Studio Tsuto Sakamoto

AY20/21 Semester 1 Options Design Studio

Sea Level Rise

in East Coast

Foreword: ***Singapore Under Sea-Level Rising***

The task is to make kin in lines of inventive connection as a practice of learning to live and die well with each other in a thick present. Our task is to make trouble, to stir up potent response to devastating events, as well as to settle troubled waters and rebuild quiet places.
-Donna J. Haraway

Issue and Approach
Singapore, a low-lying island state located near the equator, is vulnerable to climate change. Recently, it has experienced unprecedented torrential rains and prolonged dry spells. Possibly the most impactful is the sea-level rising that threatens the state land significantly. Although its process is extremely gradual and would not create a dramatic sea water inundation immediately, for the low-lying state, it would be a great concern as its assets – buildings and urban infrastructures are threatened.

The temporal and physiographical nature of this climate change in Singapore: the graduality that gives an impression an immediate response is not required and the low-lying landscape that develops a fear of the life-threatening impact, create a unique situation for its climate change defences. As Prime Minister, Lee Hsien Loong, mentioned in National Day Rally on 18 August 2019, the state should take the sea-level rising 'with utmost seriousness' for 'over many years and several generations', and it will cost an estimate of $100 billion or more over 100 years to protect the country against rising sea-levels.

The studio explored a potential urban and architectural design that respond to the sea-level rising and water related disaster mentioned above. Considering the nature of issue, the studio set a 'long-term transformational masterplan' as an overall approach. Along with future techno-social transformations: popularization of driverless cars, and burial of express ways, decentralization of workspace depending on network, rising e-commerce and delivery system using drones, the existing landform was gradually modified to accommodate and live with the disasters, yet avoiding devastating impacts.

As Donna Haraway suggested in the quotation above, the studio trusted that our future lies in how we make and settle manageable size of troubles, live with them and learn from them, instead of in a heroic structure that assumes that it solves the problem once for all.

Overall masterplan
Taking up the East Coast area in Singapore as a project site, the studio pursued urban and architectural design to prepare for the possible water disasters from around 2050 through 2100.

Consisted of a reclaimed shore that facilitates the East Coast Park, and a high-rise public and private housings, and the original inland with low-rise residential and commercial buildings, the area emphasizes its distinctive atmosphere. Furthermore, numbers of shophouses as cultural heritage add historical flavour to the atmosphere. However, the area is extremely susceptible to the sea-level rising as its altitude above sea level is the lowest in Singapore.

The studio proposed the 'long-term transformational masterplan' by providing an effective drainage system: widening existing canals and adding new canals to respond to the increasing precipitation under torrential rain. Such canals are provided with a series of retaining ponds to adjust the flow. The long-term transformation of the land is closely related to a systematic construction plan for the canals and retaining ponds: the excavated soils for the water system are piled to the adjacent sites to increase the altitude of the lands. The construction is planned to be conducted locally one by one to maintain the overall function of the area.

Based on the principle mentioned above, the existing urban grid will be gradually replaced by the archipelago typology due to the increase of the water surface. By the time, the project expected that the vehicular circulation and MRT would be buried, while pedestrian and light vehicular circulations are provided on the series of islands and connected by bridges. Human and material transportations are also supported by boats circulating on the canals.

Architectural Explorations

Architectural proposals not only extend the system provided by the overall masterplan, but also scrutinizes how people will conduct their life, develop their sensibility, respond to contingencies demanded by the surrounding nature.

The 'transformational plan' demands a series of environmental change for people. A familiar neighbourhood, community and scenery will constantly change. Under such circumstances, Ng Yun Hui, Sharyl's project attempts to reclaim a solidarity of people by proposing a 'communal storage,' while Choon Wong Yen, Gabriel's project turn a process of rehabilitation from destructive disasters to a series of communal events by articulating material conditions that the community experiences.

A life with water will be essential for the people who live in the environment. Tan Hong Xi, Clarence's project envisages a life on a marshland where people's daily tasks are scheduled based on the nature – fishing and harvesting in daytime and office works and conferences are conducted in the evening. Sharmaine Lee Pui Fong's project attempt to enhances people's sensibility towards natural phenomena by providing data centres sunken in the water. A hum emitted from the servers blended with wave and the flickering light with fireflies, create alternative phenomena.

A self-sustenance is one of the agenda for the people to survive. Hansel Lim You An's project proposes a complex of a piggery, abattoir and market taking advantage of the natural setting at a shore area, a part of the current East Coast Park. Tan Se Yong's project, taking advantage of sea water and exploiting desalination technology and capillary action, proposes a vertical vegetable farm and salt farm on the land. Both projects not only provide foods for survival but also integrate water, animals, plants and minerals by using full resource in the situation given.

A community's response to the contingence is inevitable for the survival. Ethan Mok Shao Wei's project engages with a moment of failure of electricity. Taking a transportation hub – a circulation centre for delivery, as a site, the project designs a perfectly automated logistic system that immediately turns to manually operated system when electricity is not available. Vernice Yu Hui Qing's project provides an area of refugees in case of a flooding. Accommodating considerable number of refugees in shophouses under conservation, and maintaining hygienic conditions, the project allows a systematic operation for further procedures.

A conservation of heritage is one of the major issues to be considered. In the East Coast area, how to protect the existing shophouses designated for conservation will be a particular issue. Yaw Jia Ying, Elisabeth's project protects the buildings with gabion dykes filled with debris of dismantled buildings under transformational plan, while providing additional structures using the same material, expecting the whole complex will turned to be a container of memory of the past.

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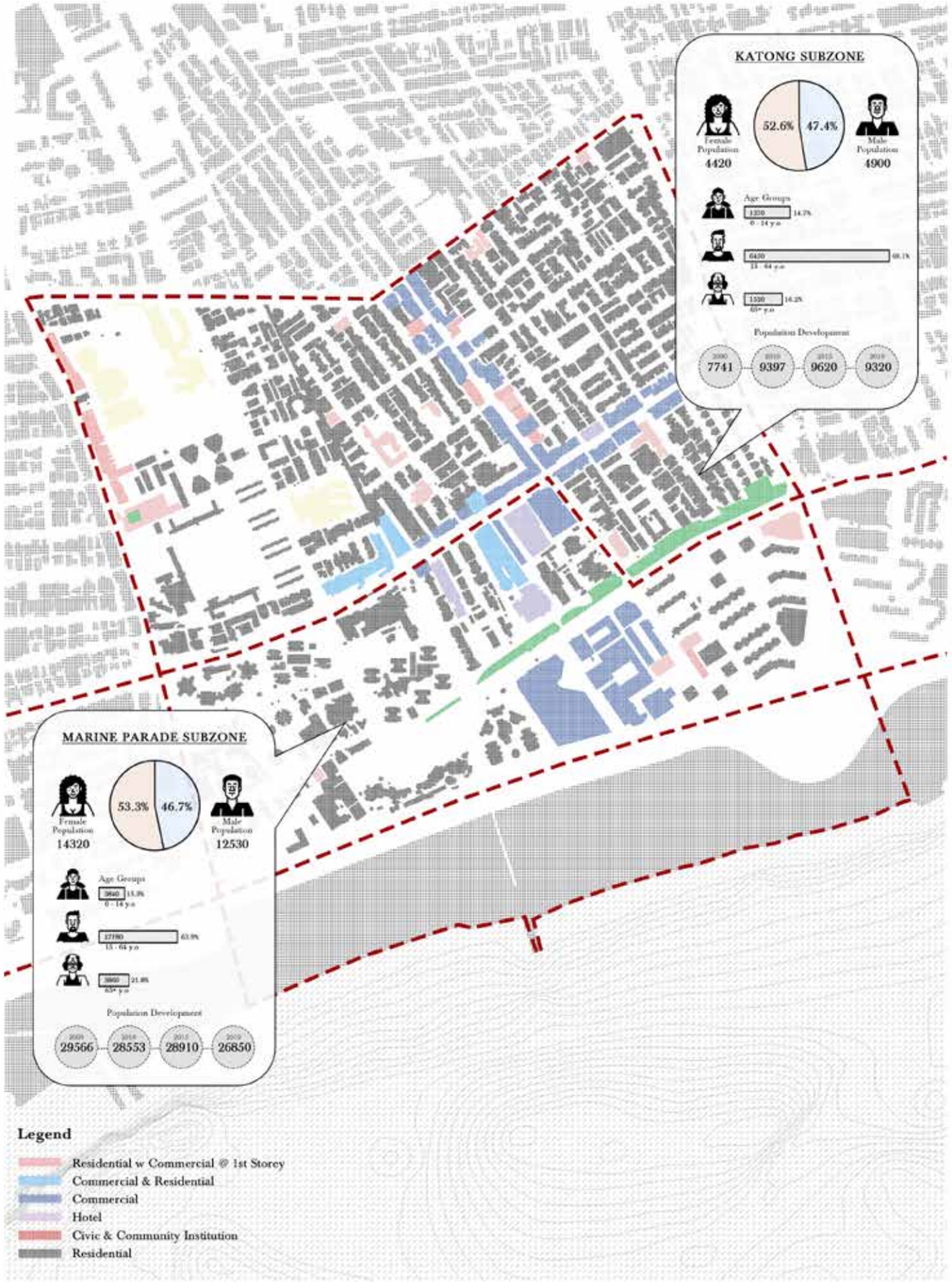
Acknowledgements:

Melvin Tan Jia Herng (Interim Reviewer)

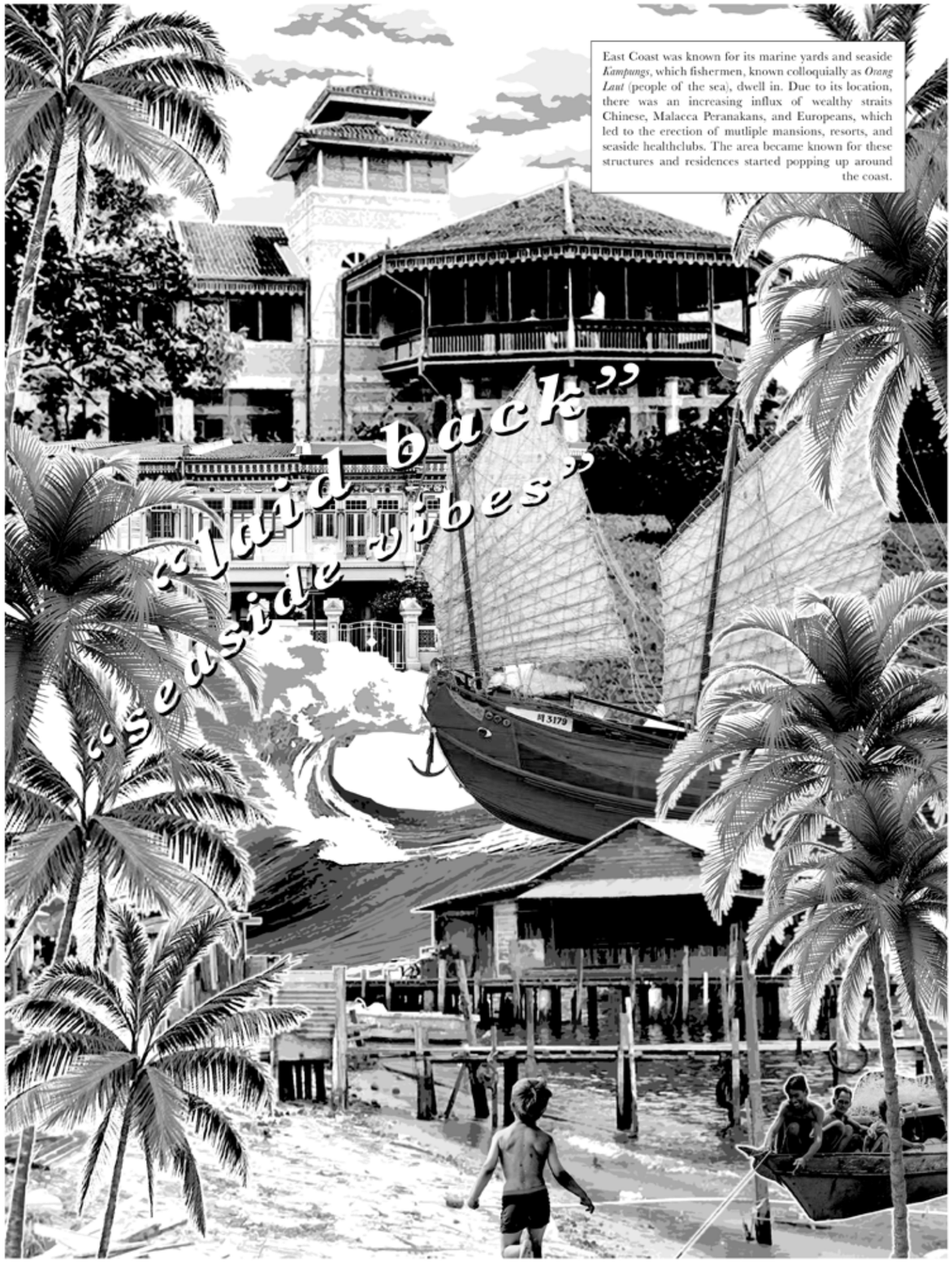
Content

HISTORY & CULTURE

Research Report



Demographics
Scale 1:12500 (A3)
Information credits to: URA Master Plan 2020



East Coast Collage
Not To Scale
Dynamic shift from a Fishermen Coast and Plantations
to Coastal Resorts and Houses for the Wealthy


Colonial Shophouses 1

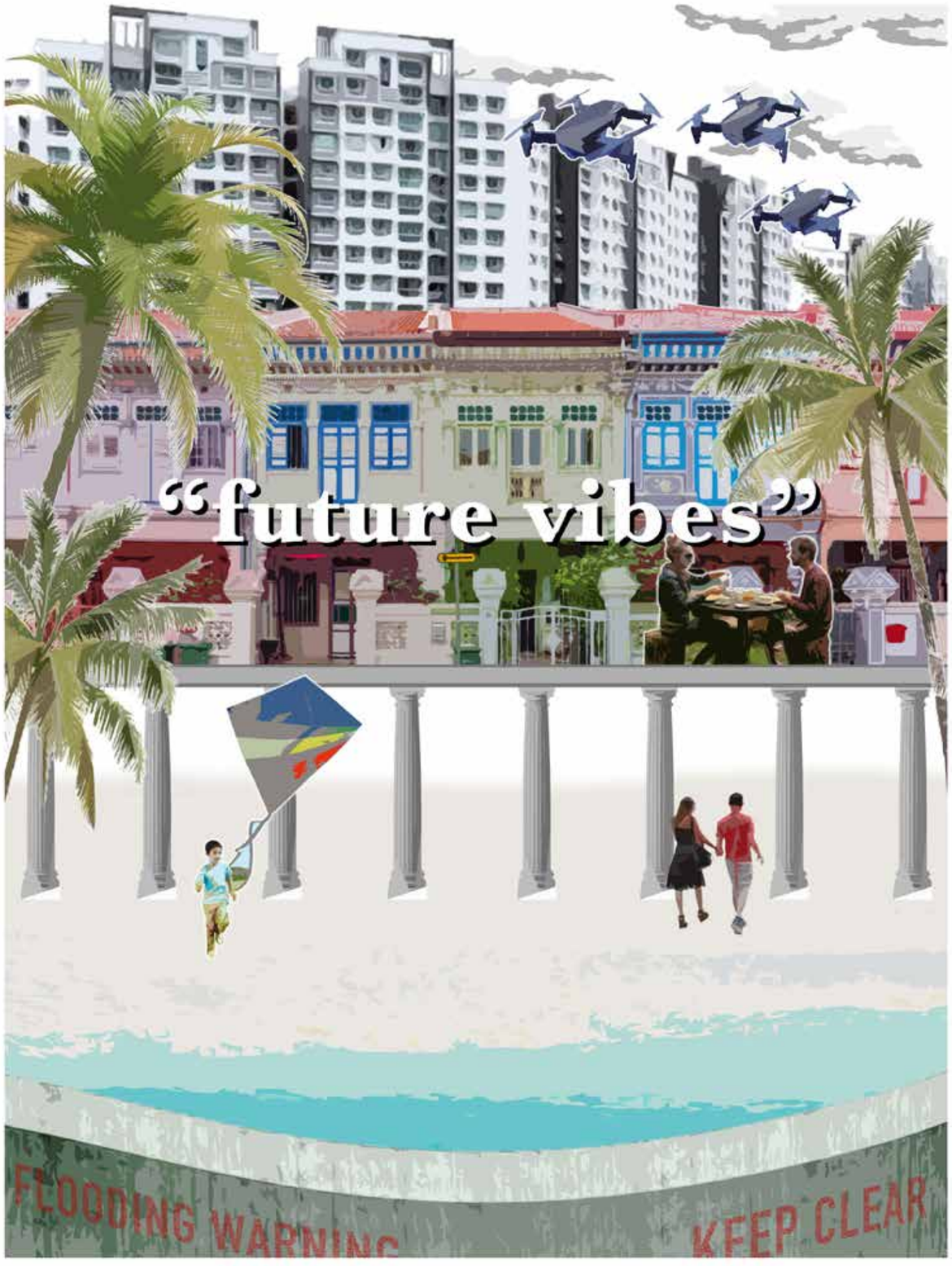

Colonial Shophouses 2


Katong Laksa

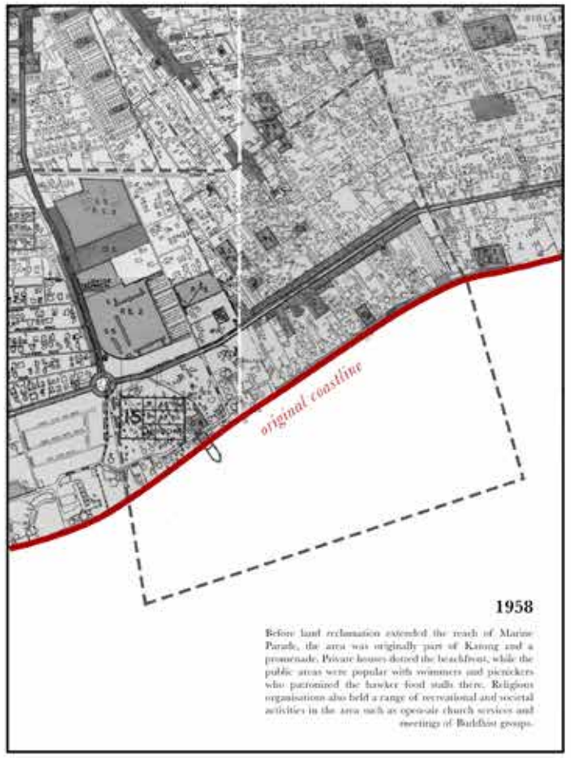
"Thick rice noodles in a bowl of coconut milk and prawn stock, blend flavoured with curry spices (rempah), topped with stir-fried prawns, curry leaves, fishcake and blood cockles (see hum)"

Katong Laksa has a deep history in the East Coast, beginning just after the War ended in the 1940s. A poor Chinese Straitsman named Ng Jaut Swee married a Peranakan woman (Nyonya), and was forced to sell the family's traditional recipe of the Laksa for livelihood due to post-war conditions., making him the first to peddle Laksa in Katong. Katong laksa became so famous that it attracted multiple competitors all over the area. The orginal Katong Laksa and its competitors eventually franchised and spread the flavour across Singapore.

Influence on Architecture and Food
Not To Scale
Straits Chinese and Peranakan Influences in East Coast

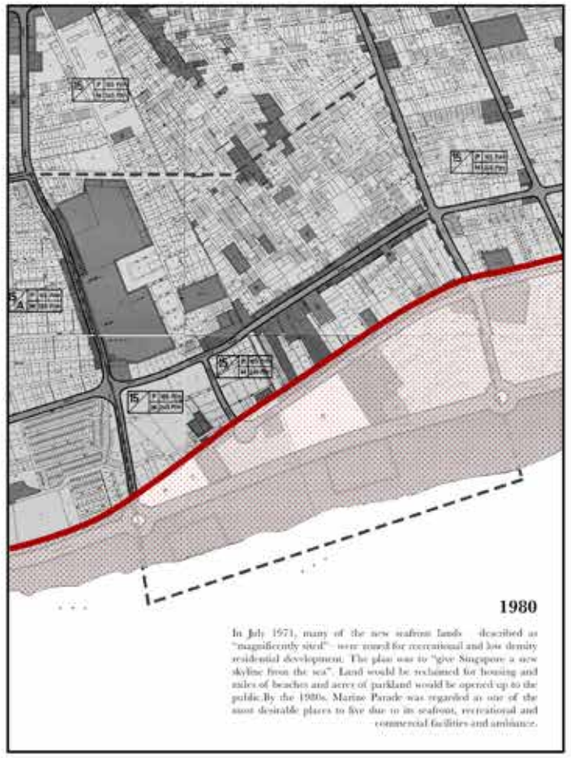


Future Culture (?)
Not To Scale
Can East Coast still preserve its rich heritage while inevitably embracing more land reclamation and technology to keep itself afloat amidst rising sea levels?



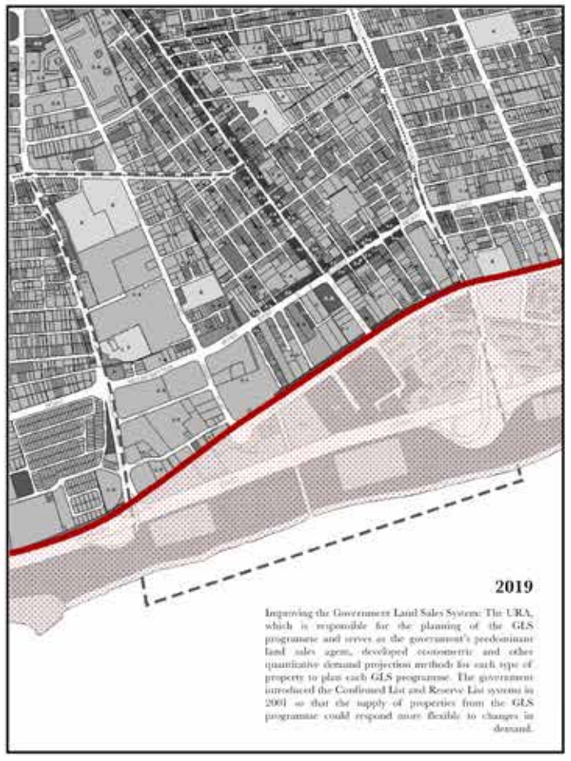
1958

Before land reclamation extended the reach of Marine Parade, the area was originally part of Katong and a promenade. Private houses dotted the beachfront, while the public areas were popular with swimmers and picnickers who patronised the hawker food stalls there. Religious organisations also held a range of recreational and societal activities in the area such as open-air church services and meetings of Buddhist groups.



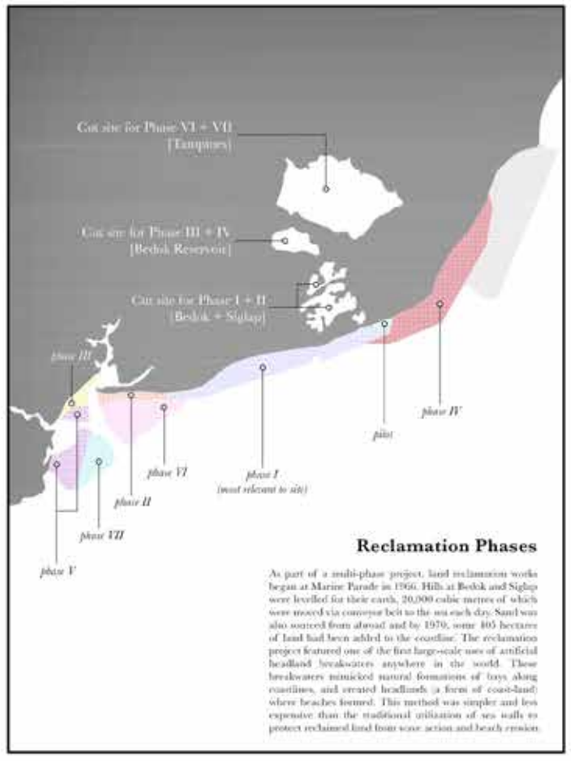
1980

In July 1971, many of the new seafront lands – described as "magnificently sited" – were zoned for recreational and low density residential development. The plan was to "give Singapore a new skyline from the sea". Land would be reclaimed for housing and miles of beaches and acres of parkland would be opened up to the public.By the 1980s, Marine Parade was regarded as one of the most desirable places to live due to its seafront, recreational and commercial facilities and ambiance.



