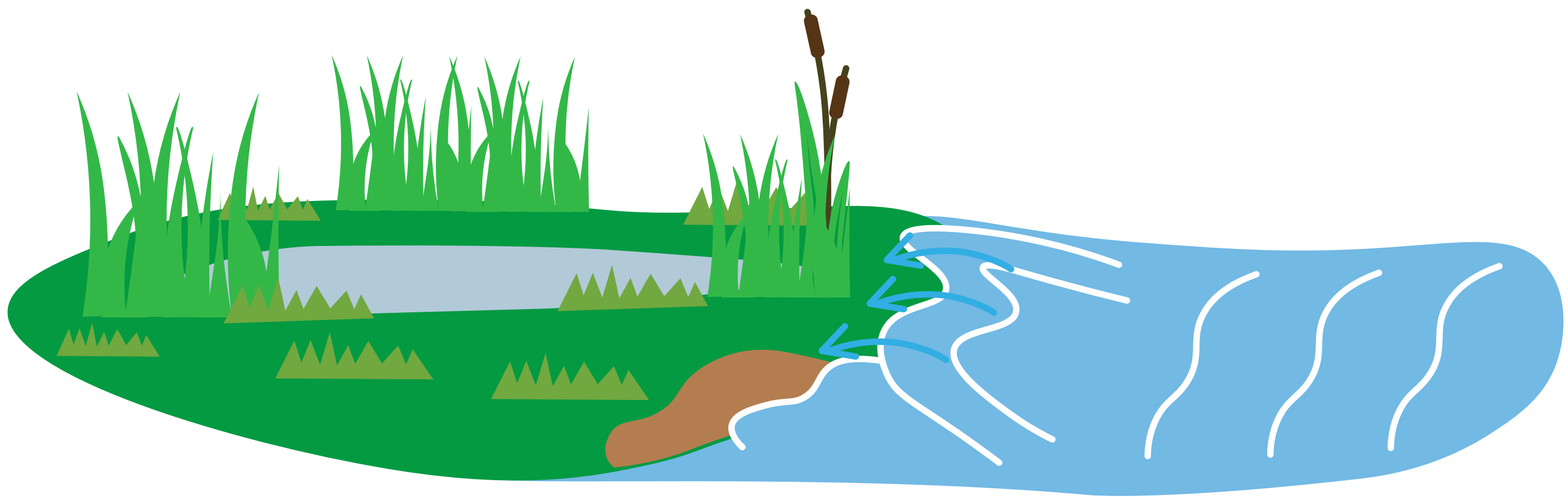
Saltwater intrusion of freshwater wetlands may lead to substantial ecosystem changes, and also impact visitor expectations of the natural area.

## Adaptation Measure:



Obtain expert engineering and environmental advice on measures needed to protect freshwater habitats from saltwater intrusion.

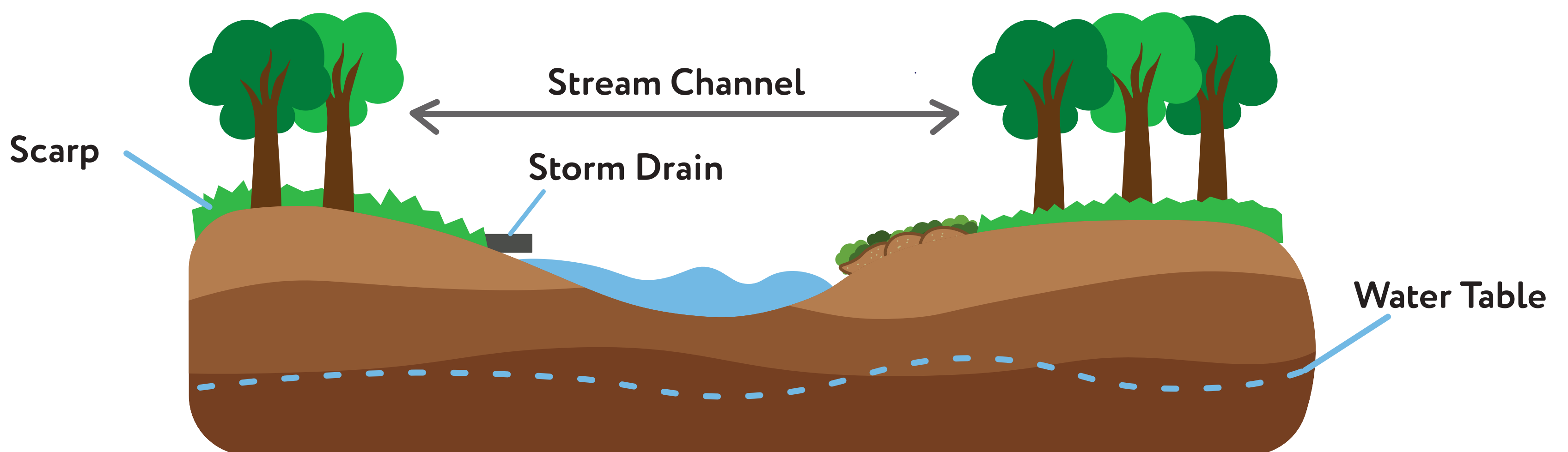
### 3. Loss Of Habitat



Encroaching seas reduce the size of wetlands and other coastal ecosystems that are the basis of nature-based tourism.

### Adaptation Measure:

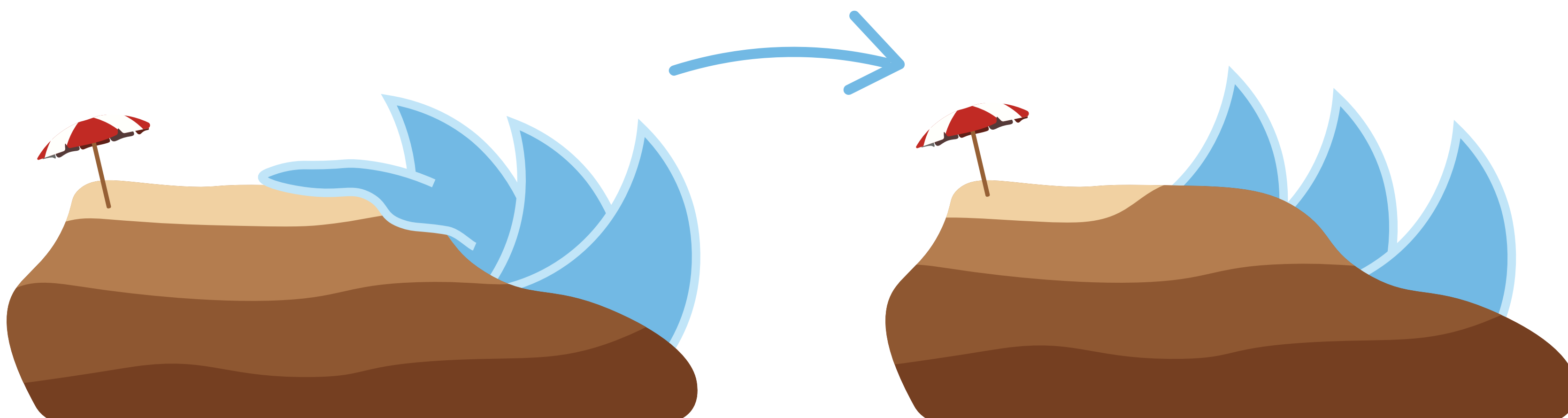
#### Wetland Restoration



Increase size of habitats, for example through restoration of wetlands, land swaps, compensation projects, etc.

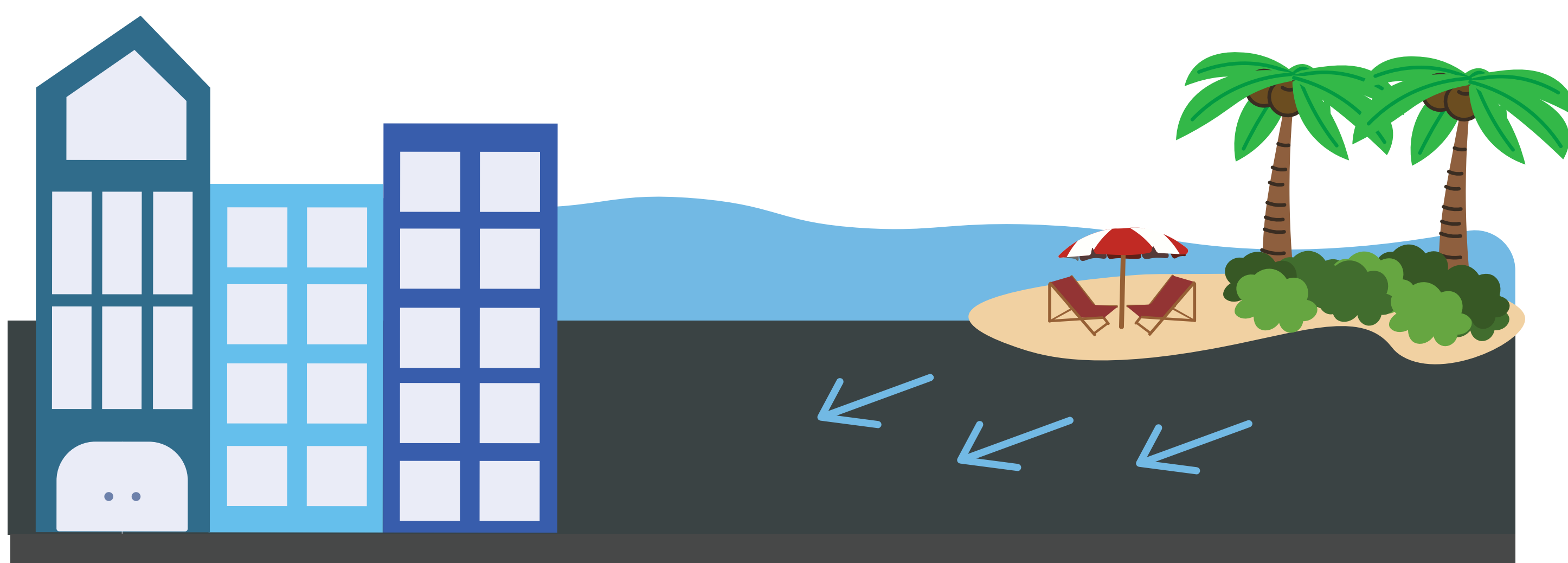


## 4. Loss Of Sand And Vegetation



While beach morphology is complex and erosion is not a result of only sea level rise, rising sea levels are likely to intensify erosion and reduce the size of beaches.

## Adaptation Measure:

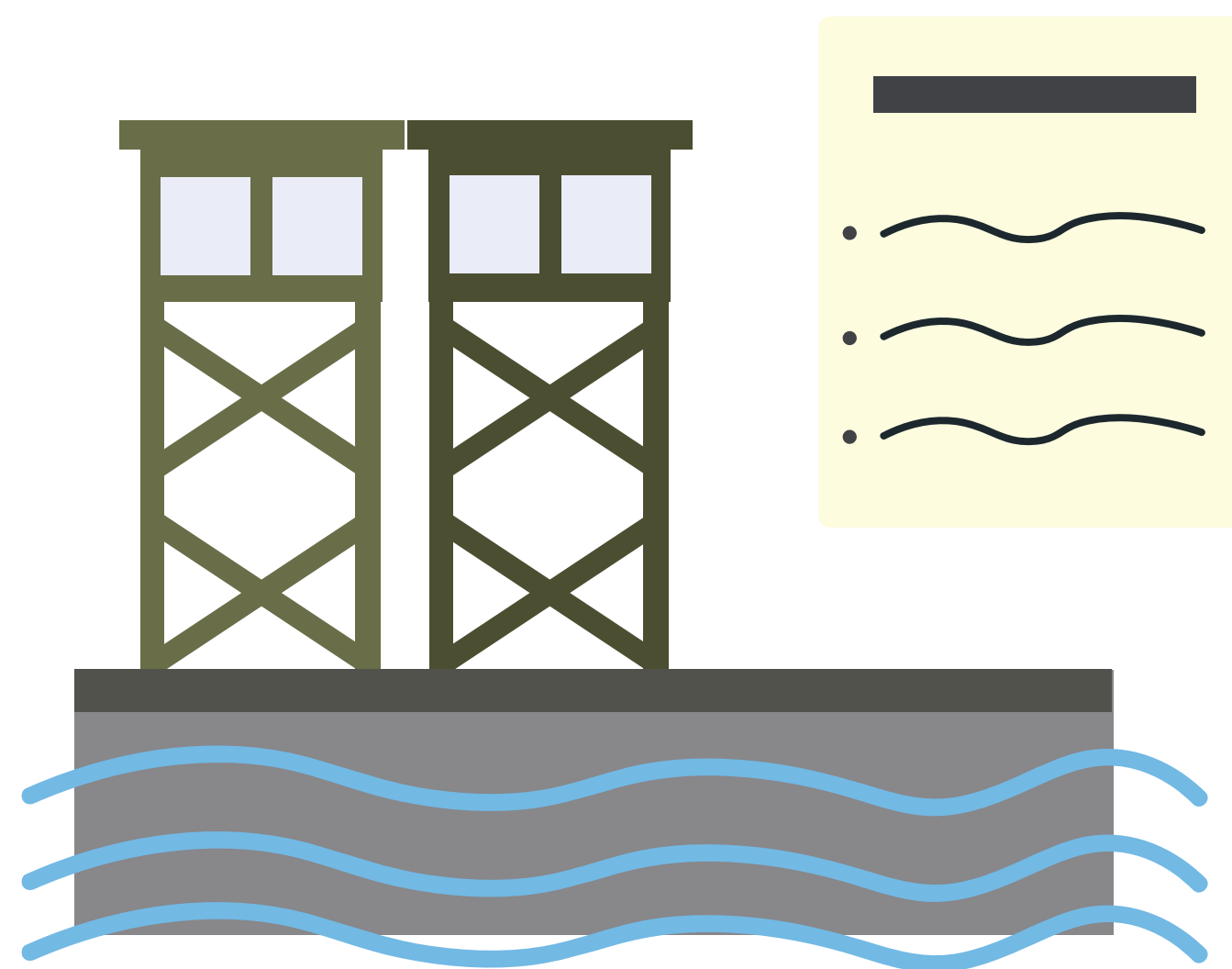


Encourage businesses/developers to avoid building structures close to the beach and plan for some form of adaptive access points to beaches.

## General Solutions



Promote mitigation and adaptation actions and initiatives



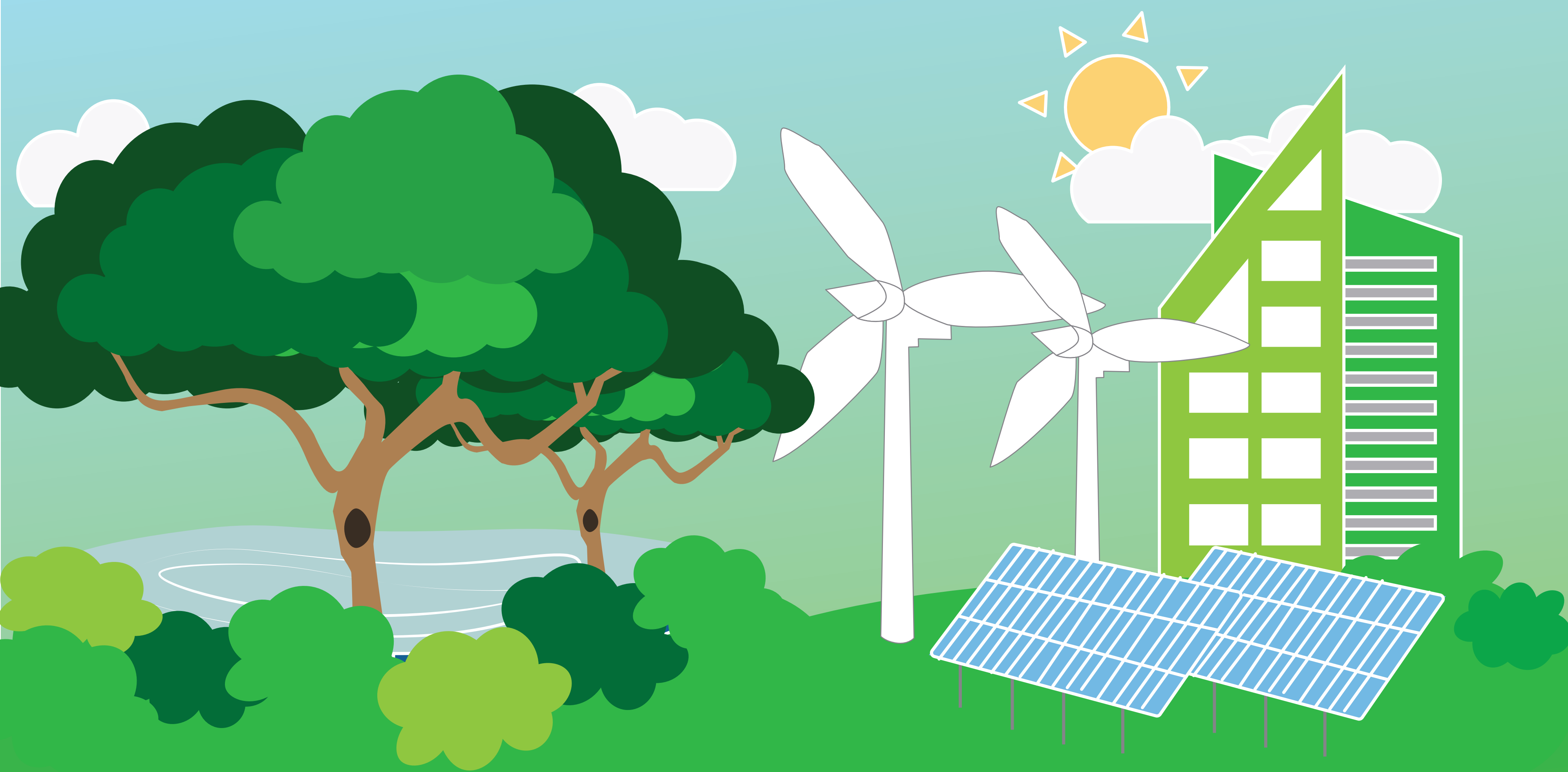
Plan the use of land along the seaside



Implementation of coastal engineering works

Source: Coastal Adapt, SciELO





## **CHAPTER 7:** Quelling the catastrophe

In the seventh chapter of this series, we learn more about how the world is tackling the problem of rising sea levels. Find out what international treaties are in place to combat climate change and its impacts, how ASEAN enhances regional and international cooperation, and the steps taken by the Singapore Government to achieve the Singapore Green Plan 2030.

# WHAT ARE INTERNATIONAL TREATIES AND HOW DO THEY HELP WITH TACKLING RISING SEA LEVELS?

## What Is An International Treaty And How Does It Work?

Countries sign a formal written agreement, which legally binds a state to follow through with its obligation to refrain from acts that would compromise its objectives and purposes.



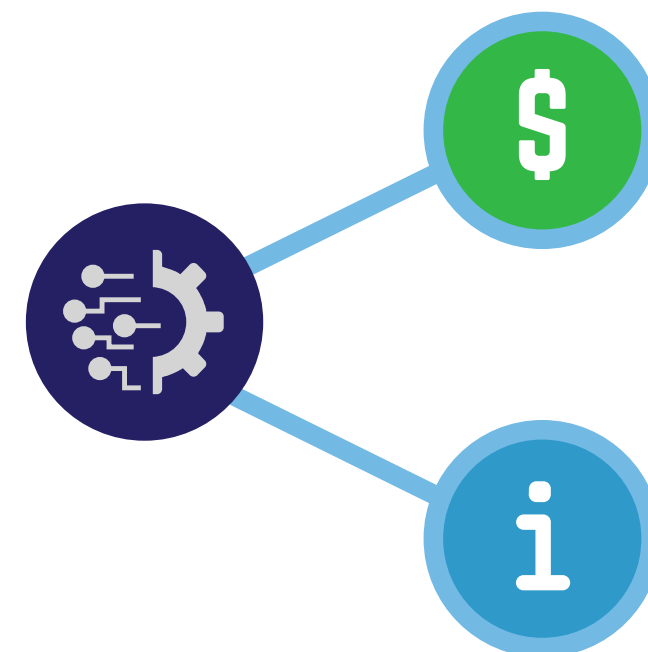
Other countries can impose sanctions, such as trade bans, on countries that break the treaties, to ensure that they honour their obligations.

## How Can International Treaties Tackle Sea Level Rise?

1. Implementing an international treaty formally acknowledges the global impact of rising sea levels, and its impact on every country.



2. Fosters collaboration between countries through the sharing of funding, technology and information.



3. Acts as a motivator for countries to fully commit to their obligations.



4. The possibility of sanctions being imposed holds countries accountable for their actions.

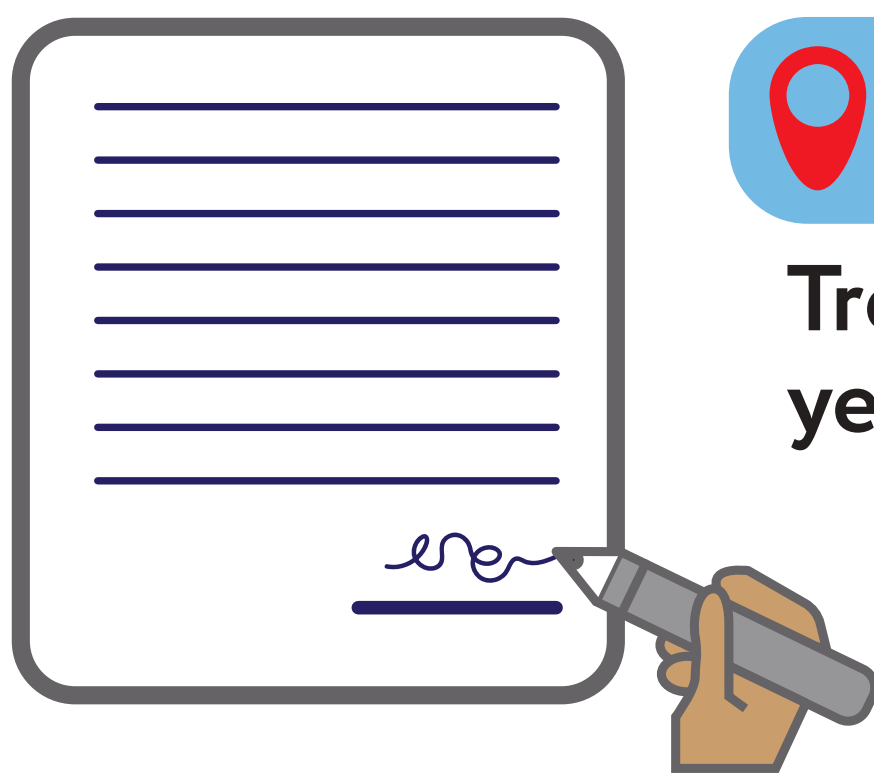




## Examples Of International Treaties:

These treaties have been ratified by many countries including Singapore and current major greenhouse gas emitters such as the USA, China and India.

### 1. United Nations Framework Convention on Climate Change (UNFCCC) (1994)



**Rio De Janeiro**

Treaty signed in year 1992



It addresses climate change with the specific aim to stabilise greenhouse gas concentrations "at a level that would prevent dangerous anthropogenic interference with the climate system."

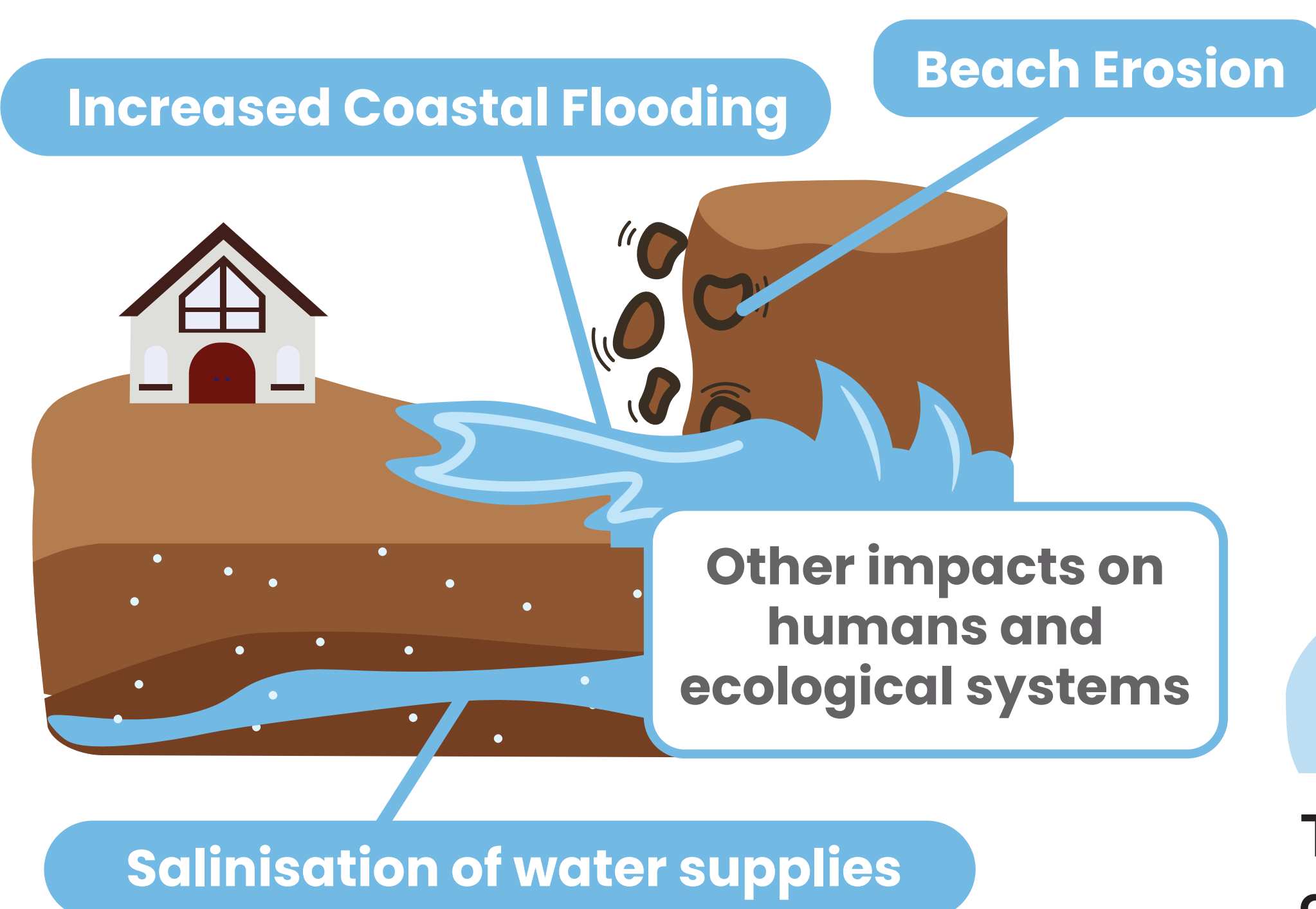
International Environmental Treaty

Human-Induced

### 2. Paris Agreement (2015)

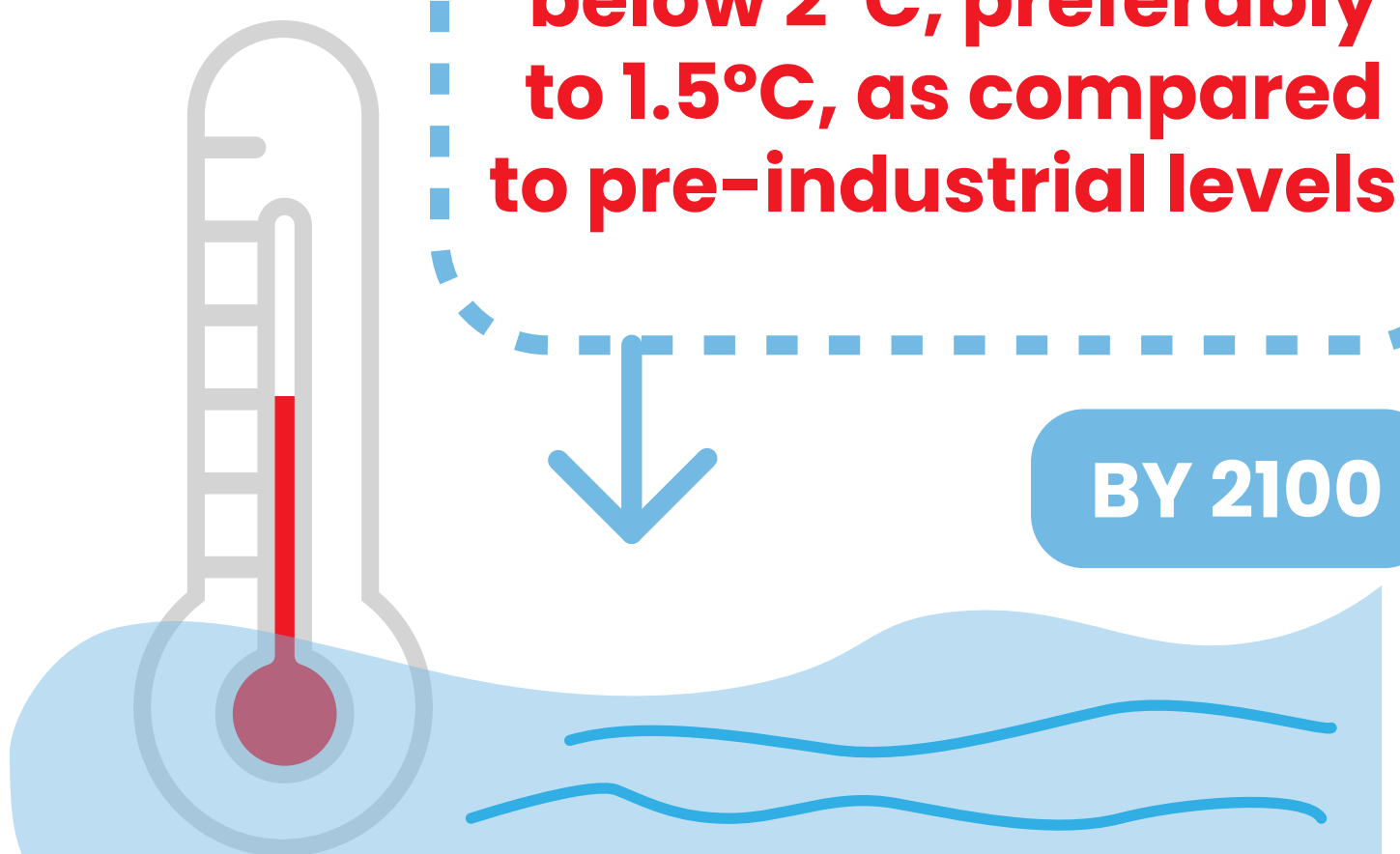
A legally binding international treaty on climate change built upon the UNFCCC.

If global temperature rises over 2°C, more than 70% of Earth's coastlines will experience sea level rise of over 20cm, resulting in:



Limit global warming to below 2°C, preferably to 1.5°C, as compared to pre-industrial levels.

BY 2100



To avoid significant and potentially catastrophic changes to the planet.

Source: UNFCCC, The Paris Agreement, Climate Change News, SP Global

# Paris Agreement (2015)

This is one of the largest current global commitments aimed at tackling the issues of climate change and sea level rise.



Countries aim to reach global peaking of greenhouse gas (GHG) emissions as soon as possible to achieve a climate-neutral world by 2050.

Every 5 years, countries submit their plans for climate action known as Nationally Determined Contributions to communicate actions they will take to reduce their GHG emissions.

## Countries Support Each Other Through:



**Climate Technology**  
Helps to fully realise technology development and transfer, to improve resilience to climate change and reduce GHG emissions.



**Climate Finance**  
Provides financial assistance to countries that are less endowed and more vulnerable.



**Climate-related capacity-building\***  
Developed countries should strengthen their support for developing countries on capacity-building to adapt to climate change.

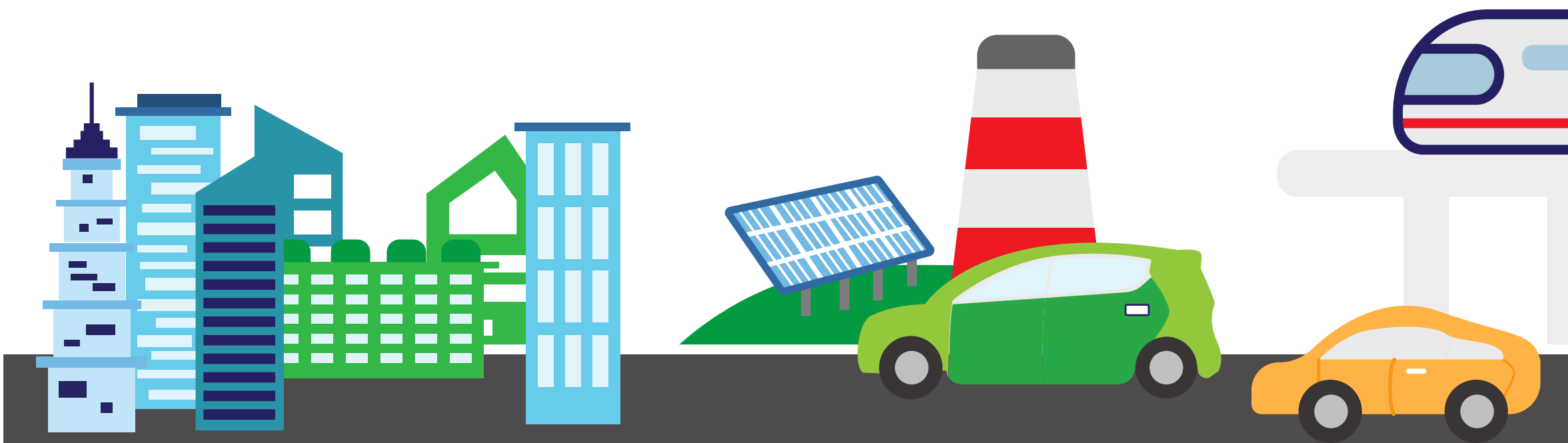
\*Capacity-building is the specific efforts to improve the organisation.

## Progress tracking through enhanced transparency framework

From 2024, countries will report on their actions taken, progress in climate change mitigation, adaptation measures and support provided or received.



## Achievements:



More countries, regions, cities and companies are establishing carbon-neutral targets.

Zero-carbon solutions are becoming competitive across economic sectors such as the power and transport sectors, which represent 25% of emissions.

Source: UNFCCC, BBC



# WHAT ARE UN SDGS AND HOW WOULD THEY HELP WITH REDUCING SEA LEVEL RISE?

## United Nations Sustainable Development Goals (UN SDGs)

The 2030 Agenda for Sustainable Development was adopted by all United Nations Member States in 2015. It is an urgent call for action to all countries to adopt more sustainable practices at the intersection of social, economic and environmental issues.



Shared blueprint for peace and prosperity for people and the planet, now and into the future.

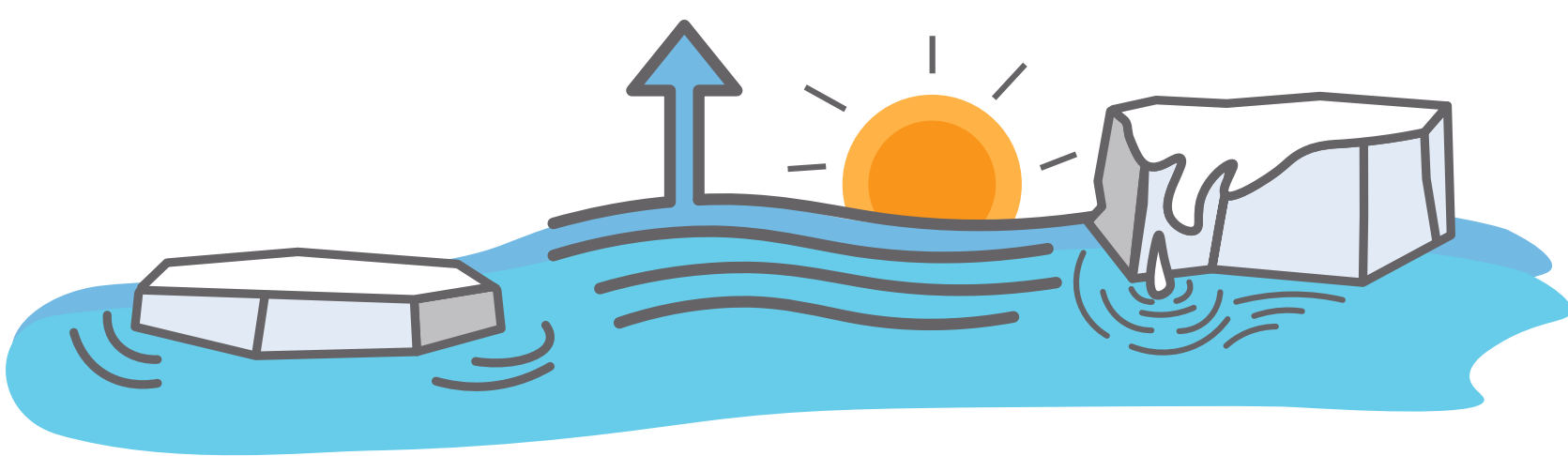
Examples of specific climate-focused goals within the UN SDGs, and the problems that they are tackling:

### Goal 13 Climate action

Take urgent action to combat climate change and its impacts.

#### Potential problem:

Global average sea level rose by 19cm

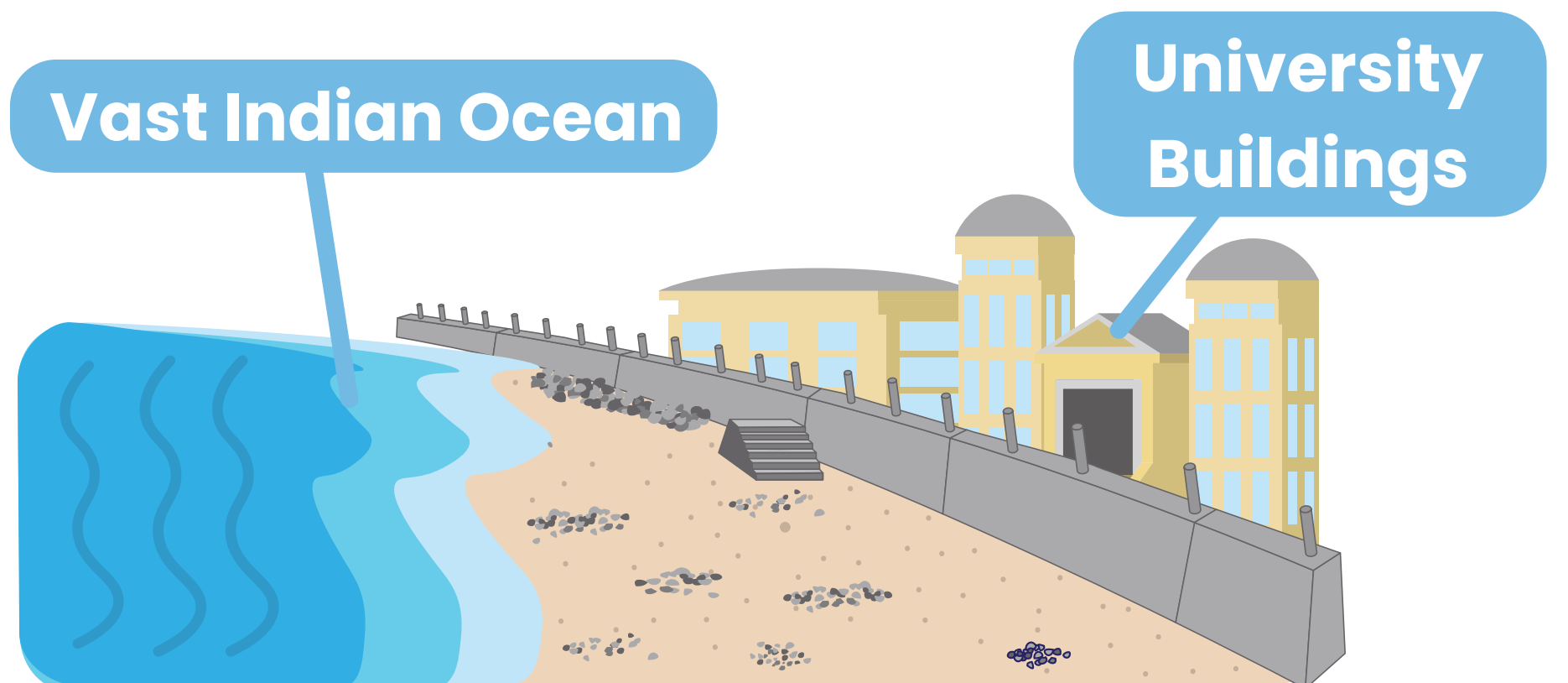


From 1901 to 2010, oceans have warmed and sea levels have risen due to global warming and melting ice.

#### Example: Tanzania

Vast Indian Ocean

University Buildings



With funding from the UN Environment Programme, the UN Office for Project Services constructed a new seawall along the shore.

## Goal 14 Life below water

Conserve and sustainably use the oceans, seas and marine resources for sustainable development.

By 2020

Regulate harvesting

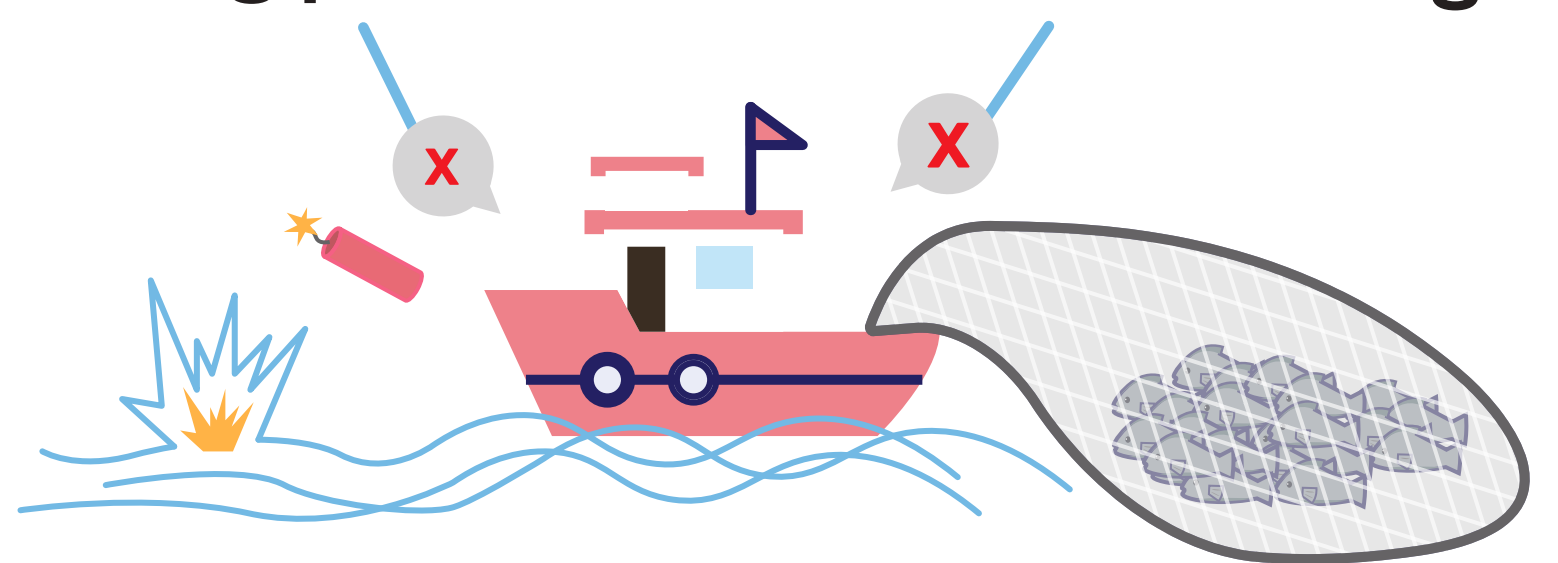


Implement management plans



End damaging and illegal fishing practices

End overfishing

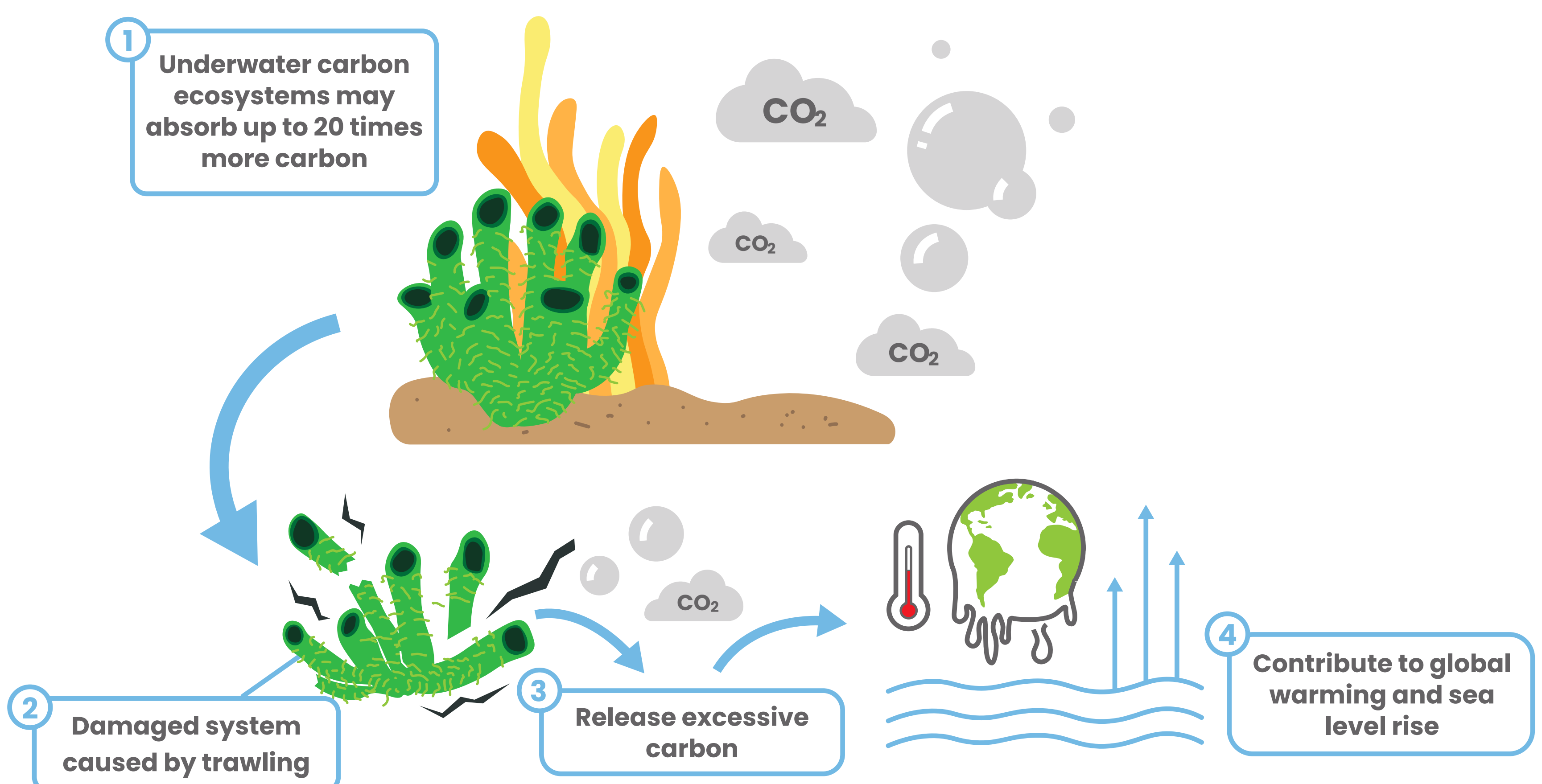


Effectively regulate harvesting to end overfishing, damaging and illegal fishing practices as well as implement management plans, in order to restore fish populations in the shortest time feasible.

### Potential problem:

Fishing practices like trawling severely damage the seafloor and the **aquatic plants** that live on it.

Significant Carbon Absorber

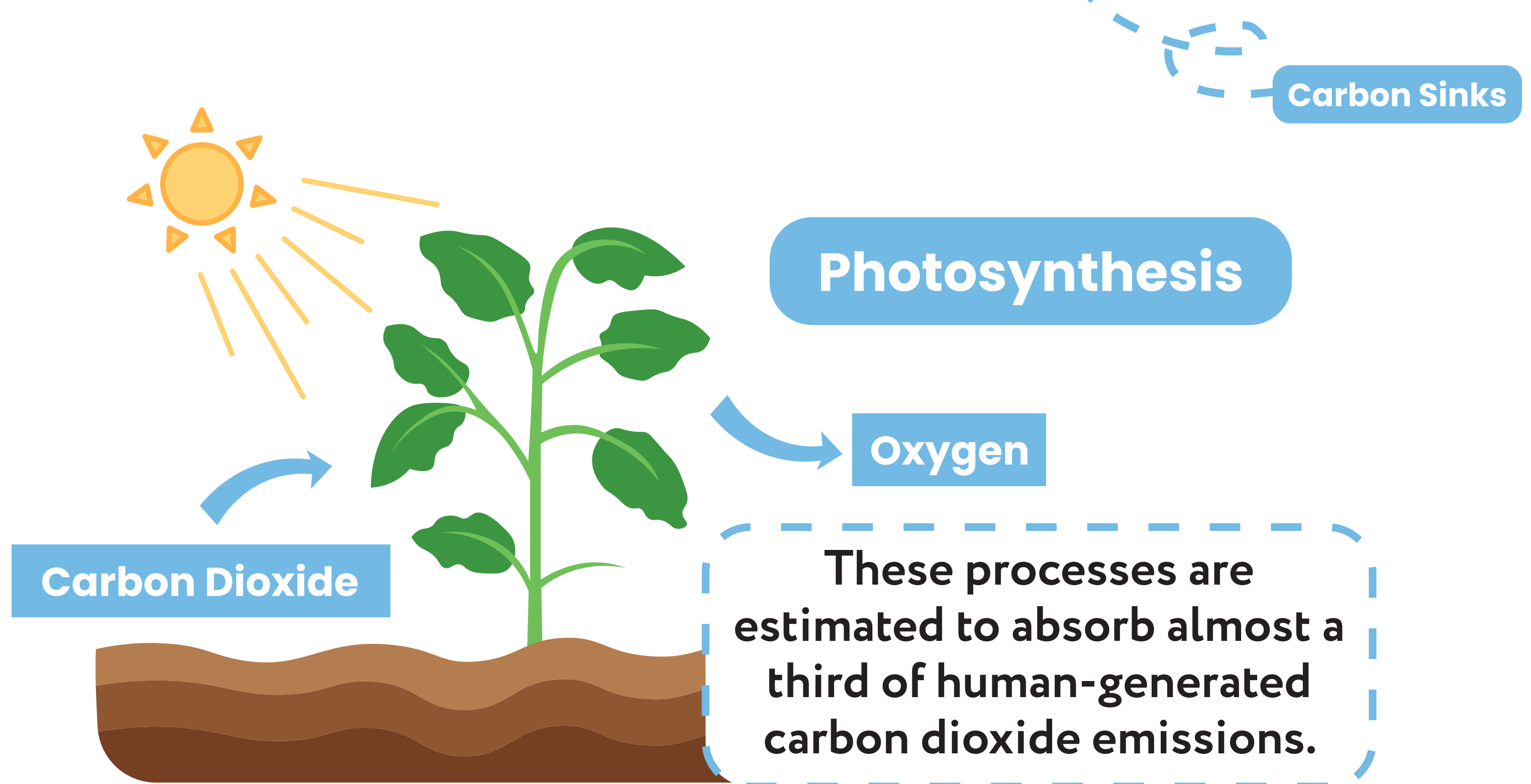




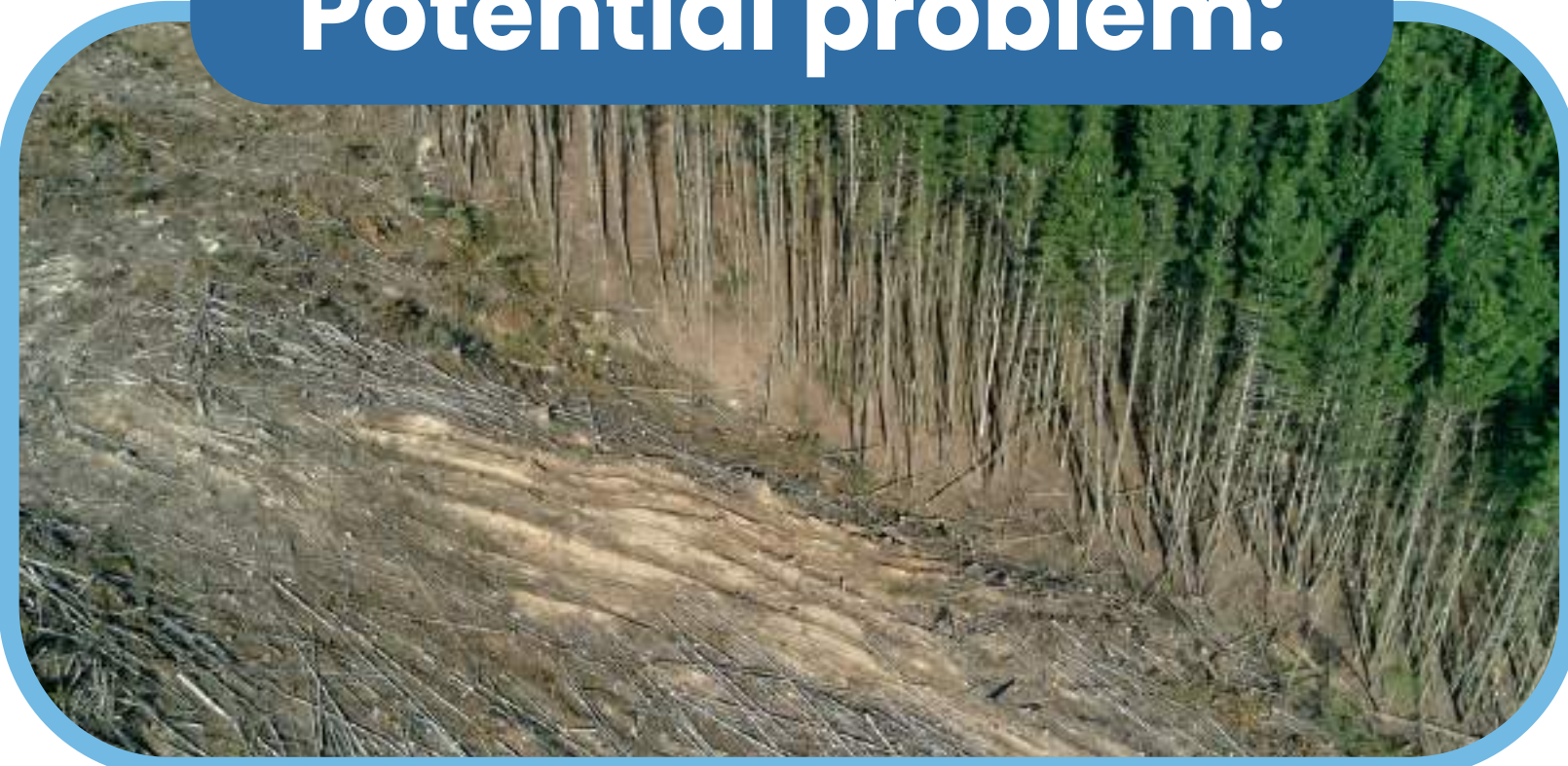
## Goal 15 Life on land

Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, as well as halt and reverse land degradation and stop biodiversity loss.

Natural land processes, such as photosynthesis, remove carbon dioxide from the atmosphere and store them in **plants and soil**.



### Potential problem:



Deforestation, logging and fires have reduced forest areas and the capacity of forests to act as carbon sinks.

### Potential problem:



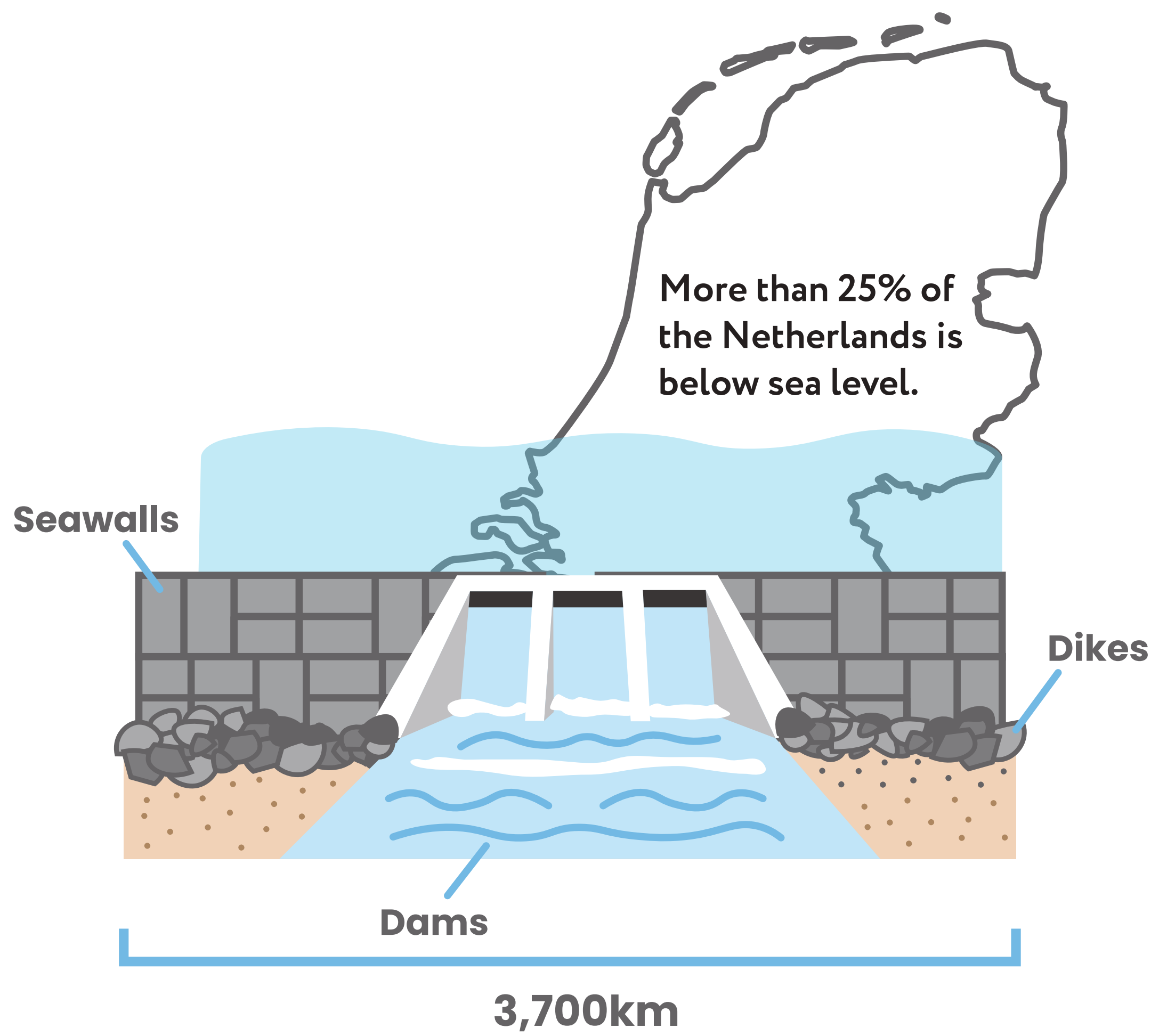
More carbon is released into the atmosphere, which contributes to global warming and sea level rise.

Source: UNOPS, United Nations Sustainable Development Goals, Oceana, CNA  
Image source: gryffyn m via Unsplash, Roxanne Desgagnés via Unsplash

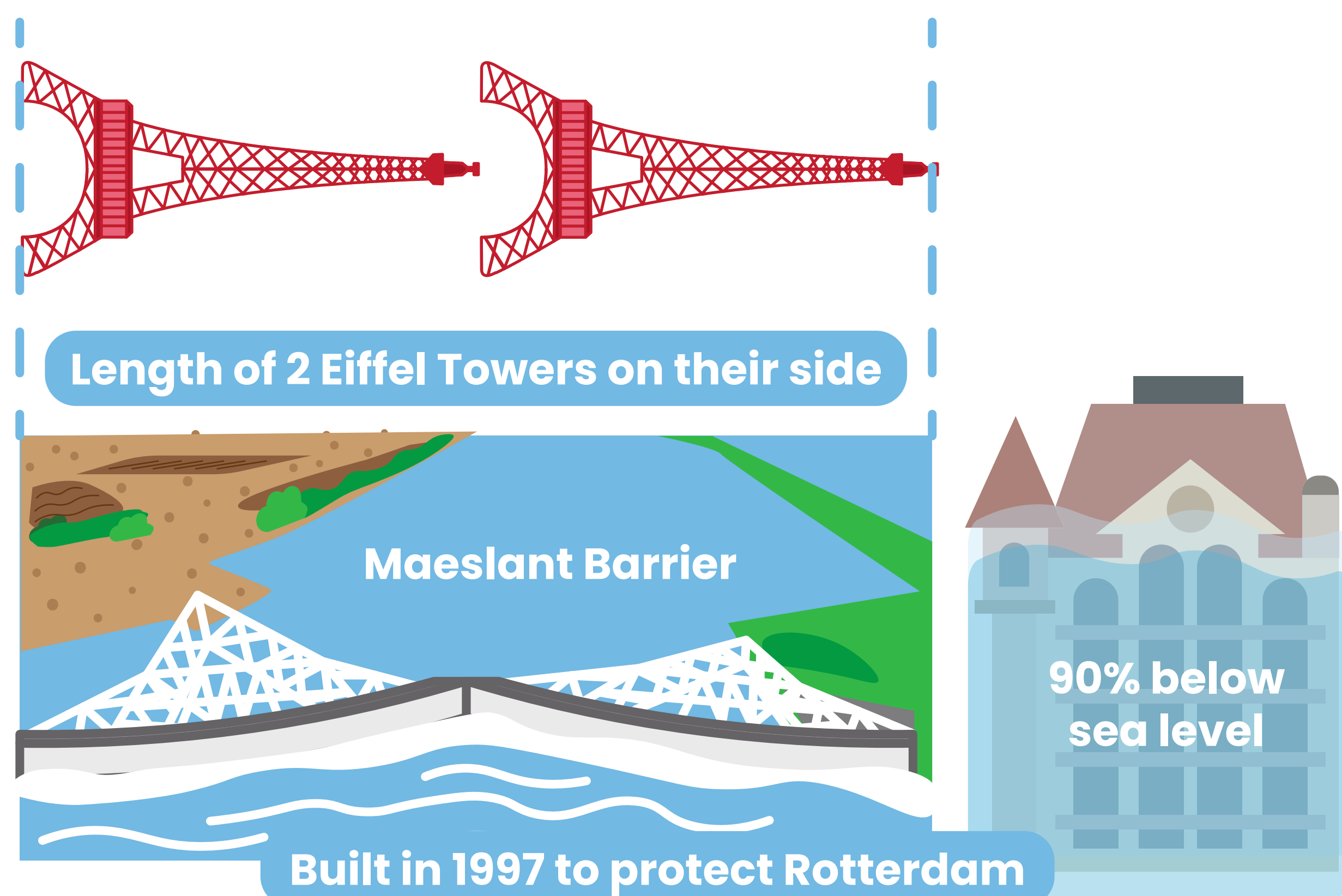


# WHAT ARE SOME STRATEGIES USED AROUND THE WORLD TO TACKLE CLIMATE CHANGE AND RISING SEA LEVELS?

## 1. The Netherlands



Hard defences have been built to protect Dutch coastal cities from sea level rise.

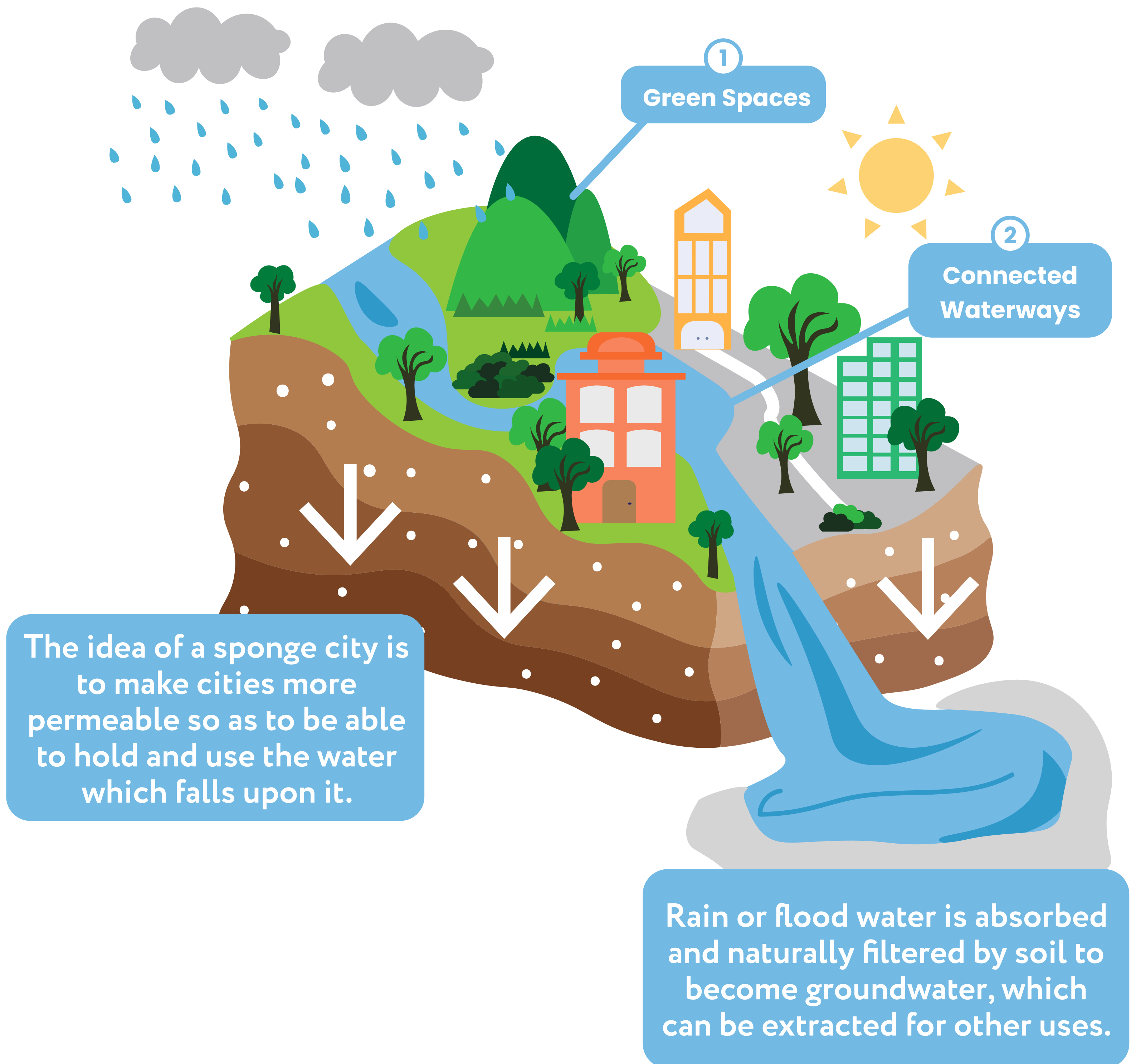


The famous Maeslant Barrier is controlled by a supercomputer which automatically closes the barrier when a flood is approaching.



## 2. Hyderabad, India

The ground has been made more permeable through the use of:

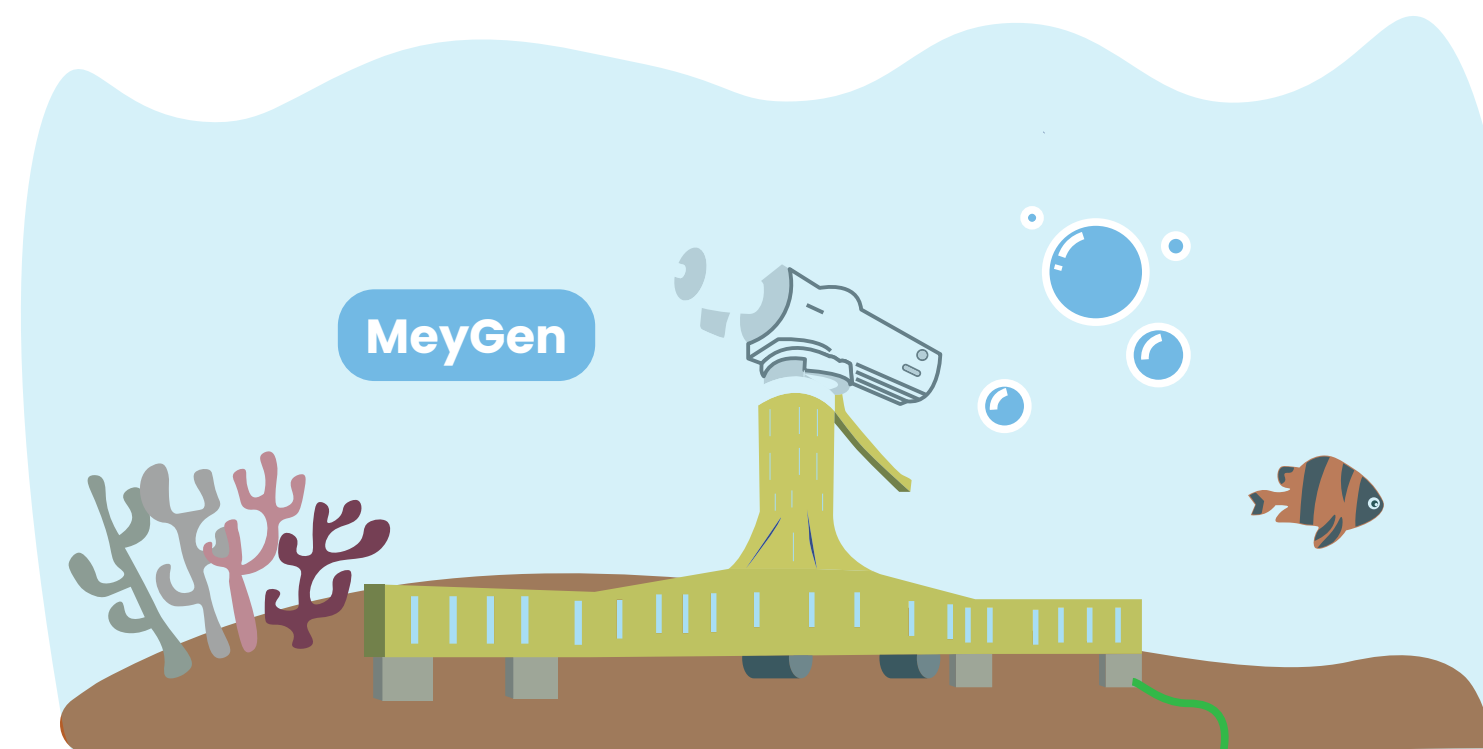


During a serious flood that occurred in Hyderabad in 2020, there were 98 casualties and an estimated 40,000 families affected.

Hyderabad was the first city in India to implement Sponge City concepts, which mitigate flood risk and increase water security.

### 3. Scotland, The United Kingdom (UK)

MeyGen is the world's largest tidal array off the coast of Scotland that makes use of ocean currents to power underwater turbines to produce energy.



It is projected to be able to power up to 175,000 homes.

Powered 4,000 homes in 2019

### 4. Brazil

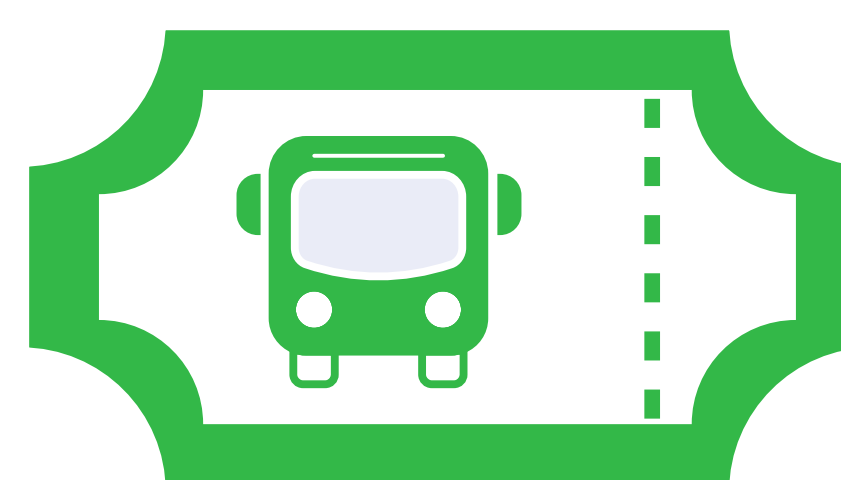
New Project



Recyclable Waste



can be exchanged for



Free Bus Passes

The coastal beaches are essential to Brazil's tourism industry and efforts have been taken to preserve its coastal environment.

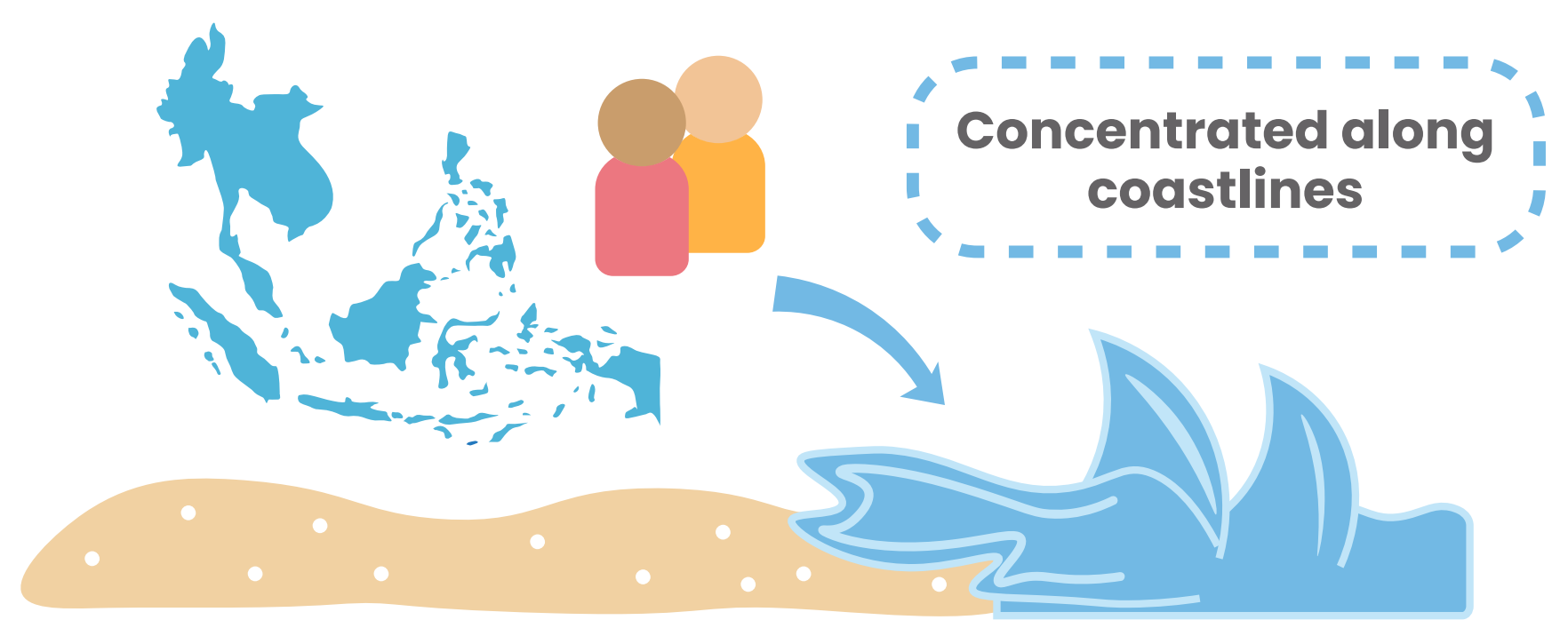
This new project not only incentivises people to opt for public transport, it also prevents waste from polluting the ocean and reduces the release of GHG from waste incineration.

Source: World Economic Forum, The Hindu, Wiley Online Library, Union of Concerned Scientists, The Global Grid, Climate Hot Map, Wikipedia



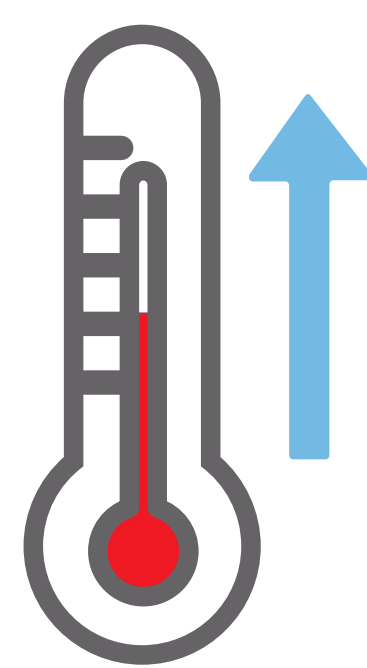
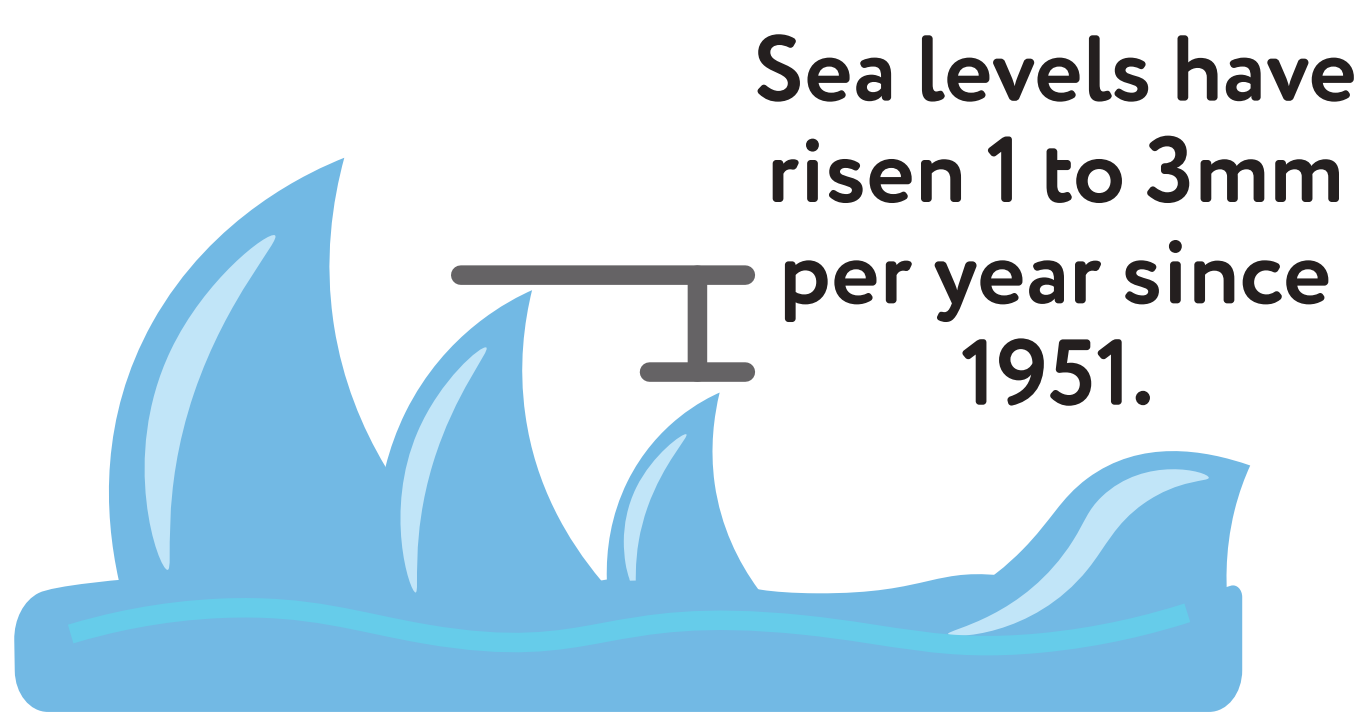
# HOW DO RISING SEA LEVELS AFFECT ASEAN? WHAT IS ASEAN DOING TO TACKLE CLIMATE CHANGE AND RISING SEA LEVELS?