2019

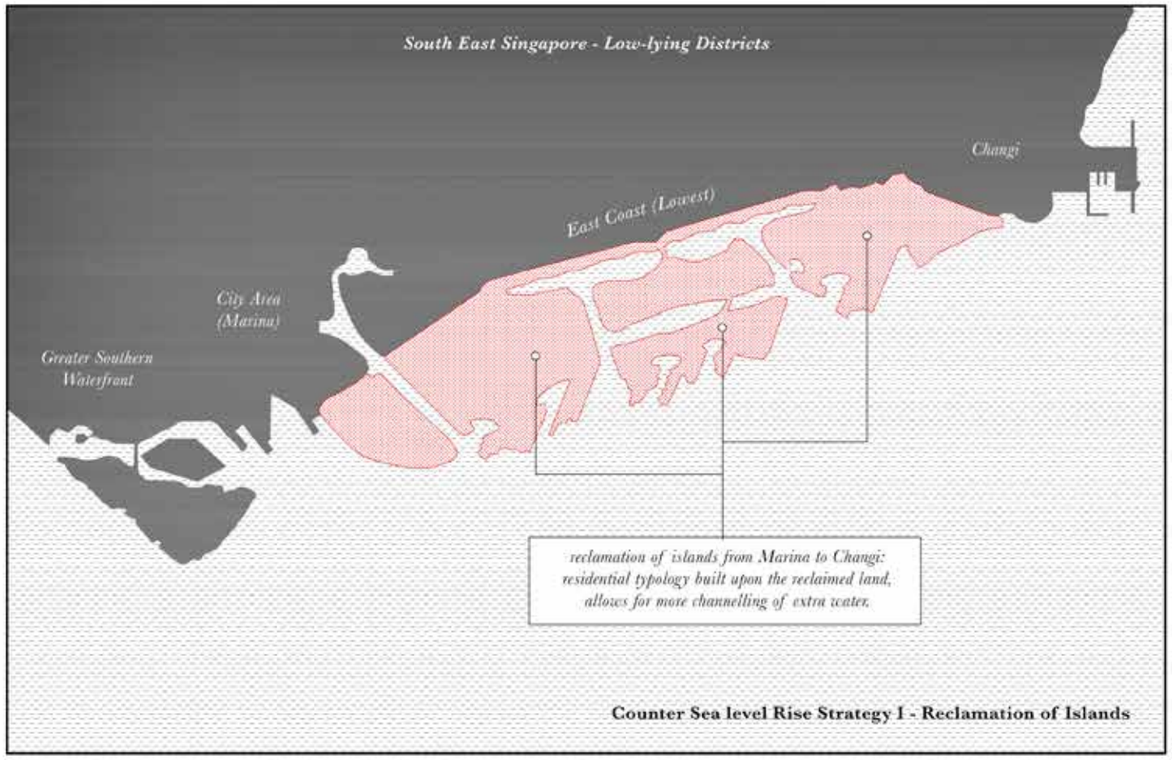
Improving the Government Land Sales System: The URA, which is responsible for the planning of the GLS programme and serves as the government's predominant land sales agent, developed econometric and other quantitative demand projection methods for each type of property to plan each GLS programme. The government introduced the Confirmed List and Reserve List systems in 2001 so that the supply of properties from the GLS programme could respond more flexibly to changes in demand.



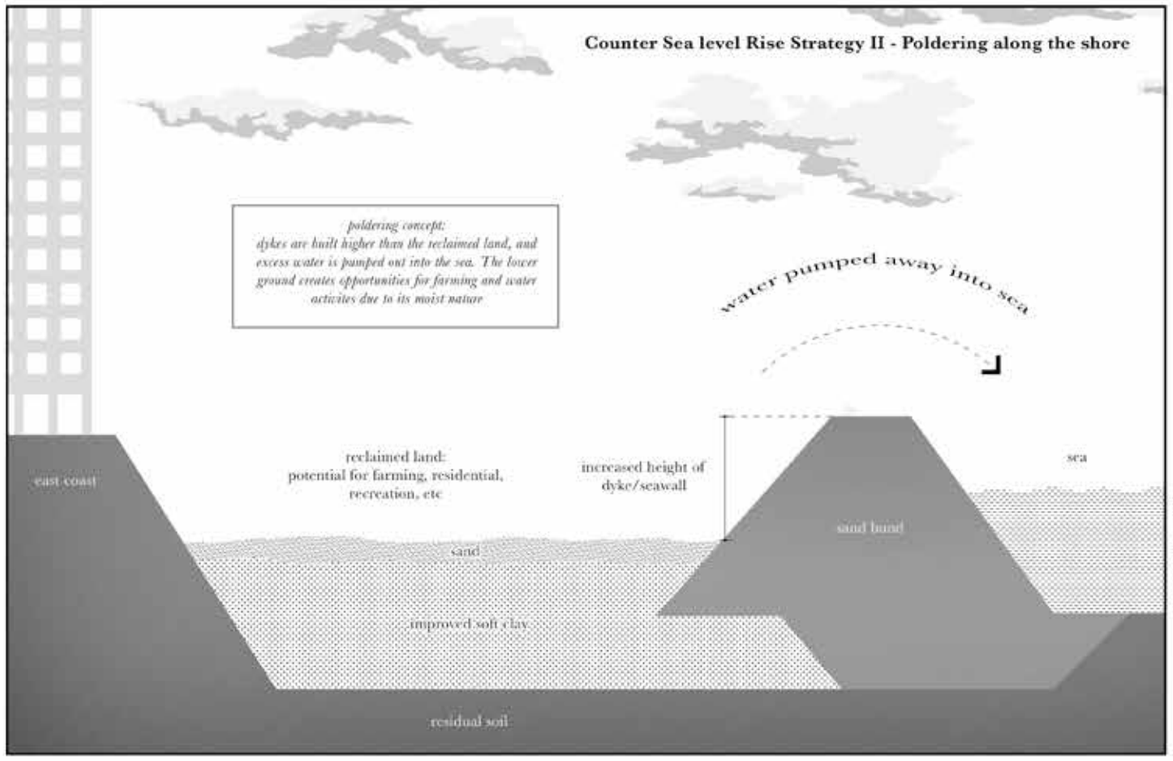
Reclamation Phases

As part of a multi-phase project, land reclamation works began at Marine Parade in 1966. Hills at Bedok and Siglap were levelled for their earth, 20,000 cubic metres of which were moved via conveyor belt to the sea each day. Sand was also sourced from abroad and by 1970, some 405 hectares of land had been added to the coastline. The reclamation project featured one of the first large-scale uses of artificial headland breakwaters anywhere in the world. These breakwaters mimicked natural formations of bays along coastlines, and created headlands (a form of coast-land) where beaches formed. This method was simpler and less expensive than the traditional utilization of sea walls to protect reclaimed land from wave action and beach erosion.

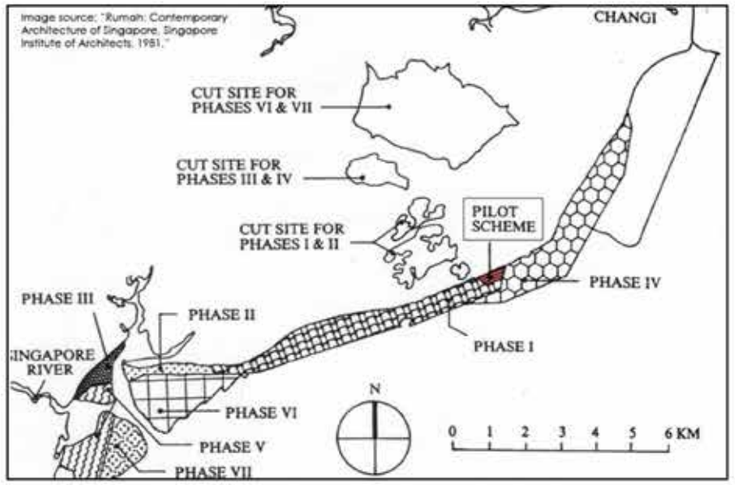
Master Plans through History + Land Reclamation
Not To Scale
Image and Information credits to:
Urban Redevelopment Authority (URA)
Singapore institute of Architects (SIA)



Counter Sea level Rise Strategy I - Reclamation of Islands



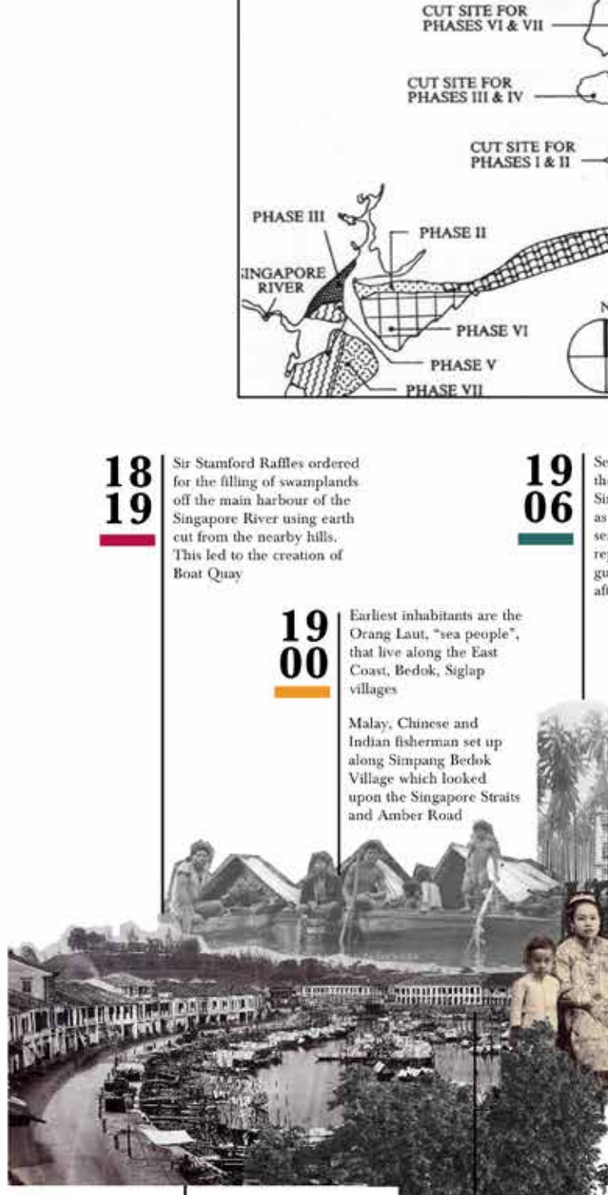
Future Plans
Not To Scale
Plans as a prevention measure for sea level rise



18 19 Sir Stamford Raffles ordered for the filling of swamplands off the main harbour of the Singapore River using earth cut from the nearby hills. This led to the creation of Boat Quay

19 00 Earliest inhabitants are the Orang Laut, "sea people", that live along the East Coast, Bedok, Siglap villages

Malay, Chinese and Indian fisherman set up along Simpang Bedok Village which looked upon the Singapore Straits and Amber Road



18 28 Lt. Philip Jackson's town plan of the creation of East Coast Road to serve as the main vein to the culturally rich and diverse Katong area

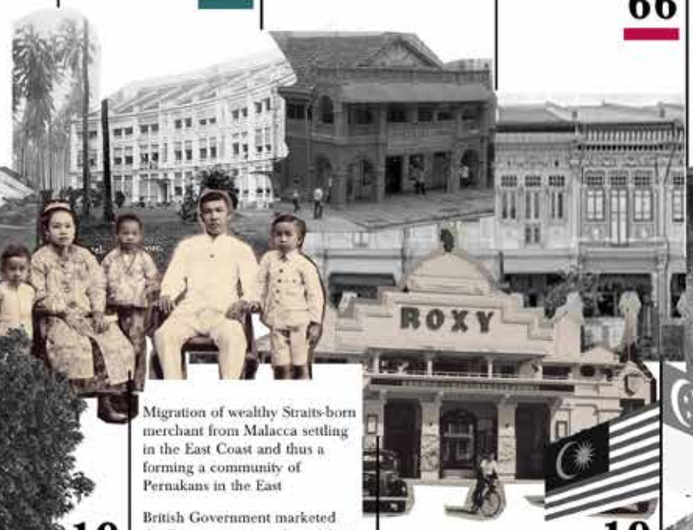
19 02 Construction of East Coast Road, a laterite road connecting Katong to Bedok

19 06 Sea View Hotel was one of the three leading hotels in Singapore. It was promoted as "the hotel on the sea-shore" and earned a reputation as a place for guests to rest and recuperate after an illness

19 20 Migration of wealthy Straits-born merchant from Malacca settling in the East Coast and thus a forming a community of Pernakans in the East

British Government marketed the East as vacation place. Many in the Eurasian community had weekend seaside bungalows where they hold parties and relax

19 25 Opening of the Red House Bakery. Popular breakfast amongst the eastern community



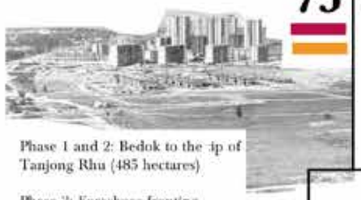
19 31 Opening of Roxy Cinema. Screens Chinese, English, Malay and Hindustani movies

19 48 Opening of Tay Buan Guan Supermarket. First supermarket in the East

19 65 Singapore gains independence from Malaysia

19 66 Start of work on the East Coast Reclamation site and would continue for a remarkable 30 years over seven phases. Start of Phase 1 and 2

Soil and earth was taken directly from Siglap and Tampiness which were once hills. The largest excavation was the Bedok Reservoir



Phase 1 and 2: Bedok to the tip of Tanjong Rhu (485 hectares)

Phase 3: Foreshore fronting Tanjong Rhu and Queen Elizabeth Walk (67 hectares)

Phase 4: Bedok to Tanah Merah Besar (486 hectares)

Phase 5: Reclamation of Telok Ayer Basin (34 hectares)

Phase 6 and 7: Foreshores of Tanjong Rhu and Telok Ayer Basin (660 hectares)

19 71 End of Phase 1 and 2 of the East Coast Reclamation, created a 9km stretch of sandy beach. Start of Phase 3 and 4 of the East Coast Reclamation

19 73 Marine Parade HDB blocks are the first housing estate in the world to be built entirely on reclaimed land

19 74 Start of Phase 5 of the East Coast Reclamation

19 75 End of Phase 3 and 4 of the East Coast Reclamation, created 553 hectares of new land

19 77 End of Phase 5 of the East Coast Reclamation, formed a new site known as Marina Centre and a massive lagoon

19 79 Start of Phase 6 and 7 of the East Coast Reclamation

19 86 End of Phase 6 and 7 of the East Coast Reclamation. Completion of the East Coast Reclamation Project

Construction of East Coast Parkway (ECP) expressway

19 78 Closing of Roxy Cinema

19 73 Opening of Katong Shopping Centre

19 84 Opening of Parkway Parade Shopping Centre

20 00 Closing of Tay Buan Guan Supermarket

20 03 Closing of the Red House Bakery

Closing of Sea View Hotel

20 04 Construction of Sea-view Condominium

20 08 'Long Island Project' plans to reclaim an island off East Coast, stretching from near Marina East to Changi for waterfront housing and recreational development and roads

20 19 Singapore getting ready for the rise in sea level, idea to reclaim of series of island along the East Coast from Changi to the city

Land Reclamation
Cultural
Economic
General

Timeline of Historical Events

Options Research Studio AY 20/21 Semester 1
Studio Tsuto Sakamoto

Research and Analysis
Category: History and Culture

SHOPPING CENTRES

Katong Shopping Centre used to be a beachfront mall; commonly referred to as the "Chinatown of the East" due to its high human traffic. This was before the East Coast land reclamation and construction of Parkway Parade which blocked the mall's iconic sea-view and diluted its business.

The first air-conditioned shopping mall in Singapore, was then well-known for a concentrated number of textile shops in its early days. It was also once a popular food hotspot. However, the crowds died down over the years as people began visiting newer malls (Parkway Parade, 112 Katong, Katong V, etc.) instead.

Today, Katong Shopping Centre consists of mainly maid agencies and services such photocopying, tailoring and beauty & wellness shops. Most of the shops in Katong Shopping Centre are up for rent and it is evident that Katong Shopping Centre no longer attracts the masses like it used to.

SHOPHOUSES

Katong/Joo Chiat has its beginnings in the early 19th Century where coconut plantations stretching from Geylang River to Siglap Road and humble attap-roofed kampung (villages) dotted the landscape. Up to the 1950s, the area was an idyllic seaside retreat for the wealthy.

In the 1920s and 1930s, many communities moved eastward out of the city centre to make Katong/Joo Chiat their home. This resulted in bungalows, shophouses and places of worship being built, a reflection of the multicultural and varied Katong/Joo Chiat community.

Today, over 800 buildings were conserved. Some shophouses were converted into offices, hotels, museums, restaurants and eateries that still preserve the rich heritage of the area.

MIXED-USE DEVELOPMENT

The Millennial generation is often looking for greater flexibility in their lifestyle and striking a balance between work and play; therefore, they often have a higher demand for better amenities near both where they work and live. Our society is also exerting pressure to drive for a more liveable, green and friendly environment. Thus, mixed-use developments are the solution to the demand for millennials and the society and government's drive for a better environment.

Marine Parade is well served by commercial facilities. To cater to greater demands of residents, shopping malls were established to offer more retail and lifestyle options. A plethora of educational institutions, such as Haig Girls School, Dunman High School, Tanjong Katong Girls' School and Canadian International School are located within the zone, easily attracting families who reside in the numerous private housing and HDB flats around the area. Residents also can easily access East Coast Park for an enjoyable weekend.

SEASIDE RETREATS

Before reclamation in Marine Parade, Tanjong Katong fronted the sea. Wealthy Straits Chinese, Europeans and Jews built mansions, hotels and recreation clubs along the beach for weekend retreats. The area became known as a health resort and was peppered with residences.

RESIDENTIAL

In July 1971, many of the new seafront lands – described as "magnificently sited"– were zoned for **recreational and low density residential development**. The plan was to "give Singapore a new skyline from the sea". By the end of 1973, the Housing Development Board (HDB) had completed the first phase of the **estate development**. The flats were of the 2/3/4/5-room varieties and market, shops and offices were also constructed.

Today, East Coast is home to many a landed property, and while there are plenty of types to choose from, the distinctive Peranakan shophouses and terrace houses that have been restored to their former glory are the jewels of the neighbourhood. That said, the neighbourhood has its share of modern designs, especially in the vicinity of Joo Chiat.

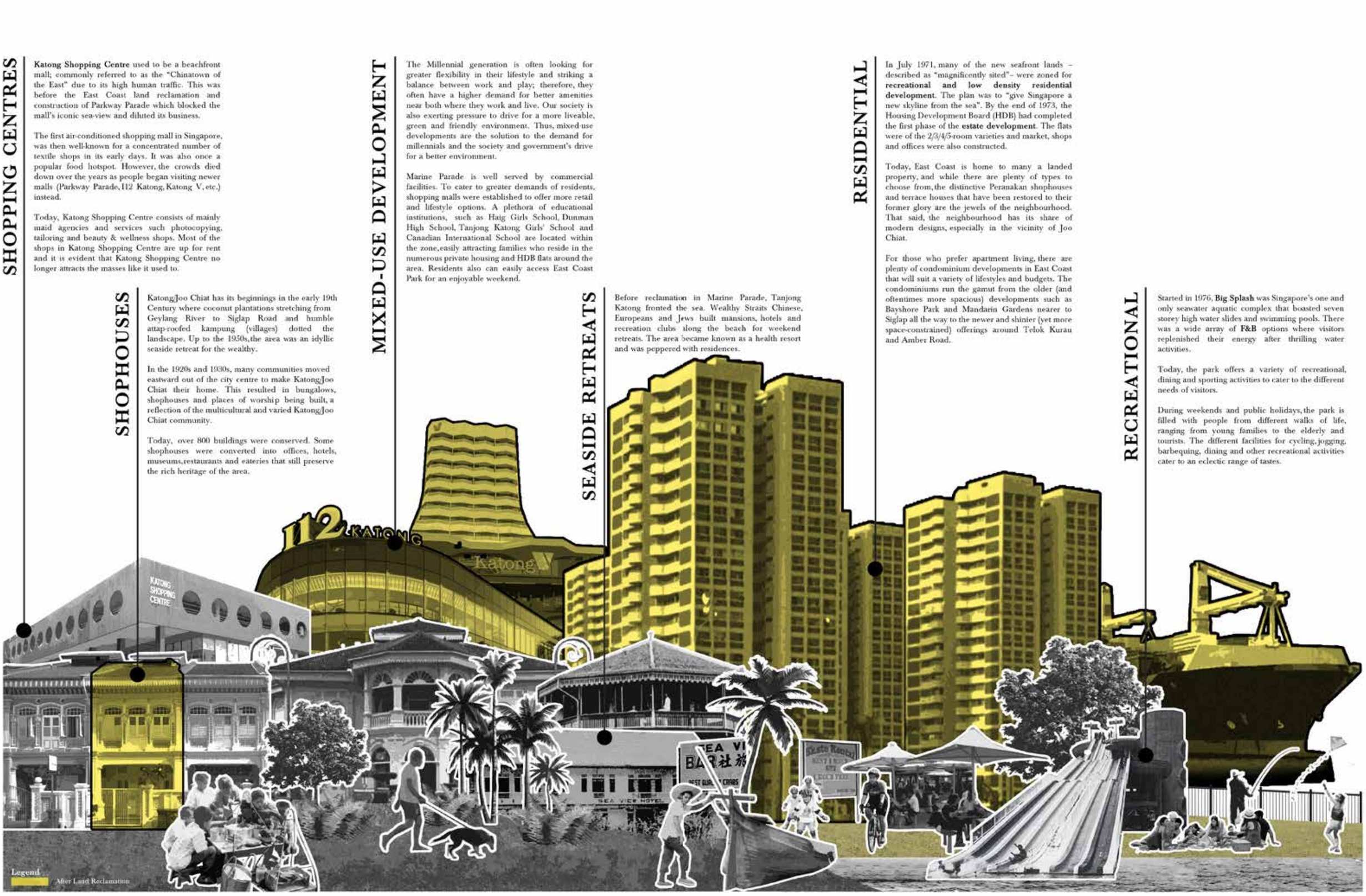
For those who prefer apartment living, there are plenty of condominium developments in East Coast that will suit a variety of lifestyles and budgets. The condominiums run the gamut from the older (and oftentimes more spacious) developments such as Bayshore Park and Mandarin Gardens nearer to Siglap all the way to the newer and shinier (yet more space-constrained) offerings around Telok Kurau and Amber Road.

RECREATIONAL

Started in 1976, **Big Splash** was Singapore's one and only seawater aquatic complex that boasted seven storey high water slides and swimming pools. There was a wide array of **F&B** options where visitors replenished their energy after thrilling water activities.

Today, the park offers a variety of recreational, dining and sporting activities to cater to the different needs of visitors.

During weekends and public holidays, the park is filled with people from different walks of life, ranging from young families to the elderly and tourists. The different facilities for cycling, jogging, barbequing, dining and other recreational activities cater to an eclectic range of tastes.



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Development of the Urbanscapes
how it affects the lifes of people

Options Research Studio AY 20/21 Semester 1
Studio Tsuto Sakamoto

Research and Analysis
Category: History and Culture

Conserved Building
New Buildings

Figure-Ground
Scale 1:10000 (A3)
Conserved Architecture on Site (Pre-Reclamation)

Options Research Studio AY 20/21 Semester 1
Studio Tsuto Sakamoto

Research and Analysis
Category: History and Culture


East Coast Road Shophouses, 1940


East Coast Road Shophouses, 2020


Esso on East Coast Road, 1950


Esso on East Coast Road, 2020


First Flats at Marine Parade, 1970


Flats at Marine Parade, 2020


Homes on East Coast Road, 1940


Shops on East Coast Road, 2020

Past VS Present
Not To Scale
Changes to the Architecture in the East

Options Research Studio AY 20/21 Semester 1
Studio Tsuto Sakamoto

Research and Analysis
Category: History and Culture

"During rainy seasons, it's hard work keeping the pigs from drowning in the rising flood waters."

"It's hard carrying the heavy buckets of water home rom the village water pump."

"My legs are in the water, not my head."

"House was flooded to knee-height but this did not dampen the spirits of this household who cheerfully helped to prepare food for Hari Raya Puasa."

"Streets were flooded with rain water, it's time for some fun!"

"I still need my coffee even if there is a flood."

Floods may occur very frequently in the past, but that does not stop the people from conducting their daily routines in life. Although it had since caused much inconveniences for the adults, the children,however, took advantage of the situation and had fun.

Floods bring Misery and Joy
Not to Scale

Options Research Studio AY 20/21 Semester 1
Studio Tsuto Sakamoto

Research and Analysis
Category: History and Culture

Flooding of the Nile (Wafaa El-Nil) in Egypt

www.skygts.com

Celebrating the Nile Flood, wiping Isis tears - Sky Gates

The River Nile wasn't only a source of great mythology. It was a significant scientific site, by which ancient Egyptians created their Calendar. The rising of the Sirius star towards the East was the sign of the Nile Flood, namely on August 15th of the m...

study.com

Egypt's Three Predictable Seasons - Video & Lesson Transcript | Study.com

Reliable seasons are very important to agricultural societies. Luckily for ancient Egypt, their three seasons were very consistent. In this lesson,...

www.egyptprivatetourguide.com

Facts about ancient Egypt culture, flooding of the Nile - Egypt Guide

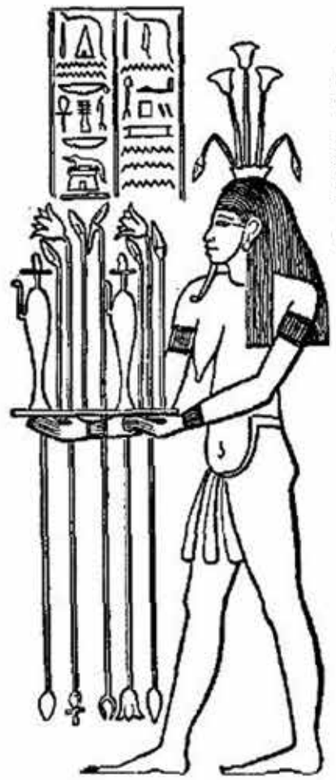
We have a lot of facts about ancient Egypt culture, and now we are going to discuss Flooding of the Nile and Nile river picnics. The ancient Egyptian was...

www.nationalgeographic.com

Egypt's pharaohs welcomed summer with this fabulous festival

When the Nile flooded, Egyptians celebrated the feast of Opet, a joyous procession the carried statues of the gods from Karnak to Luxor....

Hapi (Nile God)



"Lord of the Fish and Birds of the Marshes" and "Lord of the River Bringing Vegetation"

he was worshipped as inundation began by making sacrifices and the singing of hymns

(pic: bondi icebergs)

Flooding meant celebration, and also a change in work life/pace
Akhet - Peret - Shemmu

Every year ancient Egyptians eagerly anticipated the coming of Akhet, the flooding season. Meaning "inundation," Akhet was the all-important time when the Nile's floodwaters replenished the land and restored Egypt's fertility.

The River Nile wasn't only a source of great mythology. It was a significant scientific site, by which ancient Egyptians created their Calendar. The rising of the Sirius star towards the East was the sign of the Nile Flood, namely on August 15th of the modern calendar, and the flood was in turn the beginning of the new ancient Egyptian Year.

The ancient Egyptian year is divided into three seasons: flooding, planting and harvesting, each taking four months. Due to the importance of the Nile flood, ancient Egyptians created two Nile-meters to measure water levels in Aswan.

According to ancient mythology, the Nile flood is none other than the tears of Isis, who was mourning the death of her beloved husband Osiris, whilst trying to put together his body parts that were shredded to pieces by his evil brother Seth.

This date also commemorated the marriage of the ancient Egyptian Gods: Amoun (creator deity, often affiliated with the sun), Mut (mother goddess) and their son Khonso (moon god).

On this occasion, Egyptians have never thrown a human sacrifice into the Nile (often referred to as the 'bride of the Nile'). On the contrary, they would send wooden dolls of Amoun, Mout and Khonso, as well as the current Pharaoh, and let them sail to Karnak against the tide so they would reach the source of the Nile (the origin of the flood) as a gesture of gratitude, respect and hope for the sustenance of prosperity.'

Today, and as their great ancestors did, Egyptians still celebrate the Nile Flood day, as they prepare boats designed in Pharonic style, sailing on the river waters, with flowers, joyful chants and dances, colorful costumes, thanking their great river for his loyalty, and promising the same in great love.

Future of Flooding
Not To Scale

Flood Relief Registration - Familiar Inconvenience

Positive

Anything that could float would do and for this boy a giant pot was the answer (Source: *New Nation*, Monday December 4, 1978, pg. 1)

Negative

Call it what it is: Flooding

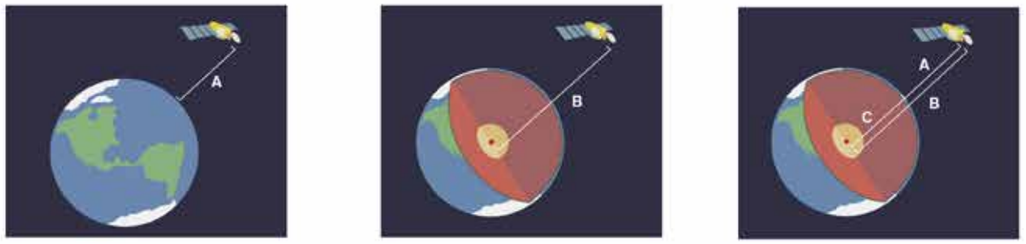
Address 'ponding' issue honestly and transparently

Positive and Negative Social Connotations of Flooding
Not To Scale
Recent Past - Present

SEA LEVEL MITIGATION & TECHNOLOGIES

Research Report

How is Sea-Level Measured?

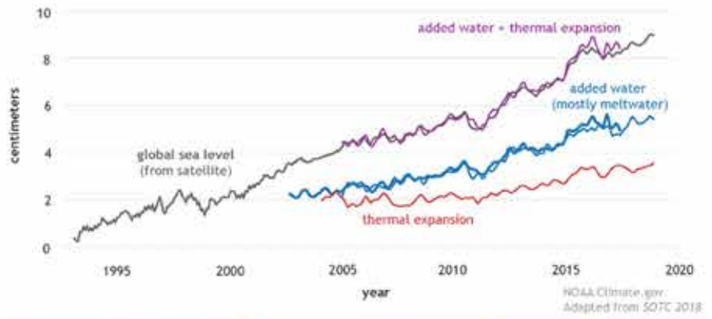


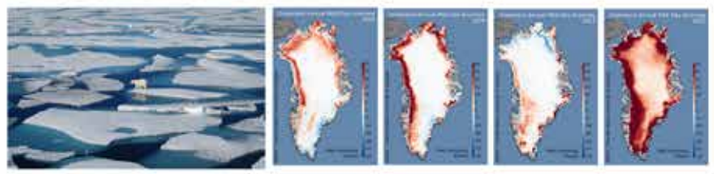
NASA's Jason-3 satellite carries an instrument called a radar altimeter. It uses radio waves instead of a ruler to measure distances.

Here's how it works. Jason-3 bounces radio waves off the ocean surface. The satellite then times how long it takes for these signals to return. Scientists can use this measurement to calculate the distance between the satellite and the ocean surface in that particular location.

By subtracting the first distance (between the satellite and ocean surface) from the second distance (between the satellite and Earth's center), we can calculate the distance from the ocean surface to Earth's center. The satellite constantly zips over new portions of the planet. In about 10 days, it measures ocean height over the entire Earth. Finding an average of all those measurements gives an average sea level for the whole planet.

Contributors to Global Sea Level Rise



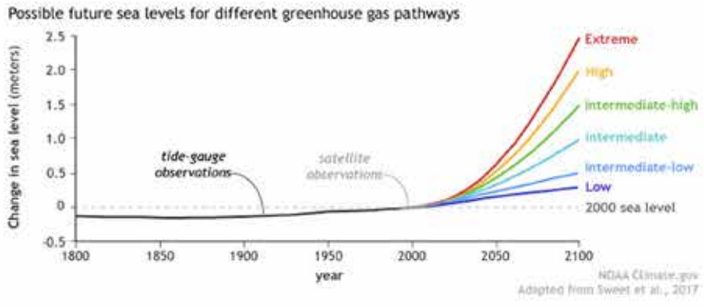


Sea Level rise occurs when seawater volumes expand due to increase sea surface temperature.

Other contributors are the melting of the world's glaciers, climate change and global warming. Other factors such as ocean dynamics, local land motion and gravitational changes do affect sea level rise.

If all of Greenland is melted, it will contribute 6m to sea level rise whereas for Antarctica, it will be 60m. The sea level near the equator/ Southern hemiphere would increase. This is called the displacement of mass. Hence sea level rise is a serious issue which requires collective planning and implementation between countries. Sea level rise is not uniform and varies regionally and at differnet time scales. On average, te 20th century global sea level has been rising at a rate of 1.2mm to 1.9mm per year.

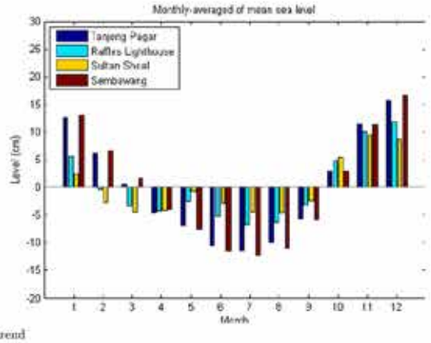
Estimating Singapore's Sea Level Rise



Singapore is particularly impacted by rising sea levels due to the gravitational-attraction impact exerted by melting ice sheets. This refers to the effect of higher sea level rise in areas that are located further away from ice sheets due to the reduced gravitational attraction on ocean waters that are in closest proximity to the melting ice sheet.

Between 1993 and 2009, the rate of increase of the mean sea level around Singapore was almost 2 times higher than the global sea level (up to 4.6 millimetres per year around Singapore as compared to 2.8 millimetres per year globally for the same period).

Estimating Singapore's Sea Level Rise (cont.)



Sea level in Singapore is measured using tide gauges,satellite and buoys. Since 1993, the beginning of high precision satellite-based records, the global average sea level has risen at a rate of about 3.24mm per year and has researched the highest level of about 90mm in 2019. The impact of Greenland and Antarctic ice sheets on sea level rise will be felt 30% more near the equator than anywhere else due to the weakening of gravitational pull at the poles arising from ice sheet melt.

It is very tough to estimate/ speculate the year in which the sea level will rise to due to the factor of thermal expansion and global warming. However, we are able to estimate the impact areas of sea level rise based on the height of the sea and the elevation of our land to help us prepare for the vulnerable areas of Singapore.

Adapted from: Tkalich, Pavel & Vethamony, P. & Quang Hung, Luu & Babu, Madavana. (2013). Sea level trend and variability in the Singapore Strait. Ocean Science. 9. 293-300. 10.5194/os-9-293-2013.

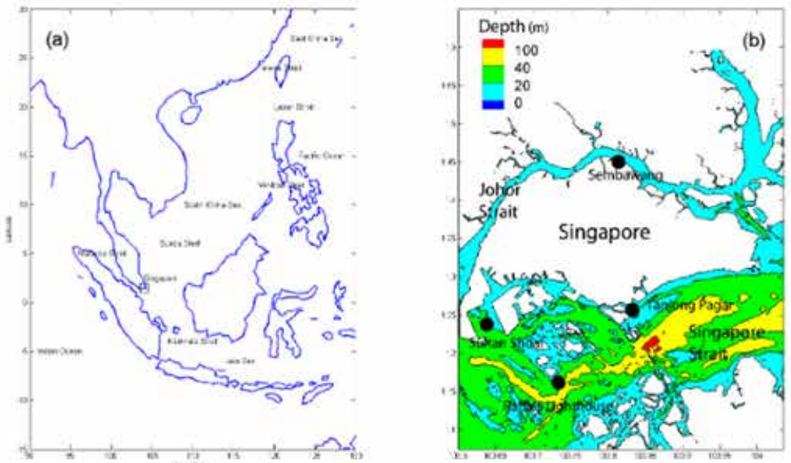
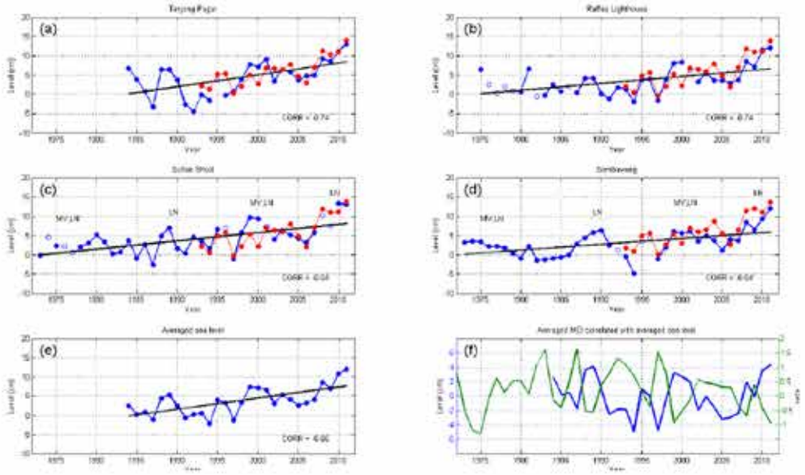
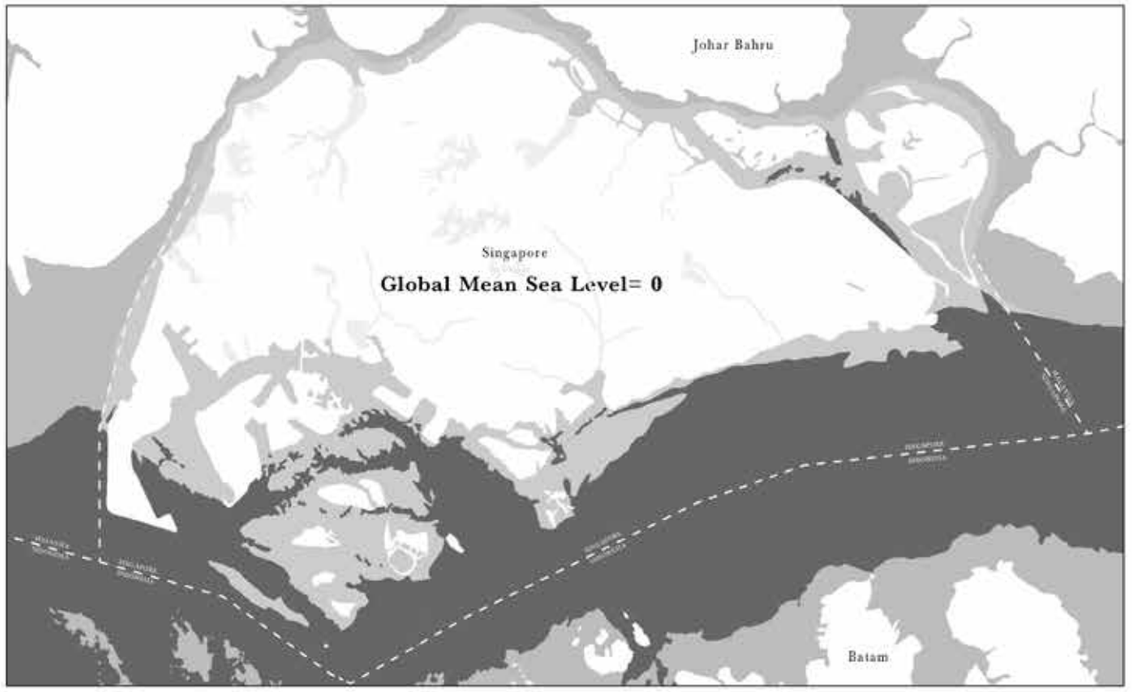


Fig. 1. **(a)** Study area. **(b)** The Singapore Strait and its vicinity (bathymetric contours are at 20, 40 and 100 m depths). Black symbols denote the locations of 4 tide gauges, namely Tanjong Pagar, Raffles Lighthouse, Sultan Shoal and Sembawang.



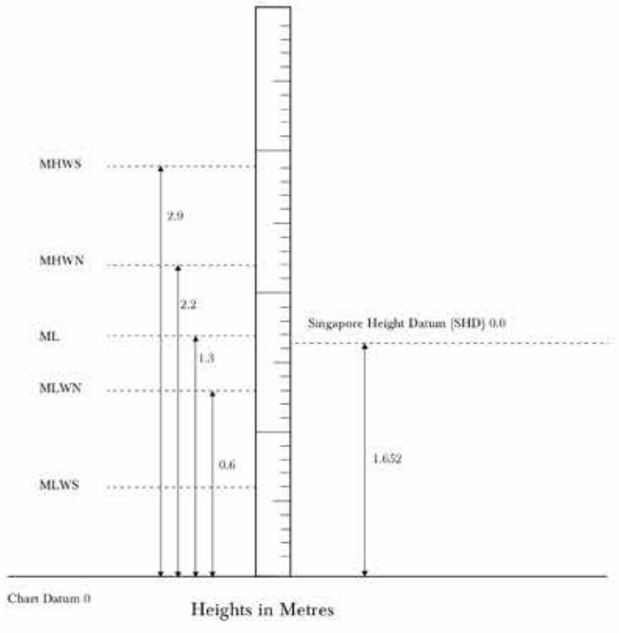
(a–e) Sea level at tide gauges in Singapore Strait (the zero reference level is adjusted to the beginning of the regression line): blue dot-line identify annual sea level at the tide gauges, with linear trend for the observation period identified by solid black lines; open blue circles indicate restored missing data; correlation of sea level and Multivariate ENSO Index (MEI) is shown for each tide record; red dot-line identify satellite altimetry for the SS region (AVISO). (f) Comparison of anomalies of average annual SS sea level (detrended, blue line) with yearly-averaged MEI (green line). Periods of sea level maxima due to multi-decadal variability and La Ni na episodes are indicated by symbols "MV" and "LN", respectively.

How much of Singapore's Land will be Affected over the next 100 years?



Vairables to be consider: Representative Concentration Pathways (RCPs), Estimated Increase Rainfall, Tides

Tide Tables



How is Carbon Emissions Calculated?

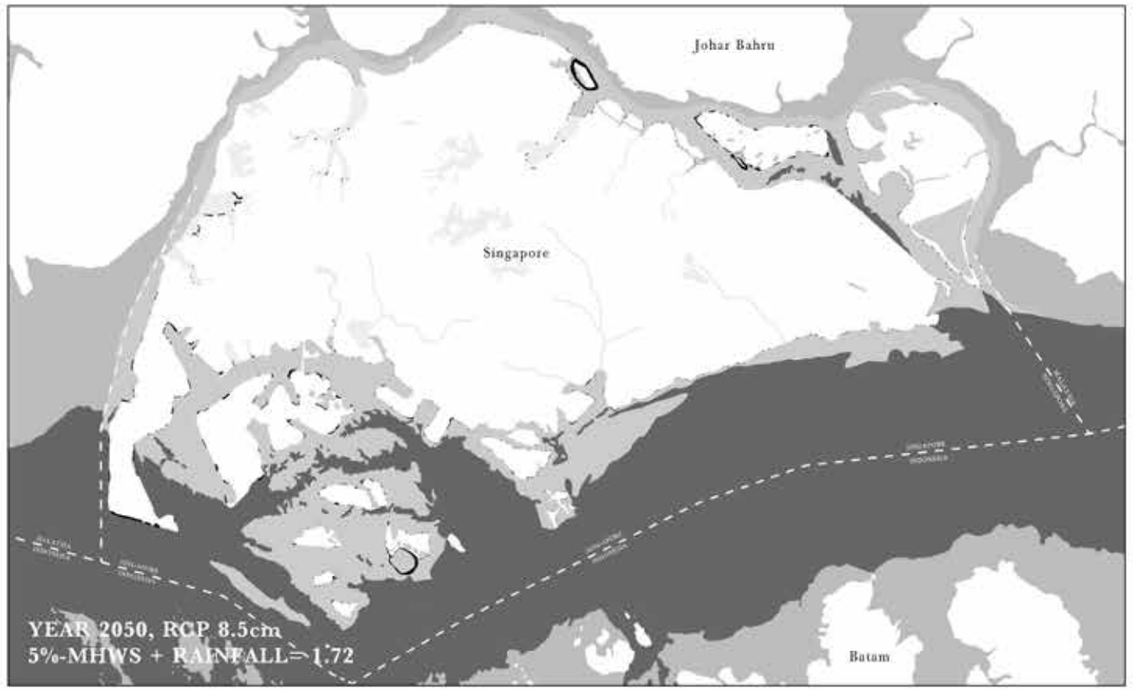
Table 1 Global mean sea-level rise projections (median, 17th to 83rd percentile range, and 5th to 95th percentile range)[a]

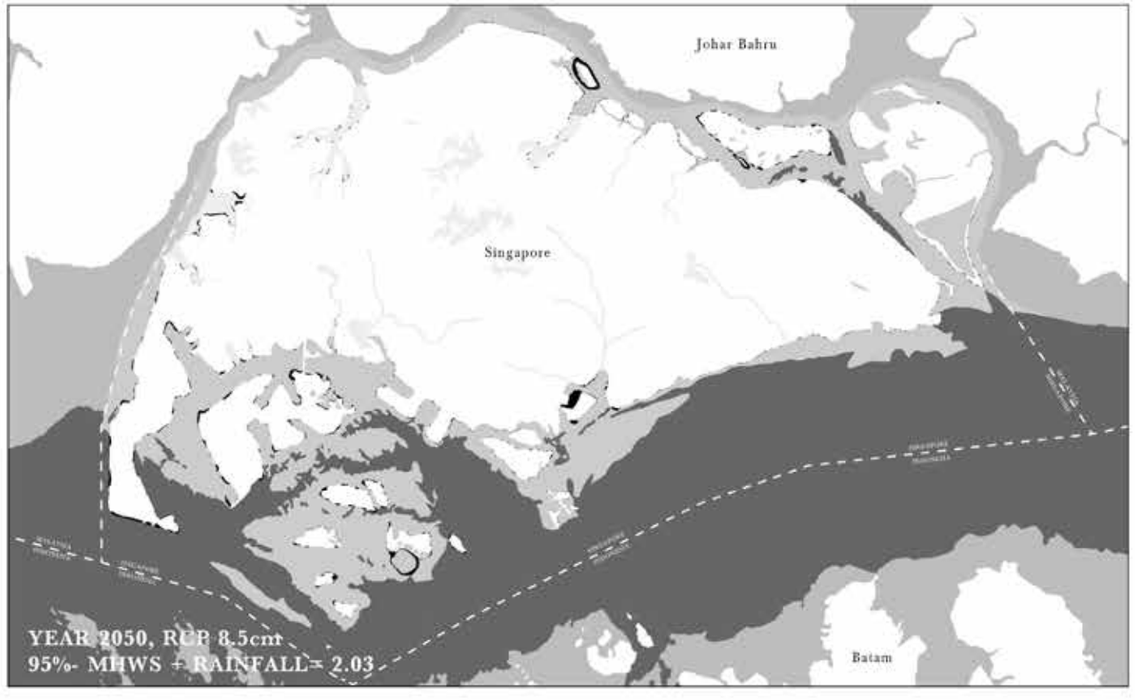
Year	Percentile range projections		
	50 (median)	17–83	5–95
	Probabilistic projections		
	Kopp14		
	RCP8.5		
2050	0.29	0.24–0.34	0.21–0.38
2100	0.79	0.62–1.00	0.52–1.21
2150	1.50	1.00–1.80	0.80–2.30
2300	3.18	1.75–5.16	0.96–7.37
	RCP4.5		
2050	0.26	0.23–0.31	0.18–0.35
2100	0.59	0.45–0.77	0.36–0.93
2150	0.90	0.60–1.30	0.40–1.70
2300	1.92	0.7–3.49	0–5.31
	RCP2.6		
2050	0.21	0.21–0.29	0.18–0.31
2100	0.50	0.37–0.65	0.29–0.82
2150	0.70	0.10–1.10	0.30–1.59
2300	1.42	0.32–2.68	–0.22–4.70
	Grinsted15		
	RCP8.5		
2100	0.80	0.58–1.20	0.41–1.81
	Jackson16		
	RCP8.5 High-end		
2050	0.27	0.20–0.34	0.17–0.41
2100	0.80	0.60–1.16	0.49–1.60
	RCP8.5		
2100	0.71	0.52–0.94	0.33–1.33
	RCP6.5		
2100	0.52	0.34–0.69	0.21–0.81
	Kopp17		
	RCP8.5		
2050	0.31	0.22–0.40	0.17–0.48
2100	1.06	1.00–2.09	0.83–2.41
2150	4.09	3.17–5.47	2.92–5.98
2300	14.69	9.00–14.09	9.13–15.12
	RCP4.5		
2050	0.26	0.18–0.34	0.14–0.41
2100	0.91	0.66–1.23	0.50–1.58
2150	1.72	1.13–2.72	0.90–3.22
2300	6.21	2.73–9.93	2.13–6.96

(Continued)

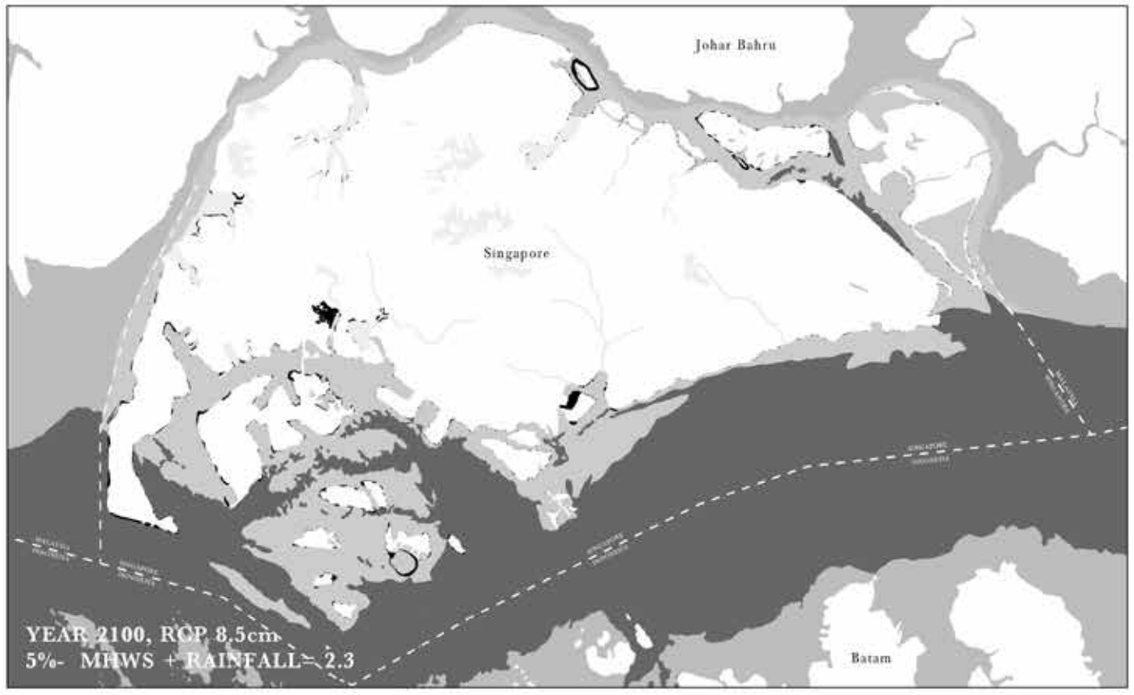
Sea Level Rise
Not To Scale

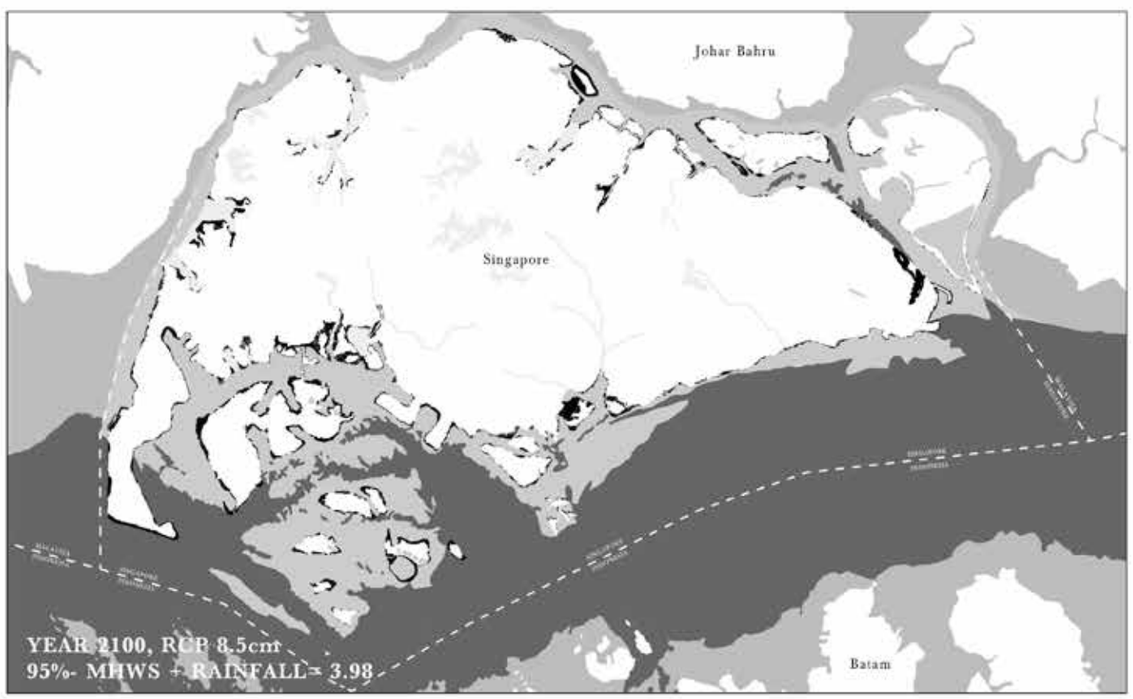
Evolving of Singapore's Coastal Land with sea level rise and rainfall