A large proportion of the population and economic activity in Southeast Asia (SEA) is concentrated along coastlines and many SEA nations are heavily reliant on agriculture for livelihoods, making these nations highly vulnerable to climate change.



## Sea level rise in countries within the Association of Southeast Asian Nations (ASEAN):

According to a study carried out by Asian Development Bank (ADB)



Mean temperature in Southeast Asia increased by 0.1 to 0.3°C per decade between 1951 and 2000.

ASEAN's largest coastal cities, such as Jakarta, Bangkok and Manila face major problems.

Millions of people to be resettled



and massive expenditures incurred



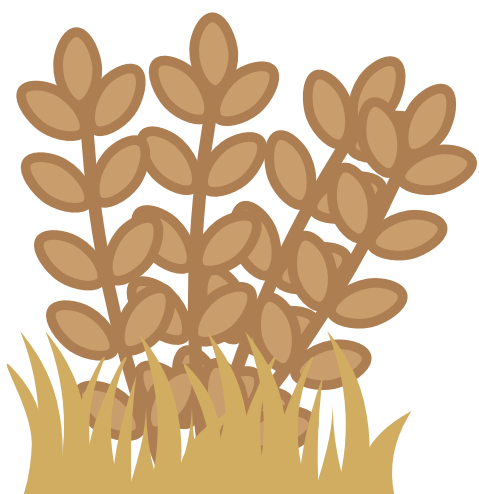
to protect the coastal cities.



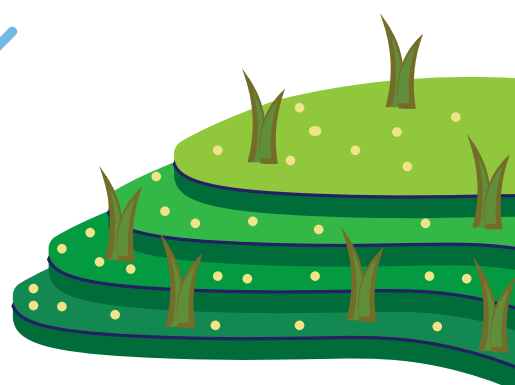
### Economic issues

Projections of economic losses by the ADB study

Decline of up to 50% of rice yield potential



Loss of 6.7% of combined gross domestic product each year by 2100



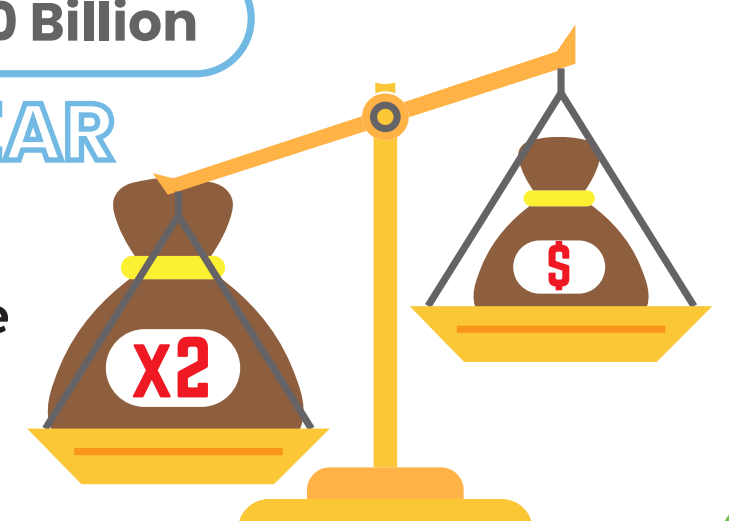
Majority of the ASEAN member states are developing countries that lack financial resources to deal with climate change mitigation and adaptation strategies.

United Nations Environmental Programme

The estimated adaptation cost for developing countries ranges from:

US\$140~300 Billion PER YEAR

and will double by 2050



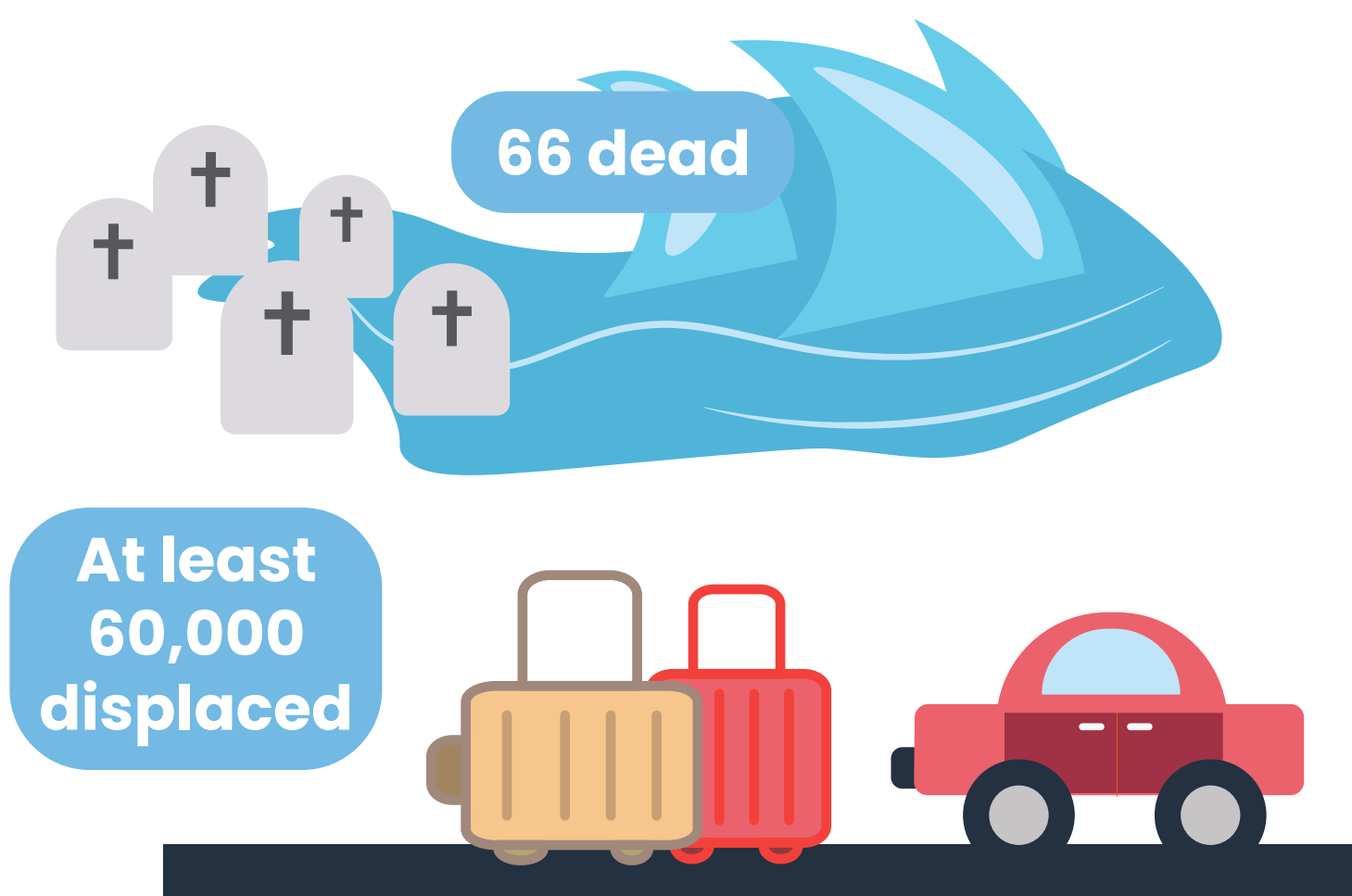
# 1. Indonesia

40% of Jakarta is already below sea level.



Jakarta is estimated to be the fastest sinking city in the world, with some areas sinking 1cm per year and others sinking as much as 20cm.

At the start of 2020, Greater Jakarta was deluged again.



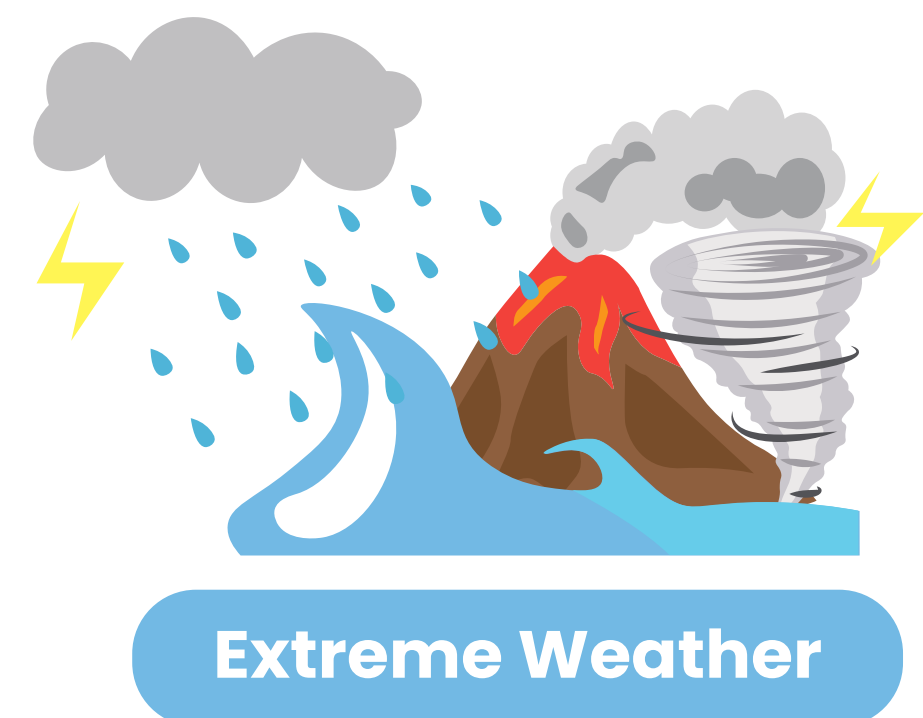
The cost of the city's coastal defence plan, the "Great Sea Wall":



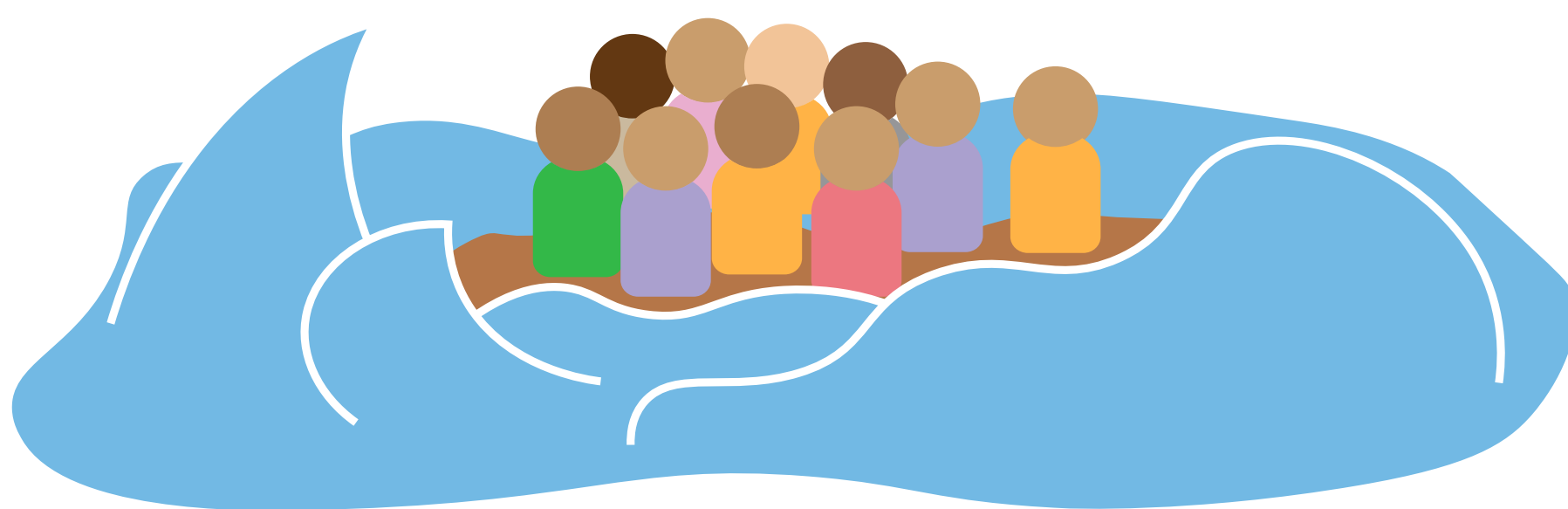
# 2. Myanmar



Between 1998 and 2018



Between 1998 and 2018, Myanmar ranked among the top three countries most affected by extreme weather on the Global Risk Climate Index.



About 2.5 million coastal residents are at risk.

Sea levels are projected to rise.

13cm by 2020

Salt water from the ocean has also contaminated the land, affecting agriculture.



### 3. The Philippines

The Philippines is one of the countries most threatened by coastal flooding.



Some parts of the national capital Manila are expected to be underwater by 2050 according to Climate Central.

This could affect up to 6.8 million people living in high-risk areas.

#### Natural Disasters:

#### Typhoon Mangkhut in September 2018

The Philippines ranked second in the Global Climate Risk Index in 2018.

Typhoon Mangkhut is a Category 5 typhoon – the most powerful typhoon recorded worldwide in 2018.



Top speeds of up to 270km/hr



Affected more than 250,000 people

About 60 people were killed, mostly by landslides due to heavy rainfall.

Source: ASEAN Cooperation on Climate Change, CNA, Reuters, Intergovernmental Panel on Climate Change, Germanwatch

# ASEAN Socio-Cultural Community (ASCC) Blueprint 2025

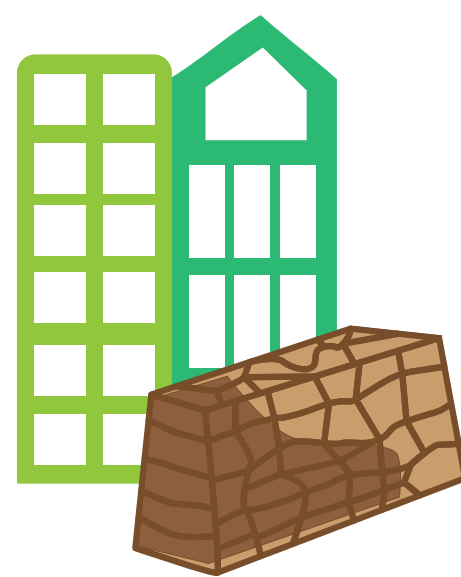
## ASCC 2025 Vision



A committed, participative and socially-responsible community



An inclusive community



A sustainable community



A resilient community



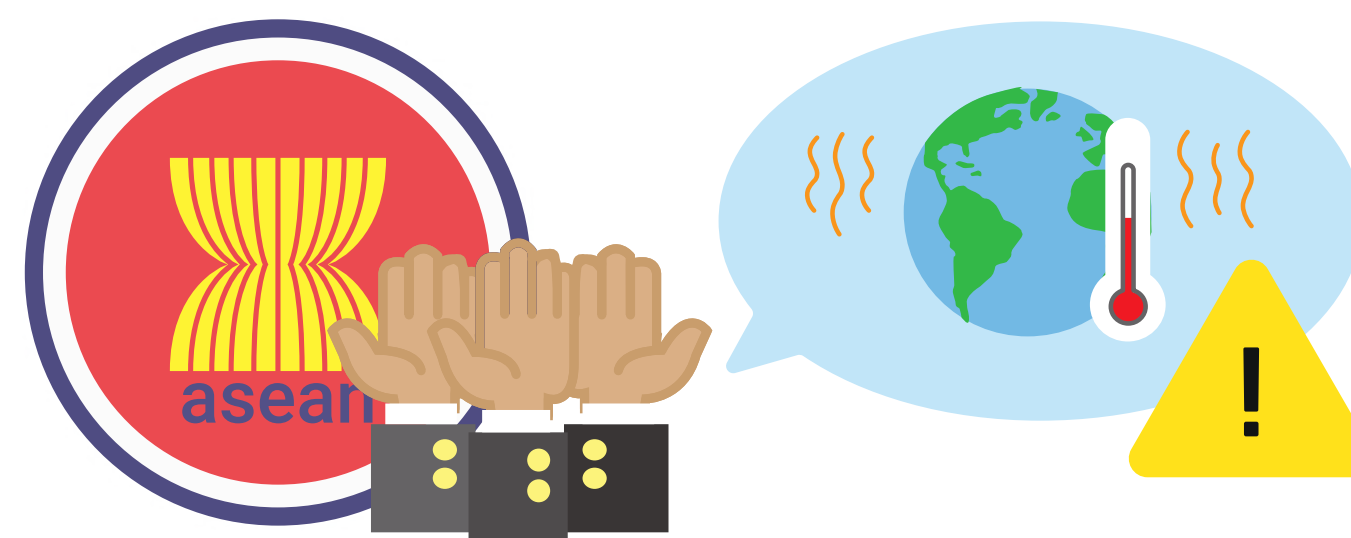
A dynamic and harmonious community

## Some characteristics and elements of ASEAN Socio-Cultural Community Blueprint 2025:



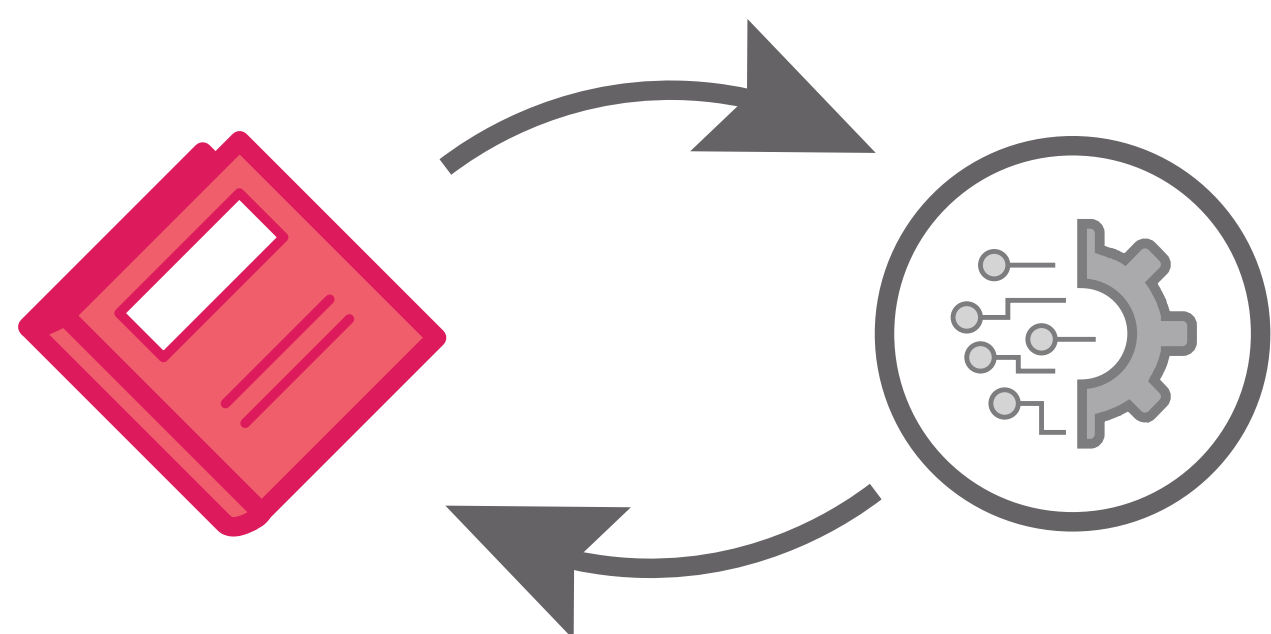
### Environmentally Sustainable Cities

Enhance participatory and integrated approaches in urban planning and management for sustainable urbanisation towards a clean and green ASEAN.



### Sustainable Climate

Strengthen global partnerships and support the implementation of relevant international agreements and frameworks.



### Enhanced Institutional and Human Capacities

Promote and consider indigenous and traditional knowledge and practices in responding and adapting to the impacts of climate change.



# Future Project: ASEAN Climate Change And Energy Project (ACCEPT)

Funded by the Norwegian Government, under the Norwegian-ASEAN Regional Integration Programme.

Joint Collaboration



ASEAN Centre  
for Energy



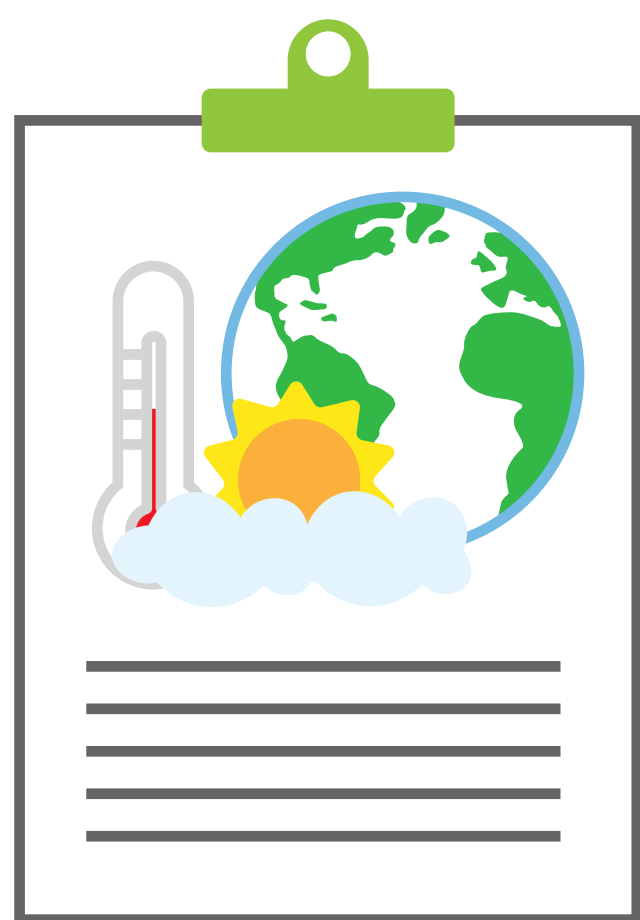
Norwegian Institute  
of International  
Affairs

34-month project

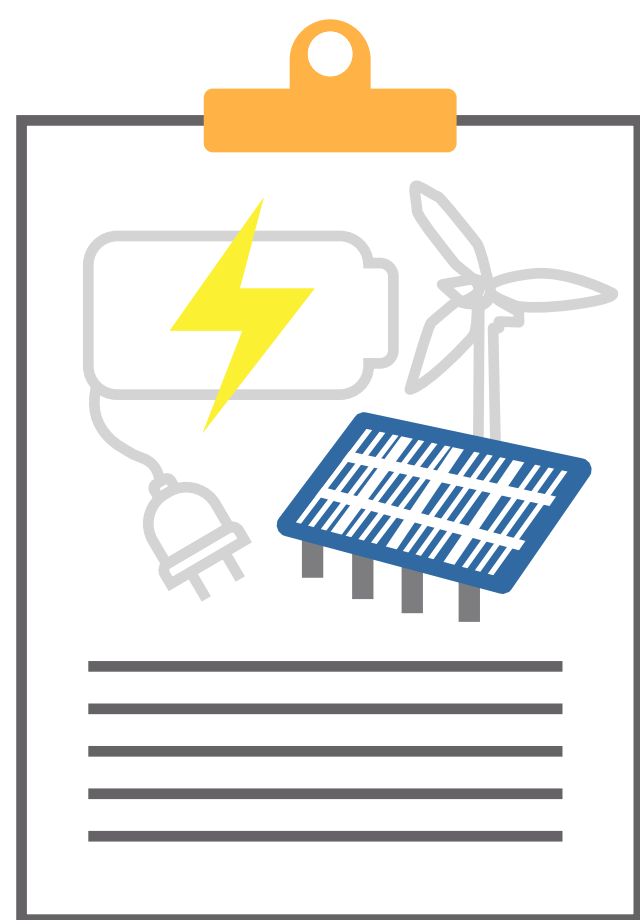


Total funding of  
US\$1,657,060

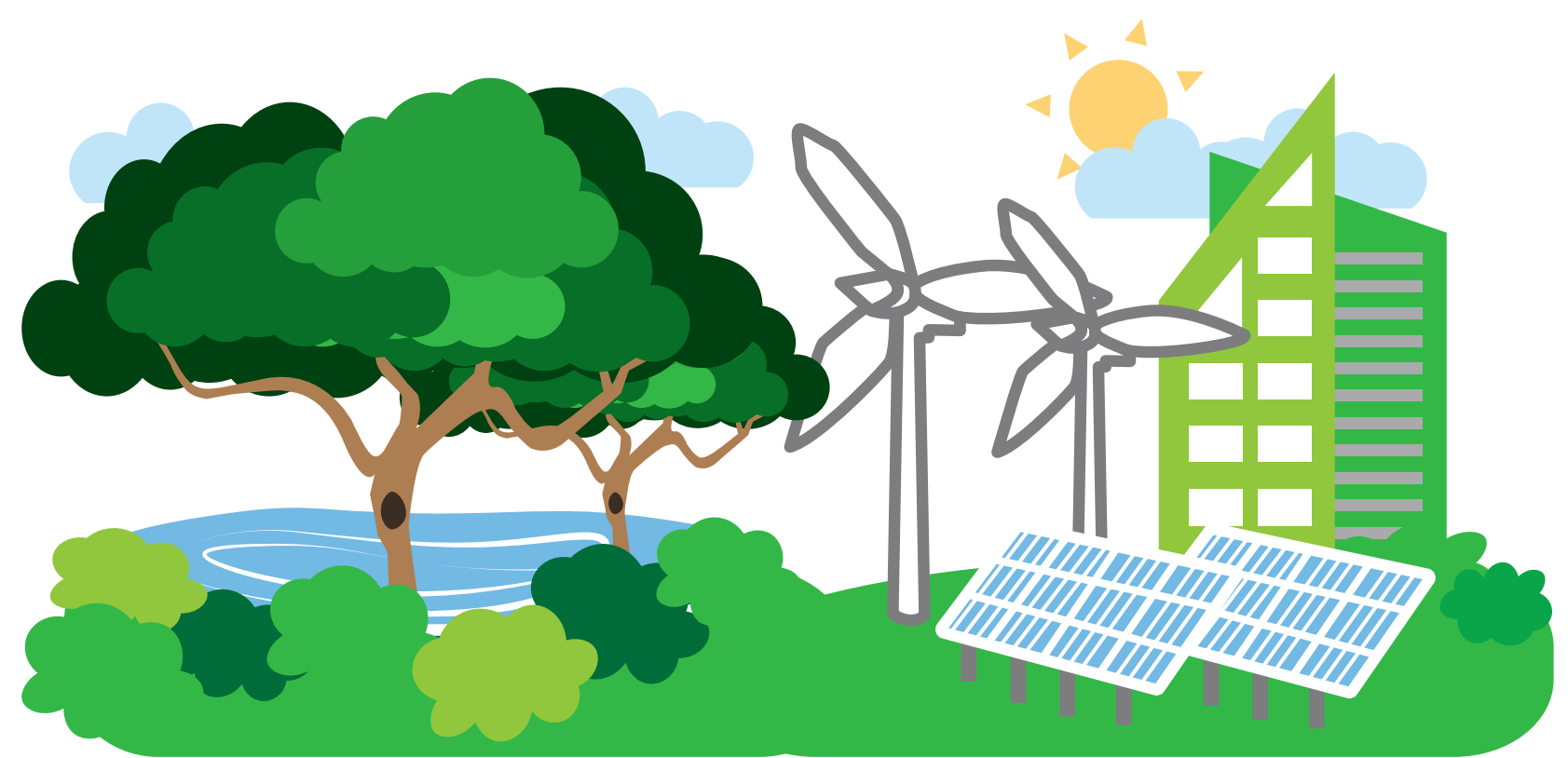
Improve Coherence Between:



ASEAN Climate  
Policies



ASEAN Energy  
Policies



Contribute to Climate-Friendly  
Development

Studies will be carried out to analyse the existing energy and climate policies, provide recommendations and assist the ASEAN member states in shaping policies.

The project will support the preparation of two documents crucial to ASEAN Energy Cooperation:

- (i) ASEAN Plan of Action for Energy Cooperation 2016-2025 Phase 2: 2021-2025 and
- (ii) 6th ASEAN Energy Outlook.

Source: ASEAN Cooperation on Climate Change, ASEAN Climate Change and Energy Project, ASEAN Organisation

# WHAT STEPS ARE BEING TAKEN BY THE SINGAPORE GOVERNMENT TO ACHIEVE THE SINGAPORE GREEN PLAN 2030?

## Singapore Green Plan 2030

The Green Plan charts ambitious and concrete targets by 2030, strengthening Singapore's commitments under the United Nations 2030 Sustainable Development Agenda and Paris Agreement, and positions Singapore to achieve its long-term net-zero emissions aspiration as soon as viable.

### "Eco-Smart" Endearing Towns

#### Example: Punggol Northshore

Punggol's Northshore district is Singapore first district of "smart" public housing, fitted with new technologies that enable residents to live with a lighter environmental footprint.



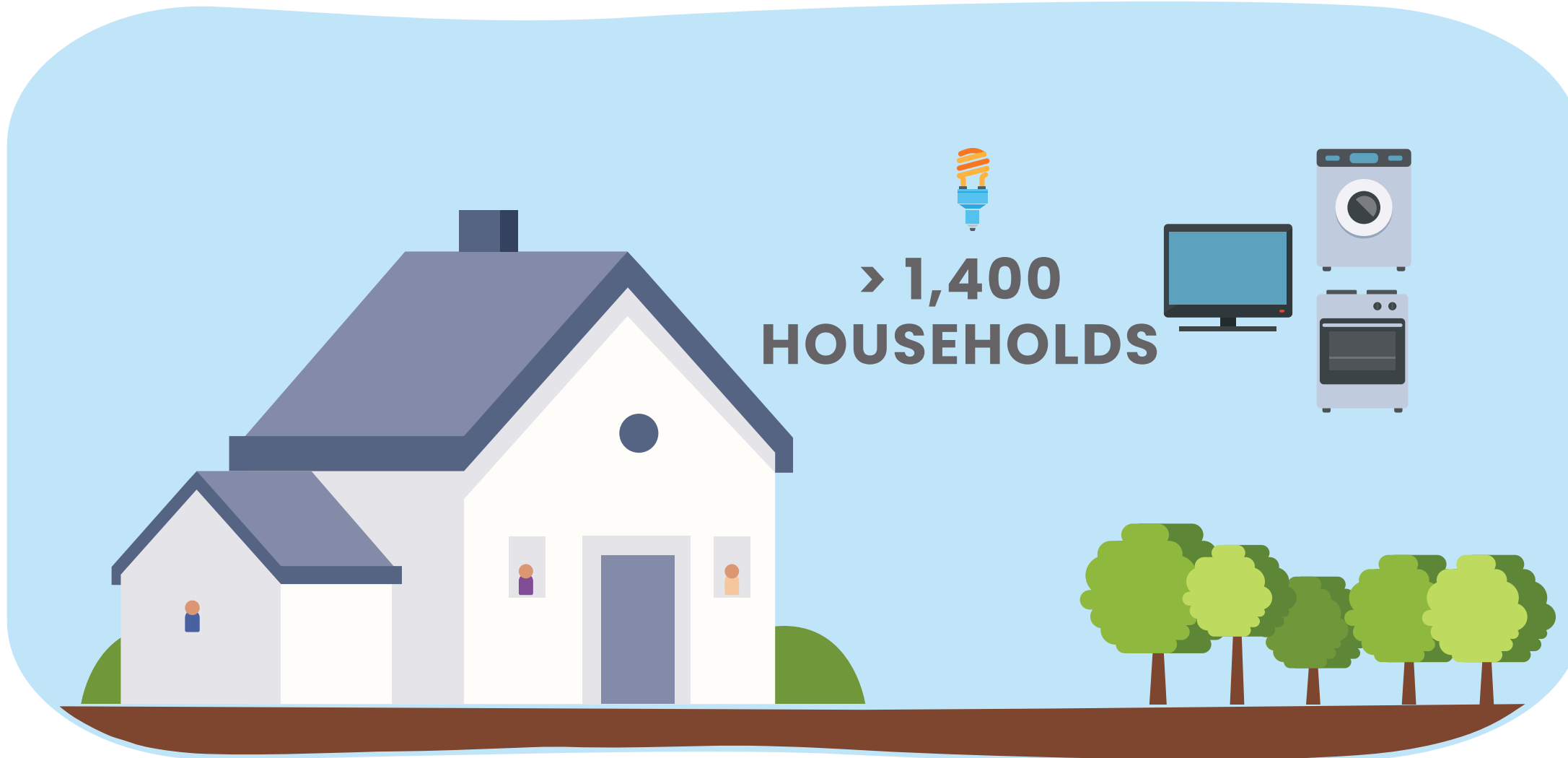
Image source: The Business Times

The coastal town of Punggol is a test-bed for:



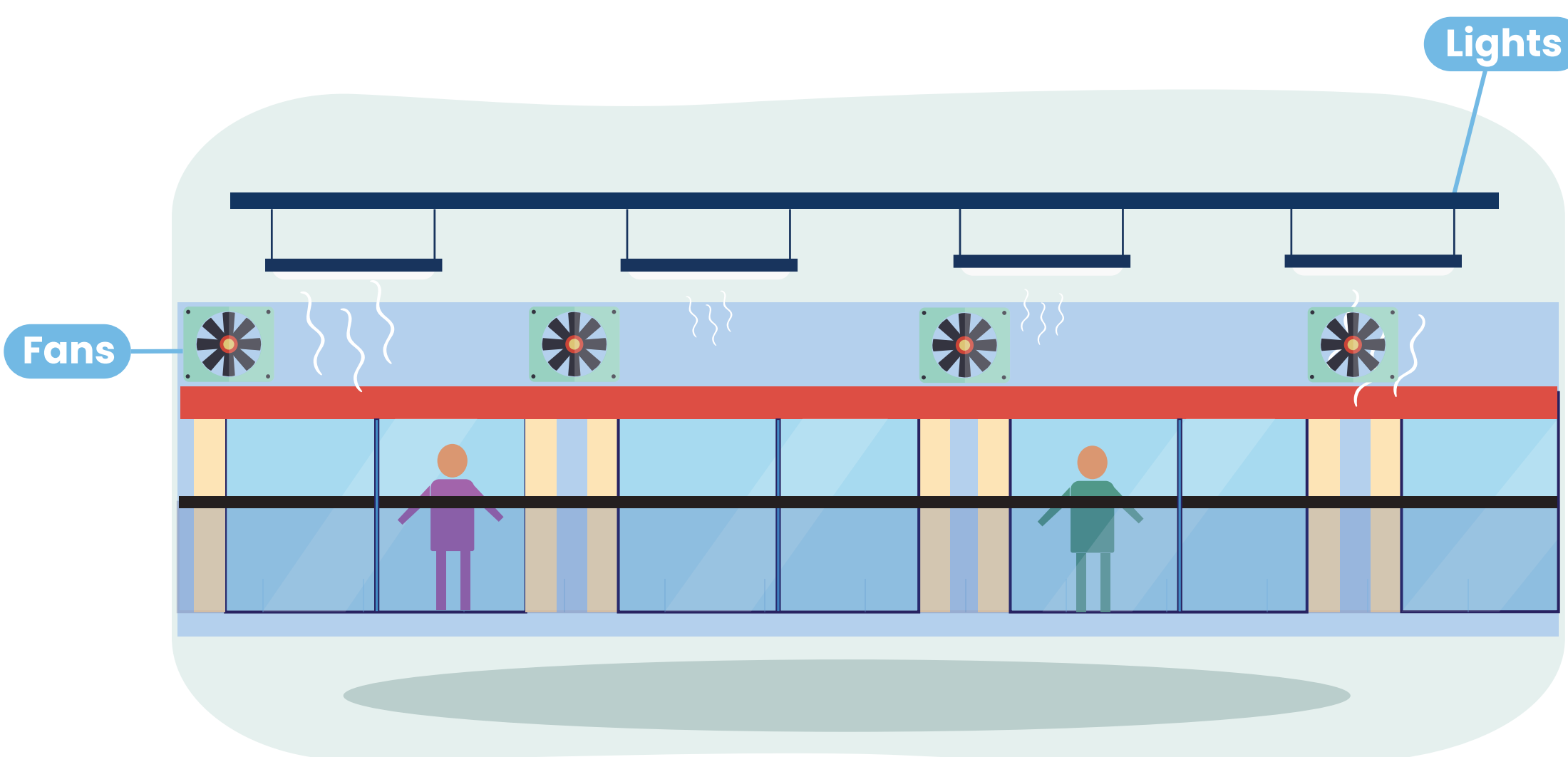


## Homes



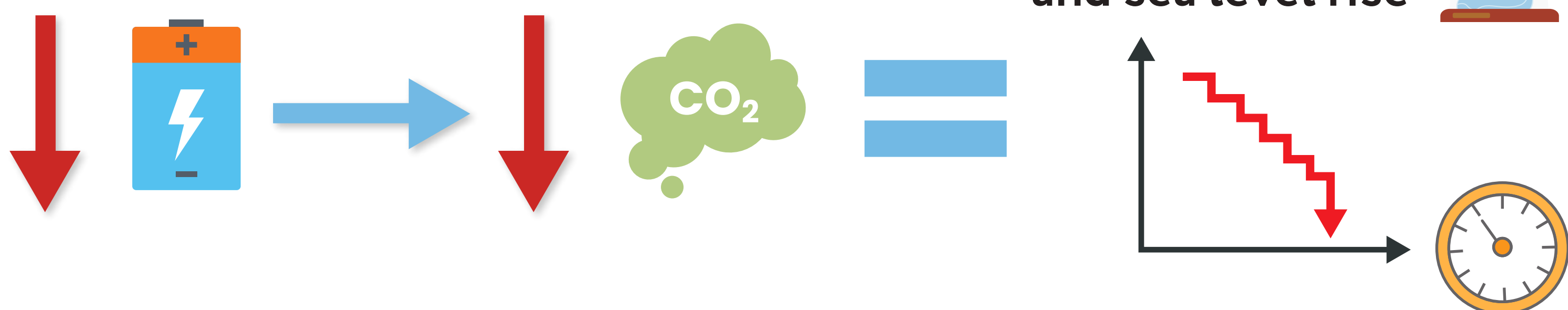
Residents will be able to monitor and manage their home energy consumption in real time.

## Common Areas



Public lights and fans will be controlled by sensors, which will automatically adjust to optimise energy use while meeting residents' needs.

By reducing energy use,



we can help to reduce GHG, which in turn slows the rate of global warming and sea level rise.

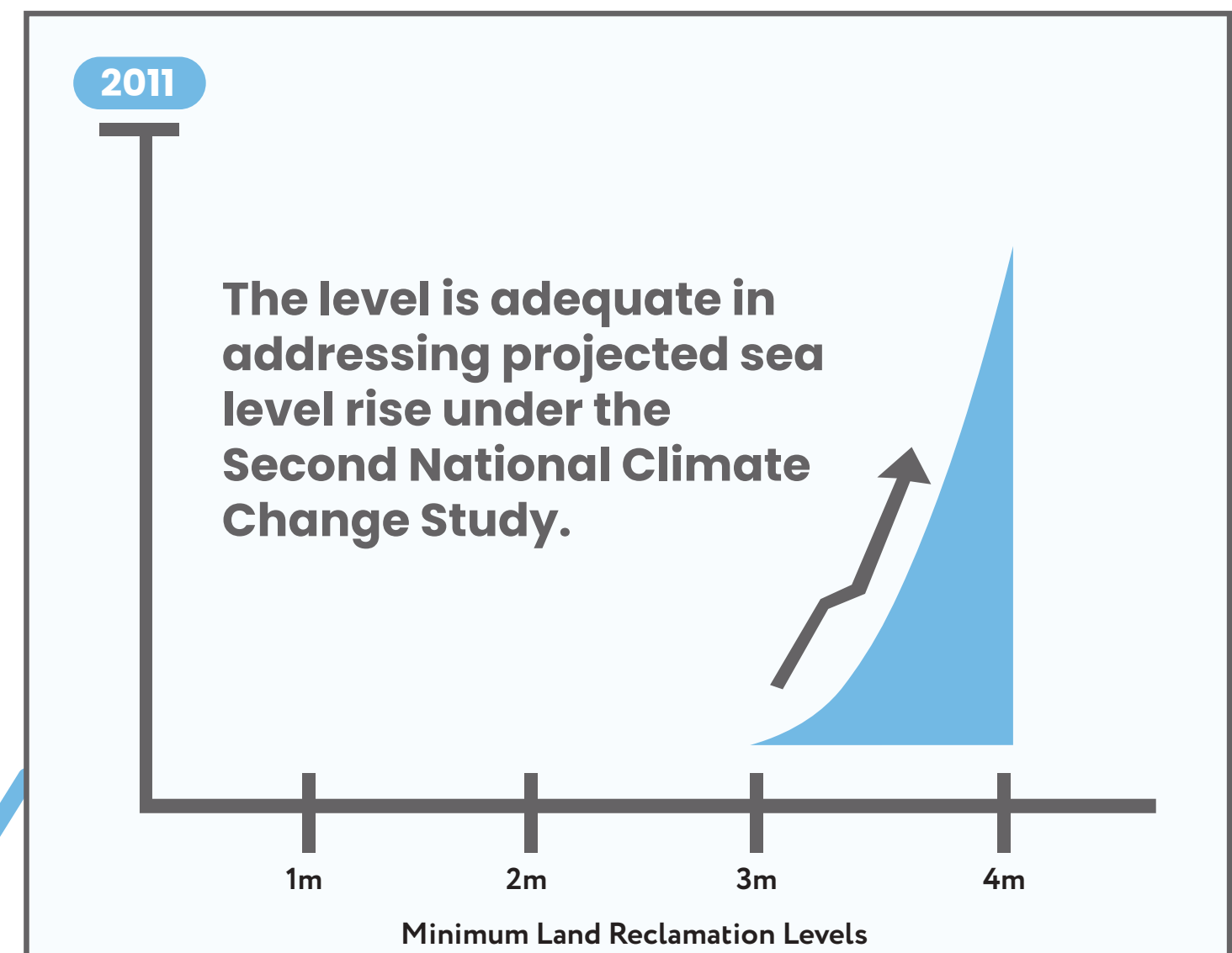
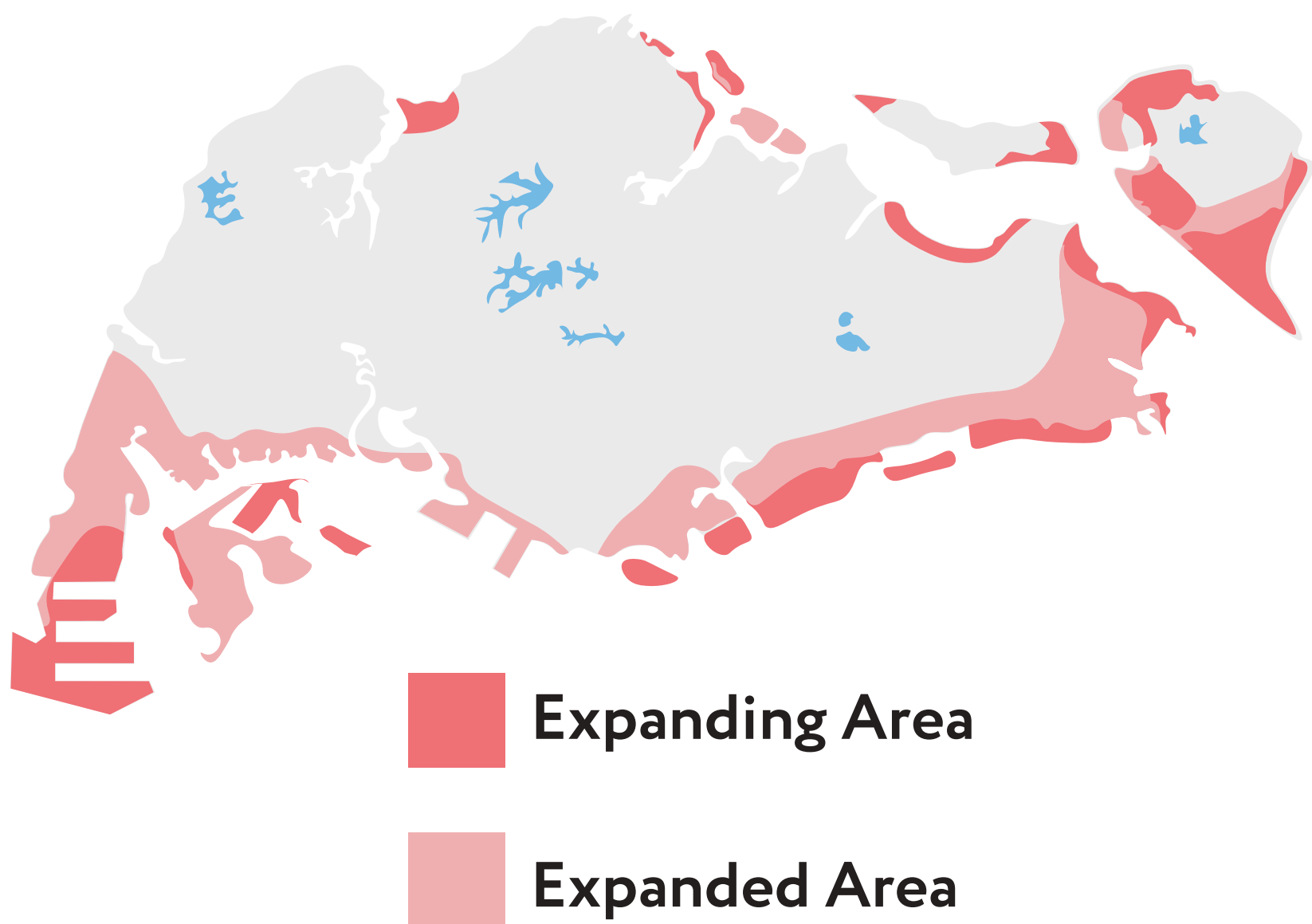
Source: Sustainable Singapore Blueprint, The Straits Times

# WHAT IS SINGAPORE'S APPROACH TO TACKLING RISING SEA LEVELS?

## 3 Aspects Of Singapore's Coastal Defence Plan:

### 1 Land Reclamation

PUB and related agencies will continue to review the minimum reclamation levels with information from new studies available.



\*The SHD is the vertical datum at the height of 0.000m. The Singapore Land Authority introduced the term in 2015 for standardisation across the construction industry.

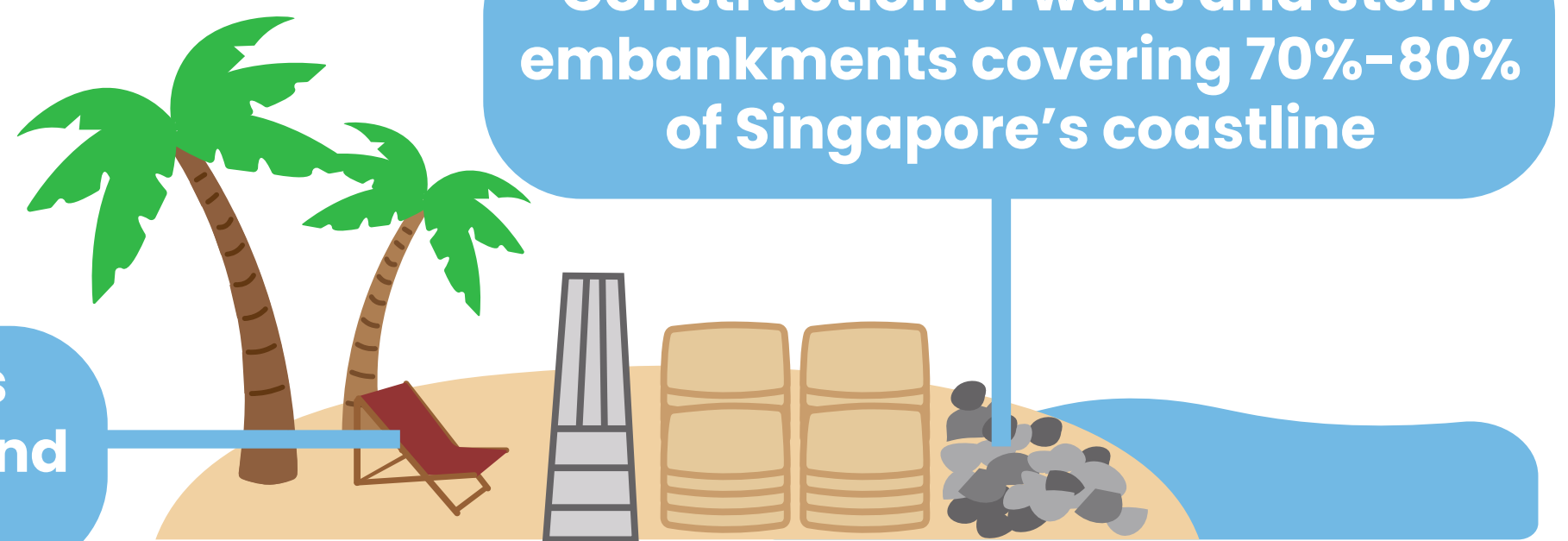
To address long-term sea level rise, the minimum land reclamation level in Singapore was raised from 3m to 4m above the Singapore Height Datum (SHD) in 2011.

### 2 Safeguarding Our Coastline

Our current efforts to defend our coastal areas from erosion includes:

Natural areas (e.g. beaches and mangroves)

Construction of walls and stone embankments covering 70%-80% of Singapore's coastline



#### THE FOUR FACTORS THAT CONTRIBUTE TO THE DEVELOPMENT OF APPROPRIATE PROTECTIVE MEASURES:



Coastal Engineering



Wave Dynamics



Coastal Morphology



Hydrodynamics

The Coastal Adaptation Study (CAS) was commissioned by the Building and Construction Authority to assess the potential impacts of coastal inundation under various climate change scenarios and to study possible long-term adaptation measures.



The Government is reviewing the findings of the CAS to develop long-term strategies to protect Singapore's coasts.



**3****Our Natural Barriers**

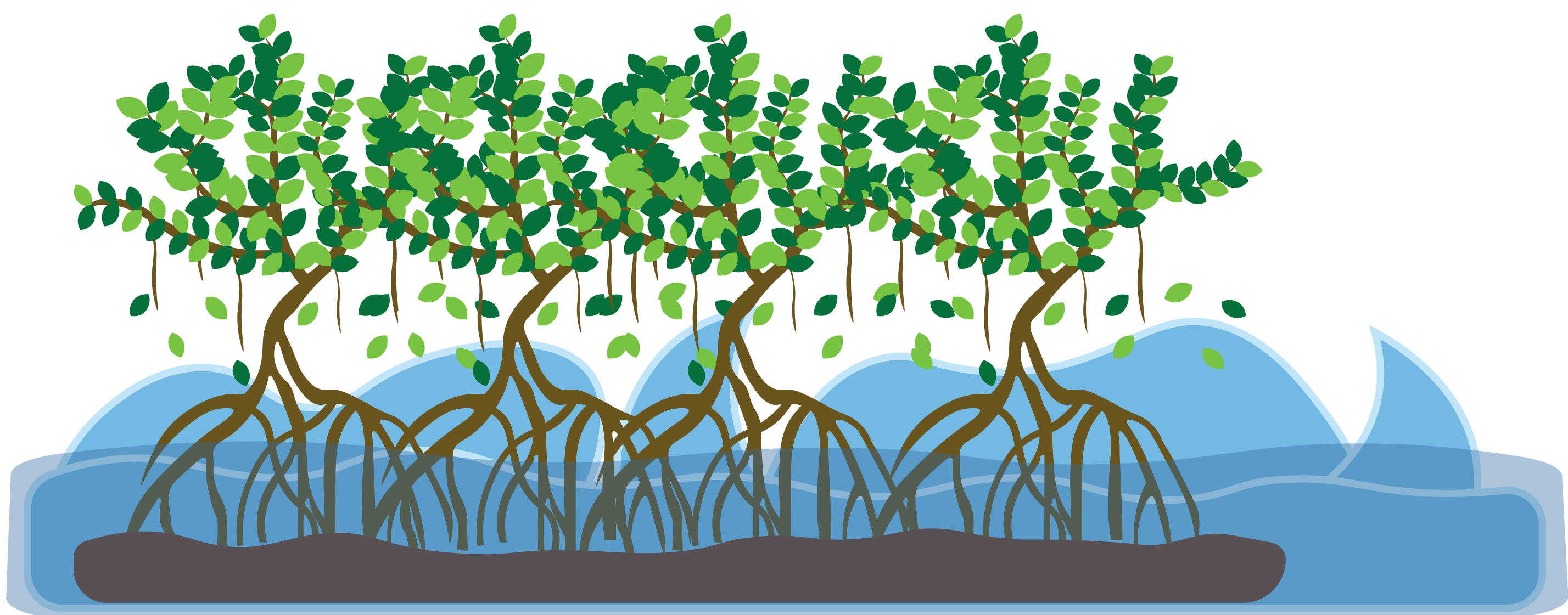
Although plants provide natural protection from the effects of climate change, they are also vulnerable to its effects.



Climate change alters our ecosystem's natural processes such as soil formation, nutrient storage and pollution absorption.



This can affect the ability of natural barriers to mitigate flooding and tidal surges.

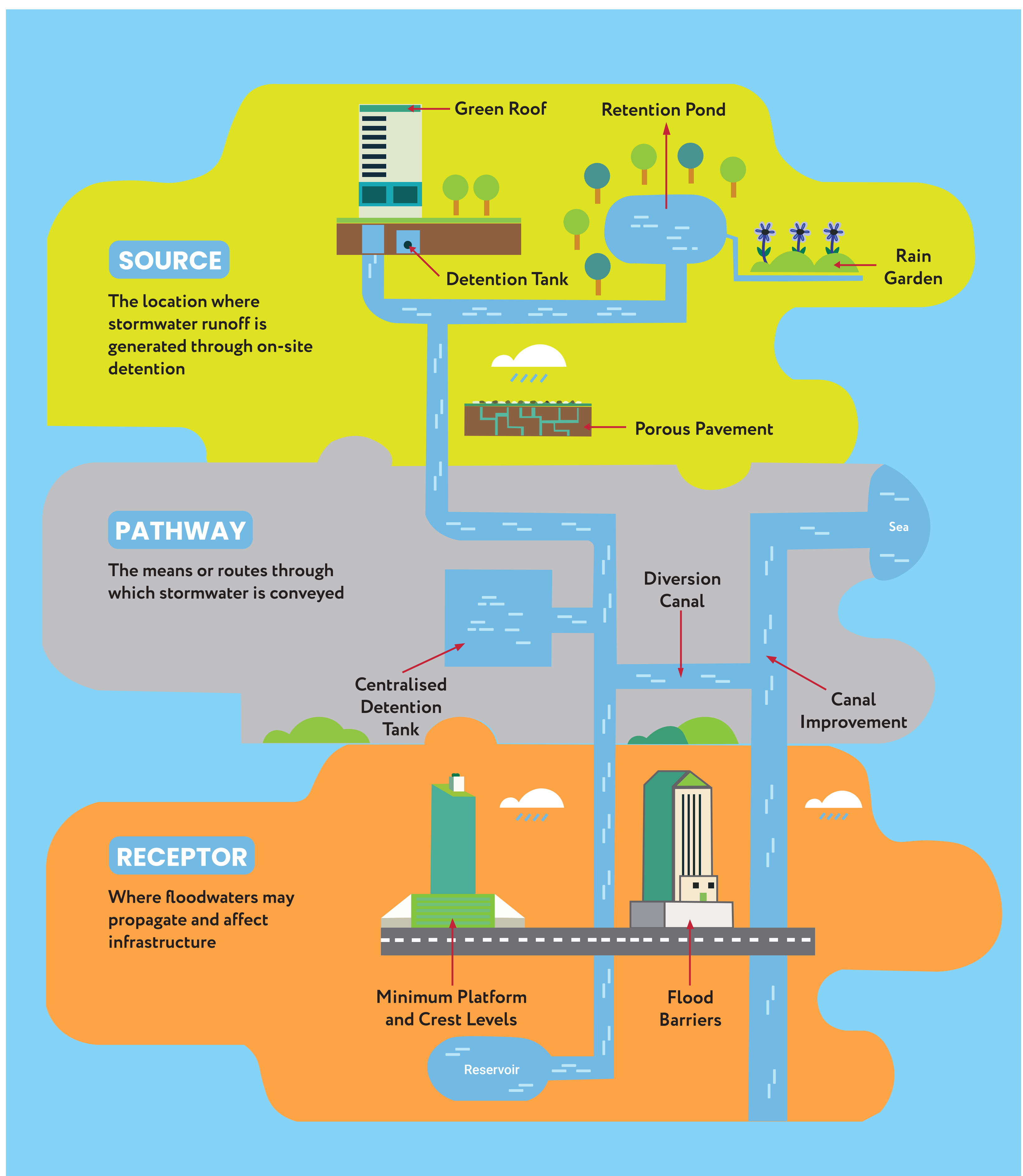


Local institutions are collaborating on the research of natural coastal protection measures such as the use of plants like mangroves and seagrass as natural barriers to inundation.

Source: 103 EAST Architects, National Climate Change Secretariat

# 1. Source-Pathway-Receptor Approach

Measures are not only carried out along the **Pathway** but also implemented at the **Source** and at the **Receptor** where floods may occur.  
(e.g. through platform levels, crest protection and flood barriers)





## 2. Stormwater Management

Singapore adopts an integrated approach to stormwater management that balances our need for water supply with the need to manage flood risks.

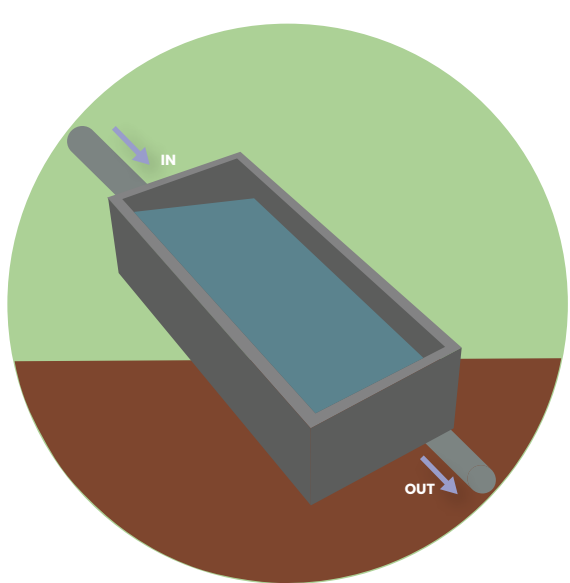


Outflow to stream, river or lake without treatment

Storm Drain

This approach is sustainable as stormwater management is addressed at all parts of the drainage system, with building owners and developers playing a role in managing the impact their developments have on flood risks.

Since **January 2014**, developers of new and redeveloped sites are required to implement on-site measures to slow down the flow of stormwater discharged from their developments into the public drainage system. These implementations include:



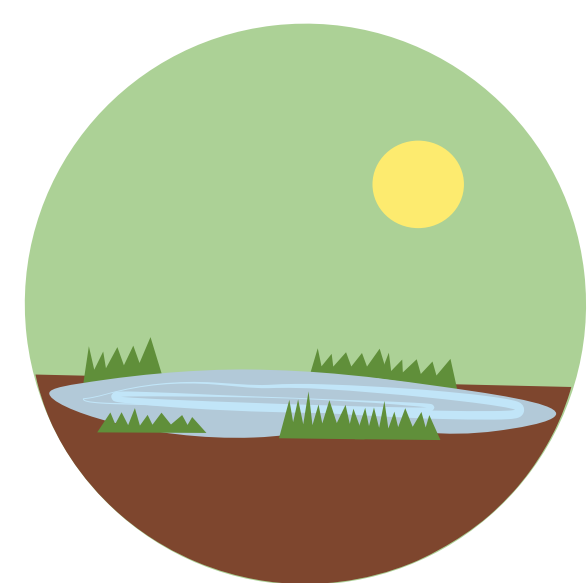
Detention Tanks



Green Roofs



Rain Gardens



Retention Ponds

Source: National Climate Change Secretariat

## CHAPTER 8: We're all in this together

In the last chapter of this series, we find out about Singapore's carbon footprint and how we can lead a more sustainable lifestyle. Learn how we can combat climate change right from our homes.





# WHAT IS CARBON FOOTPRINT AND WHAT IS SINGAPORE'S EMISSIONS PROFILE?

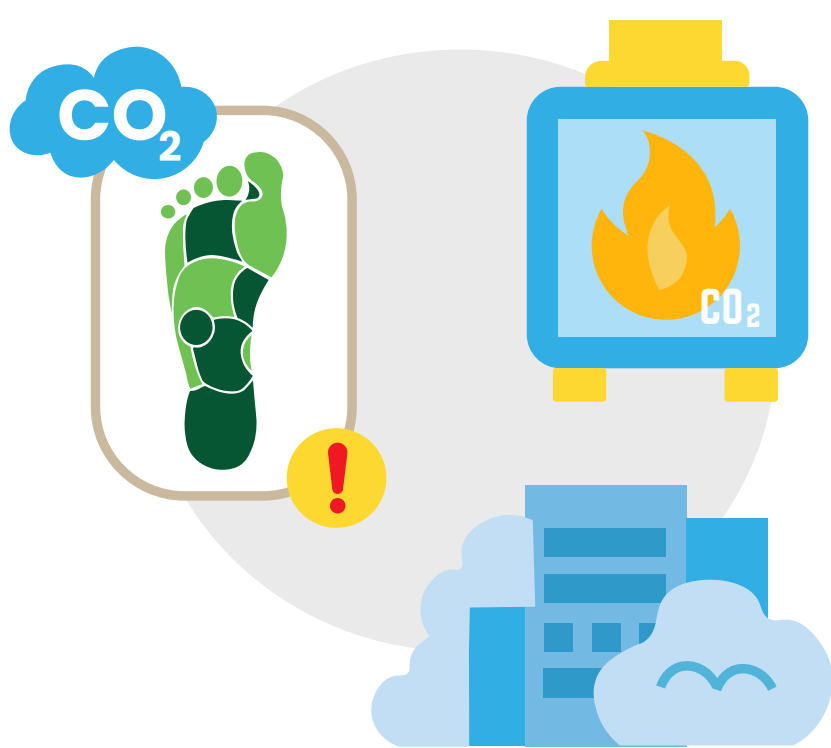
## What Is The Concept Of Carbon Footprint?

It is usually expressed as a measure of weight, as in tonnes of CO<sub>2</sub> or CO<sub>2</sub> equivalent per year.

A carbon footprint is the total amount of greenhouse gas (GHG) emissions that come from the production, use and end-of-life of a product or service.

### Greenhouse Gases

These gases trap heat in the atmosphere, contributing to global warming.



**Carbon Dioxide (CO<sub>2</sub>)**

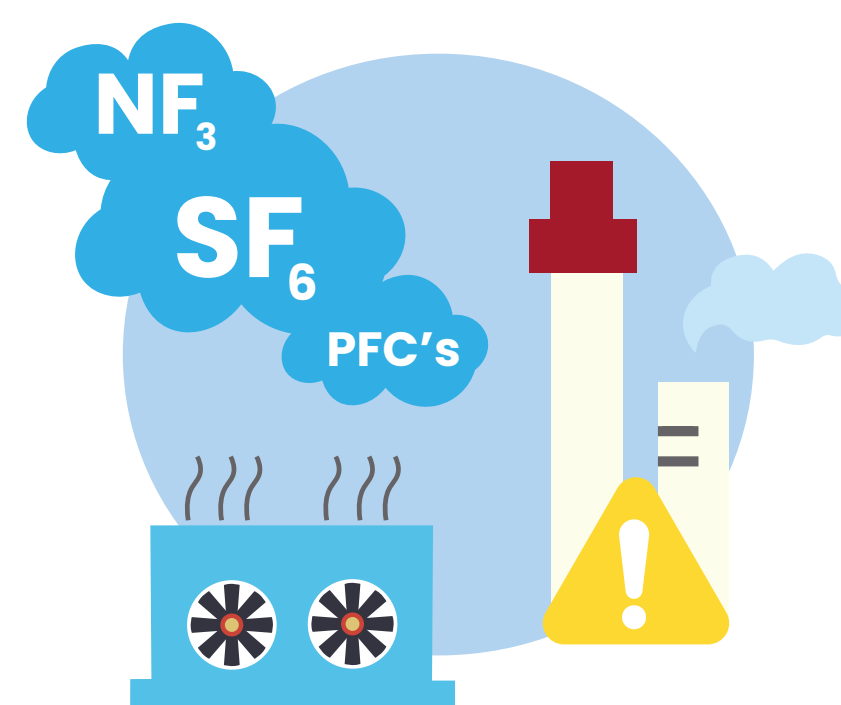
The gas most commonly emitted by human activities.



**Methane (CH<sub>4</sub>)**



**Nitrous Oxide (N<sub>2</sub>O)**

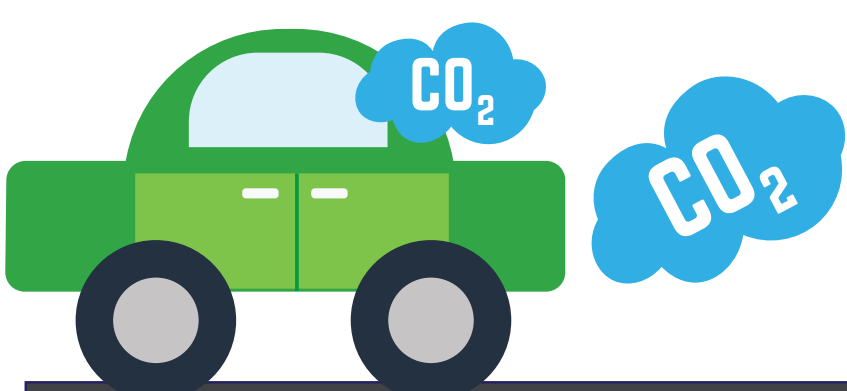


**Fluorinated Gases**

The largest sources of GHG emissions are from human activities, including through the running of buildings and factories.

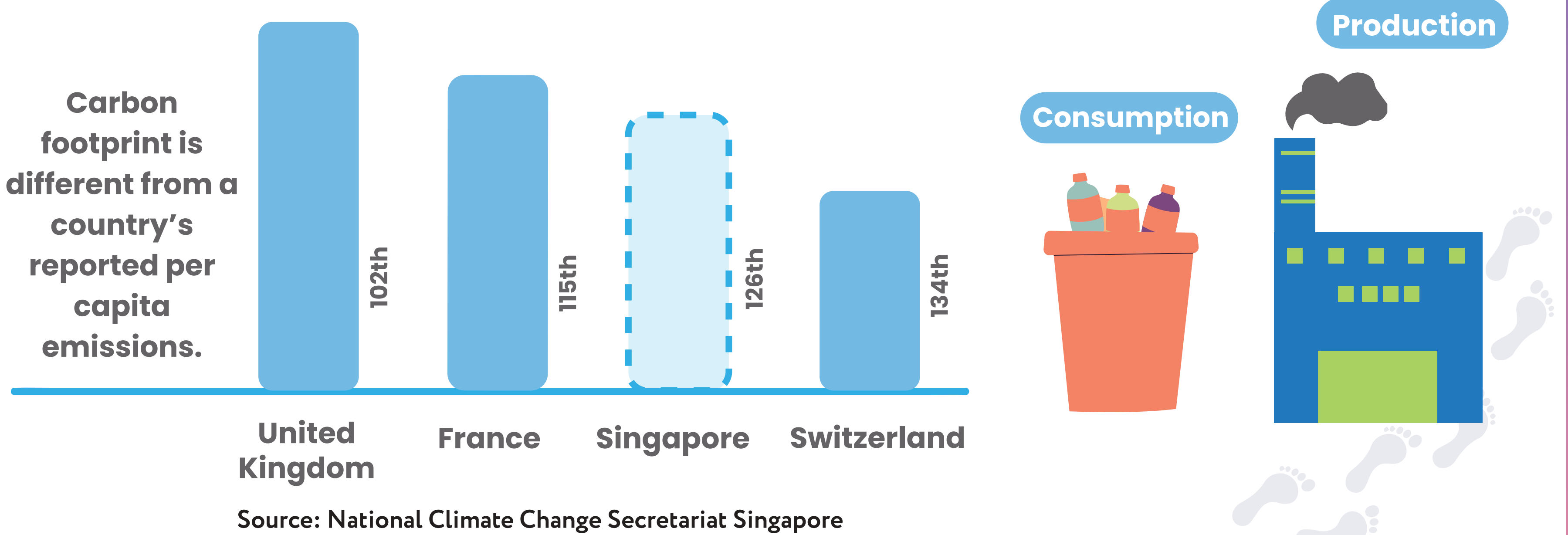
### Direct Emissions

These result from fossil fuel combustion in manufacturing, heating and transportation, as well as emissions required to produce the electricity associated with goods and services consumed.



# What Is The Difference Between Carbon Footprint And GHG Emissions?

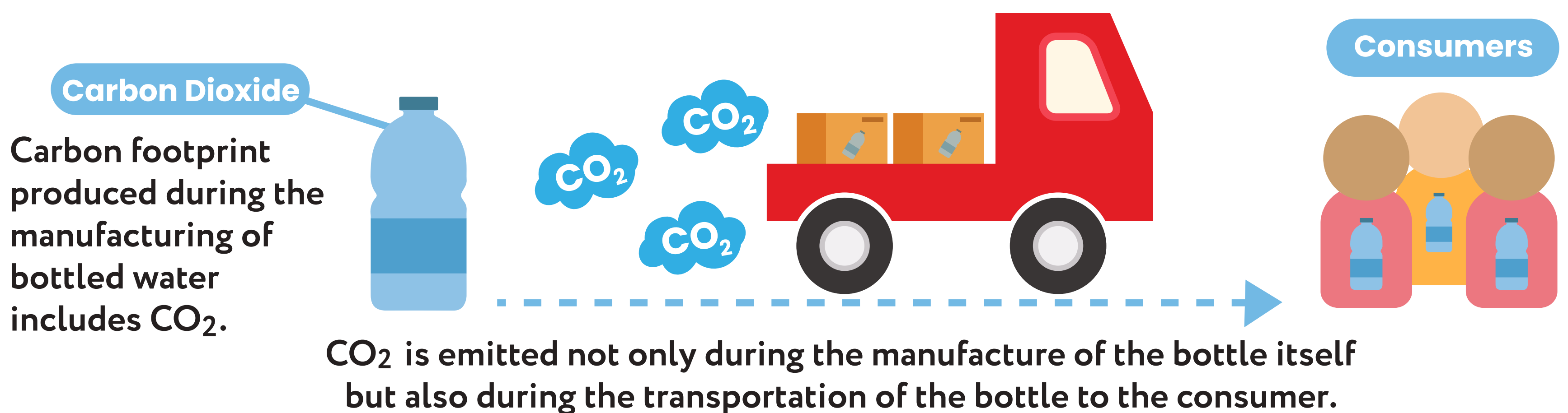
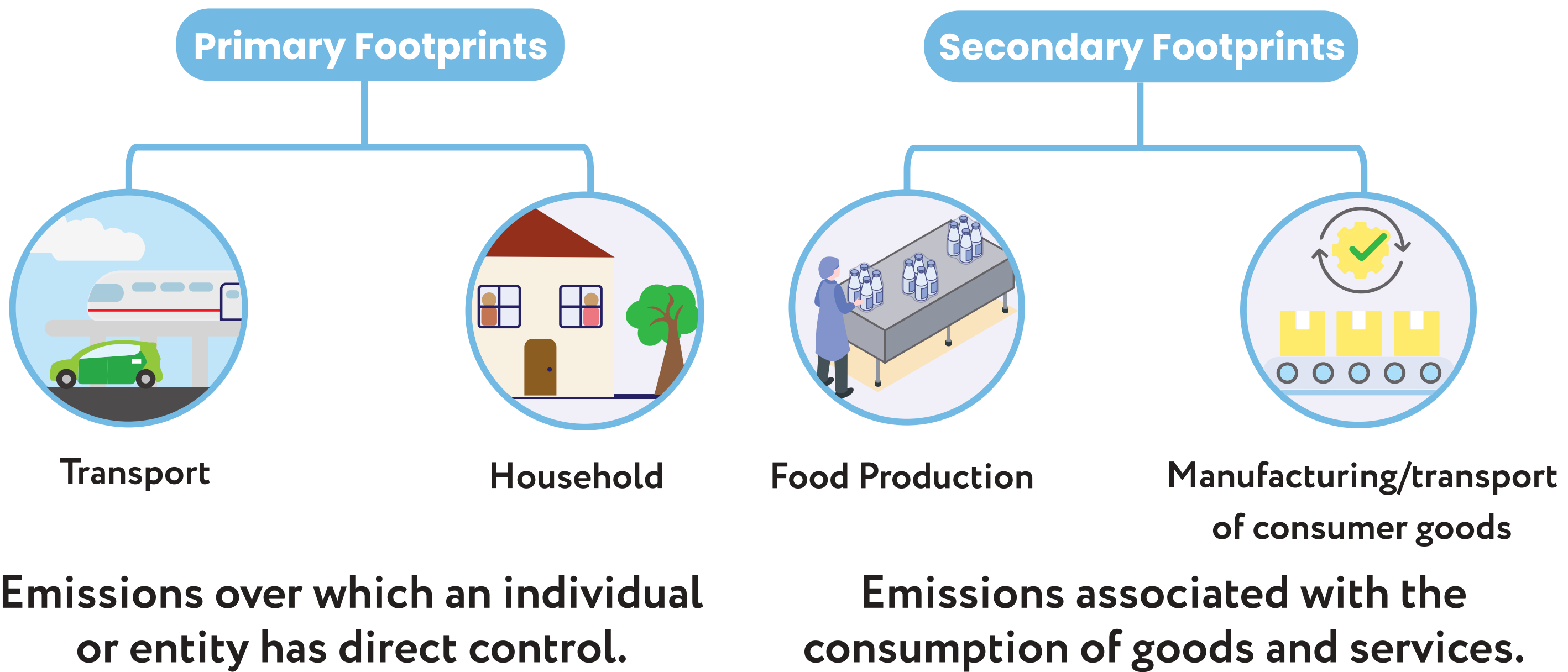
## Ranking of countries with the most amount of GHG emissions



Carbon footprint measures the GHG emissions associated with both production and consumption.

## How Is Carbon Footprint Measured?

Carbon footprints can be categorised into primary and secondary footprints.



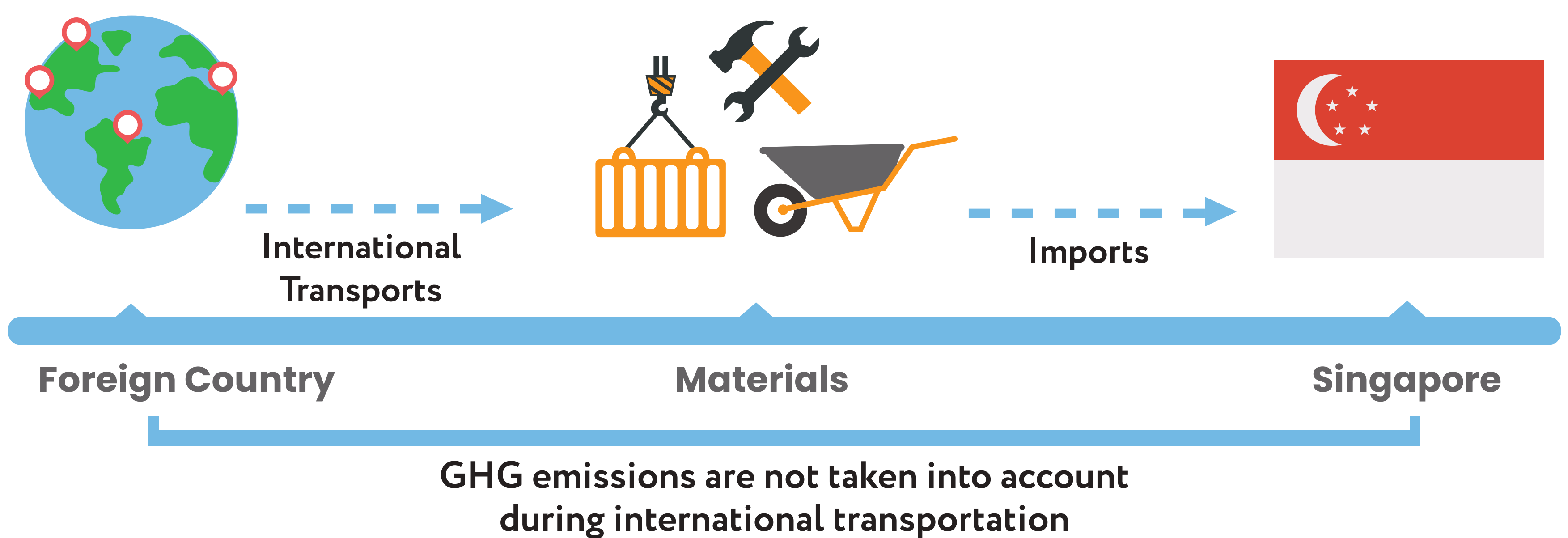
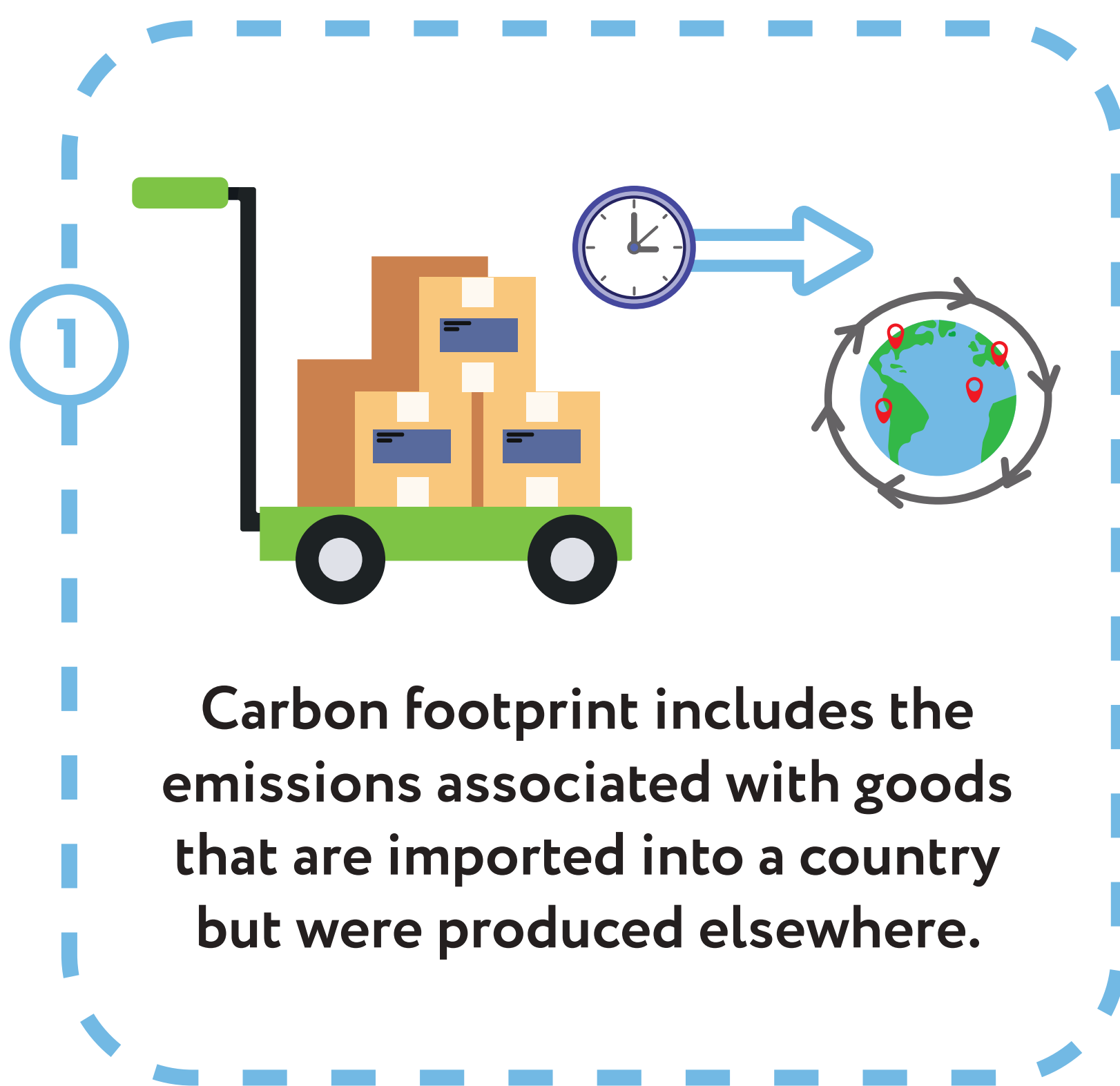
Source: Britannica, Carbon footprint, Ecology and Conservation



# WHAT IS SINGAPORE'S CARBON FOOTPRINT?

## Why Is It Not Possible To Accurately Track The Total Carbon Footprint Produced By Singapore?

Carbon footprint takes into account the emissions of the whole supply chain.