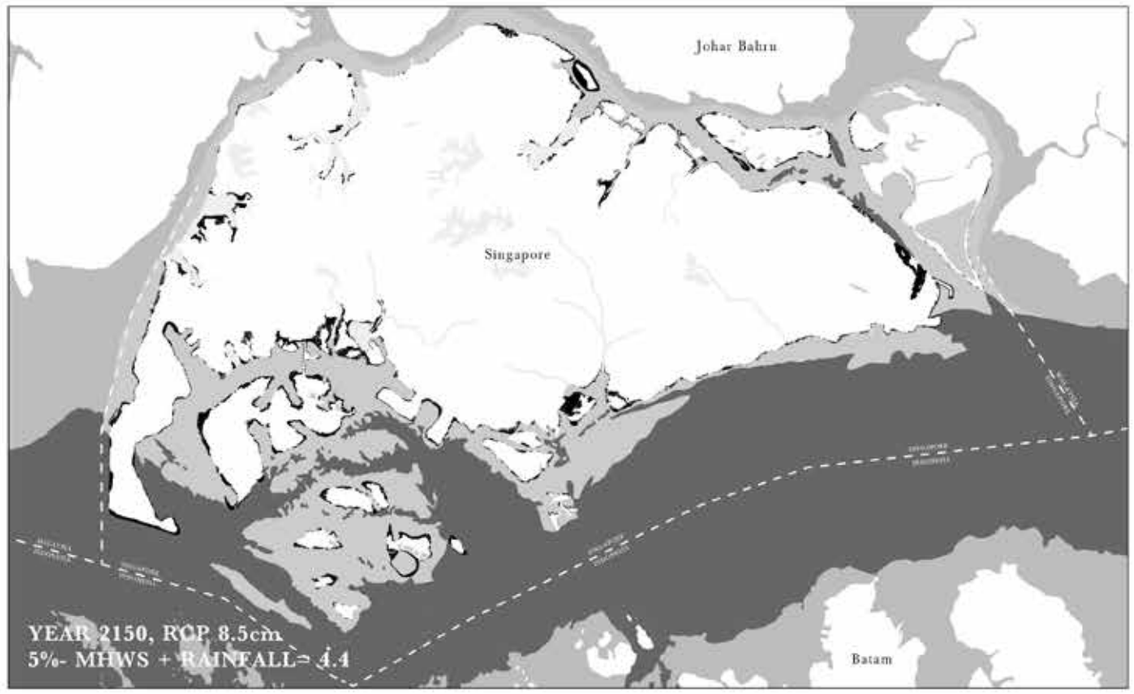
Sea Level Rise
Not To Scale

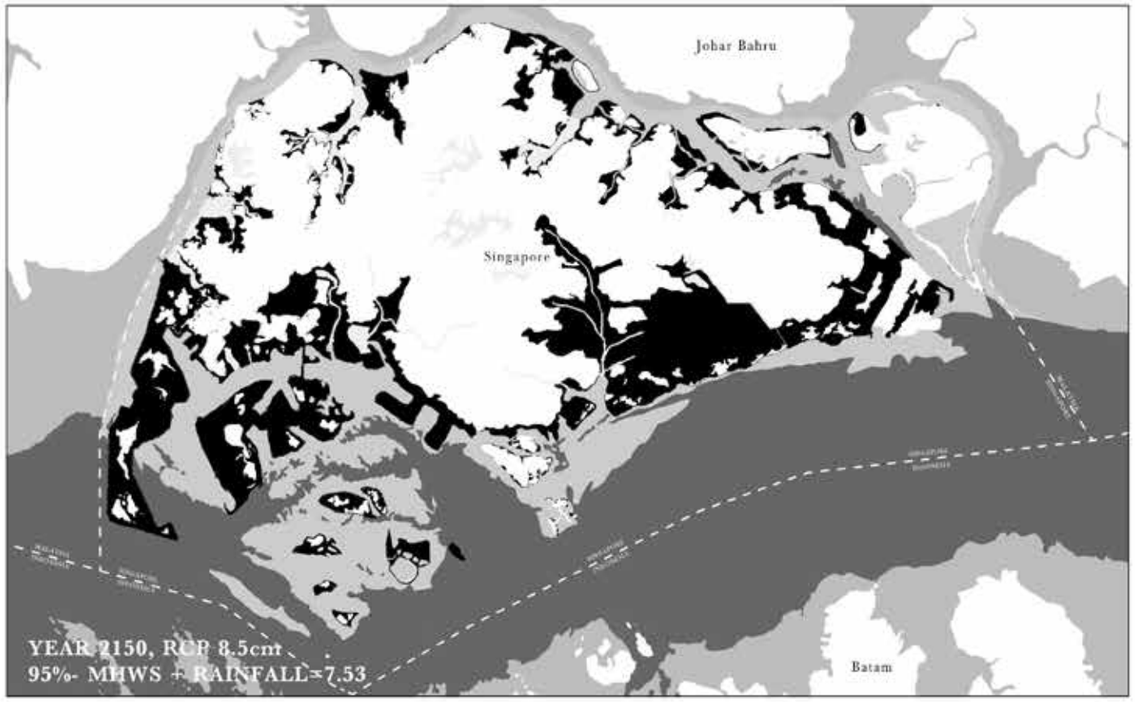




Sea Level Rise
Not To Scale

Evolving of Singapore's Coastal Land with sea level rise and rainfall





Sea Level Rise
Not To Scale

Options Research Studio AY 20/21 Semester 1
Studio Tsuto Sakamoto

Research and Analysis
Category: Techonology

Monsoons

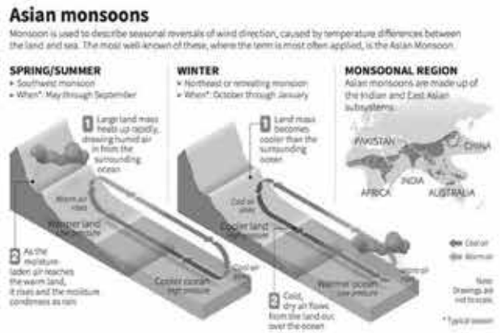
In Summer, the land is hot whereas the water is cold. Hence the cold and wet air rushes into the land, creating a breeze. Whereas in Winter, the land is cold and the sea is hot. The cold and dry air rushes out to sea.

Singapore's climate is characterised by two monsoon seasons separated by inter-monsoonal periods. The Northeast Monsoon occurs from December to early March, and the Southwest Monsoon from June to September. The major weather systems affecting Singapore that can lead to heavy rainfall are:

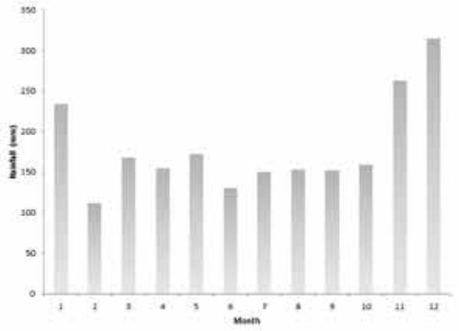
Monsoon surges, or strong wind episodes in the Northeast Monsoon flow bringing about major rainfall events;

Sumatra squalls, an organised line of thunderstorms travelling eastward across Singapore, having developed over the island of Sumatra or Straits of Malacca west of us;

Afternoon and evening thunderstorms caused by strong surface heating and by the sea breeze circulation that develops in the afternoon.



Annual average rainfall distribution from 1981-2010



Monthly rainfall in Singapore from 1981-2010

Rising Sea Levels

During the north-east monsoon - usually the region's rainy season for the year - sea levels can rise by up to 0.2m. During this period, winds blow into Singapore from the north-east or north-west. As these winds blow over the South China Sea, they gather moisture before dumping it as rain in the equatorial South-east Asia region.

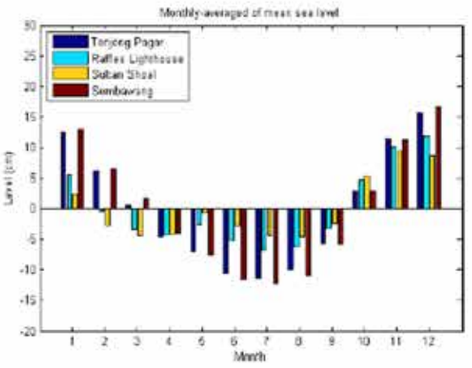
Effect of Climate Change on Monsoon and Rainfall

Warm Oceans

"The warming of the ocean's surface is likely to augment the amount of moisture the monsoon winds pick up.."
"If the ocean surface warms more rapidly than the land... this would narrow the temperature gradient that drives the winds, and so weaken circulation."
Put simply... 'Wet gets wetter' as a result of greenhouse-gas emissions. They predict, that is to say, that the moist monsoon lands will see an increase in rainfall."

Haze and Aerosols

"Aerosols absorb solar radiation, allowing less of it to reach Earth's surface. This cools the land, diminishes the temperature contrast between the land and sea, and weakens the atmospheric circulation that sustains the summer monsoon."
"Because of the way the Asian monsoon is linked to other parts of the planet's climate, it is possible that aerosols over South Asia have global consequences."
"Coupled with the impact of global warming on the ocean and the atmosphere, the instabilities multiply."



Monsoonal and seasonal influence on sea level variations (monthly sea level anomalies)

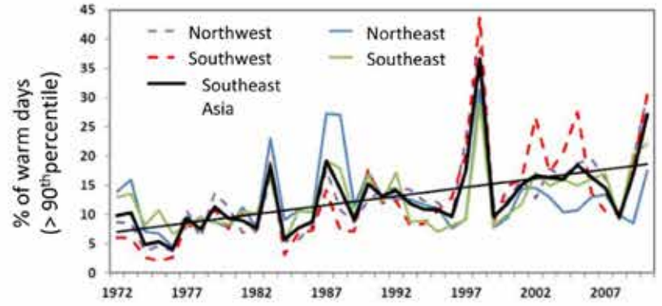
Increased Rainfall
Not to scale
Monsoon seasons and its impacts

Increasing Temperatures

Long records of observation weather stations show uptrends in extreme temperature (5-10% increase/decrease) and rainfall (50-100mm/decade).

However, trends for temperature are masked by year - on - year variability due to natural drivers, such as El Nino.

These temperature changes are due to larger-scale GHG emissions and the local "heat island" effect directly resulting from Singapore's urbanisation. Replacing Singapore's natural forests and mangroves with buildings and other infrastructure results in built-up surfaces retaining or producing considerable amounts of heat.



Rainfall anomaly map shows Singapore experiences wetter weather during the Southwest monsoon

Generally, the region is expected to be warmer with stronger warming over land. Singapore will experience more days with heavy rainfall. However there are drier and wetter conditions predicted in different parts of the region. In Singapore's region, the wet season will get wetter and the dry season will get drier.

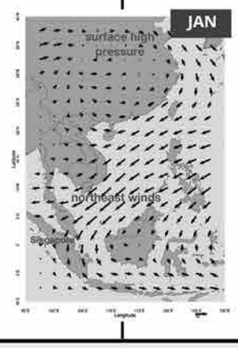
Unlike the temperature, Singapore's average total annual rainfall of about 2.4m has not changed substantially in the long-term record since 1869.

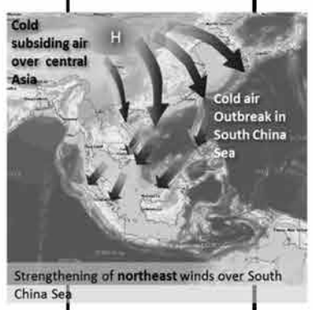
In future, climate change is not expected to alter total annual rainfall for Singapore. However, in the medium term of the next 30 years, changes to rainfall patterns, both in the excess and lack thereof, will be an issue.

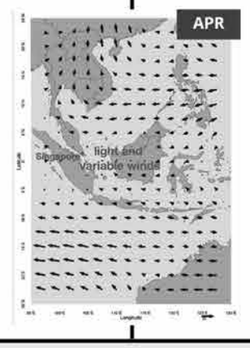
First, intensities and frequencies of local rainfall events have significantly increased over the past 30 years. Second, periods of meteorological drought, in which monthly rainfall is consistently below average, have recently been more intense for Singapore and Johor.

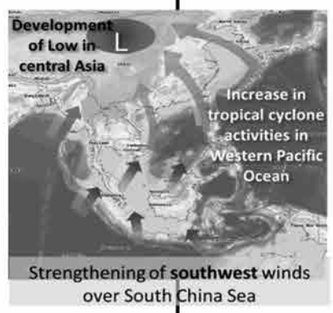
Increased Rainfall
Not to scale
Wetter wets and drier dries

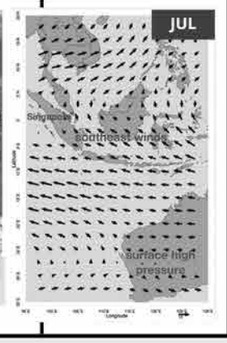
JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER











RAIN

Wet Season
(Oct - Jan)

Relatively Dry Period
(Feb - early Mar)

Inter-Monsoon Period
(Late Mar-May)

Seabreeze Thunderstorms
As air rises over warm land, cool and wet winds are brought in from the sea. Seabreezes are more common during inter-monsoon periods, when prevailing winds are light.

Southwest Monsoon
(Jun - Sep)

Sumatra Squalls
It is an organized line of thunderstorms that form over Sumatra Island or the Straits of Malacca, moving eastward towards Singapore under the influence of southwesterly or westerly winds. It typically occurs in the Southwest Monsoon and inter-monsoon periods. It usually affects Singapore overnight or in the morning. Often, a strong gusty surface wind of 40-80mk/h and 1-2 hours of heavy rain as they move across.

Wet Season
(Oct - Jan)

WIND

Northeast Monsoon
(Dec - early Mar)

Dec - early Jan
Widespread continuous moderate to heavy rain is experienced with winds of speed 25-35km/h.

Late Jan - early Mar
This period is windy and relatively dry in the later part of the season

Inter-Monsoon Period
(Late Mar - May)

Late Mar - May
Surface winds become relatively light, it is a relatively dryer inter-monsoon period and hot afternoon winds are common

Southwest Monsoon
(Jun - Sep)

Late Mar - May
Surface winds become relatively light, it is a relatively dryer inter-monsoon period and hot afternoon winds are common

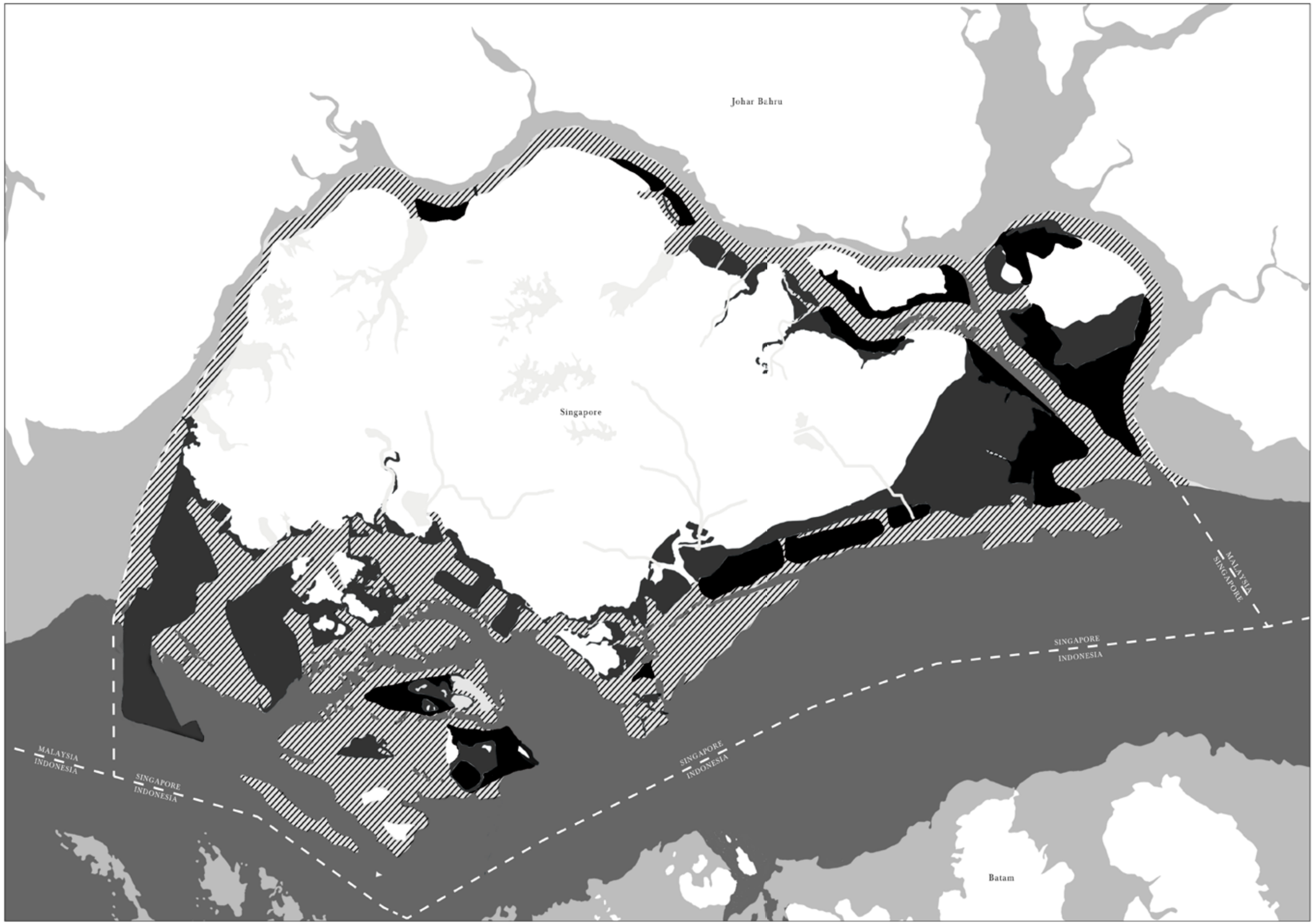
Inter-Monsoon Period
(Oct - Nov)

Oct - Nov
It is a relatively wetter inter-monsoon period. Rainfall begins to increase, peaking in December

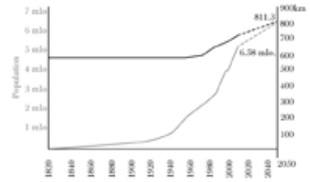
Northeast Monsoon
(Dec - early Mar)

Dec - early Jan
Widespread continuous moderate to heavy rain is experienced with winds of speeds 25 - 35 km/h

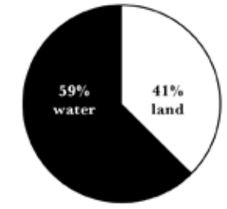
Increased Rainfall
Timeline of monsoon periods in Singapore



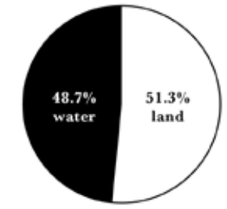
2050 Population vs Land Area



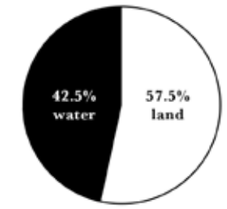
Land VS Water



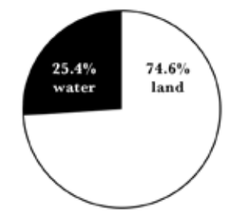
1820



2011



2050



Potential

Singapore has expanded its land territory by 25 percent since its founding. Land reclamation took place under the British colonial rule and increased tremedously after Singapore became an independent state. Since then, Singapore has ran out of locally sourced sand and fill material which resulted in the increased demand in imports for land construction. This soil trade has caused environmental, social and political problems between countries. The irony of government reference of "land reclamation" is that the new land built was not existed previously.

Legend

Reclamed Land | Planned Land | Sea Depth <20m (outside SG) | Sea Depth <20m | Sea Depth >20m

Claiming Land from the Sea (Singapore)
Not To Scale

Options Research Studio AY 20/21 Semester 1
Studio Tsuto Sakamoto

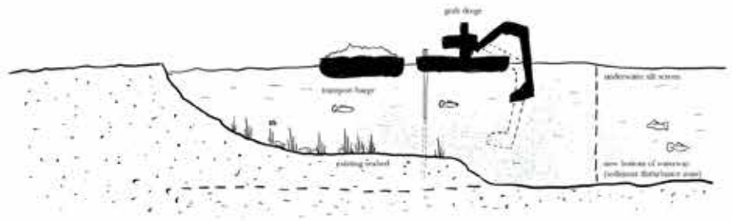
Research and Analysis
Category: Techonology

"Dredging" (Sediment Removal Process)

1. Disturbing of underwater sediments which would affect flora and fauna. Eventually, chemicals and bacteria that is accumulated in sediments will react and affect the surface of water.

2. Pollutants that are discharged affect the fishery resources and marine environment.

3. Human health will be in danger when the contaminants of water is consumed.



Traditional Process

'Drag'

'Drop'

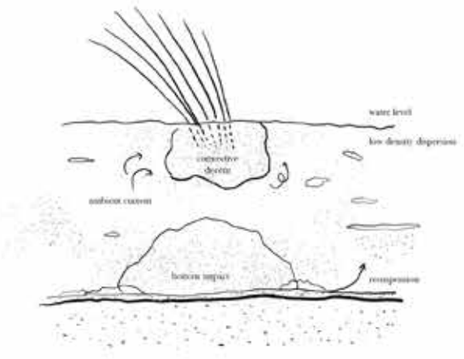
'Fill'

Sediment Spill

1. Release of sediments to the environment during disposal of dredged material. The material released becomes resuspended and will be transported by the currenet.
(over sedimentation/ sedimentation spill)

2. Sediment released are visable as plumes/clouds of sediment in the water column/ close to the water bed (Mulky water)

3. Result in environmental impact:
- shading of sea grasss, coral reefs
- additional release of nutrients and risk of algal blooms
- reduced water quality
- return of disposed sediment into harbour basins/channels



Conventional Land Reclamation
Not To Scale
Getting our hands on sand often results in irrevocable repercussions, some worst than others

Locally Sourced Fill Materials

Flattening of Singapore's hills (Case Study: East Coast)

Source: National Archives of Singapore

Newly Reclammed East Coast

Regarded as " The Great Reclamation", the East Coast reclamation project is Singapore's largest reclamation project. This brought many controvocies as many thought this development of such scale is impossible to be built using only located sourced materials. A pilot project was set out for Bedok's and Tampines' hills to be the sources of fill materials. Both areas became a flat land after the hills were cut into the earth using bucket wheel excavators before being transported b a conveyor belt to be dumped into the areas marked for reclamation. The reclamation of East Coast not only expanded in land but also added a new body of water within Singapore, Bedok Reservoir. According to government records, East Coast Park was a gift for the people. However, a few rogue NUS academics state that the land reclamation technique that was implemented in the area was imperfect; if developments were built on it, the gound would have turned to mush. Overtime, one of the breakwaters which was thought eruded was actually a natural coastal formation as the initial reclamation of East Coast Park hadn't properly modelled the beach against the flows of the tide, so the tide picked up the slack, and formed the beach properly.

Marine Parade was the first HDB that was completely built on reclamed land completed in 1973. Most people were relocated from Kampong where the dwellers were living in bad conditions without plumbing or electricity and under constant threat of flooding and fire. Resettled Kampong dwellers though that the flats would fall back into the sea, saw cracks in the pavement as a sure sign of doom.

Flattening of Singapore's Hill for fill materials

Large Conveyor belt used for the transportation of materials from the hill to the development

Marine Parade

Dredging at the Straits of Singapore

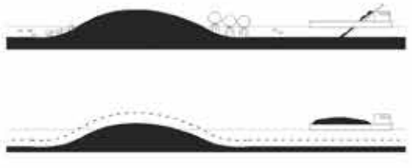
Nipah Case Study (Dredging within Singapore Waters)

Source: Architecture of Territory

Palau Nipah in July 2003

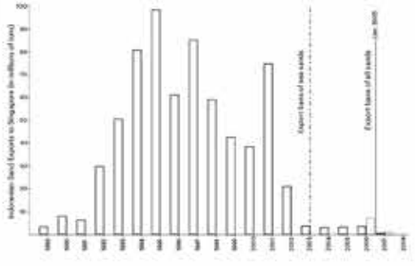
Palau Nipah in May 2008

Massive dredging in the straits around the Indonesian Riau Archipelago has diminished sea bed stability and caused some smaller islands to crumble into the sea. Palau Nipah is one of Indonesian islands which was used to calculate the international border with Singapore. By 2005, it was so depleted that it barely broke the water surface at high tide. Indonesia, fearing that the border could be recalibrated to Singapore's advantage rebuilt the island over the next years.



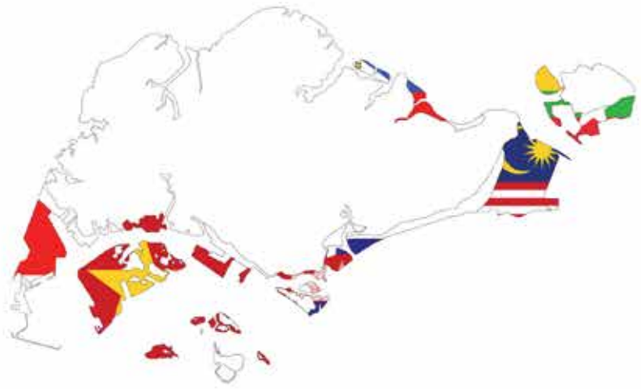
Dredging the sea bed

Erosion, destruction of mangroves, corals and fish spawning grounds



Locally Sourced Fill Materials
Not To Scale
Getting our hands on sand often results in irrevocable repercussions, some worst than others

Trade Ban & Territory



Source: Architecture of Territory

Trade Bans in Effect (2010)

Export bans are passed for different reasons, as each nation has a different relationshi with Singapore. The early Malaysian and Indonesian bans were due to political disputes and the ban in Cambodia was the result of public pressure over environmental concerns.