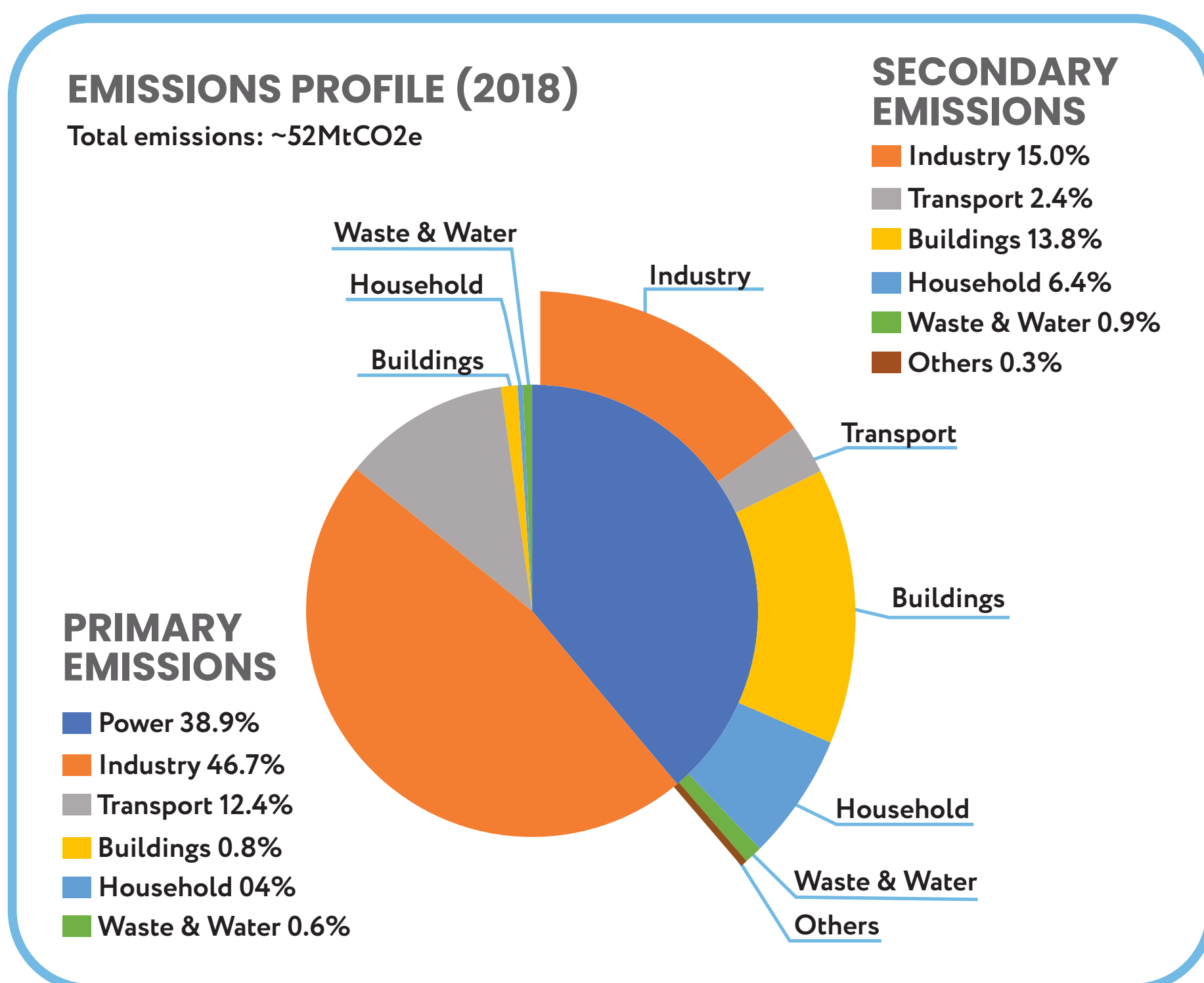


GHG emissions are only taken into account during construction



Although the emissions profile gives us a good look at how much carbon we are producing, the **actual carbon footprint of Singapore is much higher.**

### Singapore's emissions profile in 2018:



Metric tonnes of carbon dioxide equivalent or MTCO<sub>2</sub>e is the unit of measurement in this tool. The unit "CO<sub>2</sub>e" represents an amount of a GHG whose atmospheric impact has been standardised to that of one unit mass of carbon dioxide (CO<sub>2</sub>), based on the global warming potential (GWP) of the gas.

Source: <https://www.epa.gov/>

**Singapore ranks 27th out of 142 countries in terms of emissions per capita based on the latest International Energy Agency data.**

Source: National Climate Change

### Singapore disposes of much of its waste through waste-to-energy initiatives.



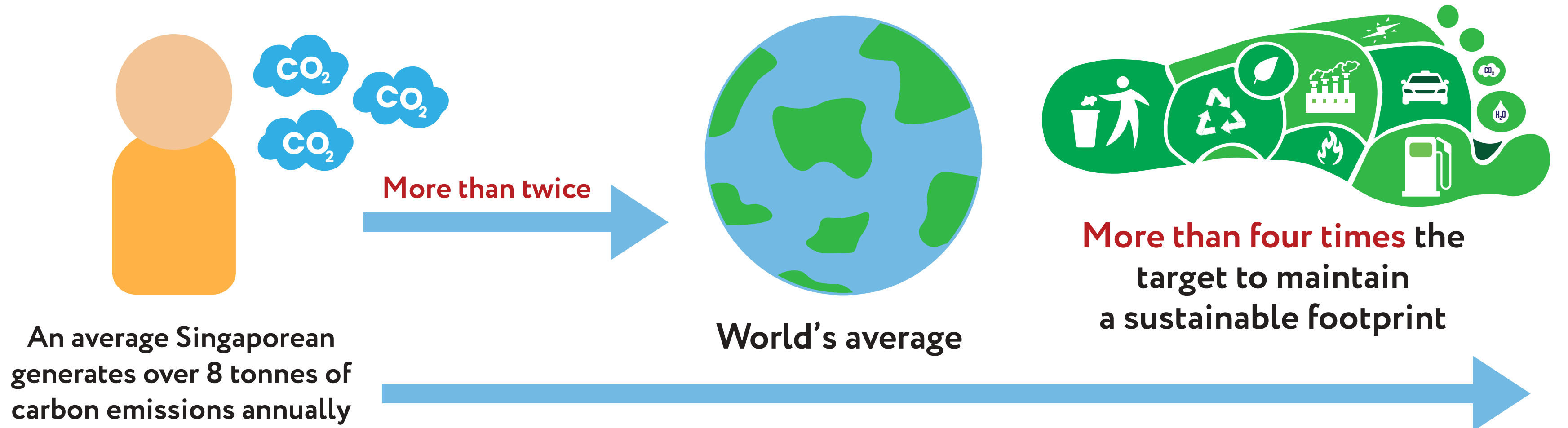
Incineration is preferable to land filling, since the direct burial of waste produces methane, a GHG.

**Recycling is an important method that can help reduce the amount of waste generated and their emissions. Singapore is aiming to improve our current recycling rate from 59% to 70% by 2030.**

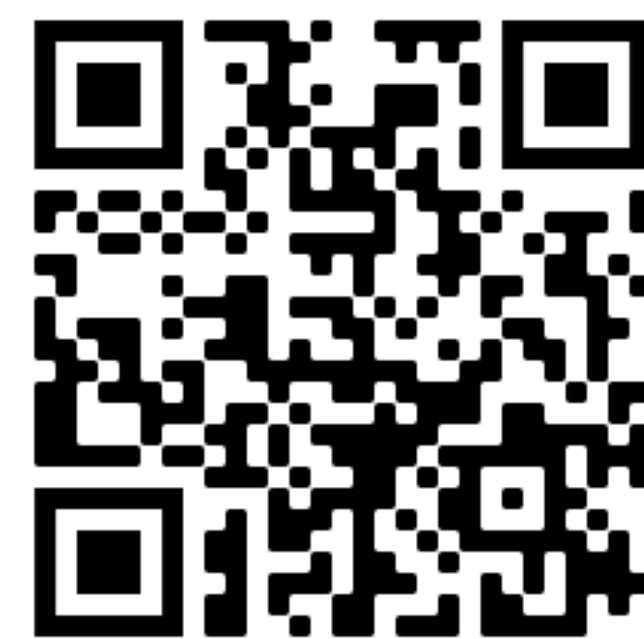
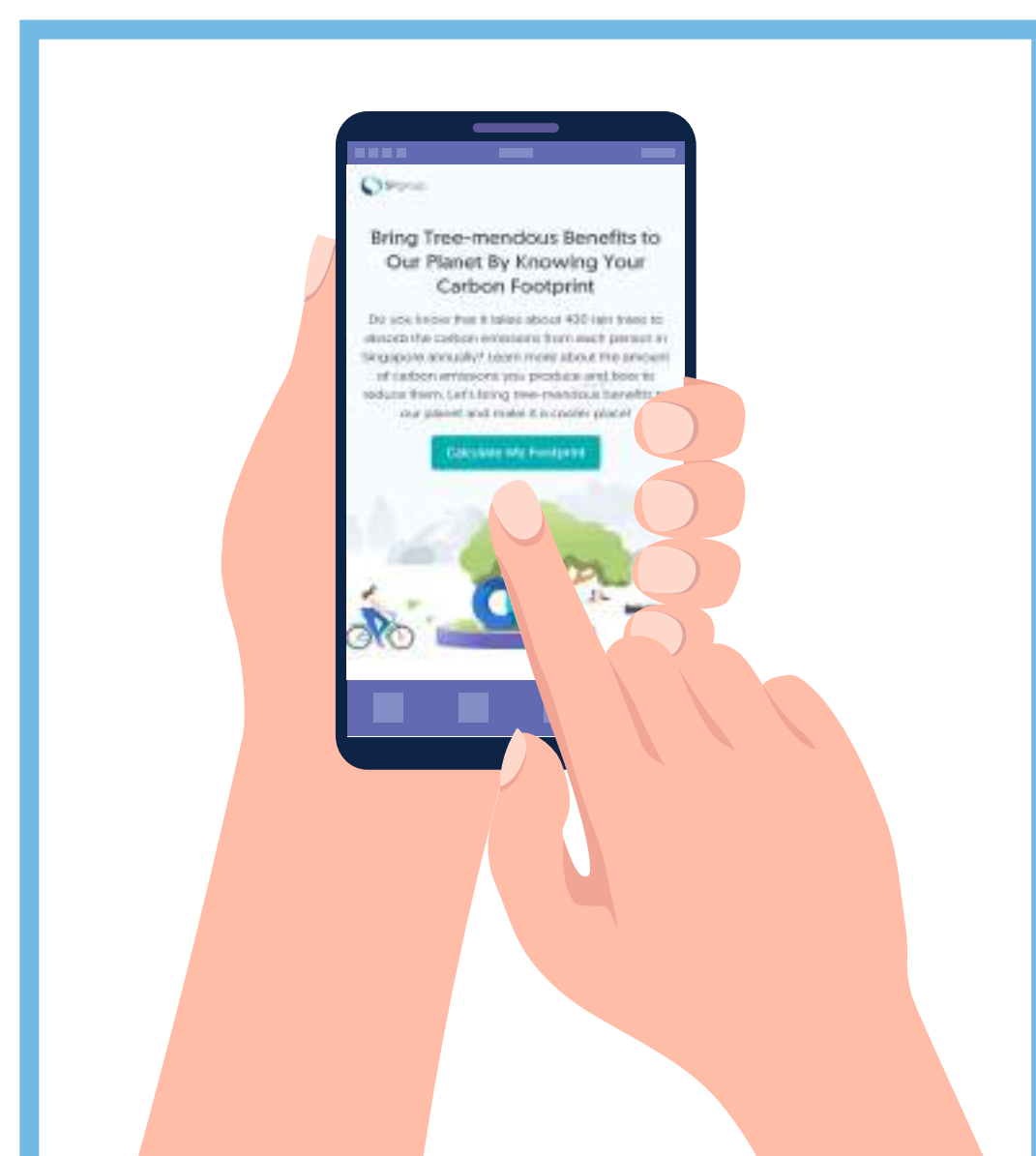
Source: Eco Business, The National Climate Change Secretariat



# Concept Of Carbon Footprint



More than 400 raintrees are required to absorb the annual carbon emissions of an average consumer in Singapore.

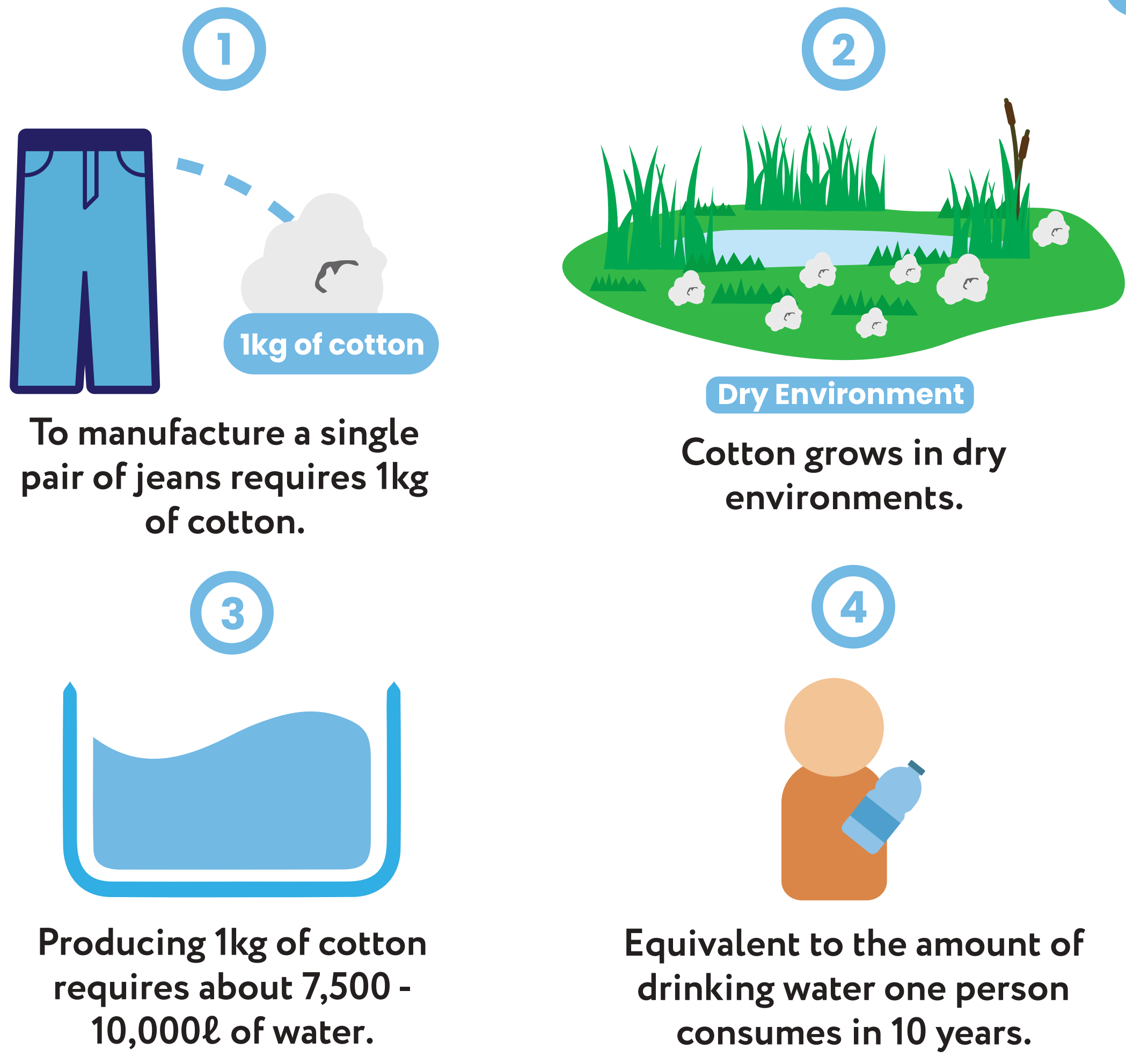


Scan to view!

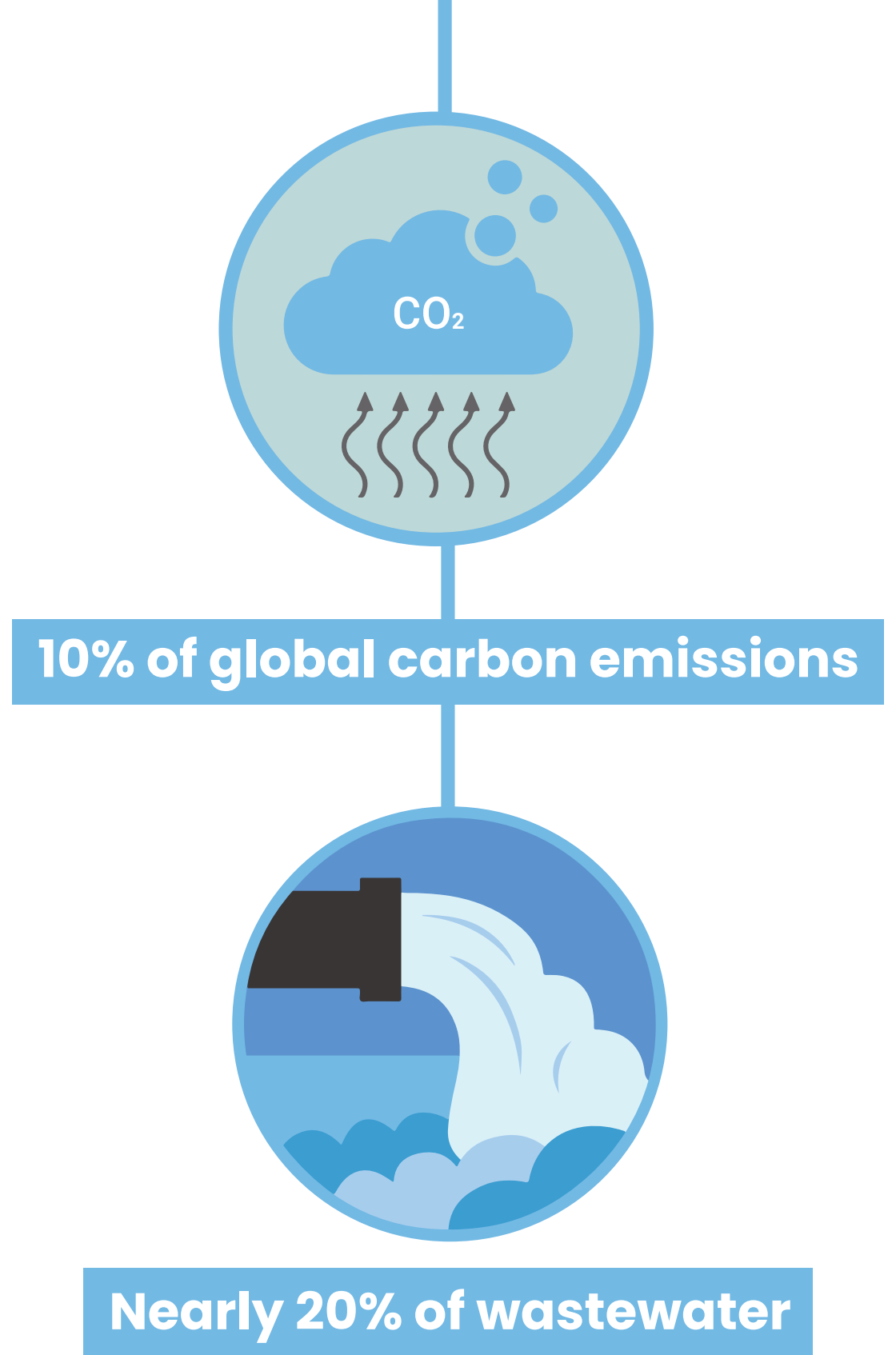
Calculate your own carbon footprint!  
<https://mycarbonfootprint.spgroup.com.sg/>

# 1 Carbon footprint produced by the manufacturing and consumption of everyday items

Carbon footprint life cycle of fashion items:



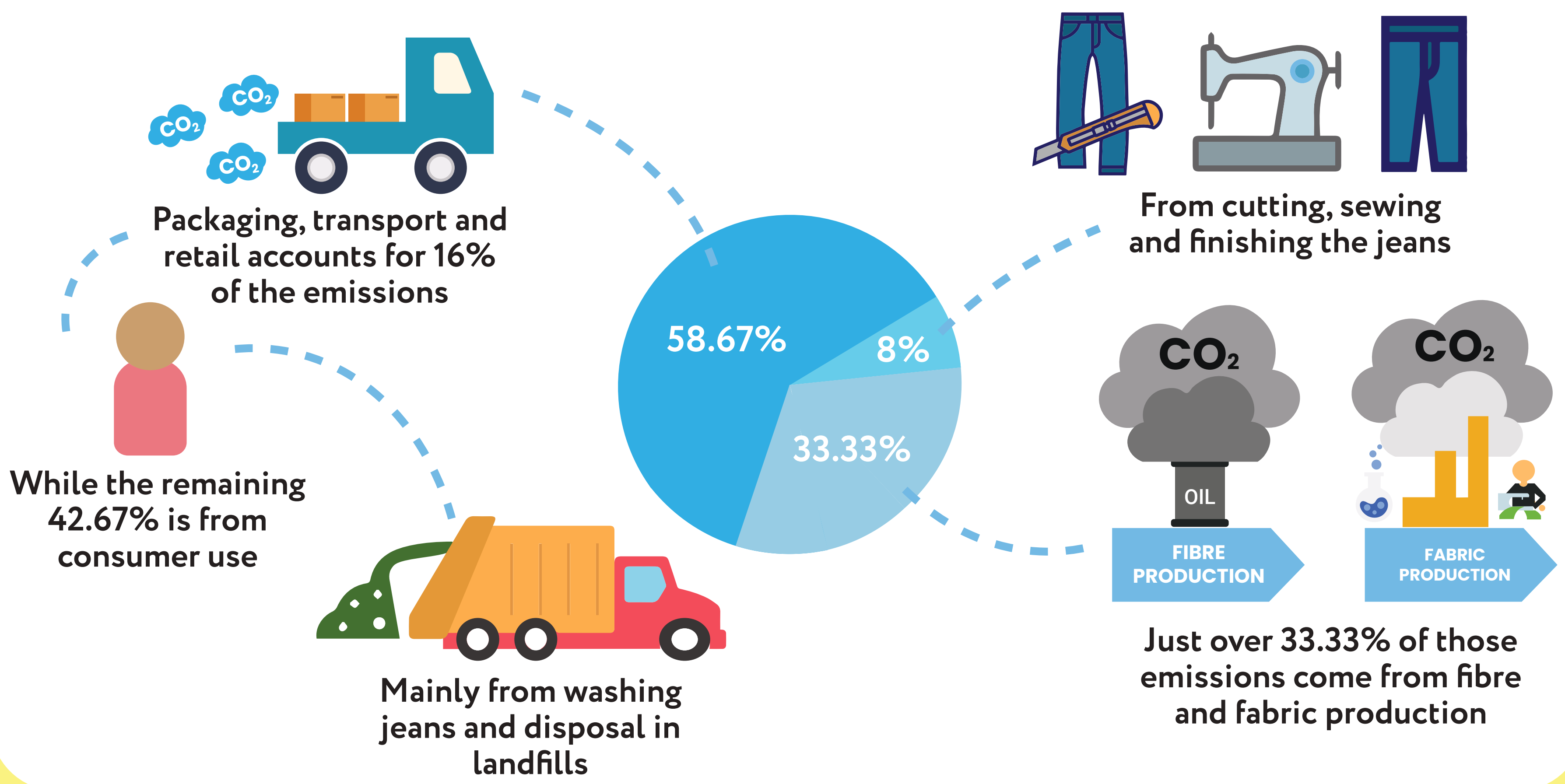
The fashion industry accounts for



**Jeans manufacturer Levi Strauss**

Estimates that a pair of its iconic 501 jeans will produce the equivalent of 33.4kg of carbon dioxide across its entire lifespan - about the same as driving 69 miles (or around 111 km) in the average US car.

Source: BBC





## 2

### Carbon footprint produced by transport

For the year 2017, major bus, taxi and rail businesses in Singapore, Australia and the UK registered carbon emissions of about 1,301,688 metric tonnes in total for all 3 countries.

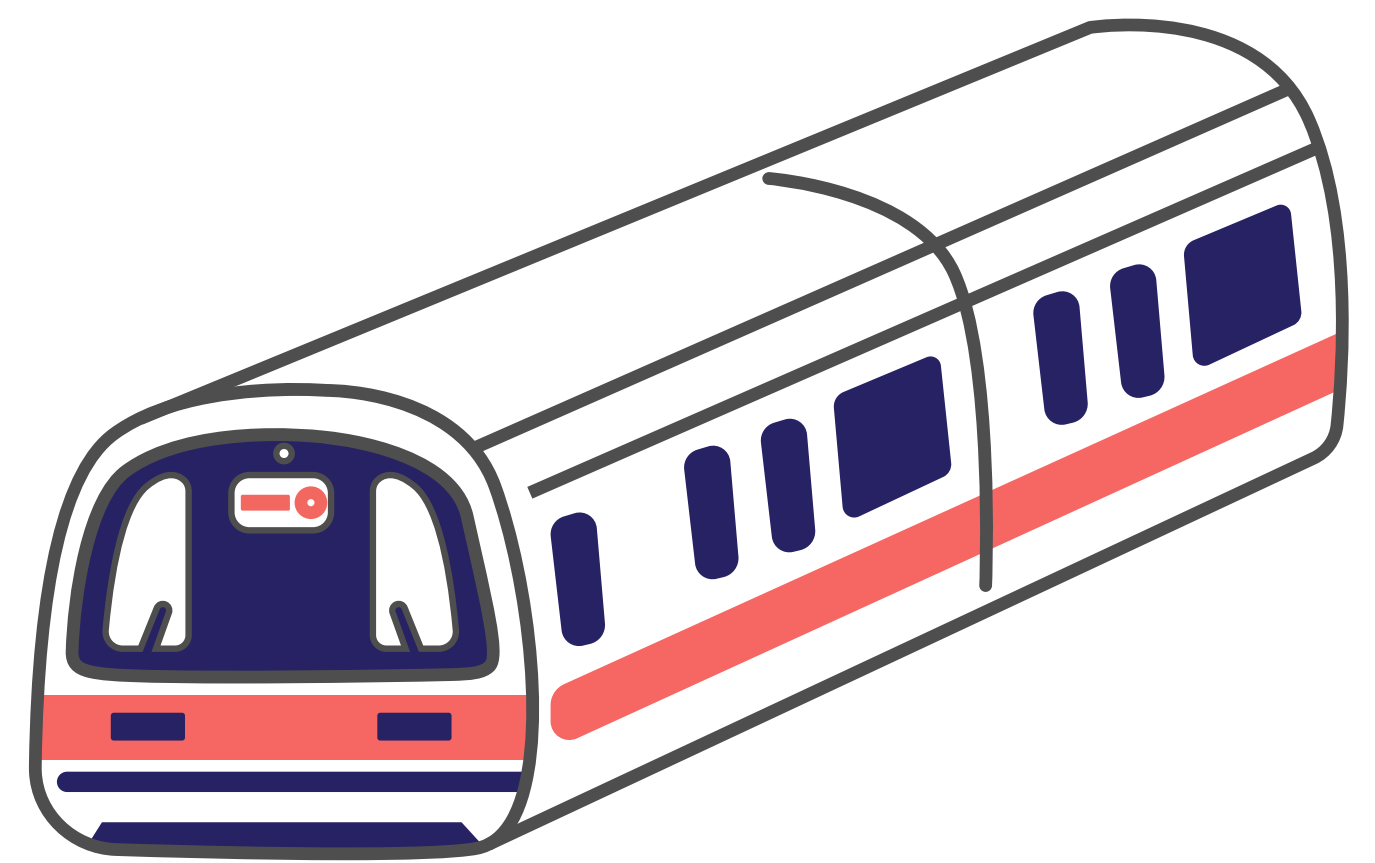
Taxis



Buses



Rail Businesses



A typical average-sized car emits about 4,700kg of carbon dioxide per year.



That is heavier than 3 average-sized cars!

Source: ComfortDelGro

# WHAT COULD BE CONSIDERED SUSTAINABLE ALTERNATIVES TO CURRENT PRACTICES, RESOURCES AND ENERGY SOURCES USED?

## What Does Sustainability Mean?



The United Nations Brundtland Commission defined sustainability as “meeting the needs of the present without compromising the ability of future generations to meet their own needs.”

A more sustainable alternative to current production practices means that the factors and processes of producing that product can be maintained for a longer time.



Sustainability takes into account:



Environmental Stewardship

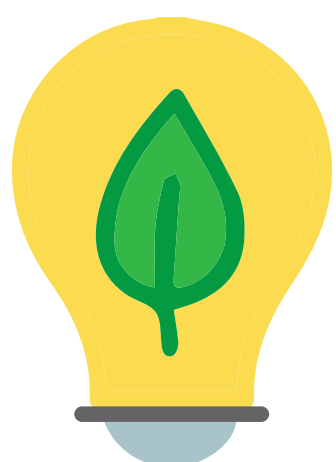


Economic Viability



Social Responsibility

For example,



New eco-friendly alternative

can have



Environmental benefits

but



High cost



High labour

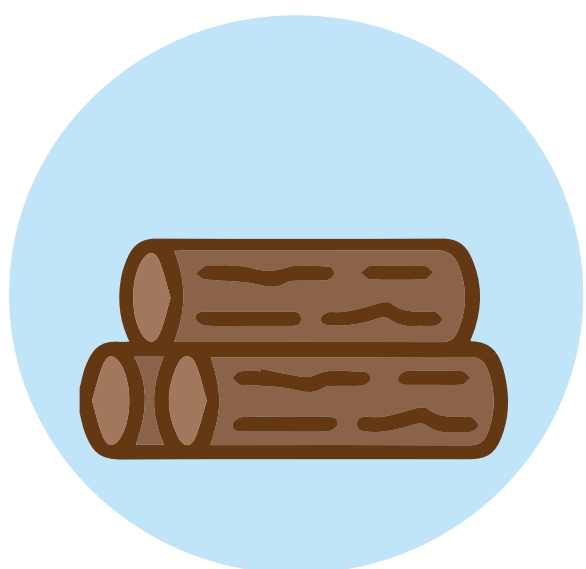
Source: International Institute for Sustainable Development



# Sustainability In Resources:

## Renewable Resources

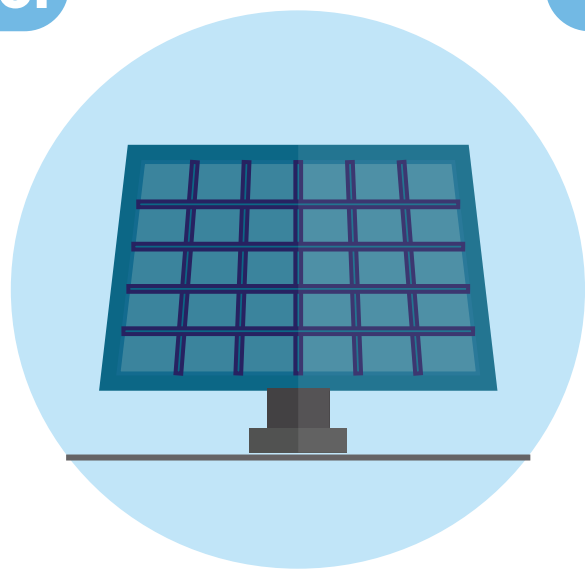
A renewable resource can replenish itself at the rate it is used, and some examples include:



Timber



Wind



Solar Energy

## Non-Renewable Resources

A non-renewable resource has a limited supply, and some examples include:



Coal



Fossil Fuels

Source: National Geographic, Education. Resource Library, Resource Types

## How Can Sustainable Alternatives Help To Slow Down The Rate Of Sea Level Rise?

1



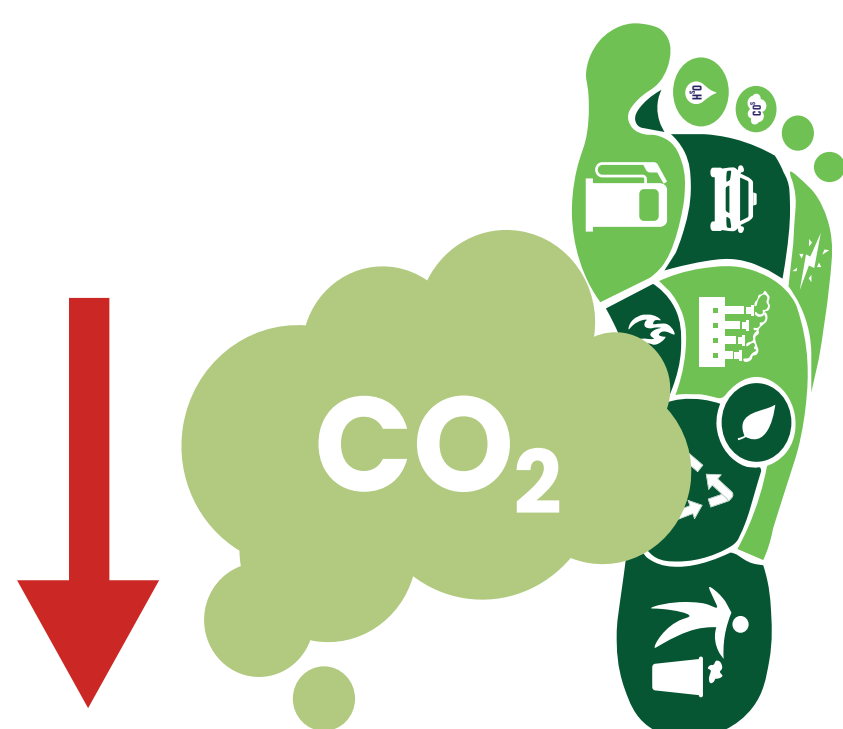
Sustainable alternatives have a lesser negative impact on the environment than whatever we are currently using.

2



The production, transport, consumption, and disposal of these alternatives results in less GHG emissions.

3



Lesser GHG emissions are produced, creating a smaller carbon footprint.

4



If we were to use more of these sustainable alternatives, we may be able to slow down global warming, sea ice melting and sea level rise.

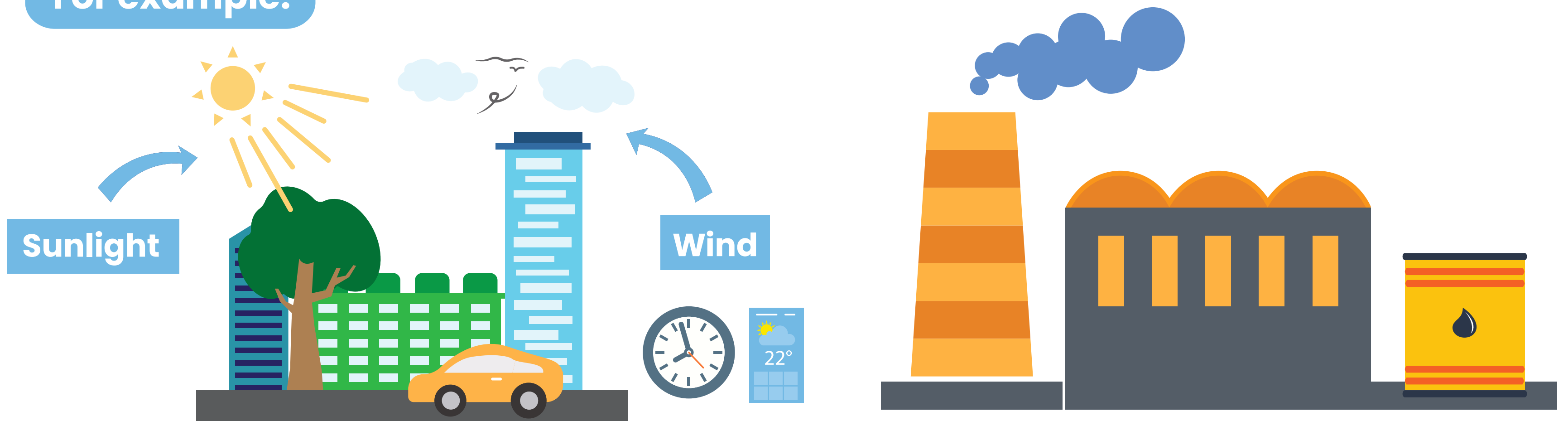
Source: Britannica, Carbon footprint, Ecology and Conservation

# WHAT ARE THE DIFFERENT SOURCES OF RENEWABLE ENERGY?

## Renewable Energy

It is often referred to as clean energy, and comes from natural sources or processes that are constantly replenished.

For example:

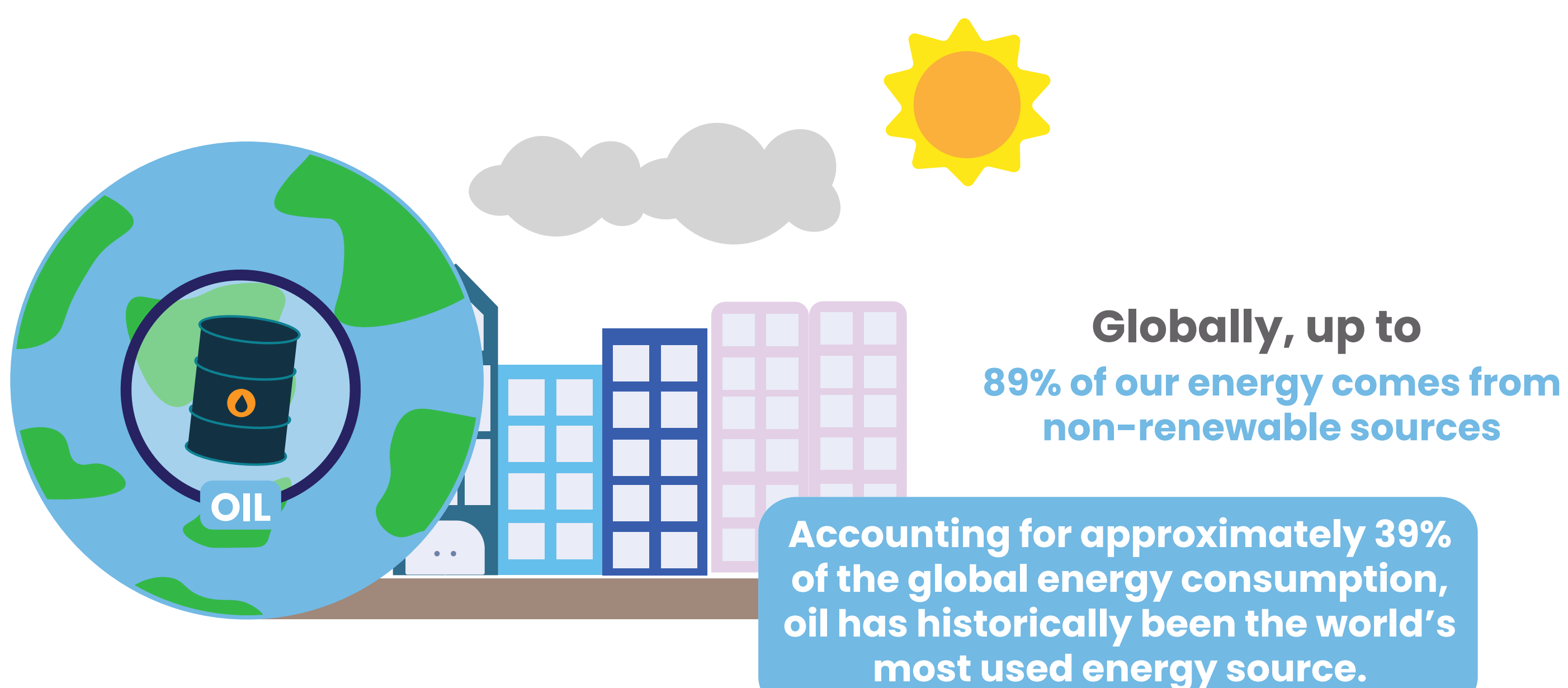


Energy from sunlight and wind is harnessed through solar and wind farms. The sunlight and wind will continue to be harnessed even if their availability depends on the time and weather.

Energy sources such as fossil fuels are non-renewable because they have finite supply.

Source: National Geographic

## What energy sources do we use right now?

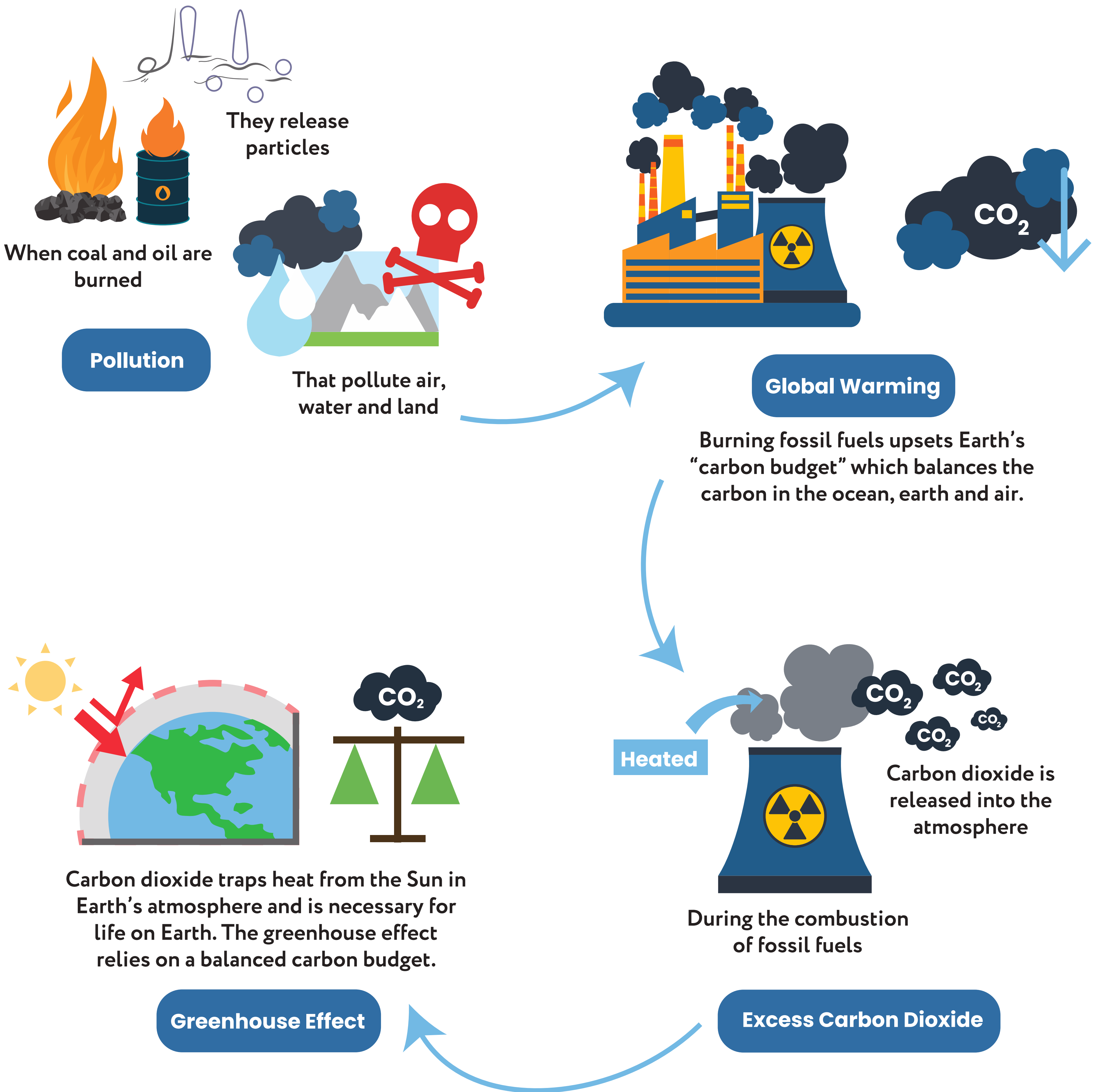


## Why is this a problem?

It is unsustainable. Most non-renewable energy sources are fossil fuels: coal, petroleum and natural gas.



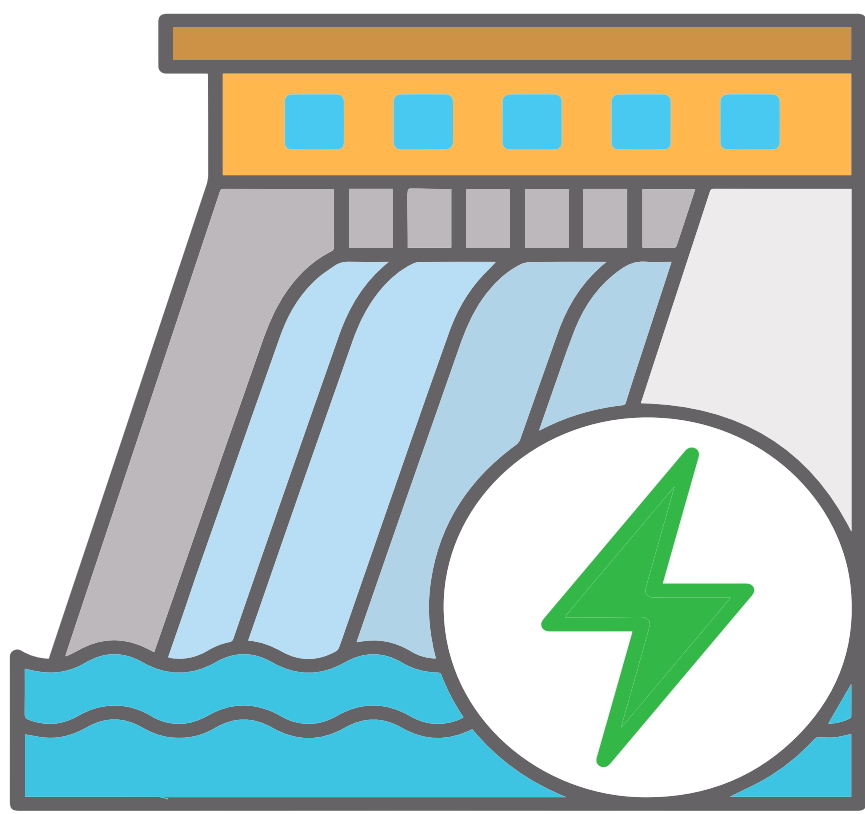
# Environmental Problems From Fossil Fuels



Source: NS Energy Business, Fossil Fuel, Coal and Gas, The World's Most Used Energy Sources

# Sustainable Alternative Forms Of Energy

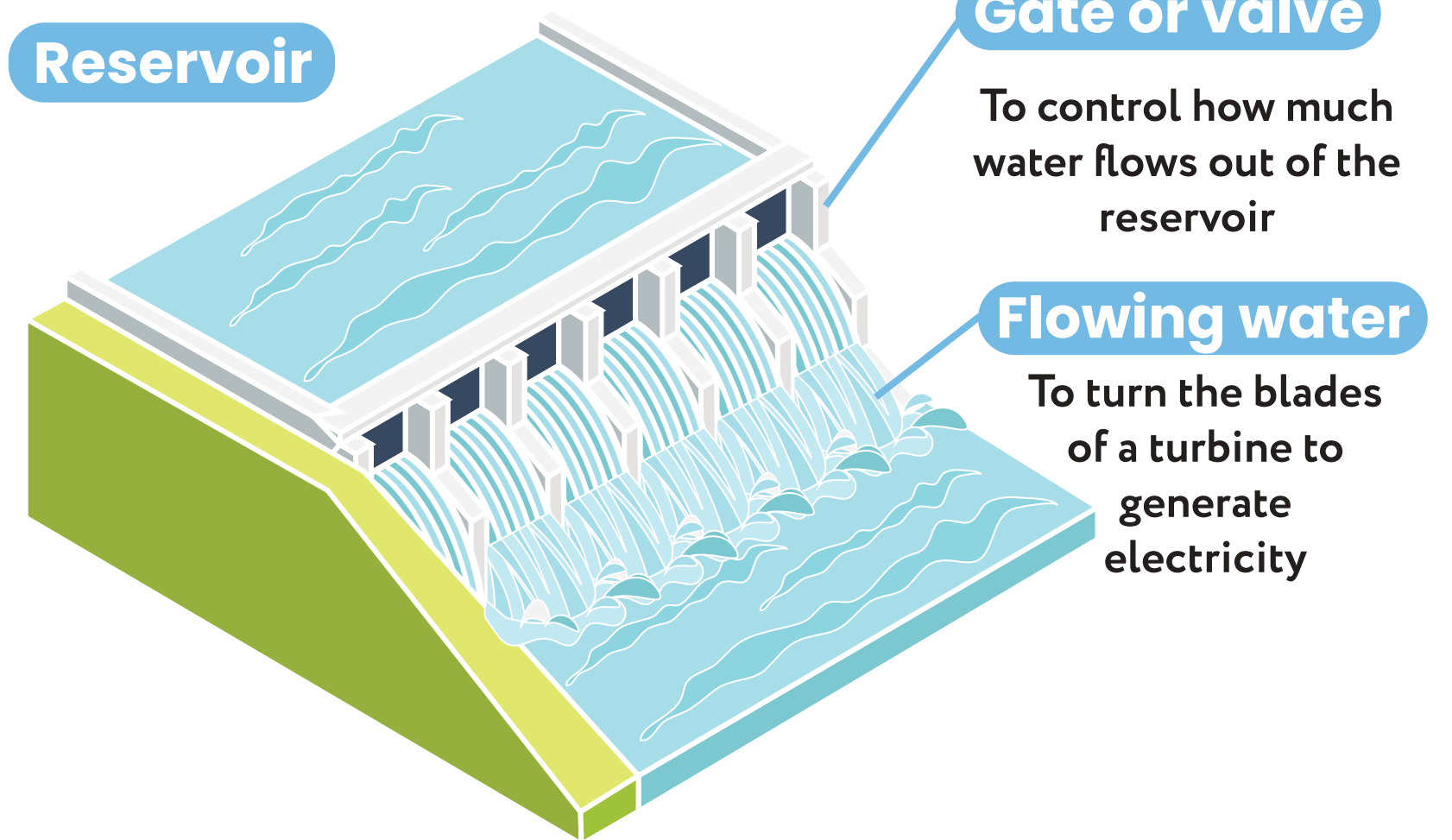
## 1 Hydroelectricity



Hydroelectric Power

It is a form of energy that harnesses the power of water in motion - such as water flowing over a waterfall - to generate electricity.

Reservoir



Gate or valve

To control how much water flows out of the reservoir

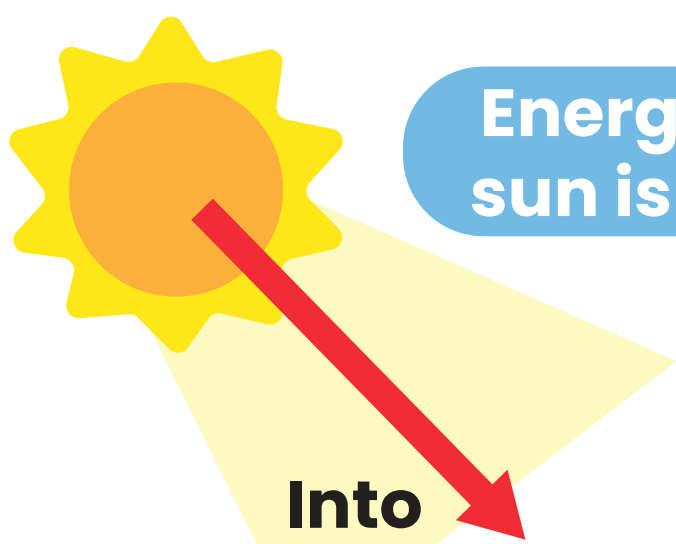
Flowing water

To turn the blades of a turbine to generate electricity

The electricity is then distributed to the power plant's customers.

Source: National Geographic

## 2 Solar Energy



Energy from the sun is converted

Into

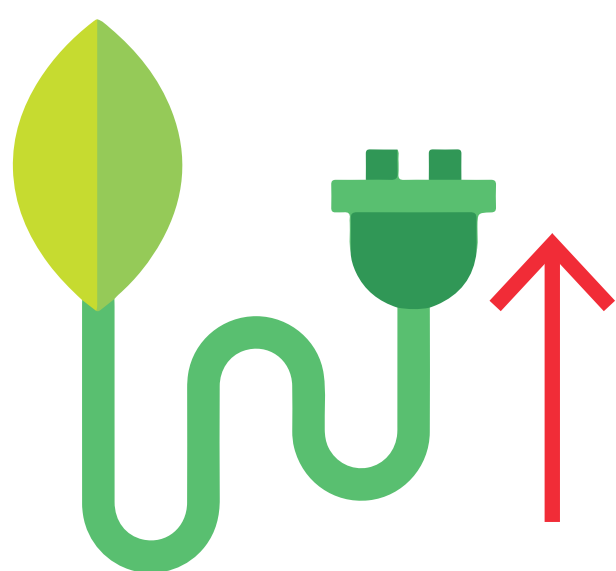
Thermal or electrical energy

Solar Technologies



Including generating electricity, providing lighting, and heating water for domestic, commercial, or industrial use.

Can be harnessed for a variety of uses.



Solar power has been fast gaining ground as a preferred energy source, with installed capacities having more than quadrupled in the past four years.



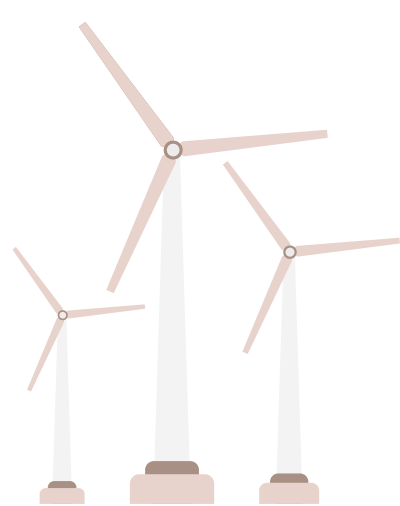
Solar Energy Share

It has doubled its market share in recent years and currently stands at approximately **0.8%**

Global Power Generation

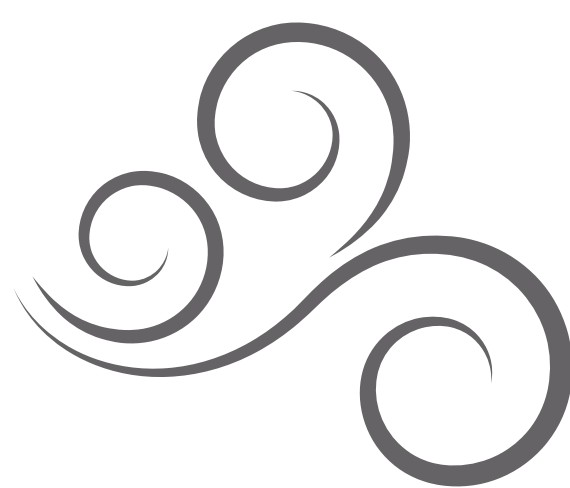
Source: Solar Energy Industries Association

## 3 Wind Energy

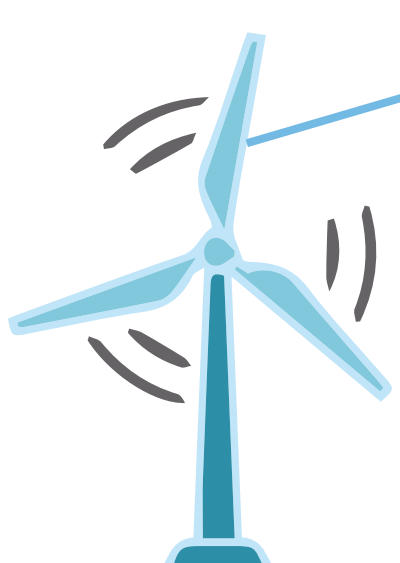


Wind Power

Wind is used to generate electricity.



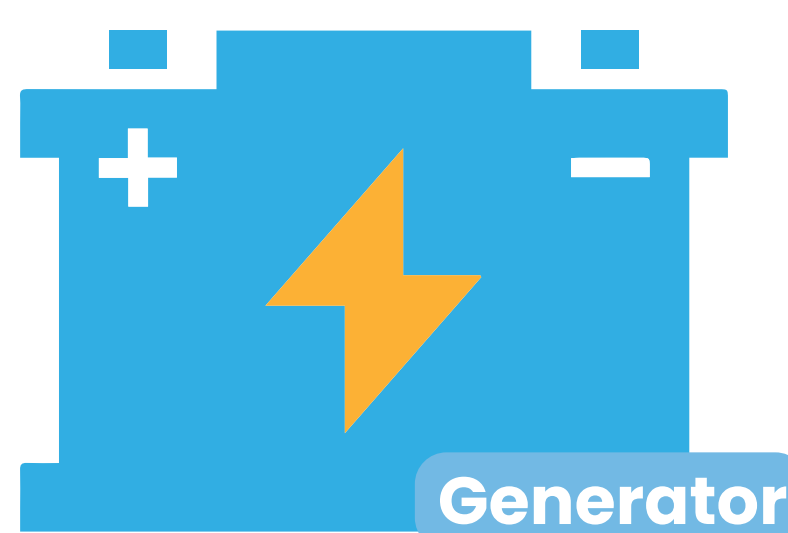
Wind, which contributes approximately 3% to the global electricity generation, has witnessed a double digit growth in consumption, growing at a compounded annual growth rate of 23.5% in the recent decade.



Wind Turbines

Convert kinetic energy in wind into mechanical power.

Turbines can be located onshore or offshore.



Generator

Mechanical Power



Electricity

A generator can convert mechanical power into electricity.

Source: Open EI, Wind Energy



# WHAT ARE GREEN BUILDINGS AND WHAT ARE SOME EXAMPLES?

## What Are Green Buildings?



It is a building that, in its design, construction or operation, reduces or eliminates the negative impact of climate change on the environment.

Any building can be a green building



Home



Office

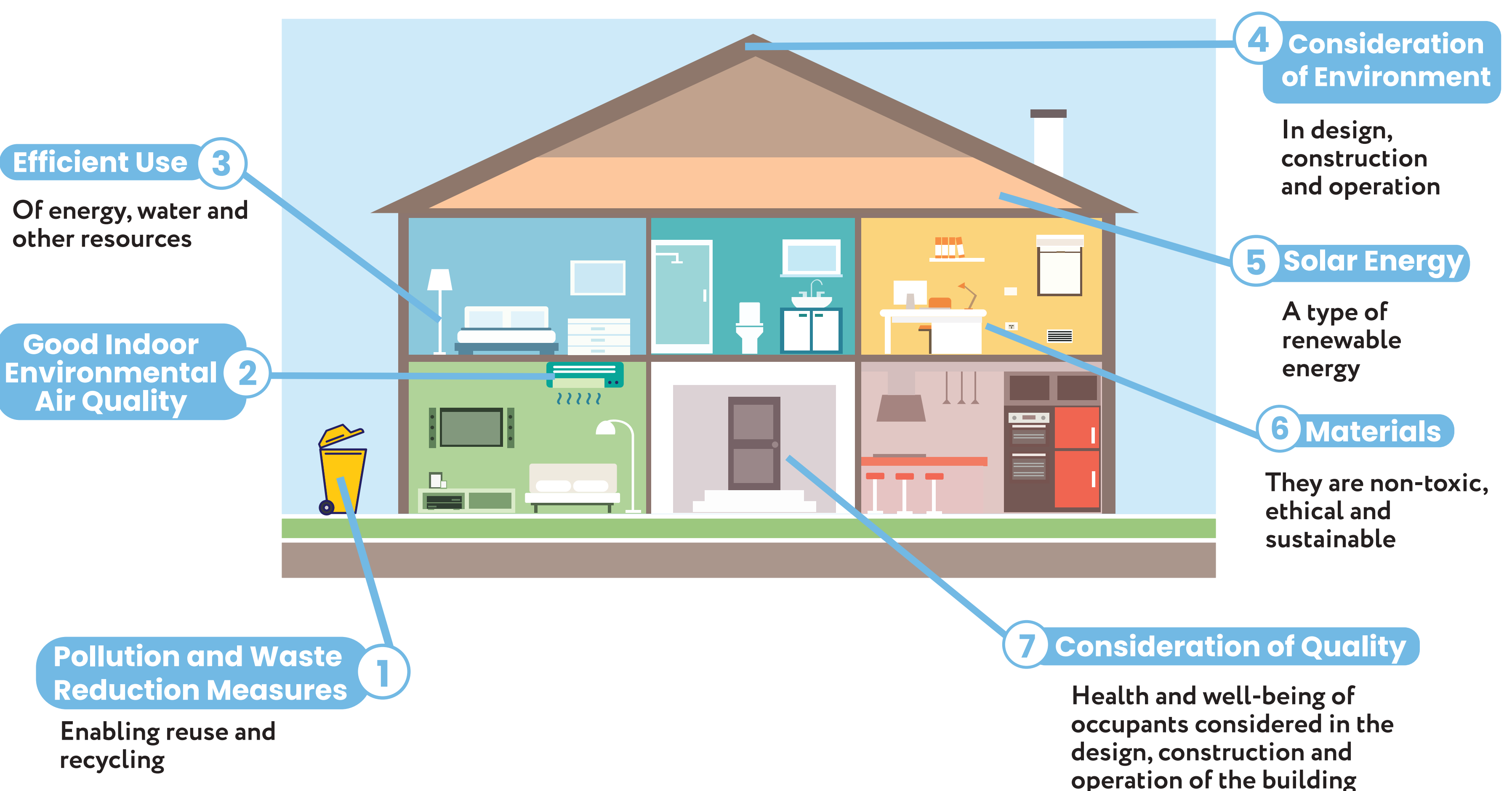


School



Hospital

There are a number of features which can make a building 'green':



A design that enables adaptation to a changing environment

Source: World Green Building Council, About Green Building



# Examples Of Green Buildings Around The World:

1

## Keppel Bay Tower



### PV Panel System

Allows the harvesting of about 100,000 kWh of energy per annum

### Energy-Efficient Air Distribution System

Features air handling unit fans which are about 45% more energy-efficient than other best-in-class technologies

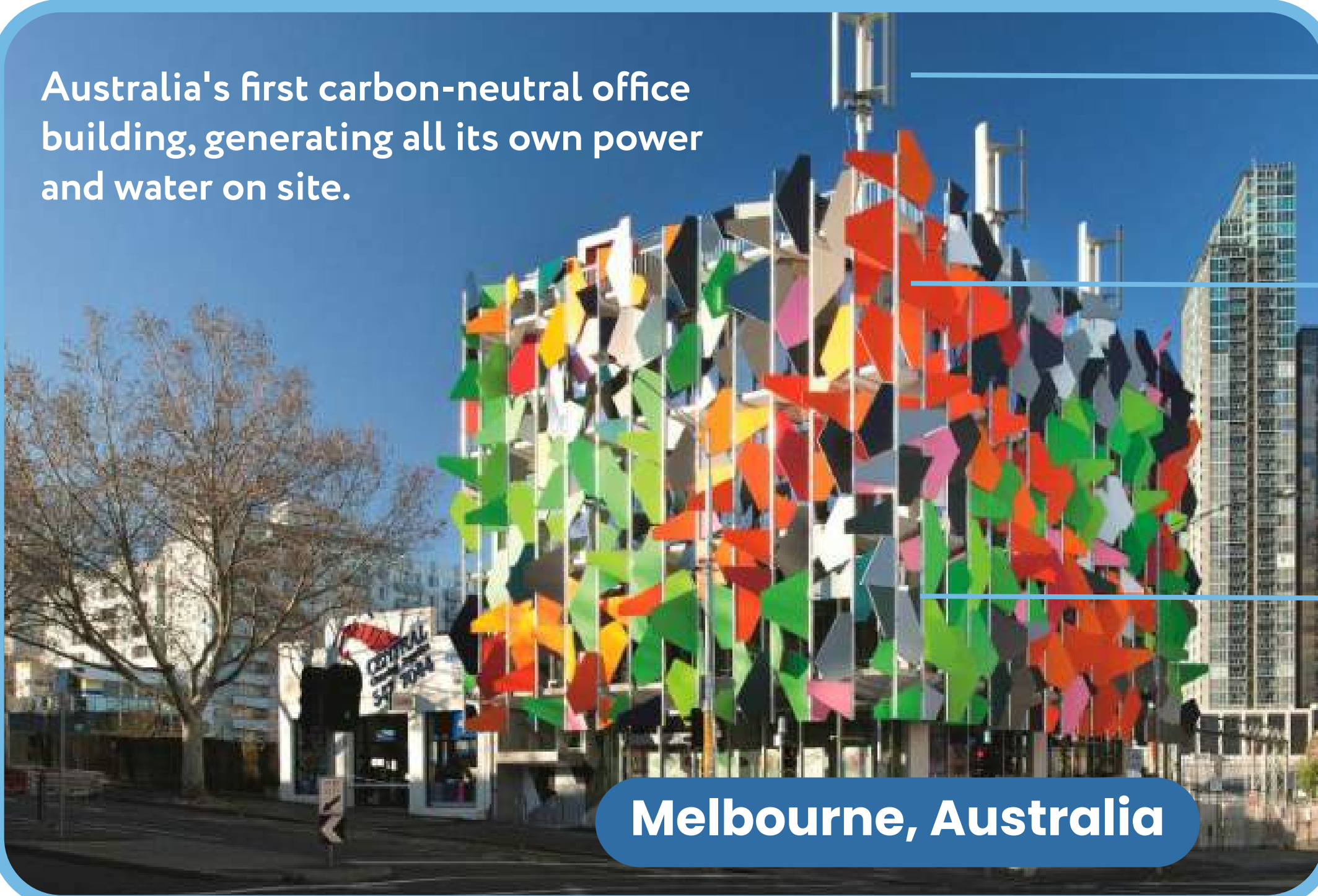
### Smart Lighting System

Utilises occupancy sensors which allow seamless transition in lighting levels according to building occupancy

2

## The Pixel Building

Australia's first carbon-neutral office building, generating all its own power and water on site.



### Roofs

Capture rainwater

### Panels

Provide shade and maximise daylight as needed

### Vertical wind turbines



3

### Museum of Tomorrow



Rio de Janeiro, Brazil

#### Solar panels

This fin-like structure is made of solar panels which are adjustable

#### Pumping system

Takes cold water from the nearby Guanabara Bay for use in its air-conditioning system

4

### Shanghai Tower



Shanghai, China

#### Transparent second skin

Wrapped around the building and creates a buffer of captured air that serves as natural ventilation, reducing energy use

#### 270 wind turbines

Incorporated into the facade power exterior lights

This tower uses significantly less power than other skyscrapers and has a Platinum LEED certification

Source: CNN Style, Going Green, Architecture, Green Buildings: 18 examples of sustainable architecture around the world



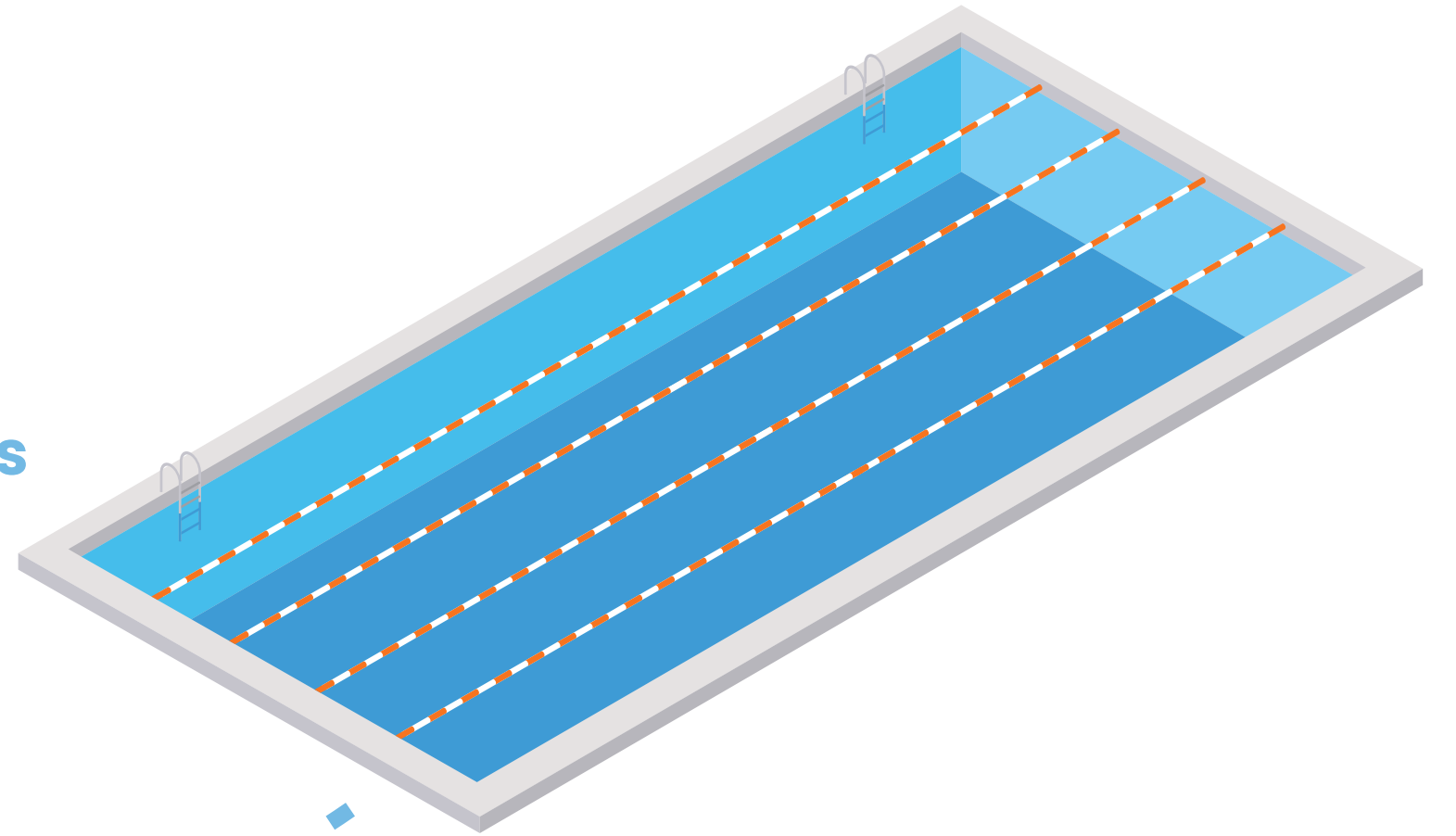
# WHAT ARE SOME EVERYDAY ITEMS WE CONSUME THAT AFFECT THE ENVIRONMENT?

## 1. Water Bottles

A study released in 2018 showed that about

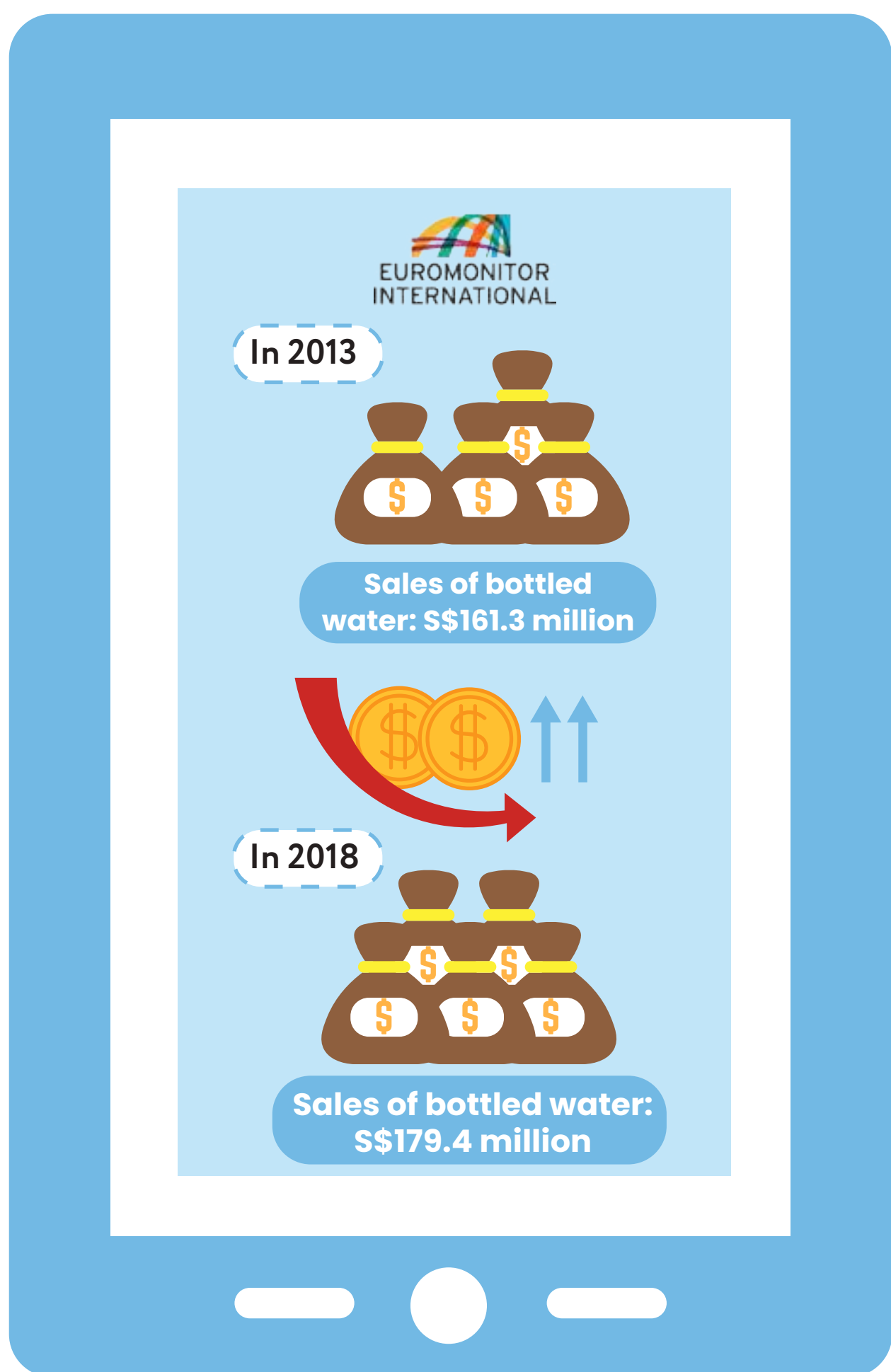


467 million polyethylene terephthalate bottles are commonly used for drinks, sauces and marinades in Singapore each year.



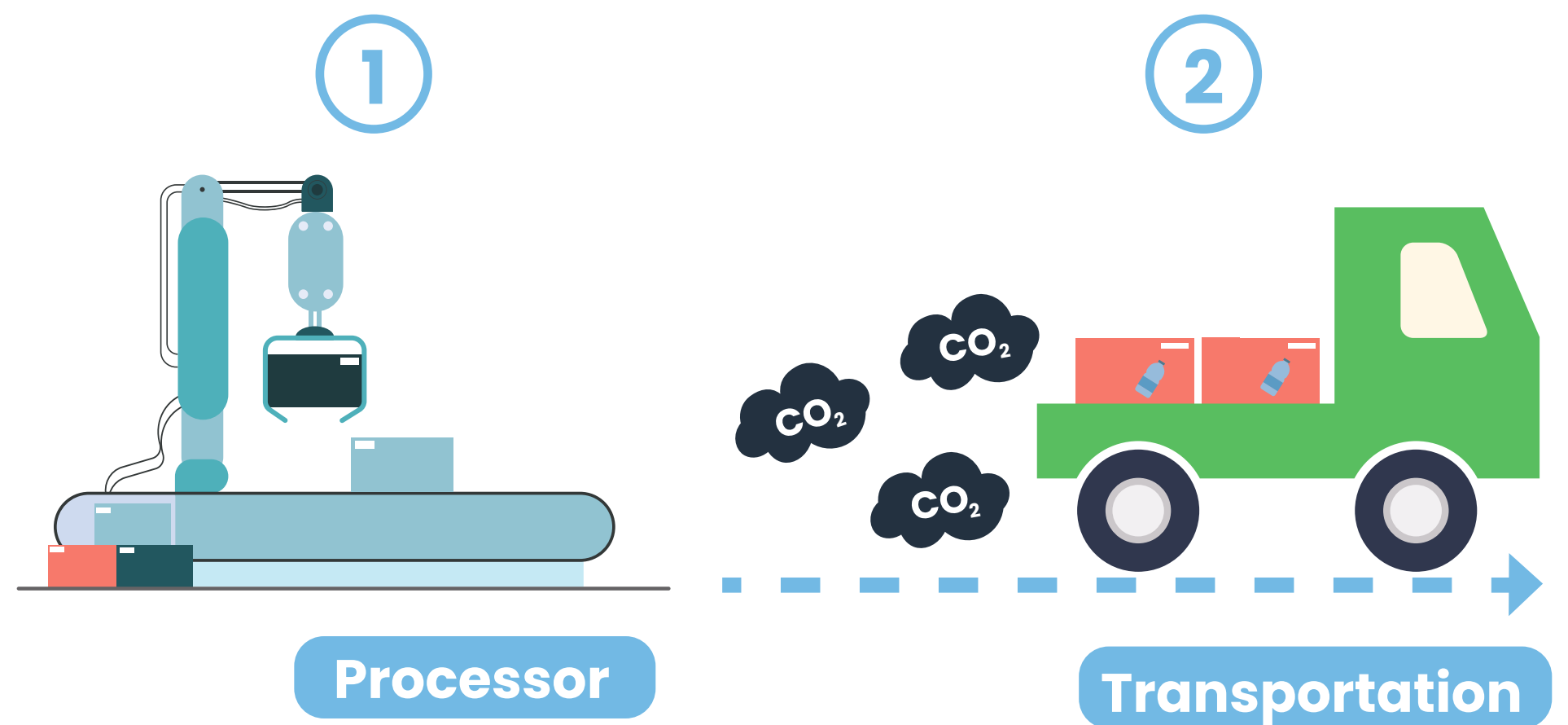
This works out to the volume of 94 Olympic-sized swimming pools

According to data from research firm Euromonitor International:

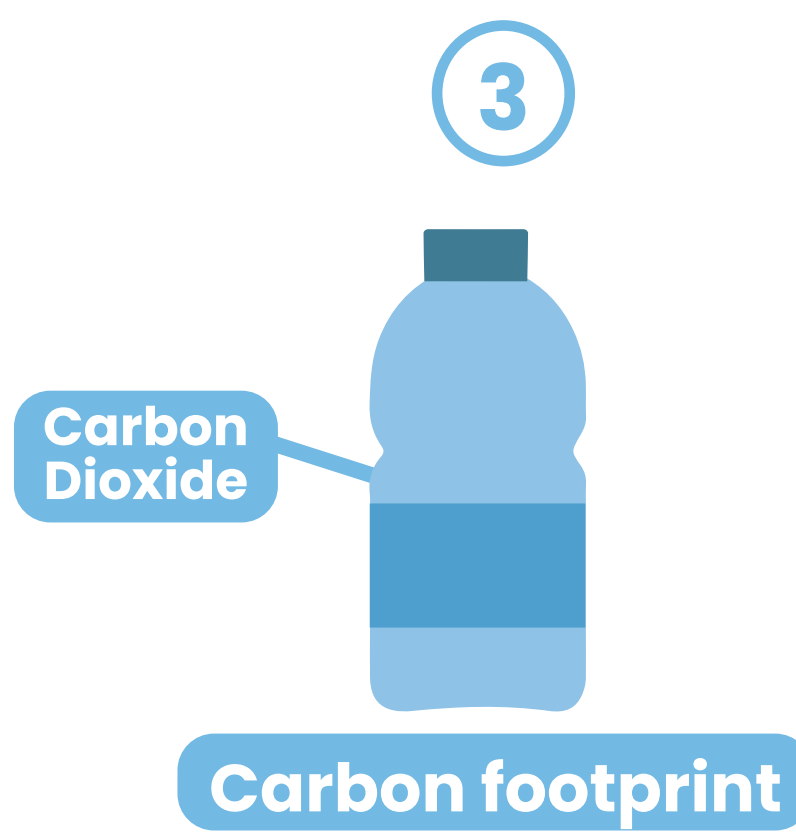


Source: CNA, Singapore, What will it take to kick Singapore's growing multimillion-dollar addiction to bottled water?