Source: Mothership

Cambodian Environmental Activist protesting over sand trade

Cambodian Dredging for sand trade to Singapore

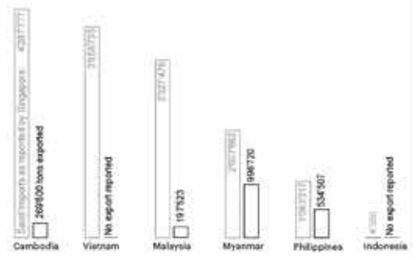
Export Bans

- All natural sands
- River sand only
- No export bans

Source: Architecture of Territory

A Global City Built on Foreign Soil

Singapore has been expanding their land rapidly where the issue of sand exploitation has gone from a local to a regional scale problem. Early land reclamation projects occured in areas in shallow foreshore and swampy inland areas. As local sources were depleted, dredging operations expanded into the Straits of Singapore creating tensions with neighboring countries. Trade with Indonesia and Malaysia reached to the extent that islands began to disappear due to erosion which led to the banned export of natural sands to Singapore. In order to replace these suppliers, Singapore expaned the radius to other unspoiled sources for willing trade partners. The trade with Cambodia have led to many controversial issues such as illegal trade which caused unhappiness between Cambodian environmental activist.

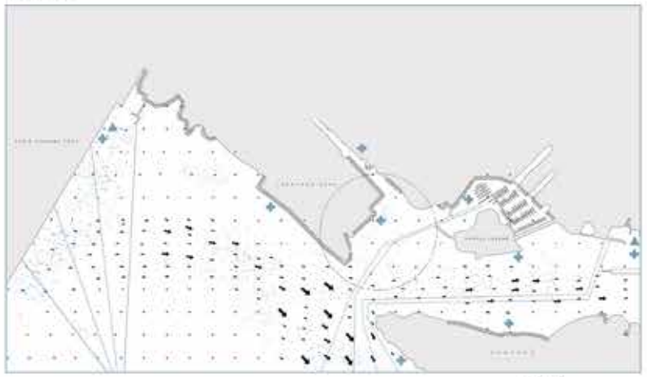


Trade Bans (Singapore with other regions)
Not To Scale
Singapore's land literally comes from its neighbours. till this day, despite several exportation bans, is the main source of sand supply for land reclamation projects

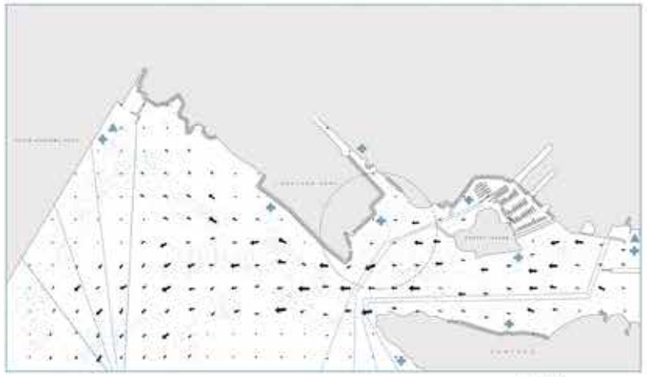
Case Study: Labrodor Park

Environmental Impacts of Land Reclamation

HIGH TIDE



LOW TIDE



Disruption of the food chain

Sediments in the water do not allow plants to survice as sunlight is unable to penetrate the cloudy water surface. With a decrease in the amount of plant means a decrease in the amount of food for the organisms down the chain. Similarly, the loss of coral reefs which serve as a form of shelter threatens the survival of these reef organisms.

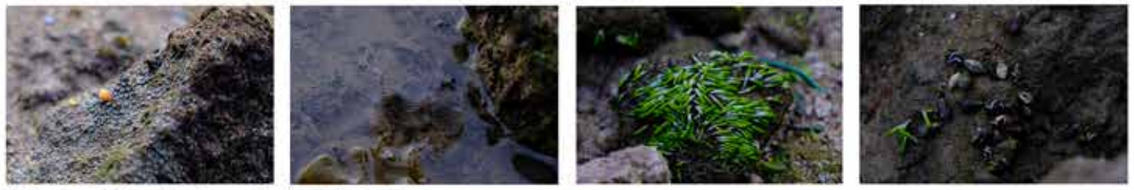
Decrease in quality of water

Land reclamation also changes the quality of the surrounding areas of water. Material used causes the water to be more acidic, and certain organisms are unable to adapt to this environment. Sediments do not allow sunlight to pass through preventing photosynthesis to happen. This upsets the oxygen-carbon dioxide levels in the water, making it hard for organisms to survive. Additionally, the loss of mangrove forest whose roots help trap sediments and other impurities would mean a natural filter is lost.

Loss of coastal ecosystems

The most grave impact of land reclamation is the loss of ecosystems. When these ecosystems are destroyed, it is very hard to bring them back. There is only a limited number of existing organisms and wildlife in Singapore. Clearing over 90% of mangroves that previously existed to build new residential areas would never grow back. Clearing of mangroves also risk coastal erosion and rising sea levels.

The Rocky Shore (Area that was untouched by Land Reclamation)



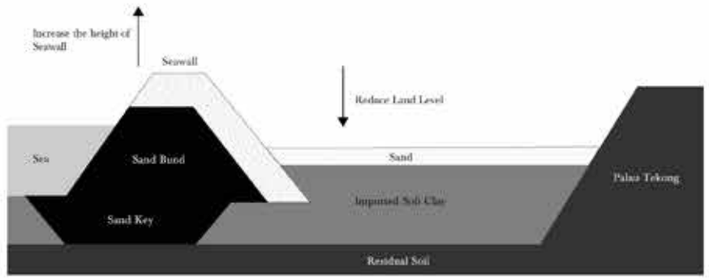
The Remains of Rocky Shore (Area that was touched by Land Reclamation)

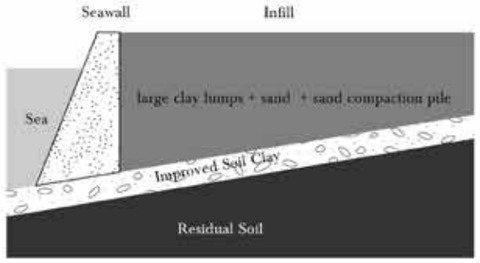
Environmental Impact of Land Reclamation
Not To Scale

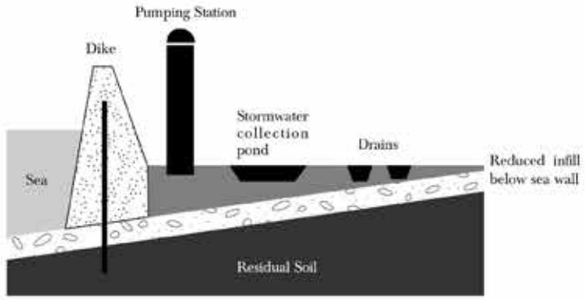
Project Case Study: Palau Tekong

Agencies Involved: HDB, Surbana Jurong, Royal Haskoning DHV

Singapore adopted the Dutch concept as a new method for Pulau Tekong. It is a cost-saving method which involves creating a tract of reclaimed land from the sea by constructing dike and a network of drains, water pumping systems and canals. A polder is a tract of low land, below low tide level. It is protected from the sea by a dike. The polder development has a comprehensive water management system, comprising a network of drains, a water body and 2 pumping system. The drains will channel the rainwater to the water body for storage. The central pumping station will circulate water in the drains to ensure good water quality. In order to keep the land dry, the drainage pumping station will pump the excess rainwater to the sea when the waterbody is full. The dike measuring 10km long, up to 15m wide and will stand 6m above sea level.







Screen or wall to minimise seawater seepage

Conventional Land Reclamation (Existing)

The first tests using large clay lumps as fill material started in 2001 at Pulau Tekong. Because of the sizeable voids between the large lumps, the upper part of the fill still needs to be made of sand. Additional sand is then piled on top to create enough pressure for the voids to close. A lot more infill materials is needed.

Land Reclamation by Polder (New Phrase)

Unlike the conventional method of infilling with sand, it reduces the amount of sand needed for land reclamation.
The involved agencies will carry out an environmental study to evaluate potential impacts of the reclamation method on the surrounding marine environment and the study was found minimal.

Palau Tekong under Construction

The dike is built at the perimeter of the planned reclamation boundary first and the water must be pumped over the dikes and then infilll with sand.

Artist Impression of Palau Tekong

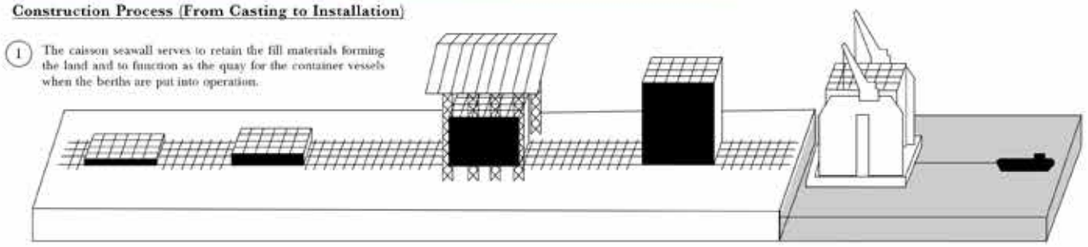
Polder Land Reclamation Concept
Not To Scale
Singapore attempts to experiment and learn hands on through their first venture into the polder process on tekong island. this will serve as the very first test bed

Project Case Study: Pasir Panjang Port

Pasir Panjang Terminal Phases 3 and 4 are being built in a way which increases efficiency and productivity while reducing environmental impact which serves as a prototype for the upcoming Tuas Port.. An alternative landfill material such as excavated earch from land construction proects were used instead of sand for reclaiming some 198ha of land off the Pasir Panjang shore. It was the first time that caissons were implement. Large caissons were used to build the sea wall and wharf structure instead of traditional piling methods. The 150 caissons used are concrete, watertight, retaining structures that sit on a foundation on the seabed and fabricated on site.

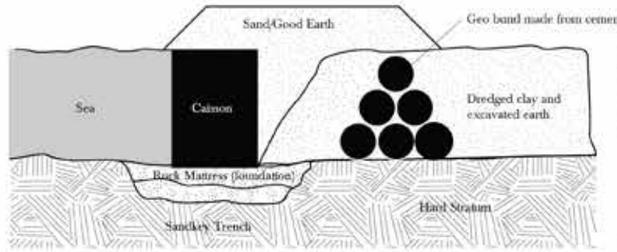
Construction Process (From Casting to Installation)

1 The caisson seawall serves to retain the fill materials forming the land and to function as the quay for the container vessels when the berths are put into operation.



Caisson Preparation (On Land)

2



Sea sand is used as main fill material. Alternative fill materials are used to redice the amount of sand required for landfill by 45%. Alternative materials include marine clay dredged from the sandkey trench and the deepening of fairways and basins, excavated earch from land-based developments (eg. road and rail projects) and cement-mixed soil.

Constructing of Seawall

Taking Care of the Environment

An Environmental Impact Assessment was carried out to investigate the impact of the reclamation before starting the project. The study determined that live corals at Labrador Nature Reserve affected by the land reclamation process be relocated.

Online monitoring of noise levels to meet regulatory limits

Floating Silt barricade was installed

Transplantation of live corals to Labrador Nature with 80% survival rate. Quarterly monitoring of coral reefs

Corals attached to rocks were harvested with hammers and chisels, while others are handpicked by divers.

The harvested corals were brought to the surface. They were covered in wet cloth and seawater to prevent them from drying out during the move. Divers then attached some corals to rock with epoxy cement, to prevent them from being dislodged by currents. Sturdier and free-living species were left on the seabed.

The health of the transplanted corals was monitored over the next nine months. Water quality and sediment conditions were also tracked.

Caissons (Seawall Construction)
Not To Scale
Singapore using the concept of Caissons in the seawall in hopes of acheiving its full efficiency for the next development- tuas port.

Netherlands Dike Typology

Sea Dikes

Systems of dikes that protect against coastal tide-level rise. Stones can be used as wave-breakers, and aslphalt can be used as revelment.

Often there can be multiple lines of dike defense. Secondary dikes are known as *Sleeper* and *Dreamer* dikes.

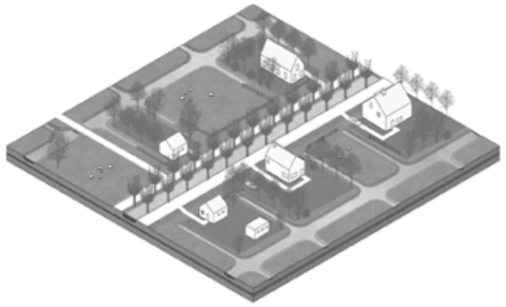
Dike System
Guardian—Sleeper—Dreamer

This strategy could be useful to reinforce existing shores in Singapore, as a way to 'harden' the shoreline against rising tides.

Polder Dikes

Polder dikes are effectively land reclamation, with a lesser need for imported sand. Dikes are formed around the circumference of a body of seawater near land, and the sea water is pumped out. The result is a reclaimed section of land that is below tide-level.

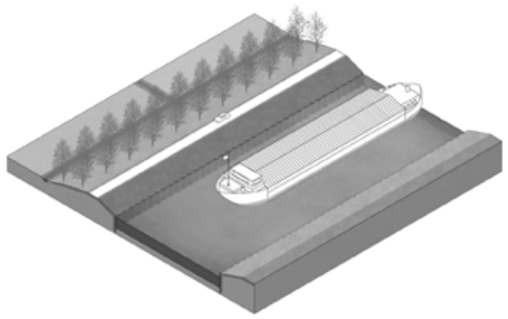
This is convered in greater detail in our study of land reclamation.



Canal Dikes

Canal Dikes flank the sides of canals, ensuring that they do not overflow in wet seasons. Artificial flood defense strategies are also implemented along these dikes, and they can be used as recreational spots for the public.

These could be helpful for our own canals and resevoir systems.



Netherlands Dike and Dam Case Studies

Maeslantkering

A storm surge barrier in South Holland for Nieuwe Waterweg canal. It consists of two 210m long barriers, which pivot to close the channel, with the width of 360m. One of the largest moving man-made structures.

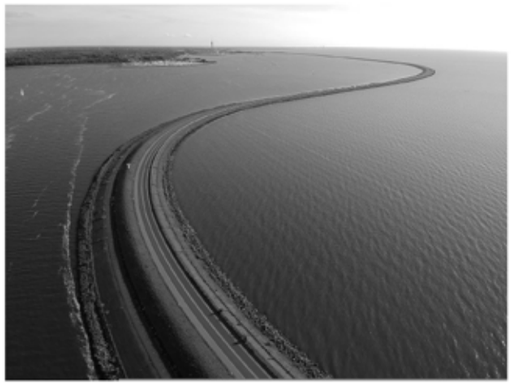
The large barrier doors are hollow, and are able to be filled with water to help them to sink and anchor. The curvature of the doors also allow water presure from the overflowing side to work with the 'closing' action of the doors.

For Singapore's context, not much aplicability apart from the canals. May be less effective for the open east coast. Also, very specialised engineering is needed to construct this.

May need to analyse singapore's meteorological and coastal context. During storms, where does the bulk of the flooding water come from? Is it the sea or the drains or somewhere else? Can the storm surge strategy be implemented there?

Houtribdijk

Houtribdijk is a dam road that connects the cities of Lelystad and Enkhuizen. It separates lakes ijesselmeer and markermeer with its 30km length of 68m width. From 2019- to mid 2020, reinforcements were completed, strengthening the dam with with sand and stone.

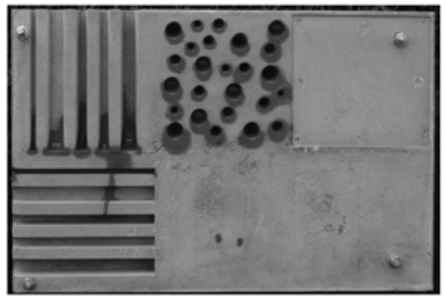


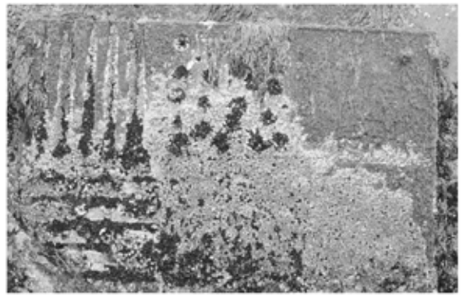
Long slender proflile allows a wide protection of an area from rising tides of a water body. However, this dam is in the context of a lake with flanking bodies of land, so may need to be adapted to address the open east coast. Use of sand at the coast may give rise toopportunities for human recreation or biodiversity.

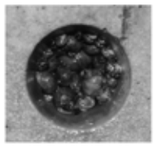
Netherlands Dike and Dam Case Studies

IJmuiden

Along the North Sea channel at IJmuiden, there is a seawall with unusual breakwaters. The breakwaters are outfitted with grooves and geometric shapes. The experiment was an investigation in 'eco-concrete', where grooves and geometric shapes could potentially provide the setting for coastal flora and fauna to grow.







The experiment proved successful. Though the grooves did not affect growth of surface-growing algae, they contributed greatly to the occurance of blue mussls and small periwinkles, as compared to the smoother surfaced breakwaters. Such biodiversity has positive impacts for the water and the coastline. Organisms can clean the water by removing nutrients from the sea, reducing free-floating algae. The propagation of biodiversity may also create biological havens for flora and fauna in the midst of a bustling city, and provide unique leisure and tourism opportunities. Such interventions can also be used in conjuction with 'sponge' and 'ABC Water' interventions as outlined in our other research.

After the experiment, new breakwaters were added which built on the original idea of using geometry and grooves to facilitate the growth of biodiversity.

Perhaps breakwaters per se may not be entirely applicable to Singapore, since our waves are rather tame. Will that change in the coming decades? Even if not, the use of grooves and the general idea of using geometry detail in ingfrastructure to facilitate biodiversity may be applicable along the east coast.

Dikes and Dams: The Netherlands
Scale NTS (A3)
Case Studies

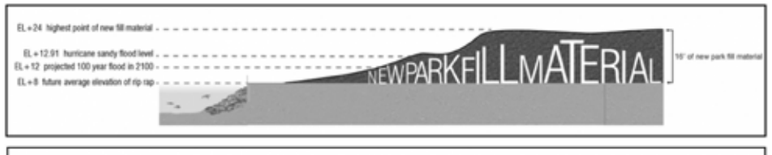
Elevating Above Tides - Case Study: NYC's Governor's Island

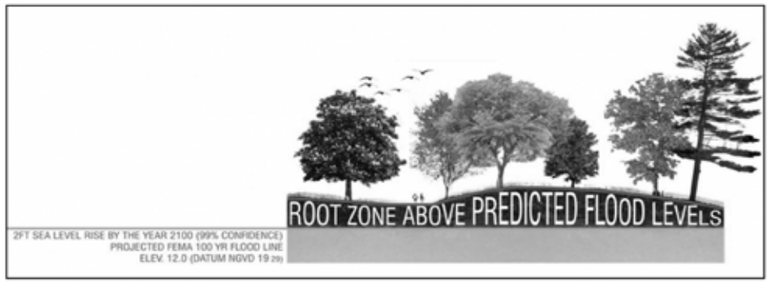
The Hills

The Hills, developed by West 8: Nearly 40 acres of land that became a series of hills. The topography was constructed from debris of old site, covered with jute mesh in what was called a "erosion control mat". These hills formed a natural barrier from the sea, being lifted, on average, about 15 feet (3.65m) above the current tide level. In addition, large amounts of flora were "overplanted", and were designed to be resilient, even against storms. Rocky sea walls and concrete seat edges at the base of the hills were also used to break up and oncoming waves and floods.

Before

After





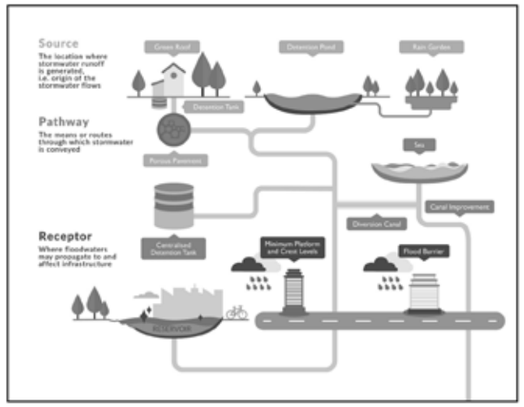
With regard to Singapore's context, such an intervention can only be executed for large-scale redevelopment of new areas. It is difficult to implement this in urban districts with existing residents and commerce, such as the East Coast and Katong neighbourhoods.

However, if implemented, it should be very effective in weathering storms and rising tides. Singapore already has such a strategy with new land reclamation: all future land reclamation projects are to be 5m above sealevel.

Elevating: NYC's Governor's Island
Scale NTS (A3)
Case Studies

Drainage: Singapore's PUB

The Public Utilities Board (PUB) in Singapore is gearing up to tackle the challenges of climate change, from more intense storms to rising sea levels. $500 milion has been slated for improvements to drainage infrastructure, and a new system of conceptualising drainage has been incepted. A subsidiary Coastal Protection Agency has been laucned as well, to delve into possible interventions to address the rising sea level.



Active, Beautiful, and Clean Waters (ABC)

Thinking about drainage systems in terms of source, pathway, and receptor is very closely linked to Active, Beautiful, and Clean Waters (ABC Waters), an initiative by PUB. We also cover this in our research on *sponge architecture*. To restate the point, using greenery and flora at each stage of source, pathway, and receptor may assist in 'sponging' heavy rainfall and runoff, allowing the entire drainage system to better cope.

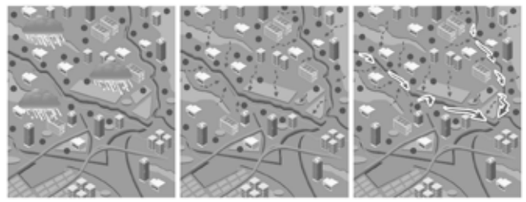


Fig. 2.5 ABC Waters management strategy

Fig. 2.6 Water levels in the canals if the ABC Waters management strategy is applied catchment-wide

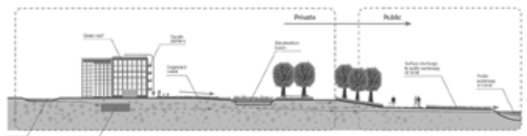


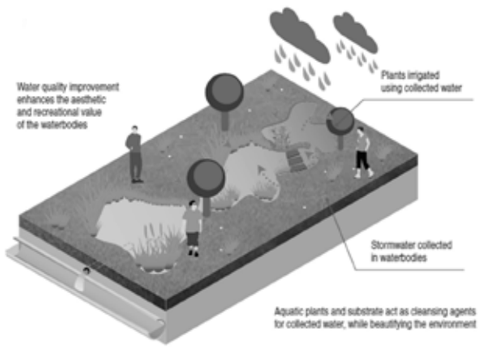
Fig. 2.7 An example of how ABC Waters design features can be integrated within a building development to slow down runoff

Source, Pathway, Receptor

Source: Interventions to slow down runoff into drainage systems: e.g. detention tanks, rain gardens bioretention swales.

Pathway: Drains and canals. Interventions involve mainly increasing its capacity.

Receptor: Such interventions involve the affected infrastructure themselves. e.g. minimum platform and crest levels, flood barriers.



Drainage: Singapore's PUB
Scale NTS (A3)
Case Studies

What is Sponge Architecture?

The Sponge City indicates a particular type of city that does not act like an impermeable system not allowing any water to filter through the ground, but, more like a sponge, actually absorbs the rain water, which is then naturally filtered by the soil and allowed to reach into the urban aquifers. This allows for the extraction of water from the ground through urban or peri-urban wells. This water can be easily treated and used for the city water supply.

Why is there a need?

Traditionally rainfall is siphoned through the ground into underground bodies of water however, as nations began to modernise, softscape was gradually replaced by hardscapes. This change, together with concrete drains have made storm water drainage harder to get rid off.
This has caused huge floods to occur within the cities, resulting in large loss of inventory as well as several fatalities.

Due to the demand for more land space to develop, the lakes have been shrinking over the years. This has lead Wuhan to suffer from one of the worst flood damage in 2016. Economy damage tallied at 2.3B yuan and 14 fatalities.

How is it implemented?

In countries like China and Netherlands, they have realised that instead of building walls up to block out water, they should give water space, absorbing it in before discharging it back out. There are two schools of thought: channelling water through softscape or programmatic landscaping.

Softscape: Ideally there needs to be contiguous open green spaces and ponds to naturally detain rainfall. Green roofs and facades are needed as well, to retain and filter the water before discharging it back to the ground.
Porous designs like bio swales and cleansing biotopes help to detain run-off water and promotes ground water infiltration. Porous pavements also help to funnel and recharge underground water.

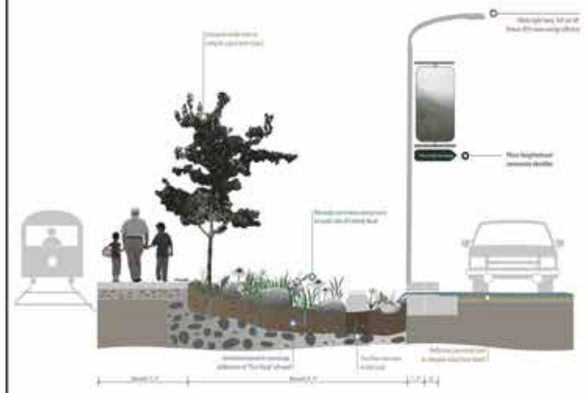
Programatic Landscaping: some designers have sought to not just create walls of concrete, but rather to introduce programme spaces into these infrastructures, further enhancing the space. The introduction of programme + infrastructure creates a duality in nature, where during the drier periods the spaces enrich their surroundings while during the rainy seasons, it becomes a water retention zone, elevating stress from the cities drainage system.