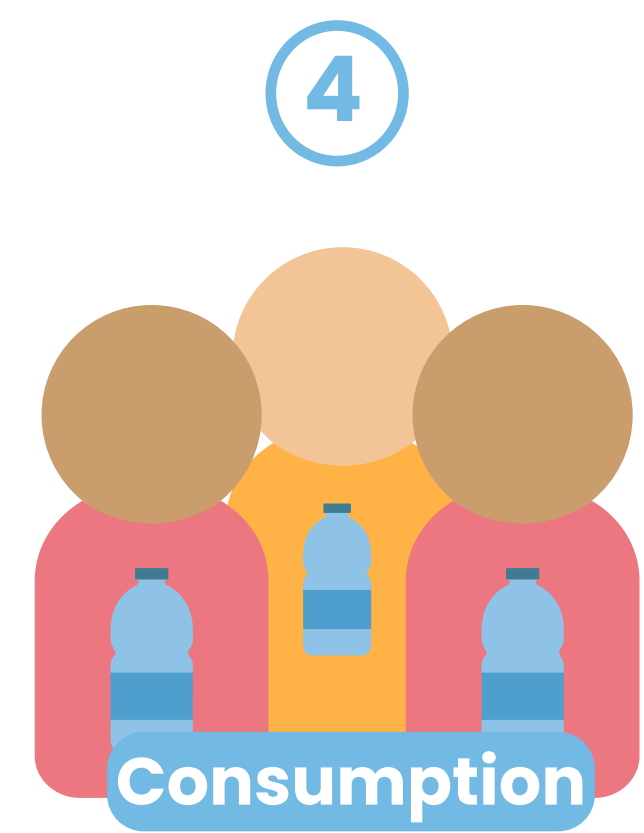
Source: Plastic Recycling Library, Resource, What is the carbon footprint of a plastic bottle



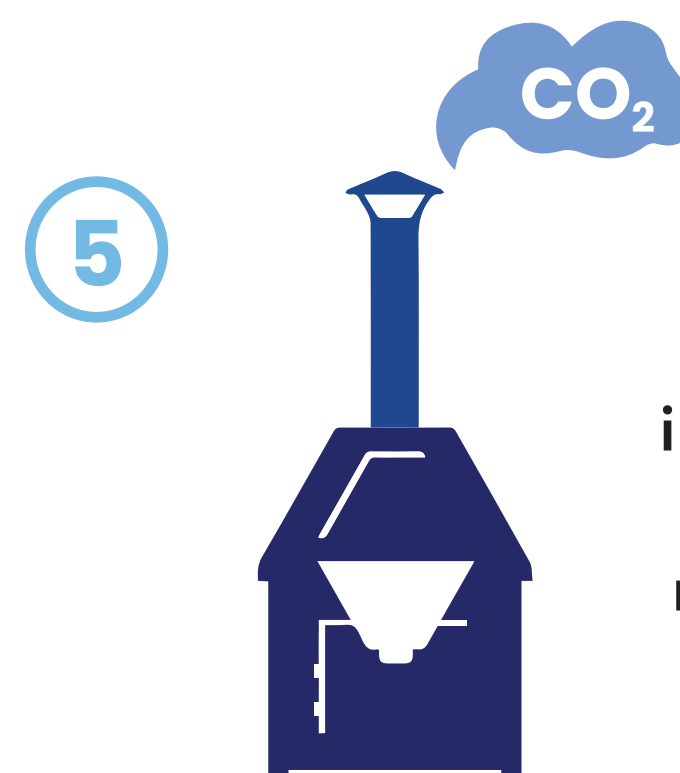
Processing plastic resins and transporting plastic bottles contribute to a bottle's carbon footprint in a major way



Estimates show that one 500ml plastic bottle of water has a total carbon footprint equal to 82.8g of carbon dioxide.



Contributes to more than 38 million kg of CO<sub>2</sub> emissions every year.



Single-use plastic waste is incinerated, which produces CO<sub>2</sub>. It may also pollute natural habitats such as the ocean and harm wildlife.



## 2. Grocery Bags

Research has found that:

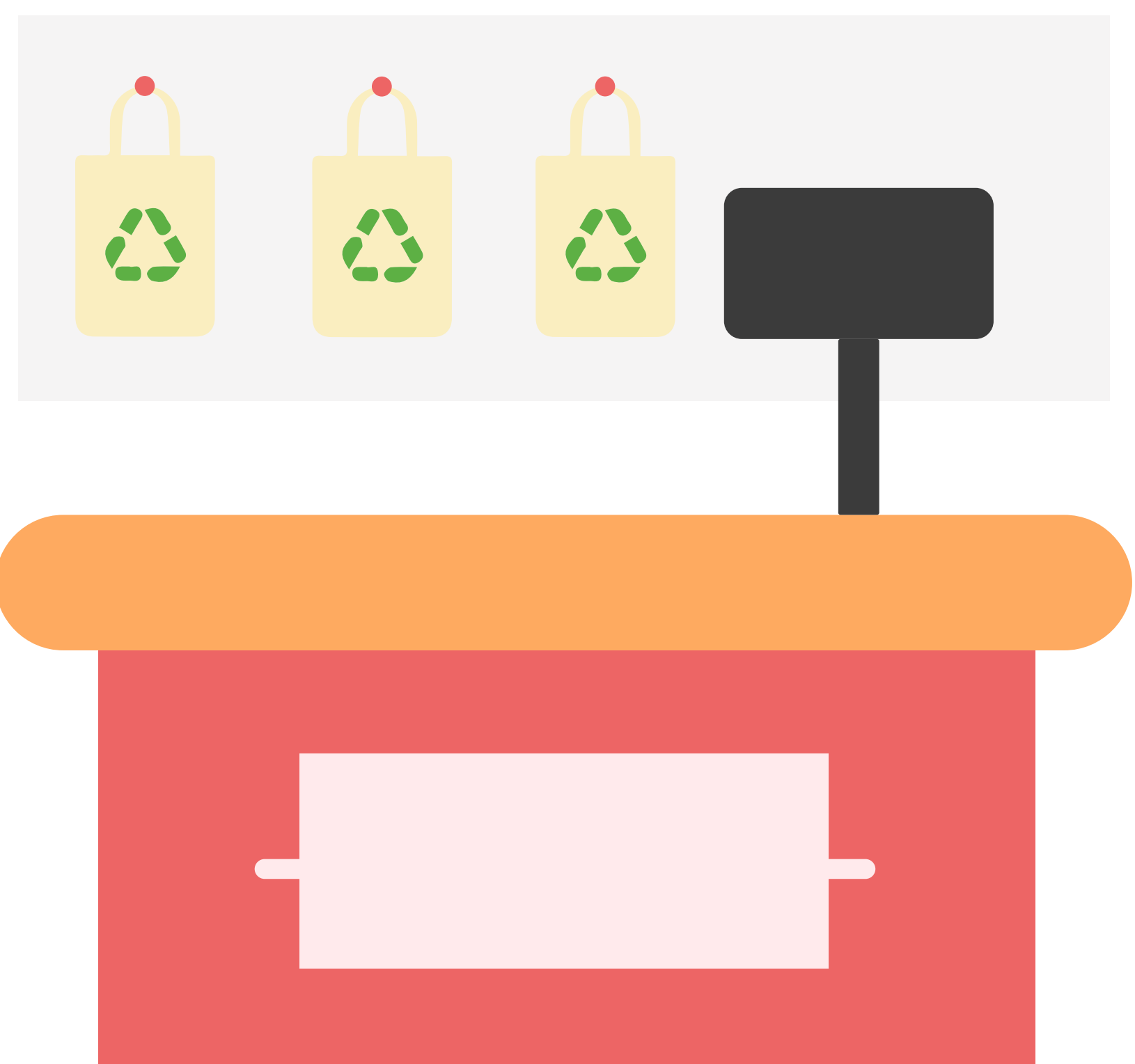


Polypropylene  
non-woven plastic

If used at least 50 times, it is the most eco-friendly option as compared to a single-use plastic bag.

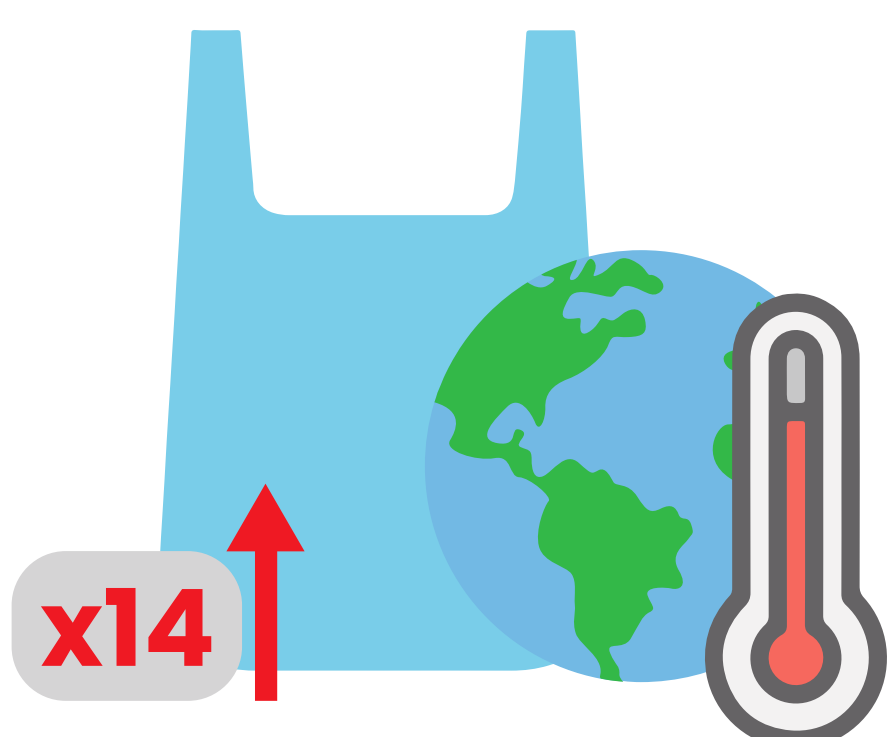
Reusable Plastic Bag

Source: The Straits Times



Grocery bags refer to the type of reusable bags commonly sold or provided at checkout counters at supermarkets.

Single-use  
Plastic Bag



It is usually given out for free and has 14 times the global warming potential...

Reusable  
Plastic Bag



x50 of a reusable plastic bag used at least 50 times

### 3. Takeaway Containers

Centre for International Environmental Law Report:



An extra **1,334 tonnes** of plastic waste was generated from takeaway and delivery meals during the two-month Circuit Breaker period in Singapore in 2020.



The report mentioned that global production and incineration of plastic would ...



**Incineration of plastic**



**Global production**

Add more than 850 million metric tons of GHG to the atmosphere.

1

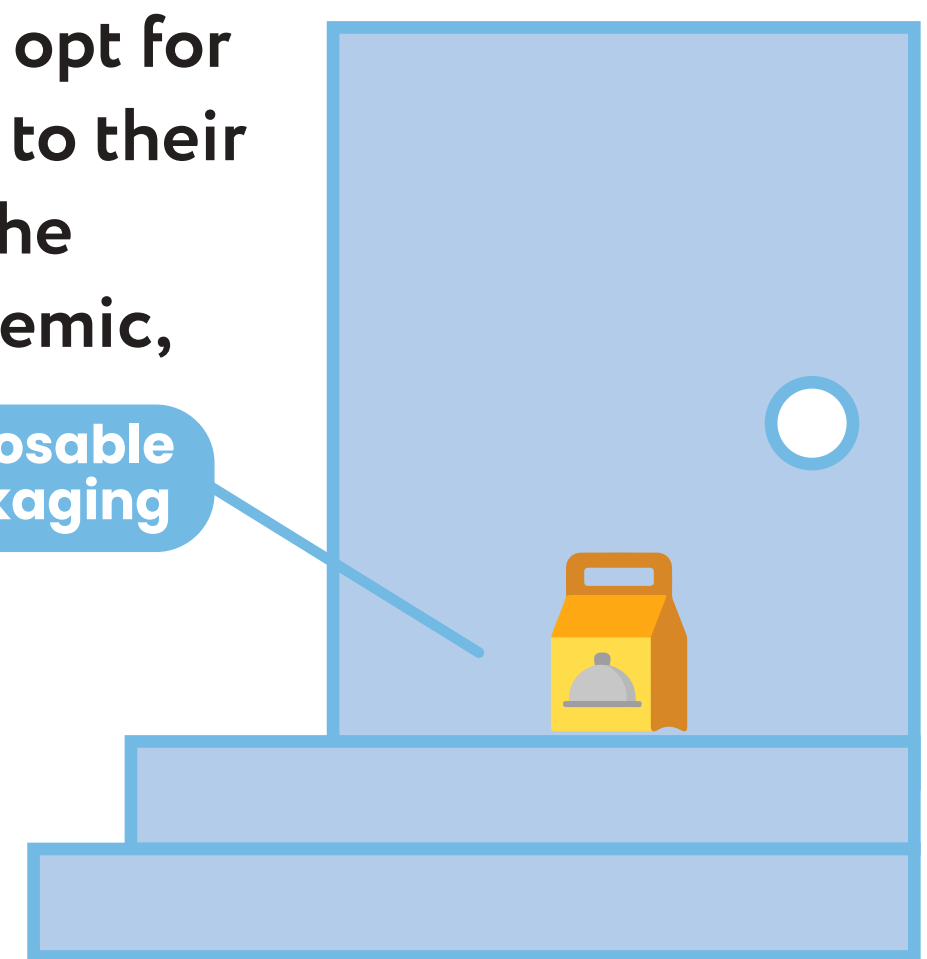


**Reusable containers**

Can reduce the potential amount of GHG emissions.

As more people opt for meals delivered to their doorstep amid the COVID-19 pandemic,

2



**Disposable packaging**

the three largest food delivery players in Singapore have made reusable containers an option to help reduce the use of disposable packaging.

3

They will have to return these containers to either the restaurants they ordered from or any merchant who partnered with the food delivery companies to reduce the use of disposable packaging.



**Customers**



**Restaurant**

Source: CNA



# WHAT ARE SOME LIFESTYLE CHANGES WE CAN MAKE TO HELP WITH RISING SEA LEVELS?

## Diet

### Reducing Meat Consumption

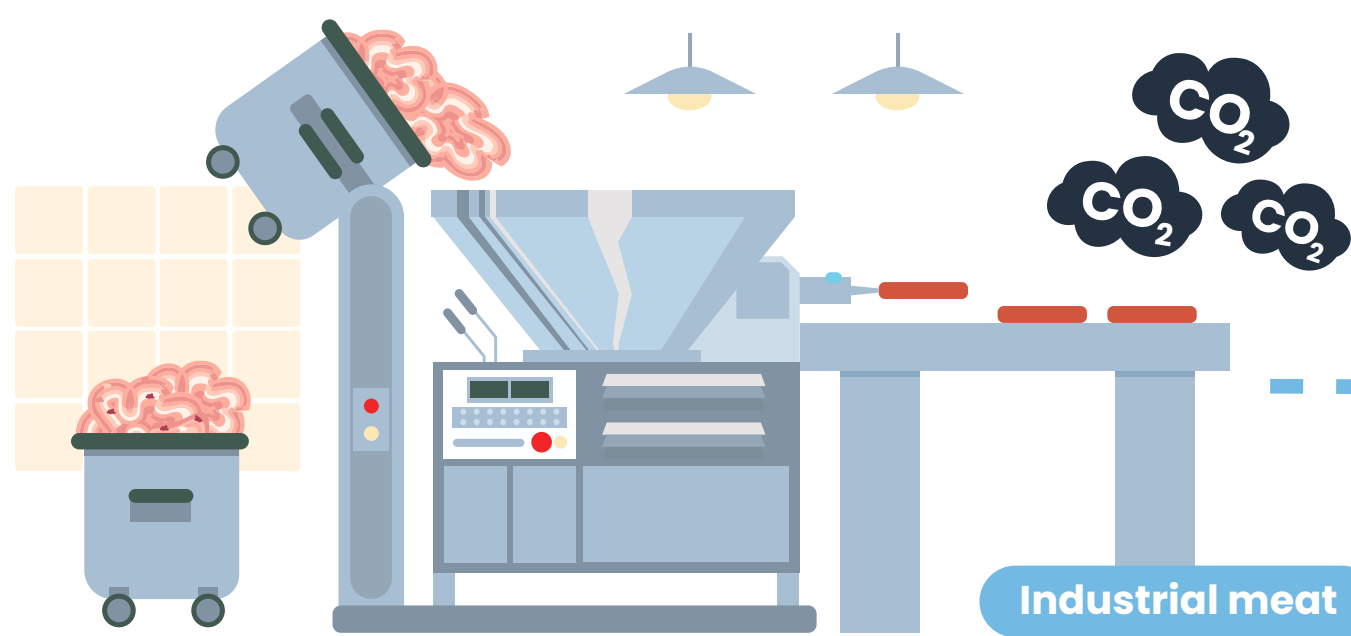
The climate impact of meat is enormous.



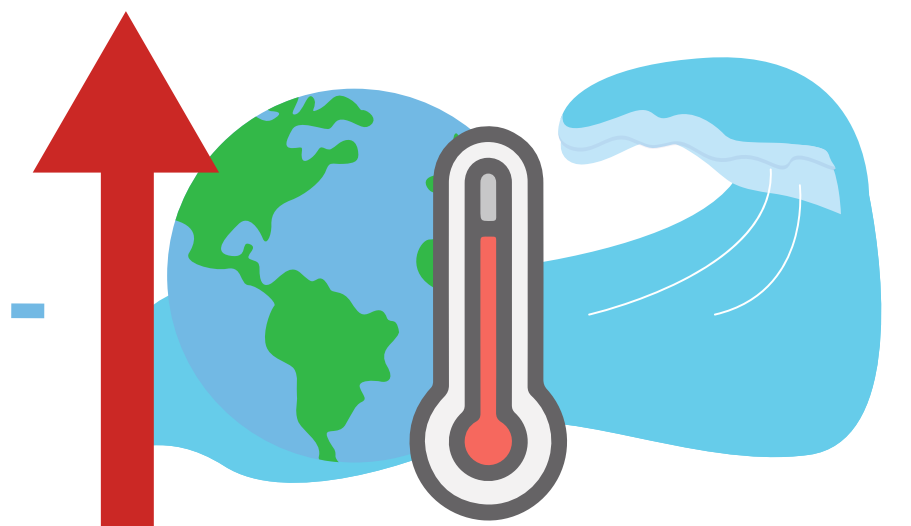
The annual global production of meat generates roughly as much GHG emissions as all the cars, trucks and planes in the world combined.



The forests are destroyed to make way for farmland.



Carbon dioxide is released into the atmosphere during the deforestation by burning and/or the factory meat production process.

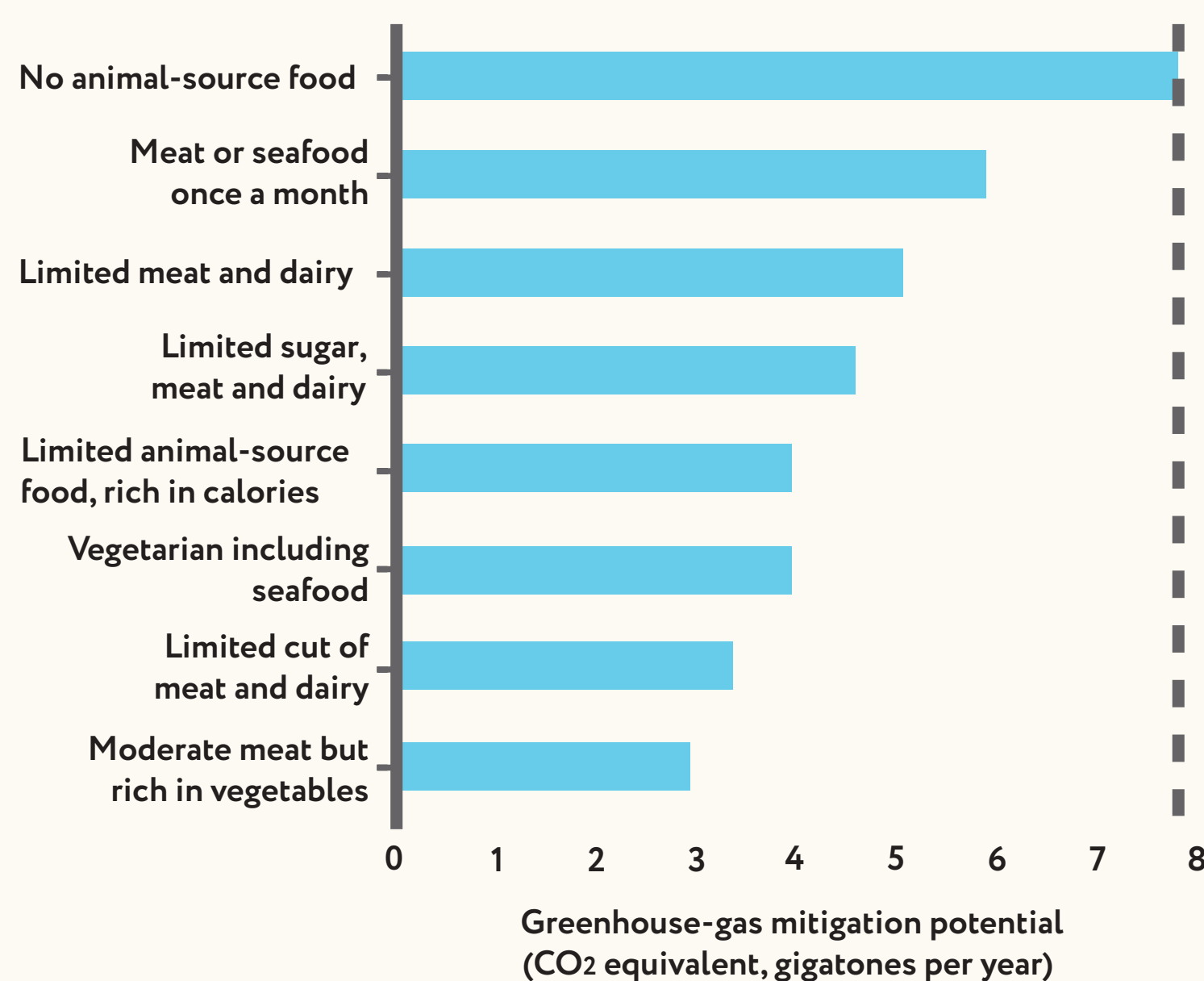


Thus, accelerating global warming and sea level rise.

Reducing meat in your diet does not necessarily mean turning vegan or vegetarian, but it could mean not eating meat at every meal, for example:

#### What If People Eat Less Meat?

The Intergovernmental Panel on Climate Change examined the estimated impact on GHG emissions of the world's population adopting a variety of diets.



### Plant-based alternatives

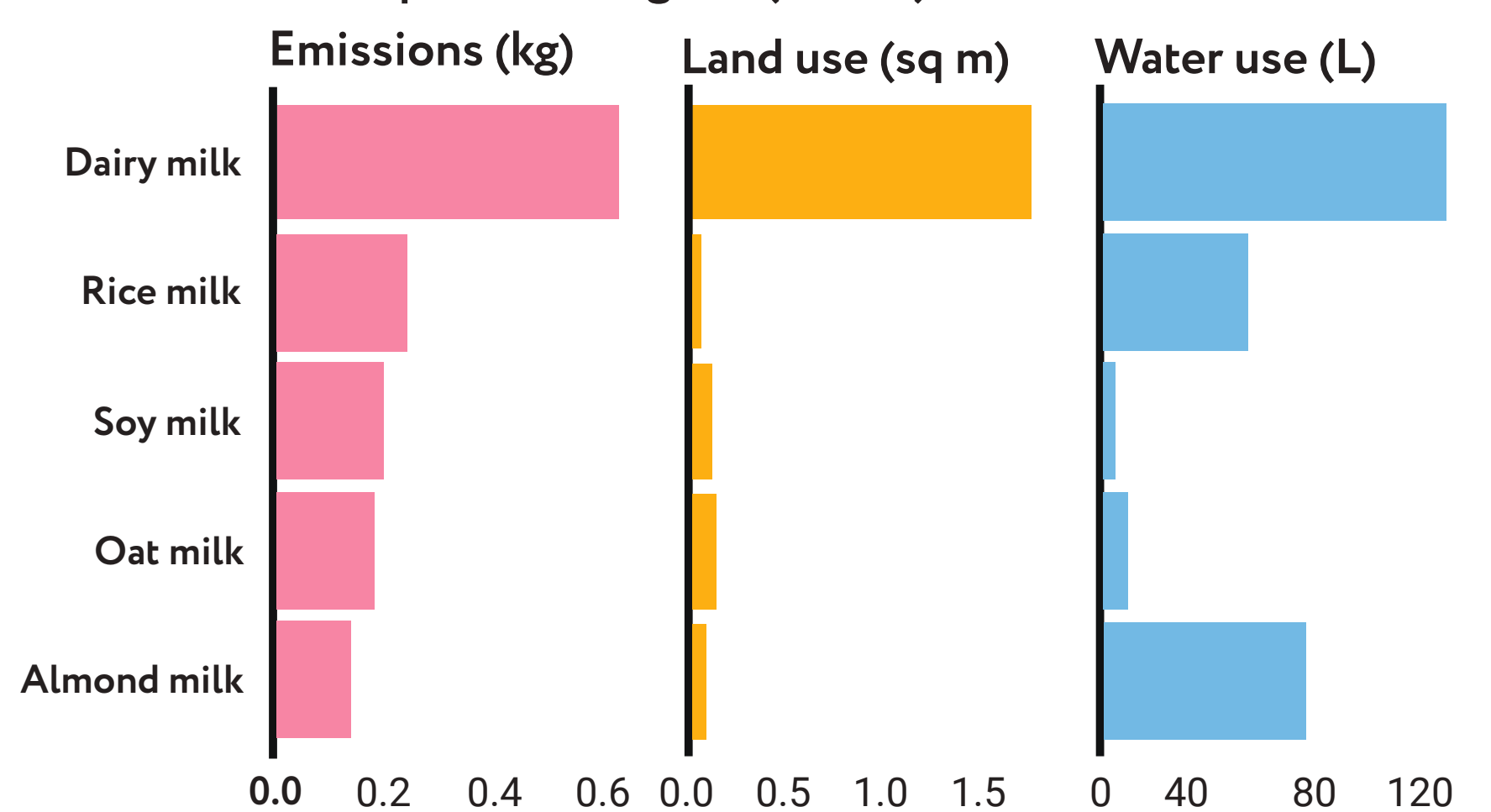


We can start looking towards plant-based alternatives instead of animal-based food.

Producing a glass of dairy milk results in almost three times the GHG emissions of any non-dairy milks, according to a University of Oxford study:

#### Which milk should I choose?

Environmental impact of one glass (200ml) of different milks

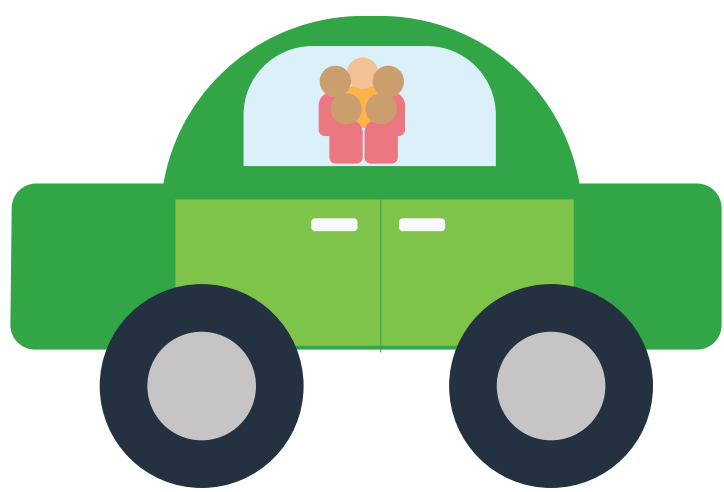


Source: Poore & Nemecek (2018), Science, Additional calculations, J. Poore

# Transport

## Moving from private to public transport

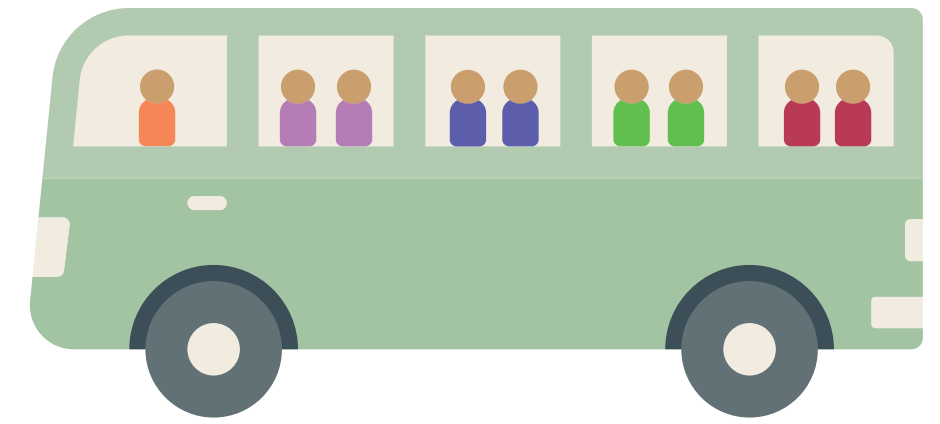
Comparing energy use among the different modes of transport per passenger per kilometre,



An average passenger car only carries up to 5 persons.



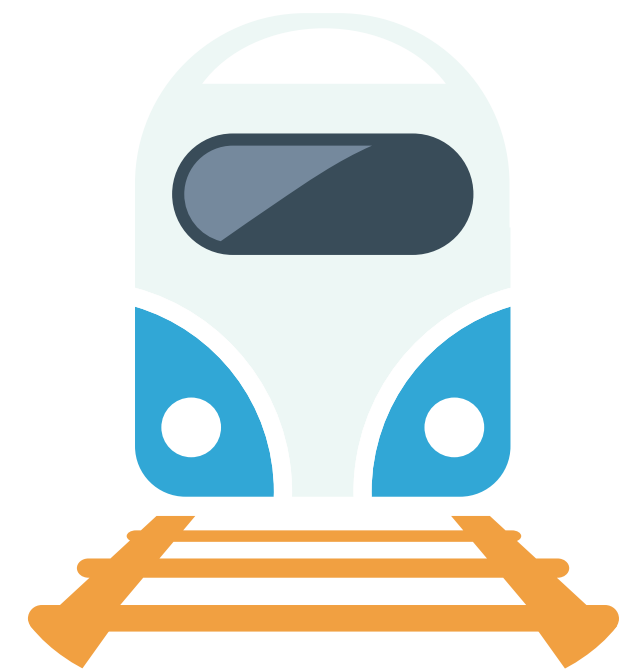
>**X9** of energy



On a single trip at full capacity, a single-deck bus carries up to 90 passengers.



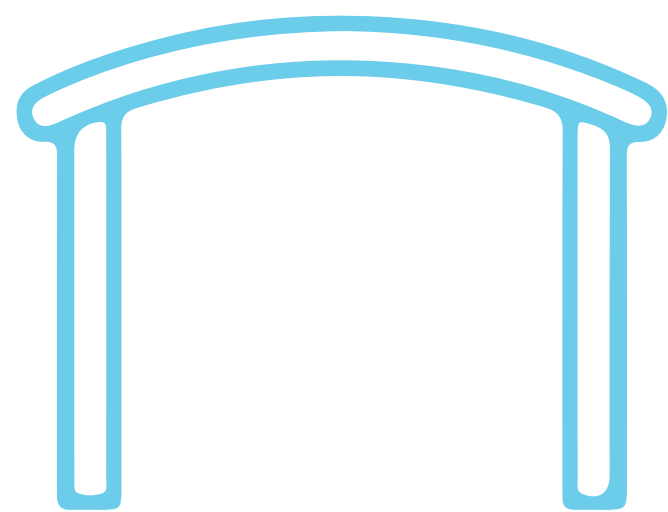
>**X12** of energy



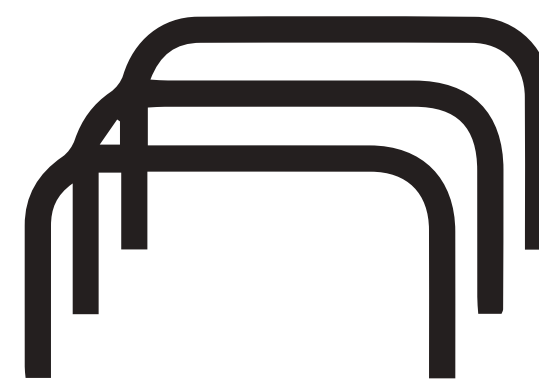
A six-car train carries up to 1,600 passengers.

## Cleaner Transport

To boost the appeal of cycling and walking as transport options, Singapore has invested in infrastructure such as:



Sheltered walkways



Bicycle racks



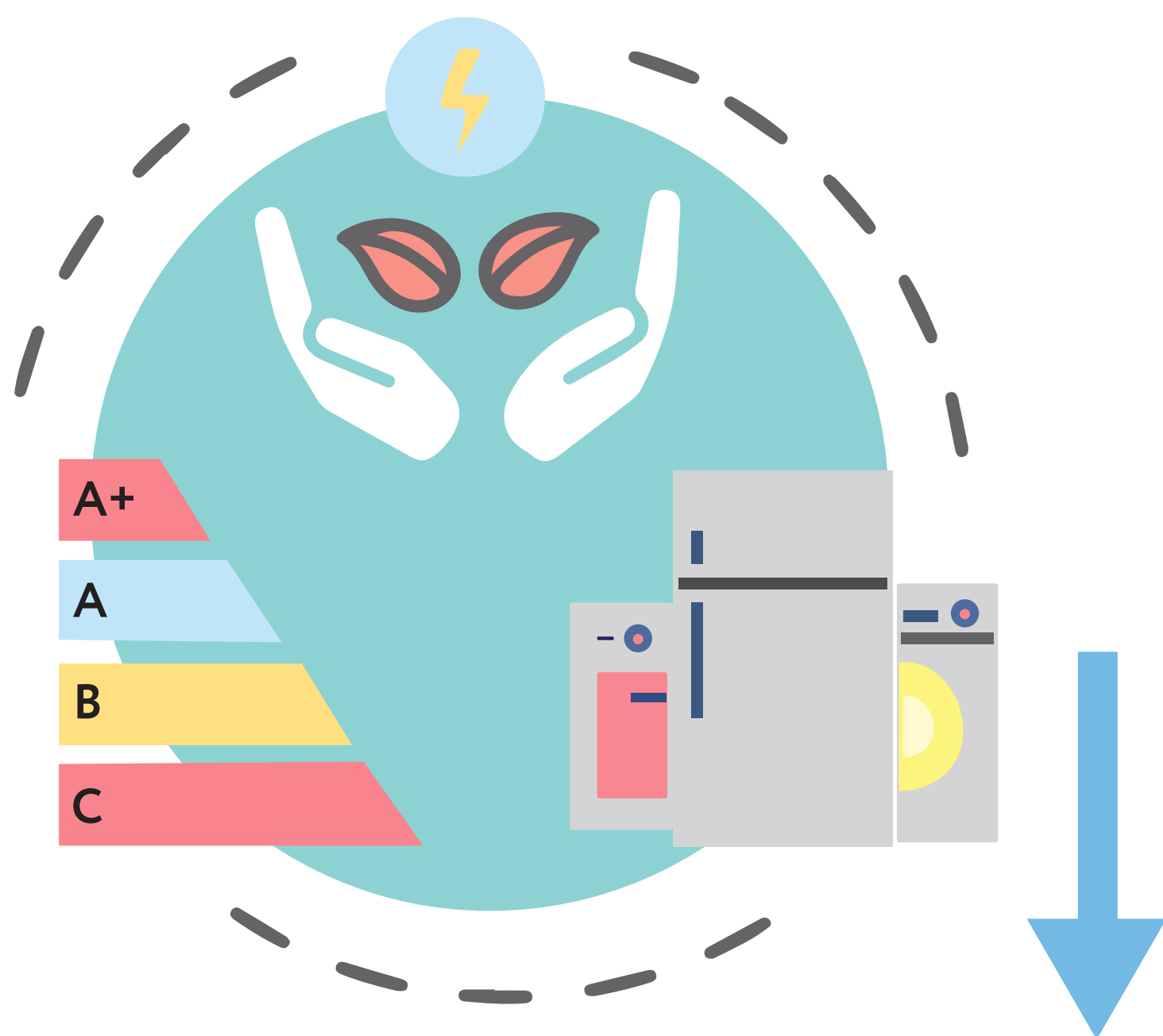
Cycling paths

Source: GreenPeace, nature.com, BBC News, Ministry of Transport (Singapore)



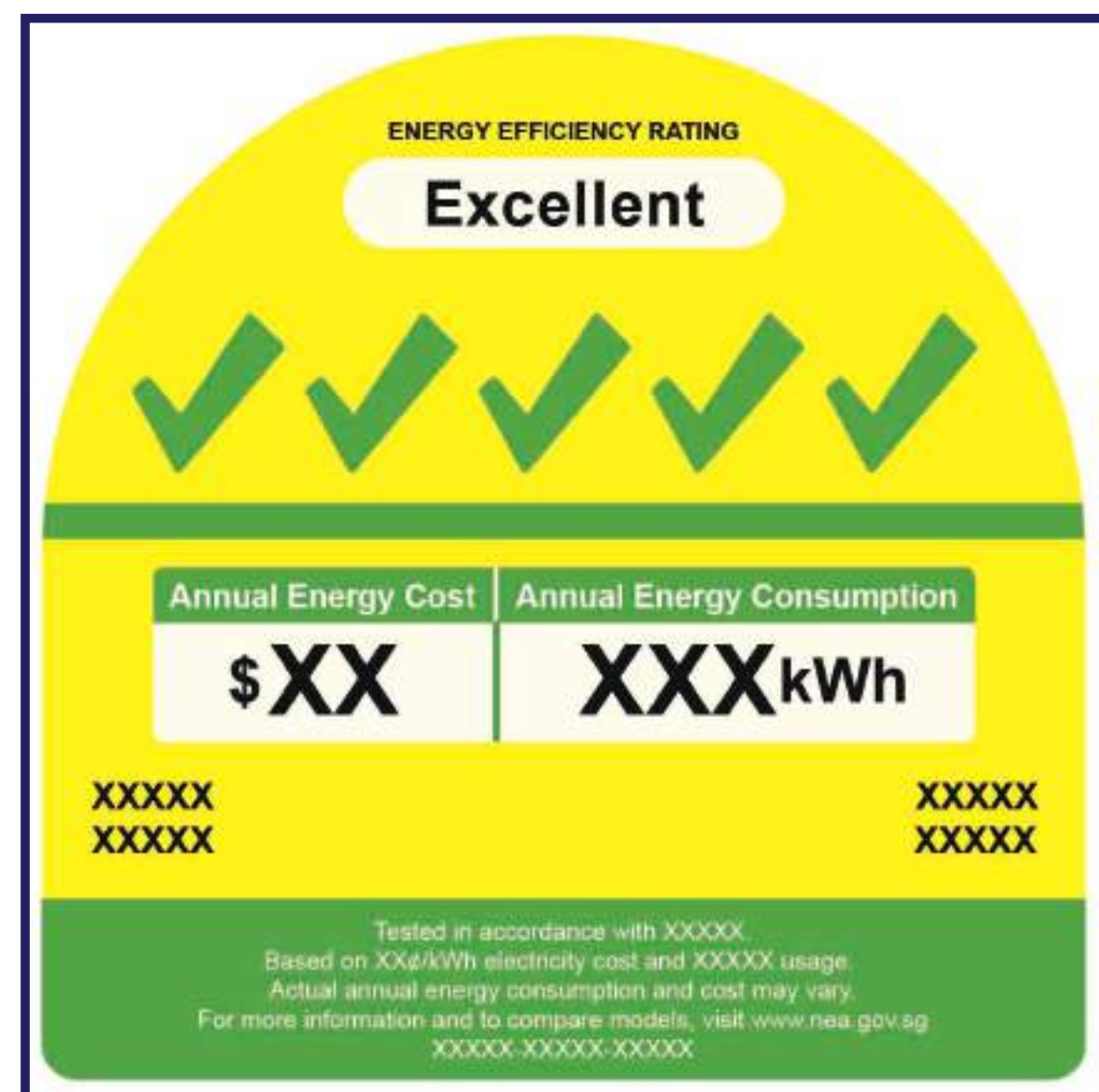
# WHAT ARE THE DIFFERENT LIFESTYLE CHANGES WHEN IT COMES TO SAVING ENERGY?

## Electricity Use



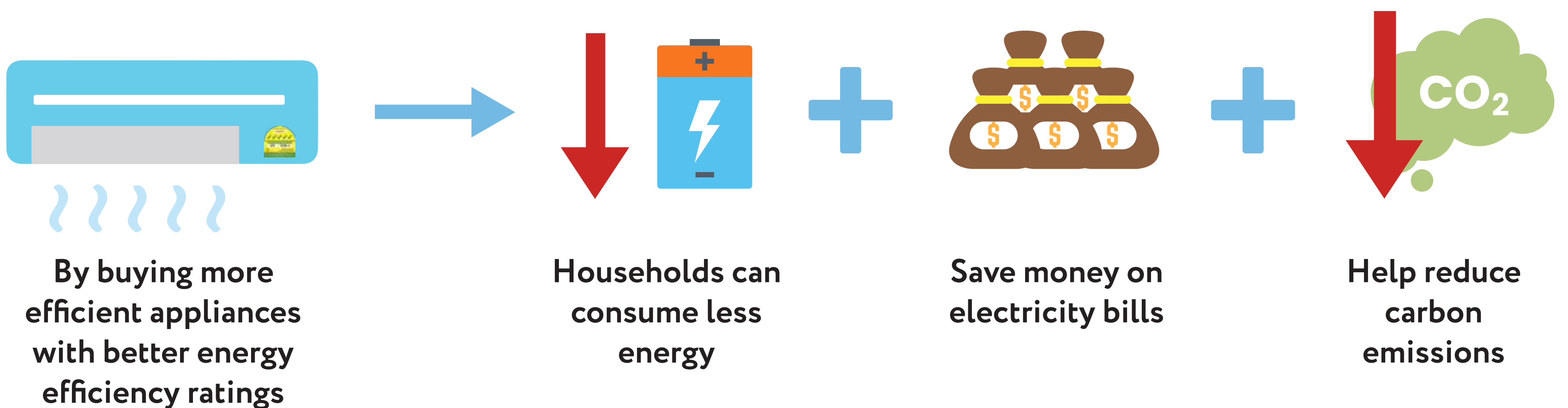
Consumers can opt for energy efficient appliances in their homes to reduce electricity consumption.

### Mandatory Energy Labelling (MELS)



### Minimum Energy Performance Standards (MEPS)

Helps improve the energy efficiency of a range of household appliances.

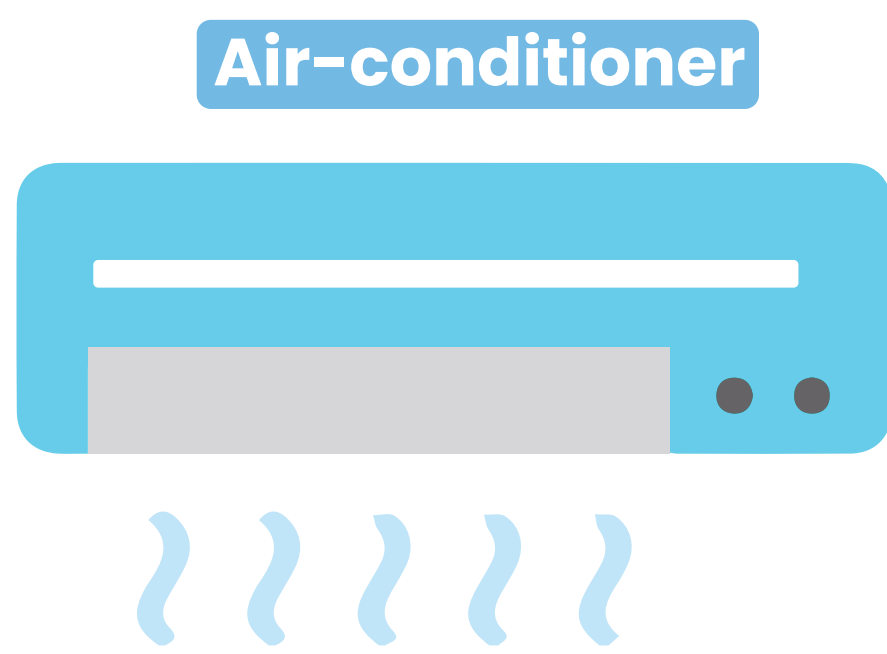


Look out for energy labels when buying new appliances, the more ticks there are, the more efficient the appliance.

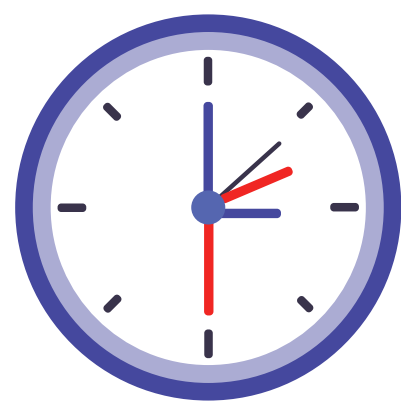
# Energy-Saving Habits

## 1 Keeping Cool

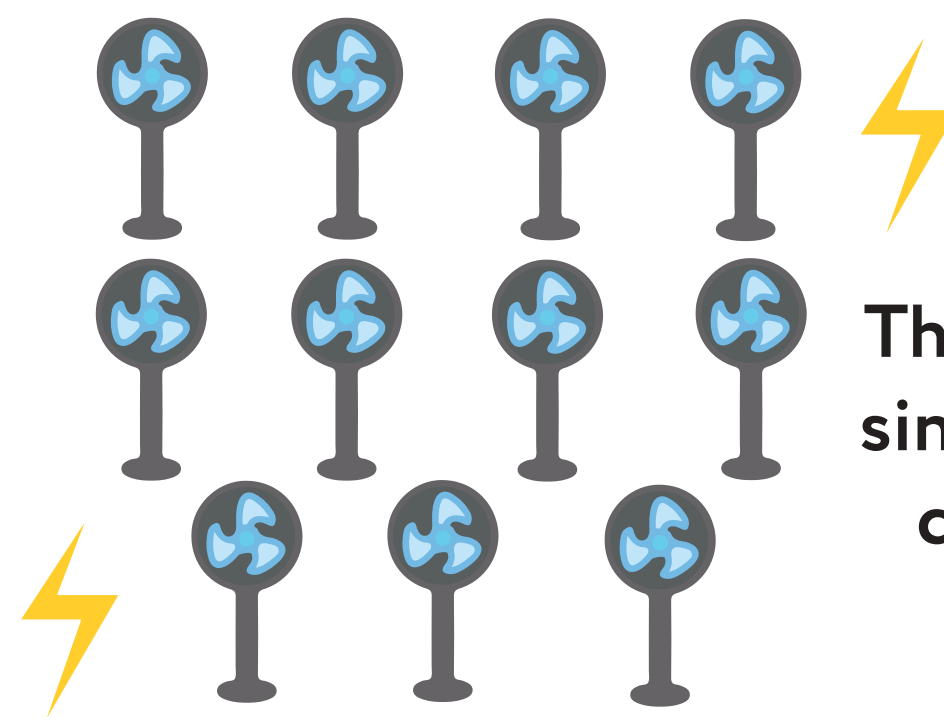
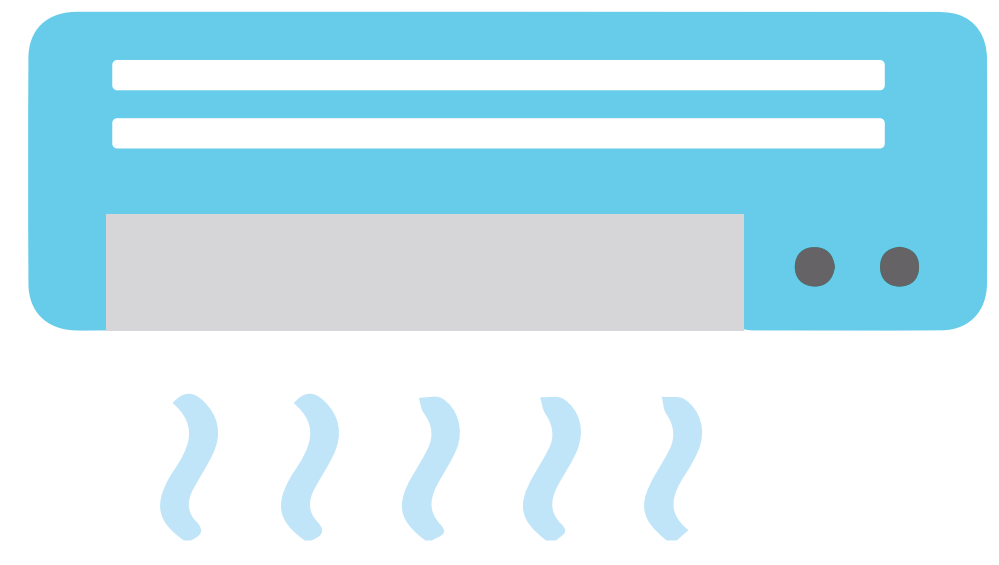
Use a fan instead of an air-conditioner.



Consider running the air-conditioner for a short while (1 hour) and switching to a fan after that to cool a room.



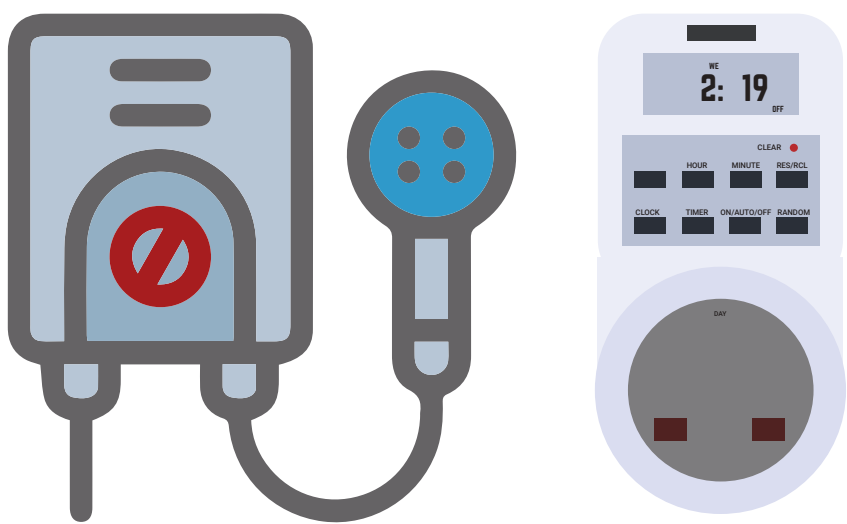
Set the timer of the air-conditioner to turn off half an hour earlier than usual.



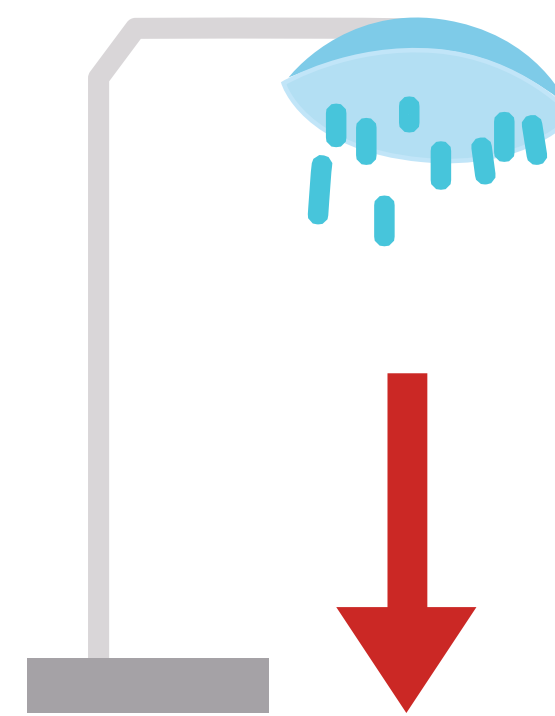
The energy used by a single air conditioner can power 11 fans.

## 2 Showering

Switch off the water heater when hot water is not needed.



Consider installing a timer for a storage water heater which automatically turns off the power after a preset time.



Cut down on long showers. Shorter showers save both energy and water.

### Did You Know?

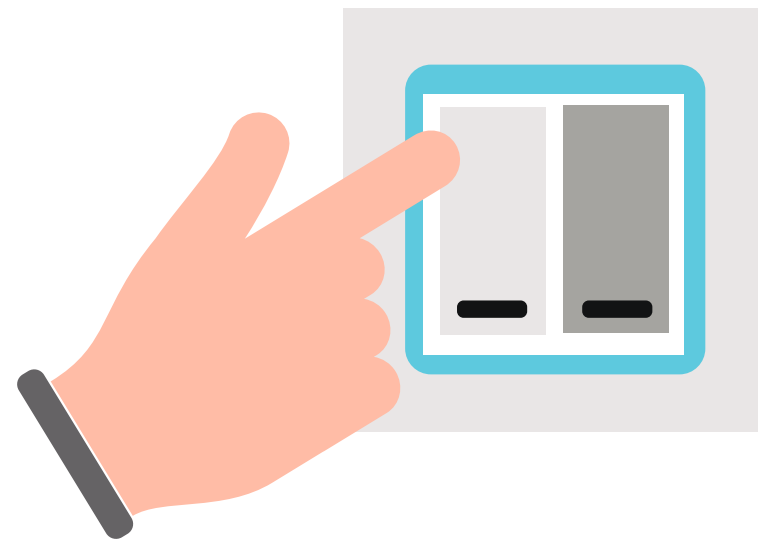
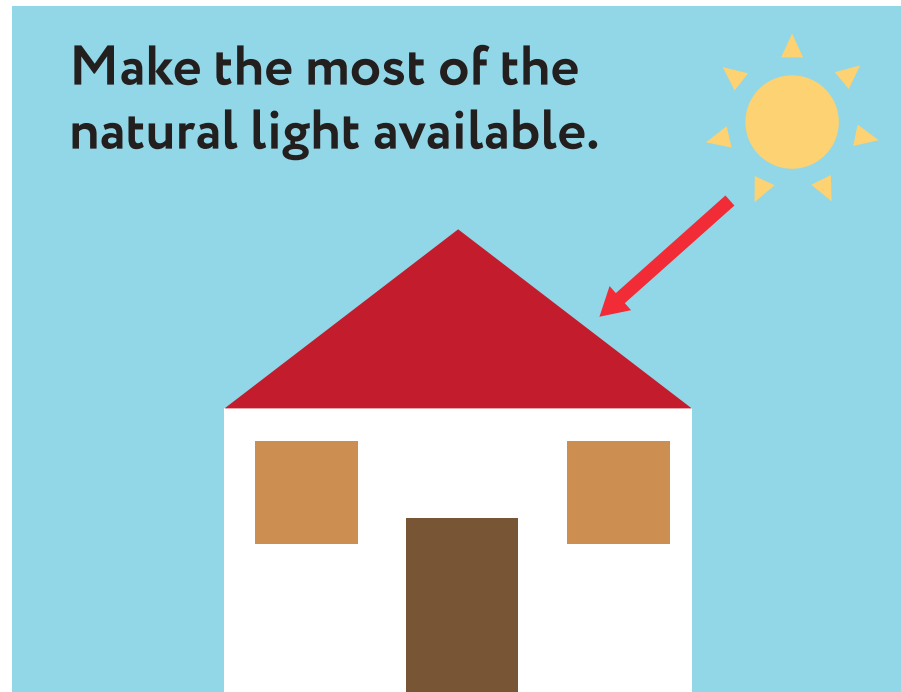
Unlike instantaneous water heaters, storage water heaters continue to use energy to heat water when they are left switched on.



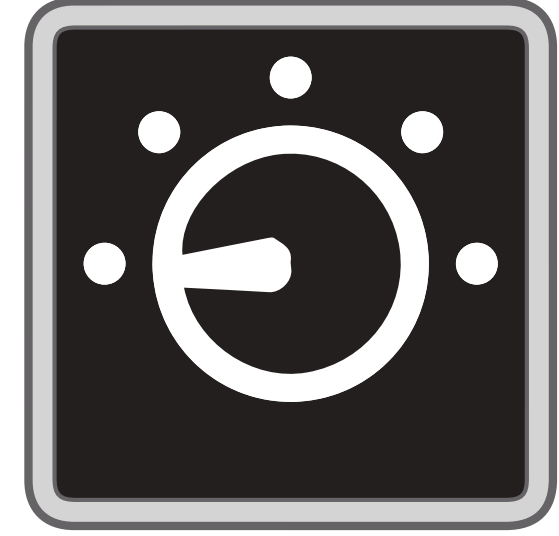
Turning off the tap when soaping and shampooing saves both energy and water.



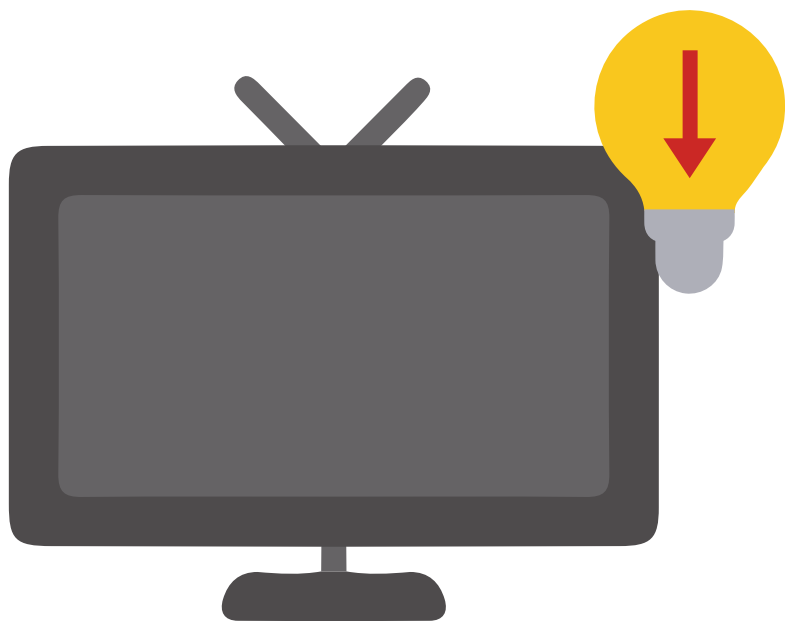
### 3 Lighting



Switch the lights off whenever you leave the room.



Use light dimmers whenever possible.



Keep the light in the room low when watching television.

This saves electricity and also cuts the glare from your TV screen.



Dust or clean lamps and fixtures regularly. Dust on lamps and reflectors reduce light transmission, making them less energy efficient.

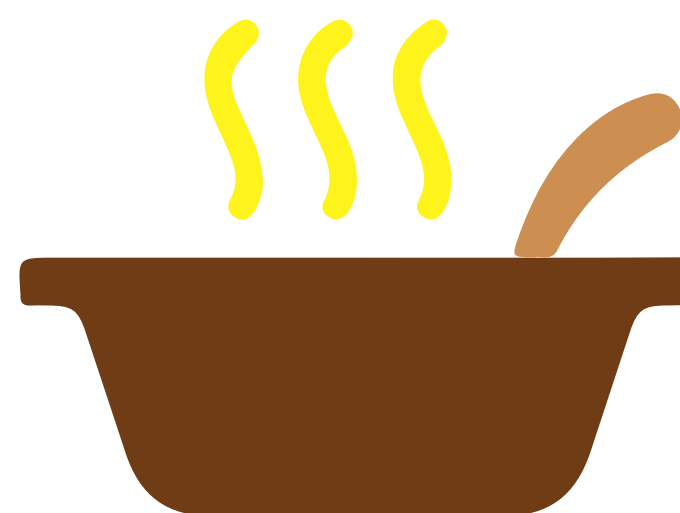
### 4 Refrigerator

Adjust the thermostat in the refrigerator to the recommended setting.



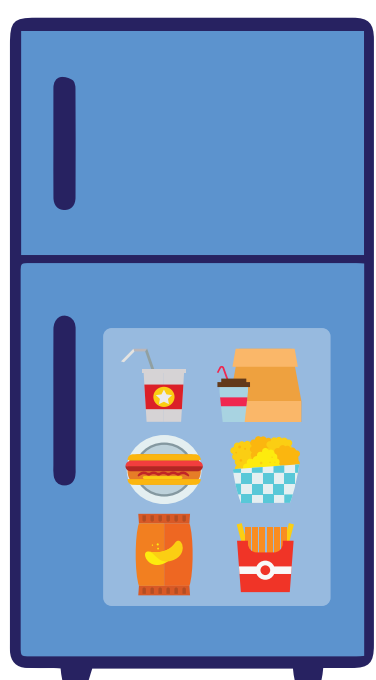
Overcooling your refrigerator wastes electricity.

Do not overload the refrigerator to ensure that cold air can circulate freely.

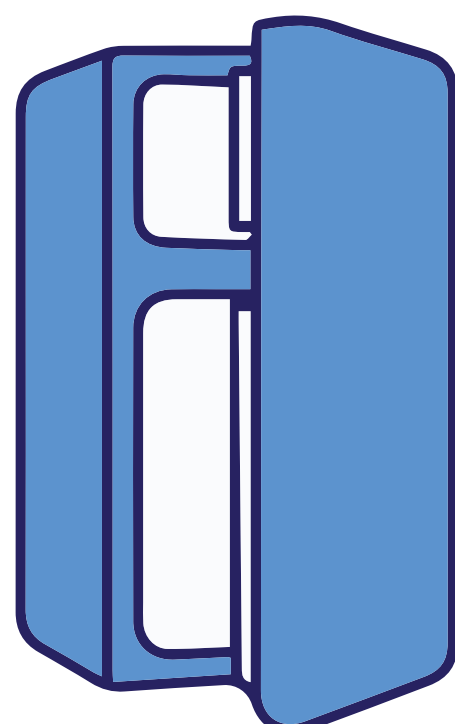


Allow hot food to cool before storing it in the refrigerator.

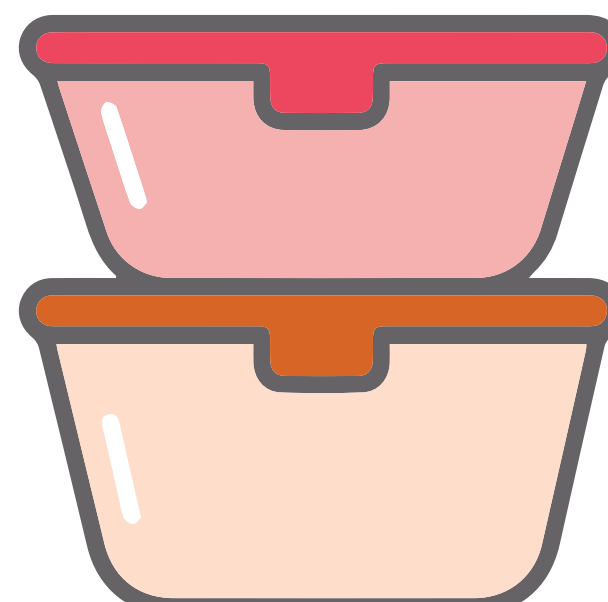
Consider using food storage containers to minimise clutter.



Too many food items may block air circulation and reduce cooling capabilities.



Do not leave the refrigerator door open longer than necessary.



Cover liquids and wrap food stored in the refrigerator.

Source: The National Environment Agency

# HOW CAN WE FIND OUT MORE ABOUT SEA LEVEL RISE?

## Education & Awareness

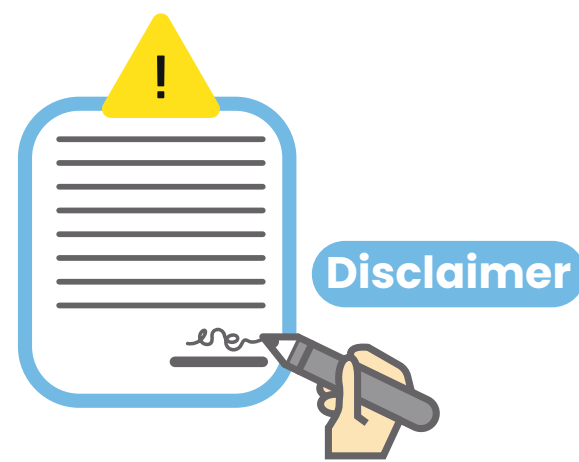
Being aware and well-informed of environmental issues can help us understand how climate change and sea level rise will affect our lives, and how we can do our part to tackle these problems.

What are the ways to check on the credibility of information sources about sea level rise and climate change?

### 1 Accuracy



Verify the information you already know against the information found in the source.

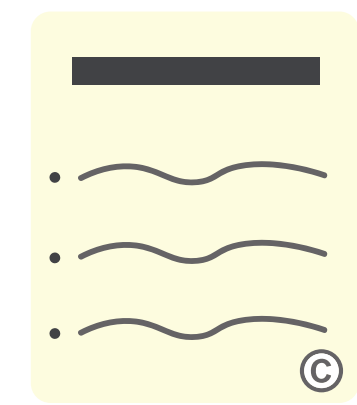


Look for disclaimers as to the accuracy of the content.

### 2 Authority



Make sure the source is written by a trustworthy author and/or institution.



If you are viewing a webpage, you can usually identify the owner/publisher by the URL or check for a copyright statement near the bottom of the page.



You may also want to double-check the information against a source that you already know is trustworthy.



Make sure the author has the proper credentials on the subject matter.



Also, determine if the source is biased. Be aware of the objectivity of the author and their viewpoints.



### 3 Currency

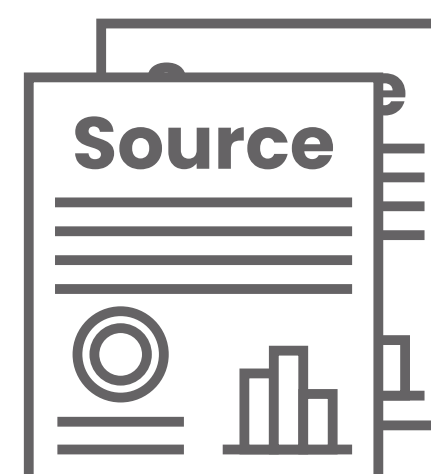


Depending on your subject, your currency needs will vary.



For webpages, you can often find a copyright date near the bottom. Also, look for the words "revised" or "updated" to find the date of the website.

### 4 Coverage



You will also want to examine the content of the source and how it fits your information needs.



Identify its relevance to your topic and whether or not it addresses the subject matter. Also, make sure it provides enough information if you are looking for a source that discusses the topic in-depth.



## How can you find out more on rising sea levels?

### Social Media

#### Instagram & Facebook

Great way to receive bite-size and easily understandable pieces of information.



@secsingapore  
(Singapore Environment Council)



@earthschoolsg  
(Singapore's first school for green education)



World Wildlife Fund  
<https://www.facebook.com/worldwildlifefund>



Plastic Bank  
<https://www.facebook.com/PlasticBank>



NOAA National Centers for Environmental Information  
<https://www.facebook.com/NOAANCEI>

### Documentaries/Videos

These can be an entertaining way to learn more about climate change and sea level rise



Climate change – living on the water | DW Documentary



Our Planet, Netflix Documentary



Earth Under Water, National Geographic Documentary



UN: Rising sea levels pose urgent threat to coastal cities Documentary

### Government Resources

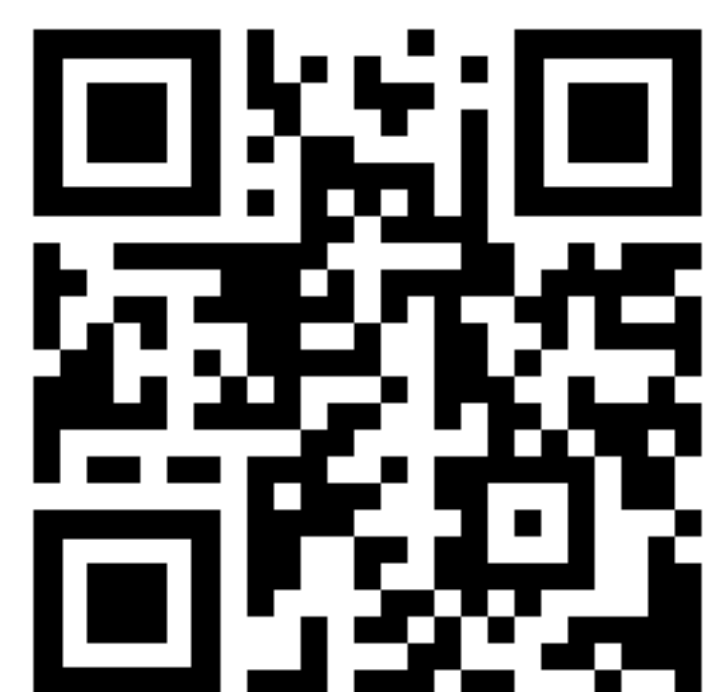
It is good to pay attention to government resources for information about climate change and sea level rise because these are specific to Singapore.



<https://www.nea.gov.sg>



<https://www.nparks.gov.sg>



<https://www.pub.gov.sg>

# WHAT CAN YOU DO TO HELP!



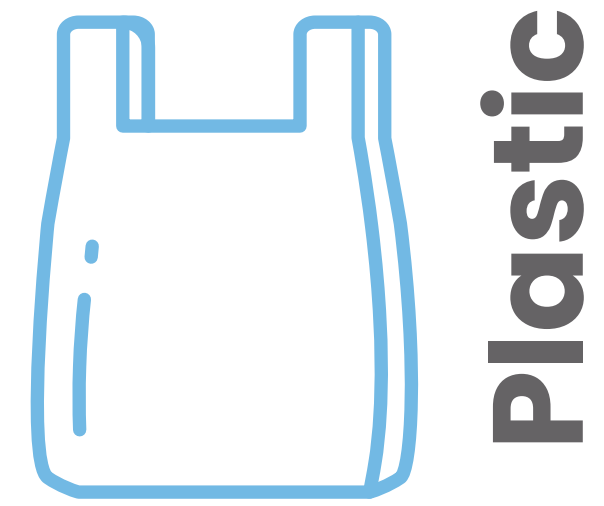
No action is too small. Scan the QR Code to make a pledge to fight climate change!

<http://bit.ly/risepledgeform>

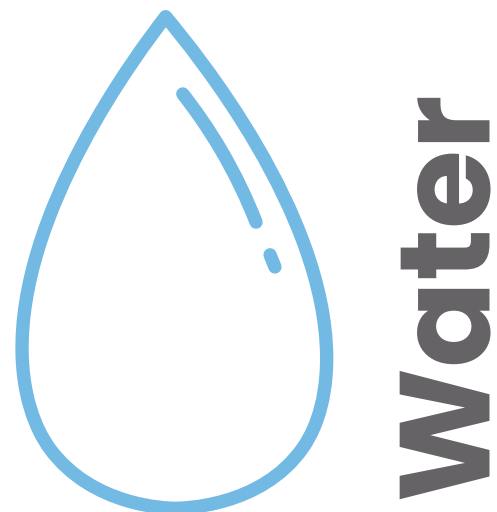
## Use Less



Whenever possible, present your work in a digital format. Use paper only when necessary!



Opt for reusable items over single-use plastic ones, like a reusable shopping bag.

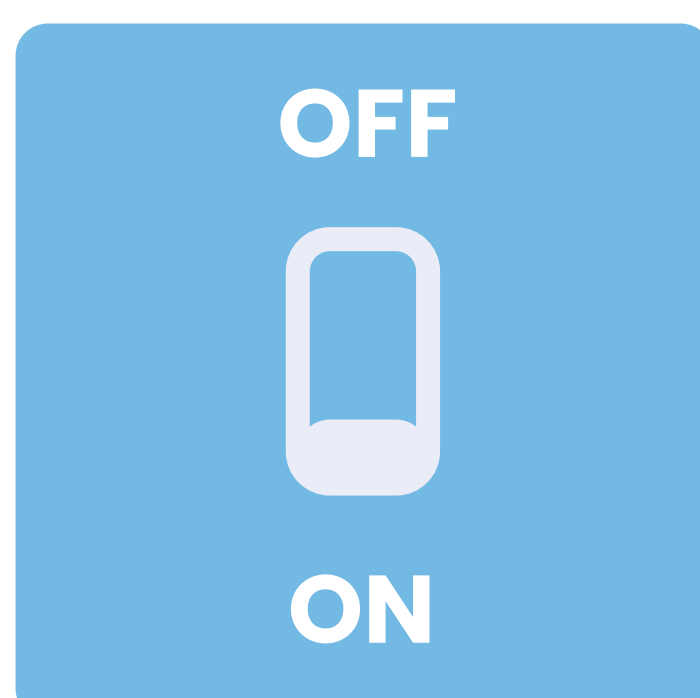


Shorter showers, wash only full laundry loads, use a mug when brushing your teeth. There are plenty of ways to reduce your water consumption!



Each electronic device we own is produced using non-renewable metals and contains small amounts of hazardous substances that may be harmful to human health and the environment if not disposed properly.

## Switch Off All Appliances When Not In Use



This small act saves energy, saves money, and saves the Earth!



# Conserve Plants

## DEVELOP A GREEN THUMB

From orchids to aloe vera to chye sim, grow your own collection of plants!

## USE PAPER WISELY

Use recycled paper, reuse paper and read e-books!

## STAY ON MARKED TRAILS

Prevents damage to saplings, animal habitats, and fragile soils. Also prevents soil erosion!



# Choose A Sustainable Lifestyle



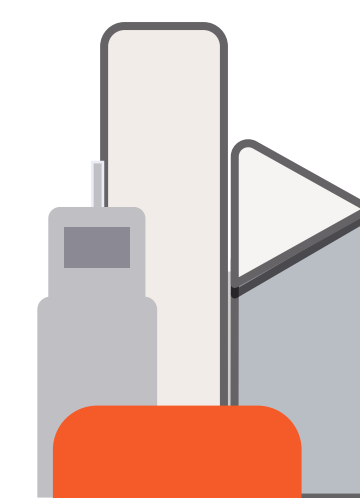
## Home

- Invest in energy-efficient appliances, such as LED light bulbs
- Take shorter showers
- Use a reusable lunch box if you need to buy takeaway food
- Cycle, walk, or use public transport instead of taking the car



## School

- Use refillable stationery
- Make crafts out of reused materials during art lessons
- Use reusable bottles instead of buying bottled drinks

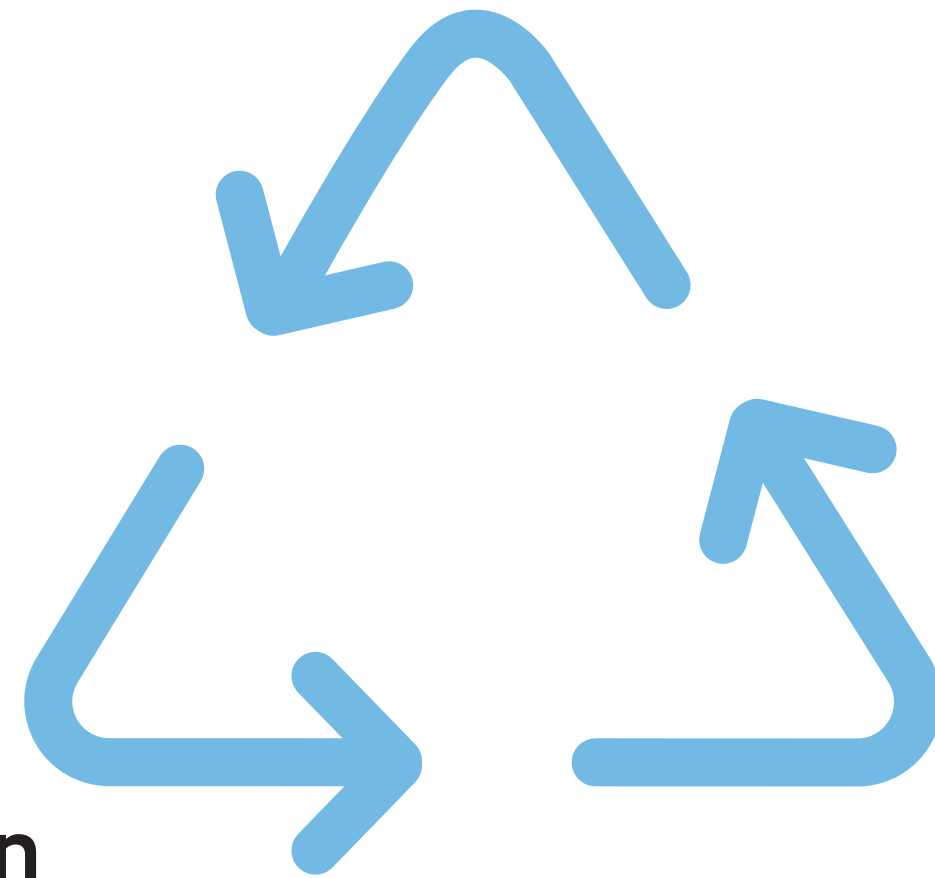


## Office

- Print only when necessary
- Set the air-con temperature to  $\geq 25^{\circ}\text{C}$
- Make use of available technology to ensure productivity and reduce waste

## Reduce, Reuse, Recycle...

**REDUCE** your waste by using and consuming less resources.



**REUSE** things more than once, such as using jam jars to store items.

**RECYCLE** used items properly and give them a new lease of life.

## ...and Upcycle!

**“One man’s trash is another man’s treasure.”**



Get crafty and create knife blocks from old books, aprons from old clothes and even spruce up a desk lamp with an old camera. Upcycling doesn't have to be difficult. You can even create a wallet from magazine covers or a pencil holder from water bottles. The possibilities are endless!





## A Sustainability Project by

**Keppel Land**



LET'S ***GAME CHANGE***  
***CLIMATE CHANGE***