Sponge Architecture
Not to Scale

Case Study: USA, Chicago

Certain regions in USA are facing issues with flooding due to reapid urbanisation, where roads and concrete surfaces replaced soil and plants. This caused a break in the water's movement as they are now no longer able to be siphoned underground but funnelled across roads into drains. As climate change continous to deterioate, nations are facing storms and floods one after another. Chicago saw some of the worse floods when Hurrican Harvey hit, displacing 1 million people and resulting in 44 deaths.

Since 2006, Chicago has been undergoing some remodelling of its pavements. Dubbed 'Green Alleys', the city has removed its concrete sidewalks and replaced it with permeable pavements. The walkways are now lined with things like Bioswales and photocatalytic cement, which reduces carbon immission and acts as ecological drains. This swales help to actively filter and absorb polluted waters. Side walks are also filled with rocks and microbes which help to decontaminate the water before feeding it to neighbouring plants and water bodies.

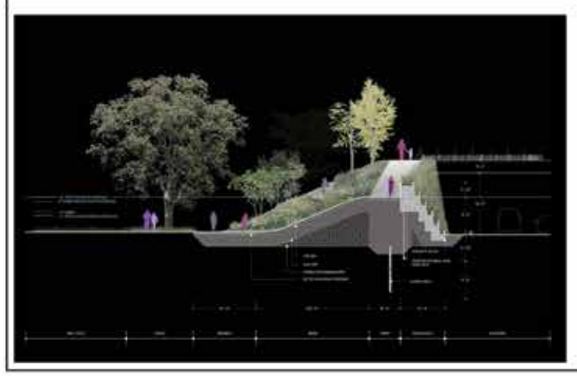


Case Study: USA, New York

5 years ago Hurricane Sandy struck New York, causing $19Billion in economical damage and 49 deaths. Due to its geographical location, New York City has multitudes of citizens that are living in high risk flood zones.

With 520 miles of coastline and thousands of acres of waterfront development, measures need to be taken so that future floods can be mitigated. BIG architects, in collaboration with others have created an urban intervention dubbed the "Big U'. This development seeks to combine existing infrastructure with new programmes, enhancing existing flood measures with new, organic ones.

Coastline developments are designed with parks that double up as splash zones, absorbing water before it can reach the inner parts of the city. This allows for the organic hydrological cycle to take place. Permeable surfaces drain run off water and bring it underground, away from the sewers.



Sponge Architecture
Not to Scale

Pros & Cons of Sponge Architecture

Pros:
- Cities can increase their greenery, biodiversity
- More green lands, water bodies, wet lands allow for water to sip through the soil and be stored in underground tanks
- Cleans up the air in cities
- Helps to lower temperature of immediate surrounding area
- Adds to the monetary value of the land
- Attracts tourists as it will not look like e conventional built up city
- Allows for a duality in city-scape

Cons:
- Retrofitting older cities might be harder to construct 'sponge sites' due to lack of space
- Older drainage systems in these cities might be worn out and damaged, need to replace
- VERY EXPENSIVE
- Takes time to change the mindset of developers that build up areas need to be more holistic and sustainable

PUB: Active Beautiful & Clean

As a peninsula nation, Singapore has recognised that she needs to take pre-emptive measures against rising sea levels and floods. Over the years Singapore has had flood issues due to overworked drainage systems. Combined with the need for self-sustaining water source, PUB launched ABC in 2006.

This movement aims at improving the water quality in neighbourhoods, while aiding in issues like floods. Bioswales and biotopes are added into the water bodies to act as natural filters, siphoning out any contamination from the surface run-off water before channelling them into the rivers.

These water bodies act as smaller retaining zones, easing the stress on our reservoirs during the monsoon seasons, preventing any floods from occuring.

Sengkang Water Front Park

Bishan-AMK Park

Jurong Lake Gardens

Sponge Architecture
Not to Scale

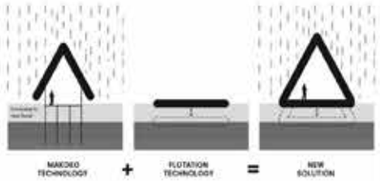
What is floating Architecture?

It is typically a building unit that has a floatation device that is attached to the base. It is often moored and unable to move by itself. Due to that, it is often towed into location by another ship.

Why is there a need for floating architecture?

Due to climate change, rising sea levels are a growing concern, especially to nations that are low laying. Additionally, due to rapid urbanisation, developed countries are running out of space for future developments. Our oceans cover about 70% of the earth's surface.

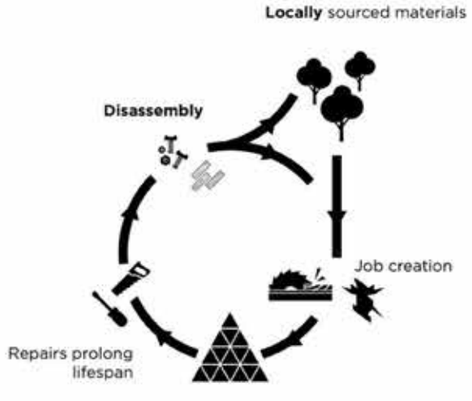
Instead of constantly piling and building into the ocean floor via land reclamation, floating structures offers a different perspective as it is not as damaging to the environment.



Pros & Cons of Floating Architecture

Pros:
- Resilient against rising sea levels, float instead of flood
- Replaces the lack of land space that smaller nations like Singapore might need for future developments
- Land can now be used for agriculture planting
- Smaller ecological footprint compared to land based architecture
- Changes the dynamics of how ppl interact w the water front now, as they are much closer now
- Allows nations that are often flood stricken to have a chance at escaping complete destruction
- Innovative/ Tourist attraction point
- Not as carbon intensive as traditional concrete
- Can be implemented anywhere with water
- Potential Disaster relief housing

Cons:
- Highly challenging, requires self-sustaining functions
- From an architectural stand point: it is site-less, doesn't respond to anything
- Political stand point: who's jurisdiction will the floating community be under
- Adequate technology required to float such a massive structure
- Very expensive
- Could endanger marine life if done wrongly

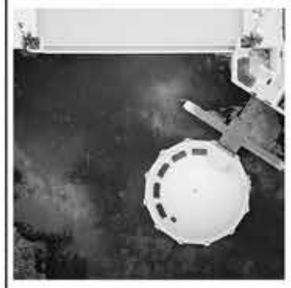


Sponge Architecture
Not to Scale

Case Study: Anthena Pod

A floating eco hotel in France, the Anthena Pod is one of the few hotels that is designed to provide their customers with a new expirience. The pod is powered entirely by solar power. Additionally, it addresses a lot of environmental issues like rising sea levels and ecological damage.

Using a bouyant base, coupled together with its sand screw anchor, the pod allows for users to expirience the marine ecology without damaging the sandbed. As it does not poses any motor, it requires a boat to bring it to its destination.



Case Study: Copenhagen Islands

Dubbed as a 'parkipelago', Studio Fokstrot has sought to create a new destination for Danish citizens to enjoy. Built with recycled floatation materials, the base is clad in steel and timber. The design introduces a completely new type of public park in Copenhagen, creating new gathering spaces, while still remaining in context with the global situation where rising sea levels are becoming a challenge for coastal habitats and recreational zones.

Apart from being a recreation zone above the waters, underneath the pods are growth zones for mollusks and seaweed. This new form of public spaces creates a new prototype for future resilient urban spaces, due to its flexible and sustainable nature. These nature pods will be positioned around the harbours, becoming catalysts for invigorating human activity.

Sponge Architecture
Not to Scale

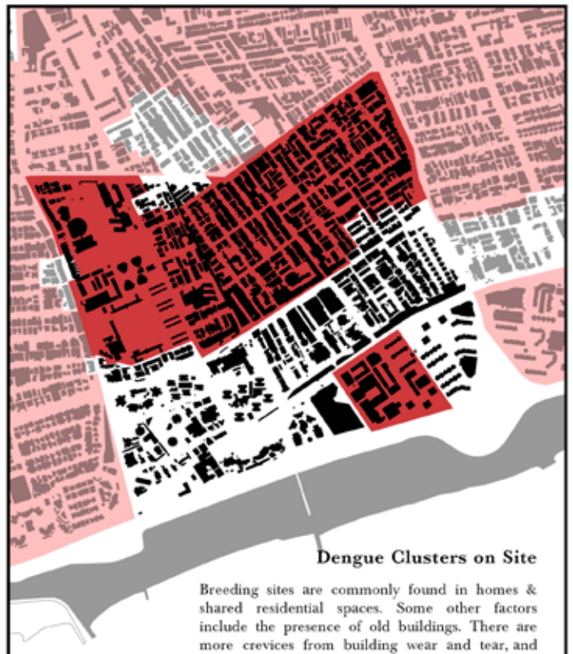
IMPACTS OF SEA LEVEL RISE

Research Report

WHY ARE SOME AREAS SO SUSCEPTIBLE TO DENGUE?

Dengue Cluster Map of high-risk areas in Singapore

The combination of people living in close proximity, the presence of Aedes mosquitoes and the availability of artificial breeding receptacles such as pails and potted plants has led to the greater concentration of dengue clusters in the east.
As Aedes mosquitoes "thrive" in housing areas,these dengue clusters likely reflect areas of urban population density. Urban settings could result in "warmer microclimates" due to dense building infrastructures, which allowed the Aedes mosquitoes to breed faster.



Dengue Clusters on Site

Breeding sites are commonly found in homes & shared residential spaces. Some other factors include the presence of old buildings. There are more crevices from building wear and tear, and now-defunct design features present similar opportunities for mosquito breeding such as the holes for bamboo poles (where people hang laundry outside windows of high-rise flats).

Drainage network (high-density)

Dengue clusters seemed to be more common among landed properties in their constituencies. Landed properties are posing particular challenges in the fight against dengue as potential breeding grounds such as drains are key risks.

Drainage network (low-density)

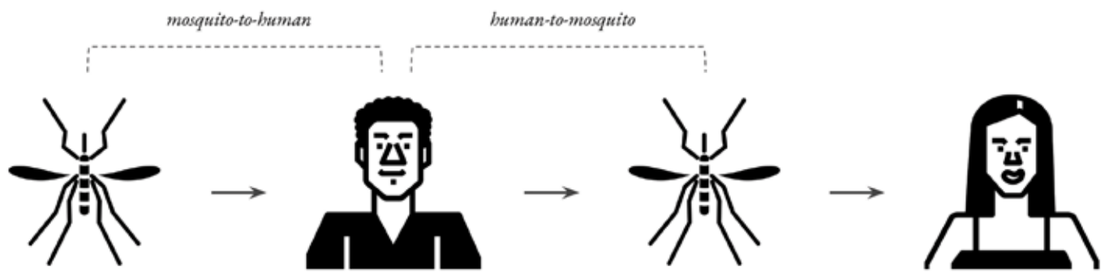
Although the drainage density of high-rise building areas is lesser as compared to that of low-rise housings, the population is highly concentrated in the high-rise neighborhoods.

Dengue Outbreak
Not To Scale
Information credits to:
National Environment Agency (NEA)

Dengue Transmission

DENV-1	DENV-2	DENV-3	DENV-4
	was previously the predominant serotype	currently circulating in Singapore	

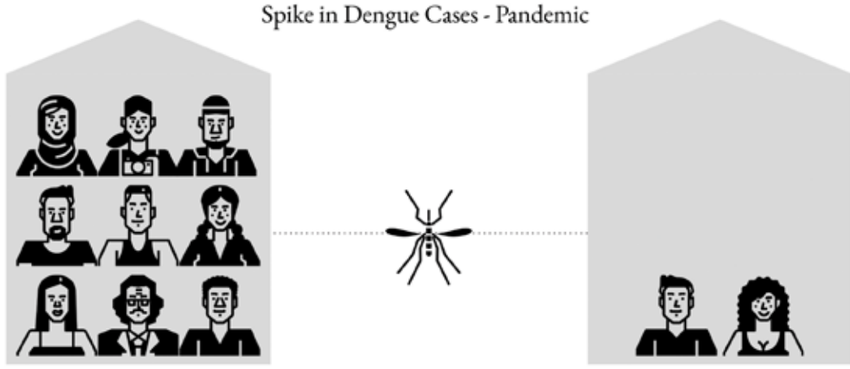
These four viruses are called serotypes because each has different interactions with the antibodies in human blood serum.
After recovering from an infection with one dengue serotype, a person has immunity against that particular serotype. Does infection with one serotype protect against future dengue infections with the other serotypes? Individuals are protected from infections with the remaining three serotypes for two to three months after the first dengue infection. Unfortunately, it is not long-term protection. After that short period, a person can be infected with any of the remaining three dengue serotypes. Researchers have noticed that subsequent infections can put individuals at a greater risk for severe dengue illnesses than those who have not been previously infected.
Singapore has low herd immunity against the disease as there is good mosquito control over the years as many people have never been infected with dengue.



aedes aegypti carries the DENV-3 virus	**infected** when bitten by the female aedes mosquitoes	**mosquito** is infected when it takes blood from a dengue-infected person	**after 8-12days,** virus is transmitted to other people they bite

X *human-to-human (dengue is not contagious)*

Spike in Dengue Cases - Pandemic



work from home more people staying at home increases the risk of disease transmission within housing estates	**day biters** harbour within indoor environment, bites in the early morning & evening before sunsets	**lesser human hosts** lower risk of getting bitten and transmission of disease

Vector-borne Disease (Dengue)
Not To Scale
factors affecting the spike in dengue cases in singapore (pandemic)

El Nino

westward-blowing trade winds lead to colder water in the equatorial eastern pacific ocean

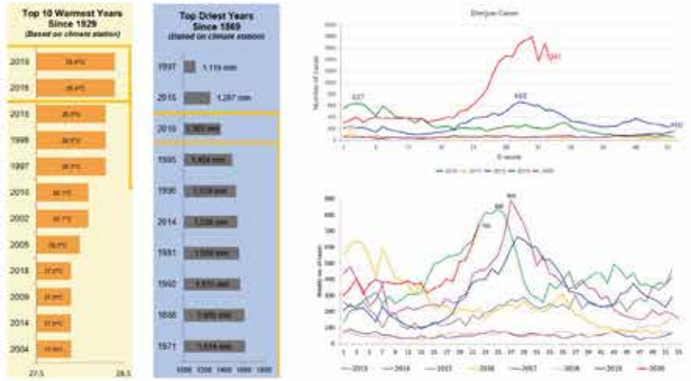
trade winds weaken & reverse in direction, leading to warmer waters in the equatorial eastern pacific ocean

The Pacific Ocean is the largest ocean basin on Earth. Unsurprisingly, it is not a uniform body of water, and the differences influence the climate of various regions. Under normal conditions, the western Pacific is much warmer than the east. The reason lies in the way the winds blow.

In the tropical Pacific Ocean, winds mainly blow from east to west. These predictable trade winds, as they are known, keeps warm water confined around the maritime continent. The waters warm as they move across the Pacific Ocean, eventually pooling around the maritime continent. Evaporating warm water fuels the rain clouds in the western part of the tropical Pacific. Singapore is situated between the Indian and Pacific Oceans, and can be affected by changes in sea surface temperatures and atmospheric pressure in both basins.

Cooler waters also cool the atmosphere above it, causing air to sink and creating an area of high pressure. This makes it harder for rain clouds to form. When an El Nino hits, on average every three to four years, it disrupts this status quo. Scientists believe the weakening of the trade winds may be what kick-starts this process, although the exact trigger is still being studied. As the trade winds weaken, the pool of warm water in the west is no longer confined to that region, and a tongue of warm water now extends from west to east. As the warm water moves towards the central and eastern Pacific Ocean, the rain clouds follow.

Spike in Dengue Cases - Warm Weather



abnormal climate changes, such as the El Niño weather phenomenon, may affect the mosquito breeding environment, accelerate the life-cycle of Aedes mosquito, shorten the incubation period of the dengue virus and drive up cases

The El Niño-Southern Oscillation (ENSO) phenomenon has profound impacts on global climate and weather anomaly patterns, often defining major peaks in spatial and temporal dimensions of drought and flood conditions. These extremes in precipitation and temperature resulting from ENSO events are known to be the background drivers of a range of vector- and water-borne diseases, and coral diseases, whose peaks in activity coincide, lag, or follow precipitation and temperature departures from normal.

Common Breeding Sites - Rainfall

Flooding rains create ideal breeding conditions for mosquitoes. More rain means more potential for puddles, and more potential for mosquito breeding. Frequent heavy rains can wash out the eggs that have been laid, but mosquitoes are smarter than we think they are.

Vector-borne Disease (Dengue)
Not To Scale
factors affecting the spike in dengue cases in singapore (climate change)

Cholera Outbreak in 1841

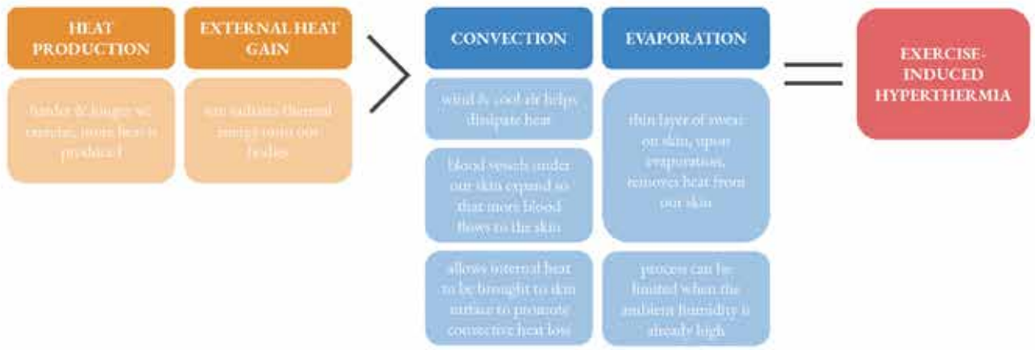
DATE	VALUE	CHANGE, %
2014	2	0.00 %
2013	2	0.00 %
2012	2	0.00 %
2011	2	-81.82 %
2004	11	1,000.00 %
2003	1	-50.00 %
2002	2	-75.00 %
2001	8	-20.00 %
2000	10	-9.09 %
1999	11	-64.52 %
1998	31	63.16 %
1997	19	

The outbreak in Singapore started at Kandang Kerbau and Kampong Kapor before spreading to Rochor and Kampong Glam. The initial cases involved patients at the lunatic asylum located next to the general hospital in Kandang Kerbau,with more than a dozen fatalities. The first case occurred on 13 July at the asylum,and soon spread to the surrounding areas.

Kandang Kerbau was swampy,made up of low-lying,flat land and hence suffered poor drainage, and coupled with dismal sanitation in the hospital's vicinity – all of which contributed to the area's high susceptibility to the spread of diseases – one of the immediate public health responses was to move all patients in the hospital and the lunatic asylum to the former military hospital building at Sepoy Lines along Outram Road. The Outram site was closer to town,spacious and located on high and dry grounds that facilitated good drainage,which reduced the chances of a cholera outbreak. One of the difficulties faced by authorities in the fight against cholera was the reluctance of some affected locals to seek medical treatment. The families of sufferers also hid the sick instead of encouraging them to seek proper treatment and more often than not,they refused to go to the hospital. This likely led to many deaths,particularly those from the Chinese community,going unreported and thus under-declared to authorities.

Today,strict sanitation regulations,modernised water supplies and good hygiene practices have led to a drastic reduction in cholera cases. In recent times, there were eight reported cases of cholera in 2001, and two cases each in 2002 and 2003. In 2014, two imported cases of cholera were reported.

Heat Stroke

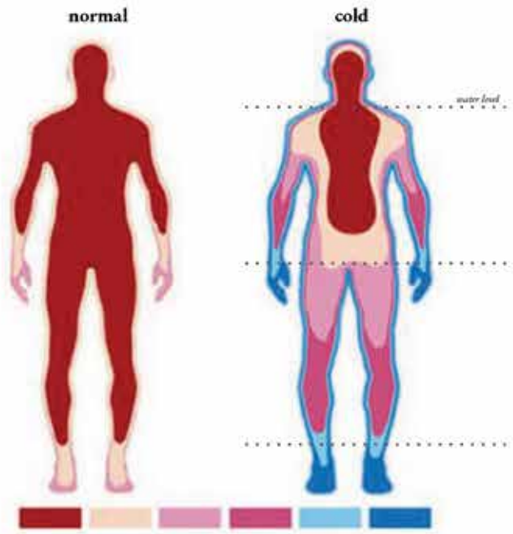


Thermal Intolerance

toes, fingers, ears & nose are at greatest risk because these areas do not have major muscles to produce heat

body preserves heat by keeping the internal organs warm, reducing blood flow to the other extremities under cold conditions

hands & feet get cold quicker than the body as they lose heat faster due to higher surface area-to-volume ratio and are more likely in contact with cooler surfaces



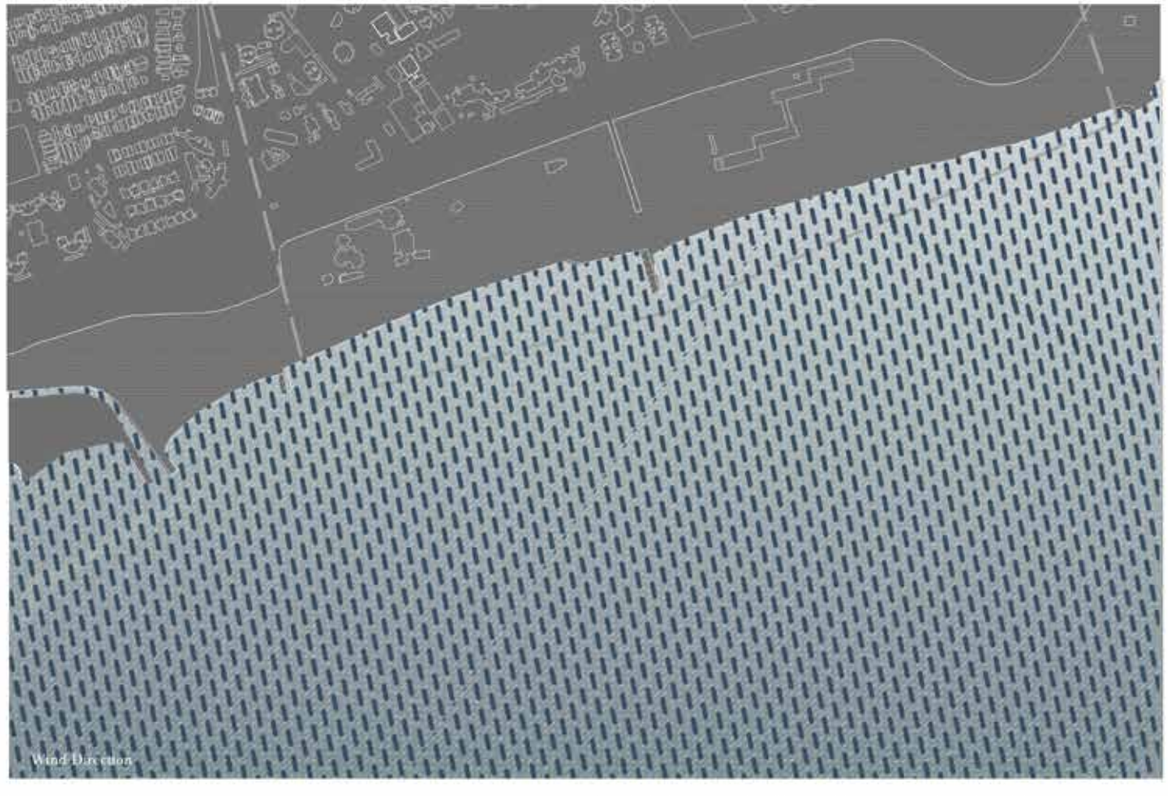
temperature of body parts

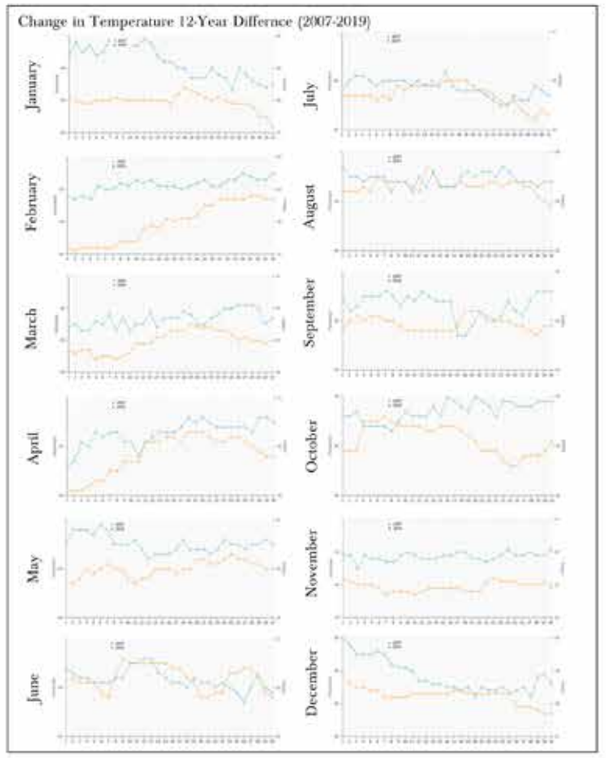
hypothermia
injury to the soft tissues, nerves, and vasculature of distal extremities from prolonged exposure to wet, cold

nonfreezing cold injury (NFCI)
injury to the soft tissues, nerves, and vasculature of distal extremities from prolonged exposure to wet, cold

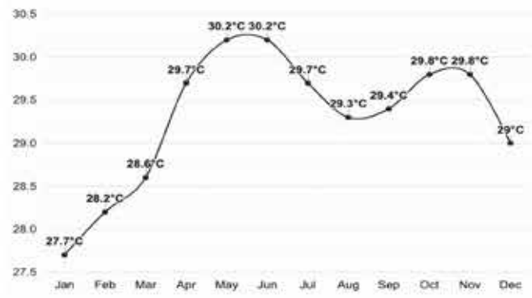
warm water immersion foot (WWIF)
painful, white, wrinkled soles of the feet due to immersion in warm water (15 to 32°C) for up to 72 hours

Water-borne Disease
Not To Scale
possible factors: unsanitary management of water / unpredictable weather





Oceanic heat content (OHC) is a term for the energy absorbed by the ocean, which is stored as internal energy. Changes in the ocean heat content play an important role in the sea level rise, because of thermal expansion.



Average Sea Temperature in Singapore 2020

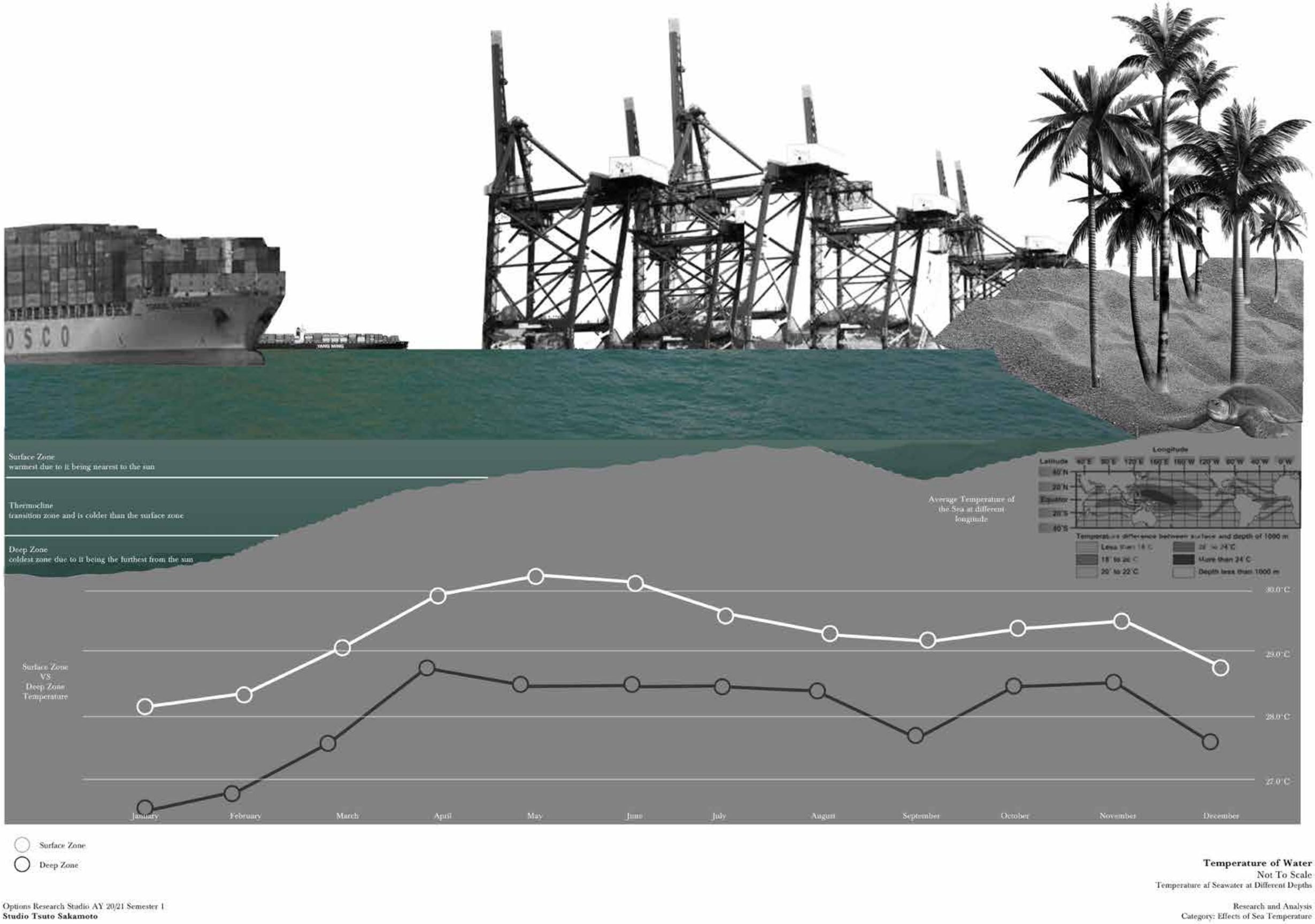
The currents in the world's oceans are a result of varying temperatures associated with the changing latitudes of our planet. As the atmosphere is warmed nearest the equator, the hot air at the surface of our planet is heated, causing it to rise and draw in cooler air to take its place, creating what is known as circulation cells. This ultimately causes the air to be significantly colder near the poles than at the equator

Singapore's Sea Temperature
Scale 1:10000 (A3)
10-Year Period

Wind Direction

Options Research Studio AY 20/21 Semester 1
Studio Tsuto Sakamoto

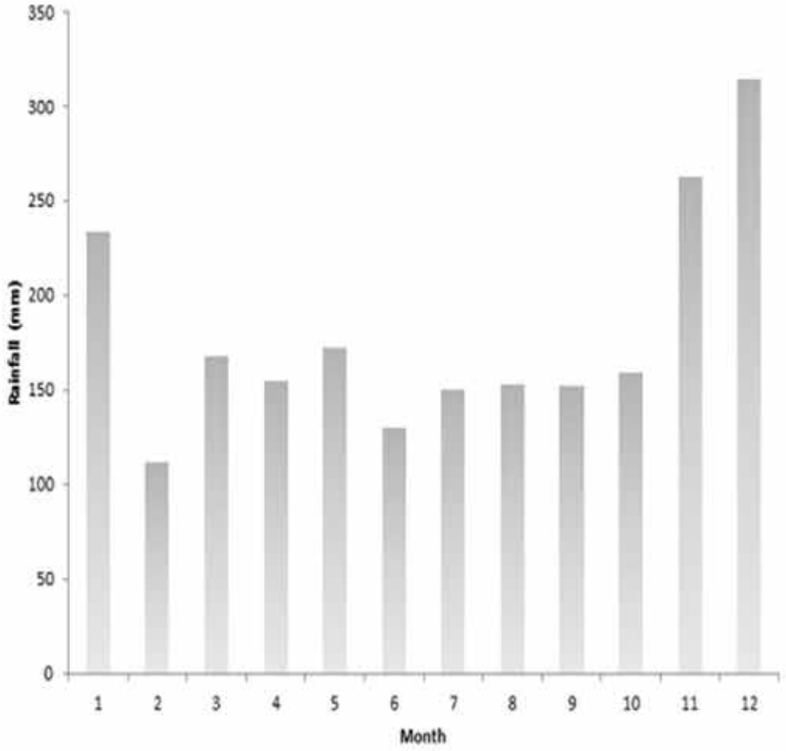
Research and Analysis
Category: Effects of Sea Temperature



Temperature of Water
Not To Scale
Temperature af Seawater at Different Depths

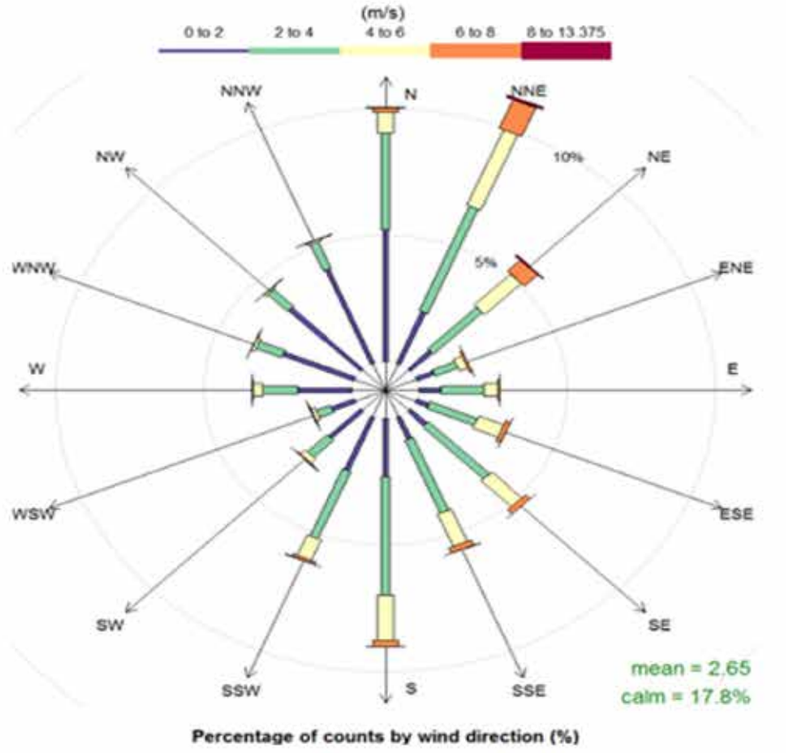
Research and Analysis
Category: Effects of Sea Temperature

Options Research Studio AY 20/21 Semester 1
Studio Tsuto Sakamoto



Rainfall Pattern

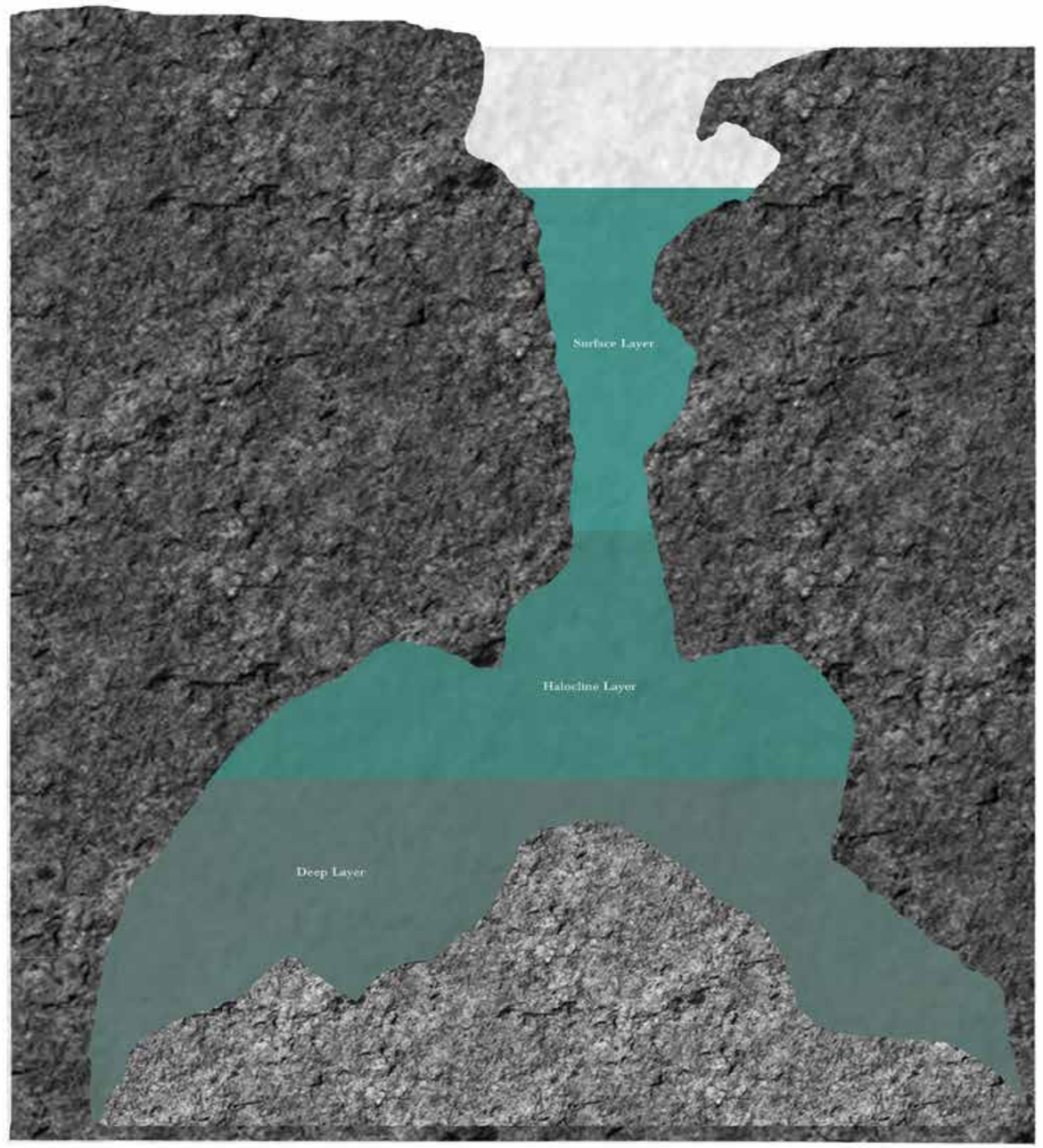
Regional weather patterns across the globe are also changing due to tropical ocean warming. This expansion of the warm pool has altered global rainfall patterns, by changing the life cycle of the Madden Julian Oscillation (MJO), which is the most dominant mode of weather fluctuation originating in the tropics.

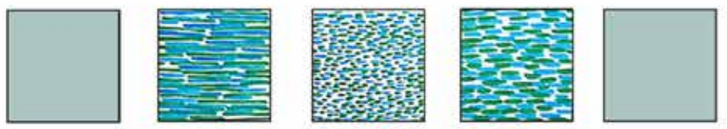


Wind Direction and Strength Pattern

Wind patterns drive surface currents which push the surface water to the higher latitudes where the air is colder. This cools the water down enough to where it can dissolve more gasses and minerals, causing it to become very dense in relation to lower latitude waters, which in turn causes it to sink to the bottom of the ocean. Driven by this sinking and the upwelling that occurs in lower latitudes, as well as the driving force of the winds on surface water, the ocean currents act to circulate water throughout the entire sea.

Temperature and Weather Pattern
Not To Scale
Effects on Rainfall and Wind Patterns





Salinity is an important factor in determining many aspects of the chemistry of natural waters and of biological processes within it, and is a thermodynamic state variable that, along with temperature and pressure, governs physical characteristics like the density and heat capacity of the water.

In certain high latitude regions the surface waters are colder than the deep waters and the halocline is responsible for maintaining water column stability- isolating the surface waters from the deep waters

The halocline is important in allowing for the formation of sea ice

Limiting the escape of carbon dioxide to the atmosphere. Haloclines are also found in fjords, and poorly mixed estuaries where fresh water is deposited at the ocean surface.

Temperature Effects on Salinity of Water
Not To Scale
Halocline Effect

Coral Bleaching

Change in water temperature causes coral to drive out algae

Corals die, reefs rarely come back. With few corals surviving, they struggle to reproduce and entire reef ecosystems, on which people and wildlife depend deteriorate

Marine fishes, seabirds and marine mammals all face high levels of mortalities, loss of breeding grounds and mass movements as species search for favorable environmental conditions

Cons of Rise in Seawater Temperature

Algae Bloom

growth, toxicity, and distribution of harmful algae blooms, deplete the oxygen around them to levels low enough to kill marine life

Increased warming of sea temperature enhances ocean stratification, which prevents nutrient mixing in the euphotic zone where there is ample light available for photosynthesis. Thus, primary production is constrained, and the region's entire food web is disrupted. If rapid warming continues, experts predict that the sea will transform into an ecological desert and will no longer be productive.

Pros of Rise in Seawater Temperature

Growth of Planktons

Increased nutrients and warmth fuel the growth phytoplankton

Increasing temperatures, although initially enhancing the growth of phytoplankton, also allowed increased grazing by zooplankton and bacteria.

This relationship between the physical environment and ocean biology effects the availability of nutrients for phytoplankton growth since these factors influence variations in upper-ocean temperature and stratification.

Temperature and Marine Biodiversity
Not To Scale
Pros and Cons of Changes in Seawater Temperature

Rising ocean temperatures also affect the benefits humans derive from the ocean – threatening food security, increasing the prevalence of diseases and causing more extreme weather events and the loss of coastal protection.

Increase of Floods

Increase in seawater temperature is causing the ocean to create more floods since it is warming up and the glaciers from the ice age are now melting causing the sea levels to rise, which causes the ocean to take over part of the land and beaches.

Melting of Polar Ice Caps

Ocean warming leads to deoxygenation – a reduction in the amount of oxygen dissolved in the ocean – and sea-level rise – resulting from the thermal expansion of sea water and continental ice melting. The rising temperatures, coupled with ocean acidification (the decrease in pH of the ocean due to its uptake of CO_2), affect marine species and ecosystems and, consequently, the fundamental benefits humans derive from the ocean.

When global warming is added into the equation, changes occur, especially in the regions where deep water is formed. With the warming of the oceans and subsequent melting of glaciers and the polar ice caps, more and more fresh water is released into the high latitude regions where deep water is formed. This extra water that gets thrown into the chemical mix dilutes the contents of the water arriving from lower latitudes, reducing the density of the surface water. Consequently, the water sinks more slowly than it normally would

Waterspout occurrence on 1st June 2020

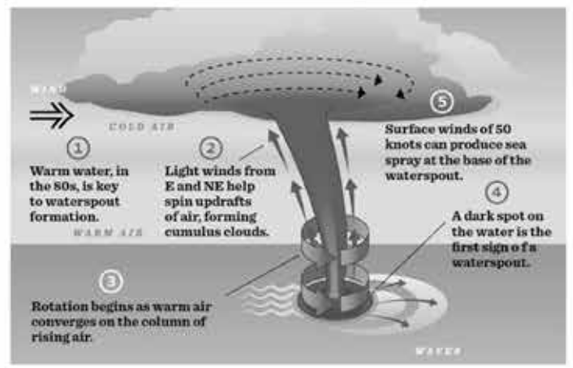
Sea surface temperature is important for tropical cyclogenesis, it is also important in determining the formation of sea fog and sea breezes. Heat from underlying warmer waters can significantly modify an air mass over distances.

Increase of the Thickness of Sea Fog

Increase in sea temperature has increased the amount of fog at sea level, making it harder for ships to navigate without crashing into other boats or other objects in the ocean. The warmness and dampness of the ground is causing the fog to come closer to the surface level of the ocean.

Increase of strength of Hurricane and Tropical Cyclone

The warm waters of the Loop Current and its associated eddies provide more energy to hurricanes and allow them to intensify. As hurricanes pass over warm water, they convert the ocean's heat into storm energy. As this energy is removed from the seas, a wake of colder water can be detected along the hurricane's path. This is because heat is withdrawn from the ocean mixed layer. Latent heat is lost directly to the tropical cyclone across the air-sea interface. Also, the horizontal divergence of wind-driven mixed layer currents results in the upwelling of colder thermocline water. Finally, the turbulent entrainment of colder thermocline waters caused by wind stirring also results in the cooling of the surface waters. (E.g. Tropical Storm Vamei hits Singapore in 2001)



Increase of the Formation of Waterspouts

Both tornadic and fair-weather waterspouts require high levels of humidity and a relatively warm water temperature compared to the overlying air. Waterspouts are most common in tropical and subtropical waters

Temperature and Natural Disaster
Not To Scale
Creation of Natural Disaster

How do moisture move/infiltrate different materials?

Air Movement

Diffusion

Capillary Action

Liquid Flow

What could benefit from the different forms of deterioration?

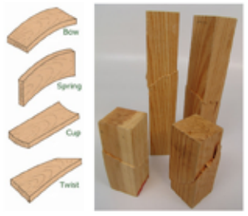
concrete

ability to mend cracks
bio-rocks

wood

baubotanik

Methods of Deterioration



Expansion beyond Reversion
Prolonged exposure to moisture of existing timber structures / components will cause expansion to continously occur. This causes mechanical stress on the joints of such structures.

Expansion & Contraction
Timber swells and shrinks as is absorbs and releases moisture to acheive equillibrium with its surroundings. Most of the time,tolerences are catered for to allow for such movements without causing structural weaking reperussions.

Warps, Twists and Cups (Distortion)
Distortion occurs when there is uneven exposure to moisture. Depending on the grain direction,either warping,twisting or cupping can occur. This usally happens to exterior timber panels without coatings.

Wood Rot (Decay)
Wood decay,or rot,is caused by a group of fungi that derive nutrition primarily from the components of wood cell walls. Consumption of cell wall material results in structural degradation. Wood decay fungi have developed relatively specialized biochemical processes to digest cell wall material. These processes require free water,in other words,a moisture content in excess of fiber saturation for a substantial period of time. There are three main types of wood decay:

1. Soft Rot
Soft rot fungi grow in wood that remains substantially wetter than fiber saturation for long periods of time, such as inside pilings just above the water line,in posts set in damp earth,and in other more or less constantly wet locations. Soft rot fungi are most closely related to the mold fungi,though their effect on the structural properties of wood,unlike the molds,can be severe.

2. White & Brown Rot
White rot and brown rot fungi degrade the cell walls of wood in ways that differ significantly from a biochemical standpoint,and the appearance of wood decayed by the two types of fungi also differs. Both, however,can cause significant structural damage to wood. In nature,white rot fungi grow on hardwood logs on the forest floor,and brown rot fungi tend to grow on softwoods.

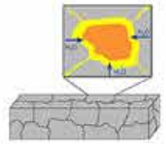
For decay to propagate, five major factors must be present: wood decay fungus, wood, regular source of water, temperature must be appropriate, and oxygen.

Mould
Molds are primarily an aesthetic problem,and often can be wiped away or removed with gentle abrasion. They generally do not penetrate deeply into the wood,and do not cause appreciable damage to the cell walls, instead living on free sugars,starches,and other metabolites (generally found in cell lumina,particularly in sapwood). Although molds do not cause structural failure of wood,they can give off unpleasant odors or produce large numbers of spores which may become an indoor air quality concern.

Stains
Microbial staining of wood is caused by fungi that penetrate the wood,often colonizing the sapwood of trees within a short time after felling as the sapwood begins to dry out. They live on the free sugars,starches,and other cellular contents of the sapwood,but do not harm the structural integrity of the cell walls. For this reason,stain fungi are not considered wood decay fungi. Stained wood is also considered unsuitable for use as siding or exterior millwork as stain infestation often results in greatly increased permeability,which in turn results in increased water absorbtivity.

Bacteria
Bacterial contamination of wood can occur where the moisture content of the wood remains substantially in excess for extended periods. Wood-dwelling bacteria generally have the ability to live anaerobically. The oxygendeficient environment of very wet wood is most conducive for bacterial growth as it inhibits growth of other microbes with which the bacteria would otherwise have to compete. Wood-dwelling bacteria generally do not cause a reduction in the mechanical properties of wood. Utilization concerns are related to strongly malodorous compounds produced during anaerobic respiration.

Wood Deterioration



Aggregate Expansion
Reactive silica can be present in water and react to different aggregate entities in concrete to form foreign substances/precipitation that causes cconcrete to expand and crack.

Carbonation
Carbon dioxide reacts with calcium hydroxide present in concrete to from calcium carbonate (similar process to decalcification).

Carbonation strengthens concrete by reversing the decomposition of carbonate aggregates in concrete.

But also reduces the alkalinity of concrete structures,which is essential for corrosion prevention of rebars.

Corrosion of Rebars - Oxide Jacking
Improper workmanship or cracks in the concrete allows water into the concrete and cause corrosion of the rebars. As they corrode,expansion occurs due to the build up of rust,causing mechanical stress.

In most cases,the expansion from rust build up causes concrete to be chipped away,exposing the rebar to further corrosion.

Microbial Corrosion
Untreated sewerage water contain (sulfate reducing) bacteria and common bacteria.

Sulfate reducing bacteria consumes sulfates from the concrete through anaerobic respiration,producing hydrogen sulfite which would be oxidised by other common bacteria through aerobic respiration in the presence of water to form sulfuric acid.

Sulfuric acid dissolves carbonates present in concrete,weakening the structure.

Leeching - Decalcification
Initial decalcification can occur when calcium hydroxide dissociate to form Ca+2 and OH- ions. These ions will be transported or dissolved by water,that has found its way into the concrete,to the outer surface of the structure. Carbon dioxide dissolves into the the solution,reacting to form calcium carbonate precipitate (Calthemite).

Concrete Deterioration

Uniform Deterioration
Characterised by a uniform corrosion along the entire surface of a metal structure.
Predictable in nature and does not cause much complications.

Pitting
Deterioration of metal on a centralised / pin point location. Can result in material fatigue of the entire structure if left unattended. It is usually caused by:

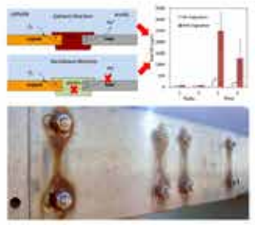
1. High concentrations of chloride
2. Localised chemical / mechanical damage
3. Localised damage to or inconsistent application of corrosion preventive coatings
4. Oxygen differential cell corrosion (metal oxidation)

Crevice Corrosion
Localised stagnant conditions on the surface of the metal can cause deterioration to occur such as:

1. Oxygen differential cell corrosion (metal oxidation)
2. Depletion of natural inhibitors
3. Creation of acidic conditions
4. Build up of chlorides

Pack Rust
Exposure to open,moist or corrosive environments along adjacent steel components compounds rust conditions due to the internal / mechanical pressures applied between to each other. Often comes together with crevice corrosion.

Fillform Corrosion
Occurs when there is an aggressive chemical reaction under a protective film or insulation layer that has been breached. Mostly due to the improper application of rust preventive coatings



Galvanic Corrosion
When 2 or more different metals are exposed to the same moisture / corrosive conditions,they can displace metal from one to the other. When a galvanic couple forms,one of the metals becomes the anode and corrodes faster than itwould on its own,while the other metal becomes the cathode and corrodes slower than it would alone. In a galvanic couple,the less noble metal will become the anode of the corrosion cell while the more noblemetal will act as the cathode.

Erosion
Deterioration by erosion is an acceleration in the rate of corrosion in a metal due to the motion of a corrosive fluid against the surface. The increased turbulence caused by pitting on the internal surfaces of a pipe can result in rapidly increasing erosion rates and eventually a leak. Deterioration by erosion can also be aggravated by faulty workmanship. For example,burrs left at the ends of a cut pipe can upset smooth water flow,which can cause localized turbulence resulting in deterioration by erosion.

Cavitation
Cavitation occurs when a fluid's pressure drops below its vapor pressure causing gas pockets and bubbles to form and collapse. This condition can occur in an explosive and dramatic fashion. This form of deterioration can easily reduce the material thickness of pump impellers and other similar equipment components. Cavitation can also exacerbate deterioration by erosion at pipe elbows.

Moisture Movement
Water can seep into pores and cracks of brick and mortar over time. It can travel through capillary action or with the help of wind and pressure differences. Moisture carries foreign particles harmful to the longevity of brickwork and causes structural weakness over time.

Microbial Growth
Unless properly ventilated,tighter buildings are actually an ideal environment for mold growth,as are the givens of modern life,including wall-to-wall carpeting and air conditioning,which causes condensation.

Salts
Salt can enter bricks through contaminated water ingress. Salt is damaging because it creates a steady expansion of crystals within the bricks. This can eventually force the structure of the brick apart. The source of salt can occur from within the bricks themselves or from the application of contaminated mortars or renders.

Efflorescence
A phenomenon that soluble salts dissolved in water are carried,deposited and gradually accumulated on brick surfaces to form an unsightly scum. Without water efflorescence cannot occur. The soluble salts may be originated from the raw material of bricks. But in most cases,efflorescence is caused by salts from the external sources such as ground water,contaminated atmosphere,mortar ingredients and other materials in contacts with the bricks.

Lime Stain
Lime staining occurs when calcium hydroxide is deposited on the face of brickwork. Lime staining will quickly absorbs carbon dioxide from the air and becomes calcium carbonate. It is virtually insoluble and can only be removed by expert and costly treatment. The calcium hydroxide can come from three main sources:

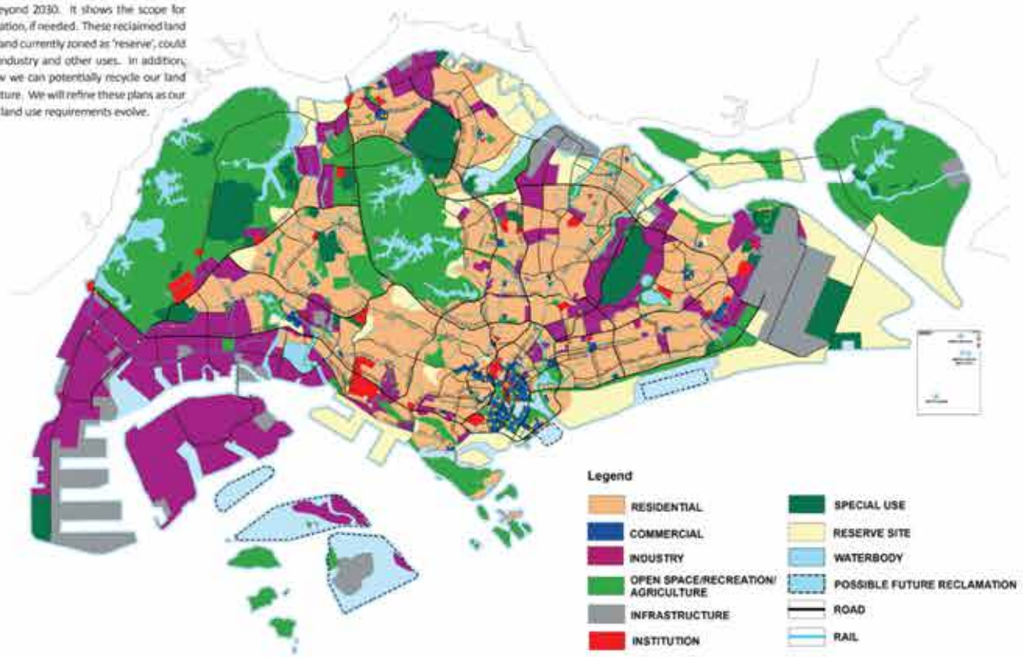
calcium hydroxide caused by the hydration of Portland cement
from hydrated lime added to mortar
from brickwork in contact with wet concrete

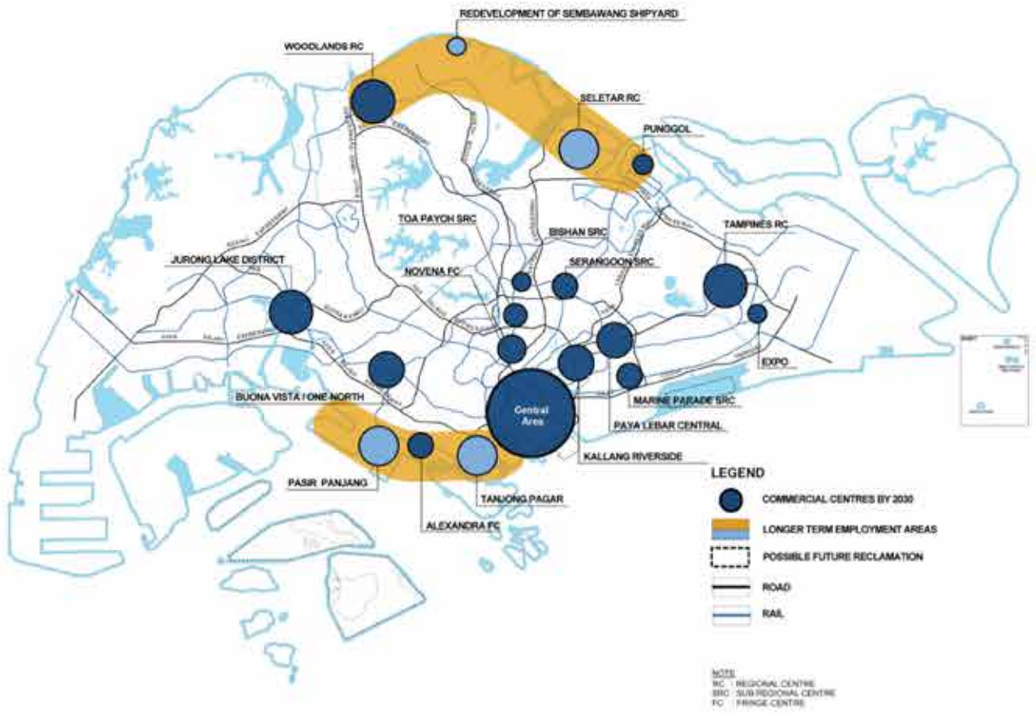
Sulfate Attack
Most ordinary clay bricks contain sulphates of sodium,magnesium or calcium. These salts are soluble in water. Normally,these sulphates are seen as the harmless efflorescence which affect appearance only and need simply to be brushed away. On rendered brickwork,sulphate attack is manifested by cracking of the rendering,the cracks being mainly horizontal and corresponding to the mortar joints below. The rendering may adhere quite well to the bricks early in the attack but areas are likely to become detached as the expansion of the underlying brickwork causes severance of the bond between the two material.

Rust Damage
Masonry wall occur these defects when brick walls have been improperly caulked where caulking should have been omitted. The most common example of this defect is the damage that occurs to a brick wall when a steel lintel over a window or door is caulked tightly between the brick and the steel. Moisture penetrating the brick wall through cracks or mortar joints is trapped around the steel lintel. Rust developing on steel lintels has tremendous lifting power as the rusting exfoliating metal expands,sufficient to crack and damage bricks around lintel.

LAND USE BEYOND 2030

This map illustrates the likely profile of Singapore and possible land use allocation beyond 2030. It shows the scope for additional land reclamation, if needed. These reclaimed land parcels, including the land currently zoned as 'reserve', could be used for housing, industry and other uses. In addition, the map indicates how we can potentially recycle our land for other uses in the future. We will refine these plans as our population needs and land use requirements evolve.





Loss of Ownership. Who will be affected?

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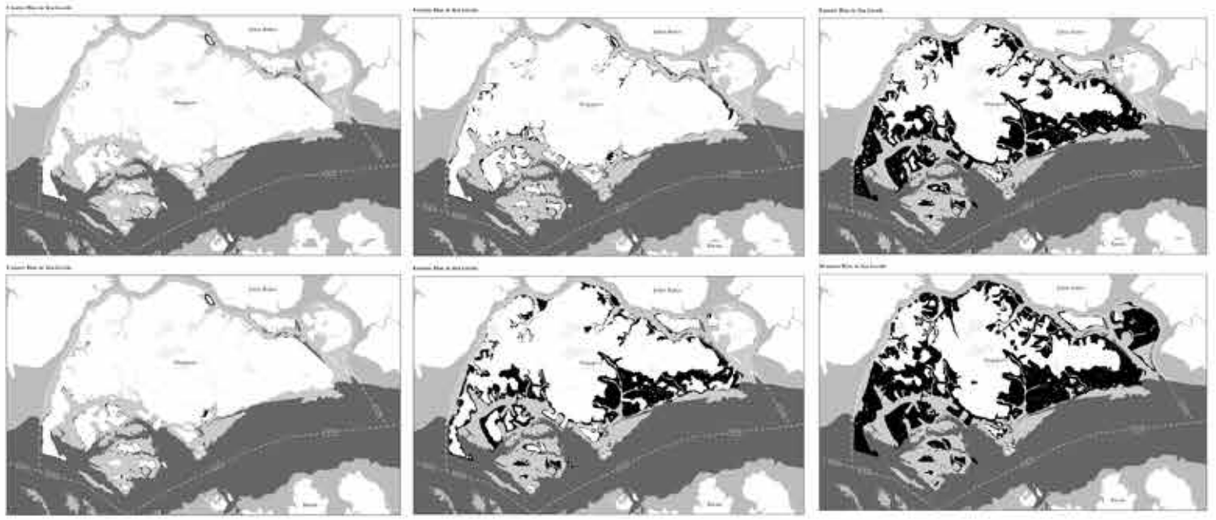
TABLE 1: OUR LAND REQUIREMENTS

Land Use	Planned Land Supply (ha)	
	2010	2030
Housing	10,000 (14%)	13,000 (17%)
Industry and Commerce	9,700 (13%)	12,800 (17%)
Parks and Nature Reserves	5,700 (8%)	7,250 (9%)
Community, Institution and Recreation Facilities	5,400 (8%)	5,500 (7%)
Utilities (e.g. power, water treatment plants)	1,850 (3%)	2,600 (3%)
Reservoirs[2]	3,700 (5%)	3,700 (5%)
Land Transport Infrastructure	8,300 (12%)	9,700 (13%)
Ports and Airports	2,200 (3%)	4,400 (6%)
Defence Requirements	13,300 (19%)	14,800 (19%)
Others	10,000 (14%)	2,800 (4%)
Total	71,000 (100%)	76,600 (100%)

www.eco-business.com

How will low-lying Singapore's built environment survive rising seas?

Singapore's response to climate change is more adaptation than prevention. So how will the vulnerable city-state protect its most valuable assets—its buildings—from rising sea levels?...



Rate of Rising Sea Level

The speculation of sea levels rise in Singapore is very important because most of Singapore land lies only 1.5m above the mean sea level. About 30% of land lies merely 5m above mean sea level.

By 2100, Singapore will rise about a metre higher than now (Singapore national climate change secretariat)

Carbon emissions causing 4 degree Celsius of warming could cause sea level to rise by 9 (Climate Centre). Submerging 745,000 homes in Singapore

Carbon emissions causing proposed internation target of 2 degree Celsius in warming could cause sea level to rise by 5.1m (Climate Centre). Submerging 101,000 homes in Singapore

Distribution of Land
Not To Scale

Research and Analysis
Category: Loss of Homes

East Coast

Business (July 2018)

Green Areas (February 2018)

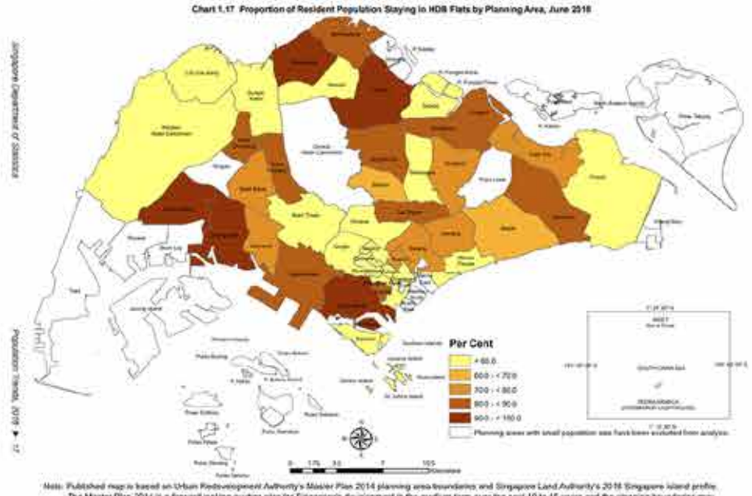
Place of Worship (January 2018)

Institutions (September 2015)

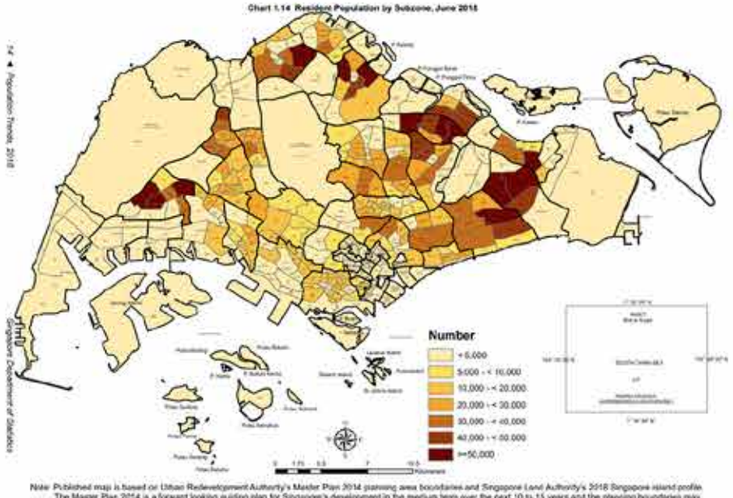
Home - Distribution of Ownership (who are the people that are affected) - about 20k people are living in the area

HDB (99 years)

5-room flat: 23.1%
4-room flat: 31.8%
3-room flat: 17.5%
1/2- room flat: 6.2%
Total: 78.6% (2019)



Note: Published map is based on Urban Redevelopment Authority's Master Plan 2014 planning area boundaries and Singapore Land Authority's 2018 Singapore island profile. The Master Plan 2014 is a forward looking guiding plan for Singapore's development in the medium term over the next 10 to 15 years and the planning boundaries may not coincide with existing developments for some areas.



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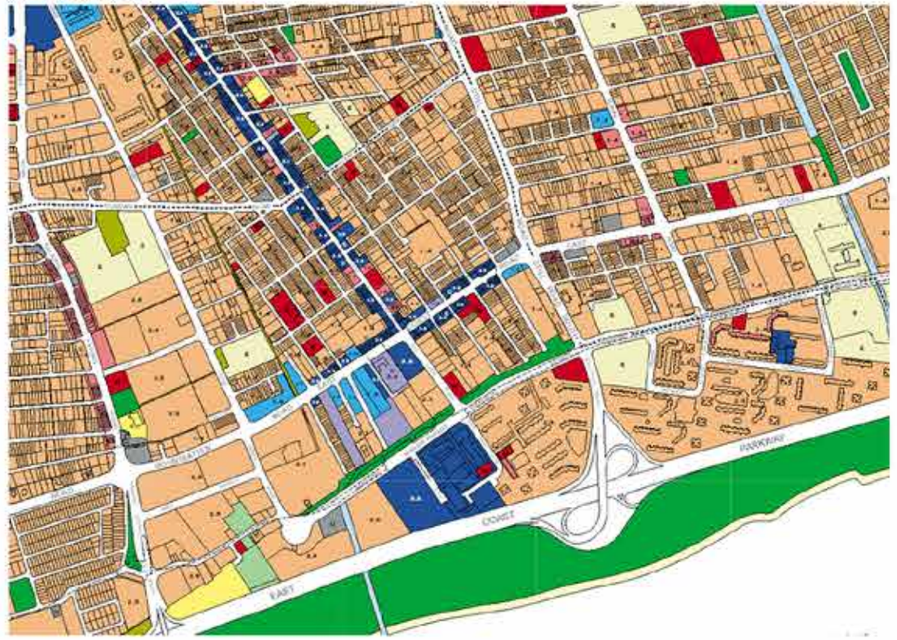
East Coast Land Use



What kind of culture, human life and economy will emerge in relation to the change?

What can be introduced to these areas?

Will the arrangement of programs be different according to how the water enter the land?

Home - Housing policies in Singapore (leasehold, freehold, privatised, public)

www.channelnewsasia.com

Commentary: An over-emphasis on home ownership can come at a cost to society. Time for a review of public housing policy

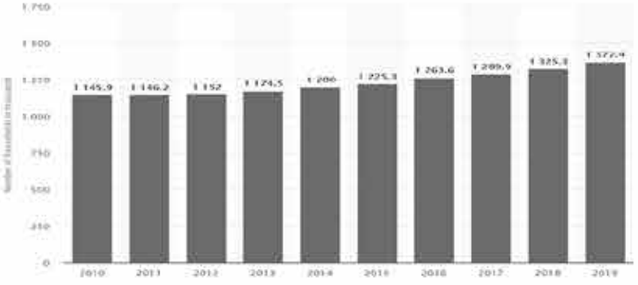
Singapore's housing policy started out with the aim of providing basic, comfortable and safe housing security for Singaporeans. Over the decades, ...

www.channelnewsasia.com

Home ownership helps Singaporeans build up assets: PM Lee

SINGAPORE: By pursuing homeownership as a key national policy, the Government has improved the lives of Singaporeans significantly, Prime Minister .....

The Government wanted to build a home-owning society where people felt they had a stake in the country and would work hard to contribute to society.



www.todayonline.com

HDB flats sold on 99-year leases 'to be fair' to future generations and for 'practical' reasons

SINGAPORE — Public housing flats are sold with 99-year leases because the government has to be fair to future generations and guard against Singapore from becoming a society split into the haves and the have-nots, said Prime Minister Lee Hsien Loong on S...

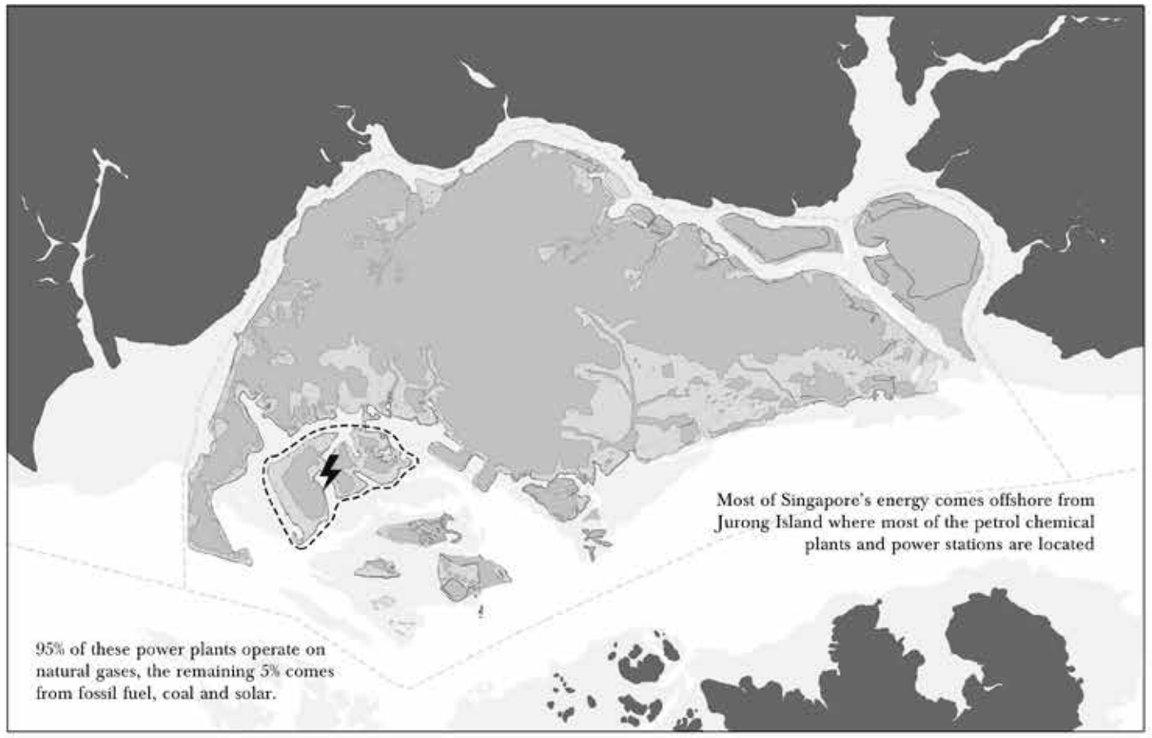
Leasehold is to allow for the recycle of land for future generations.

90% of Singapore Population have home ownership

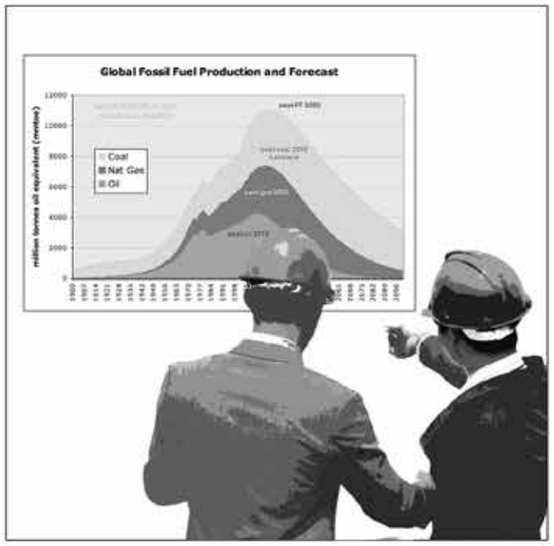
East Coast
Not To Scale

SPECULATIONS OF THE FUTURE

Research Report



With fossil fuels depleting at a steady rate, new alternatives must be found quickly



You have [1] new energy solution pending

Jurong Island houses majority of Singapore's power generating facilities. These sources are destined to deplete by 2060. Along with the rising concern of sea levels, Singapore tries its best to look into new methods and alternative sources of energy.

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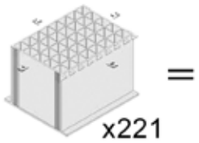
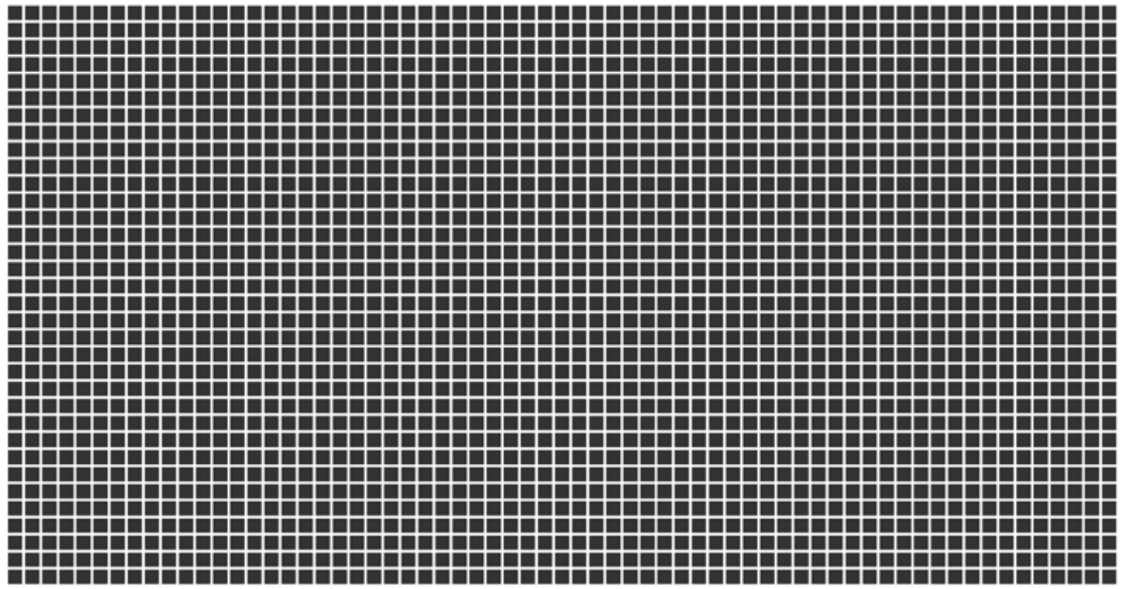
Energy Crisis In Singapore
An inescapabe future that is imminent

Research and Analysis
Category: Techonology

Caissons are massive structures that requires an immense amount of materials. Just looking at steel alone, a single caisson structure uses 10 Eiffel Towers worth of steel in the form of rebars. 221 caissons are need to construct Tuas Port alone.

Concrete is also used precious sand, the same kinds of sand that would be needed to dump into seadbeds in order to reclaim land.





2210 Eiffel Towers worth of steel!

How Much Materials To Reclaim Land
Caissons are massive stuctures submerged into the sea to hold water back. Just how much do they set the nation's materials back?

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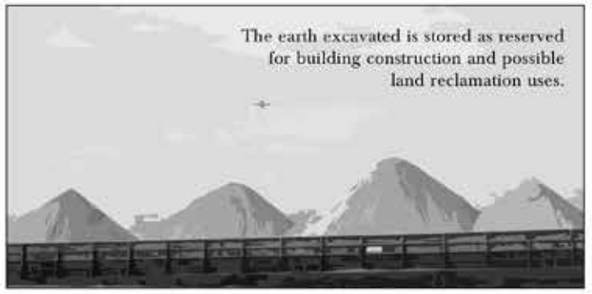
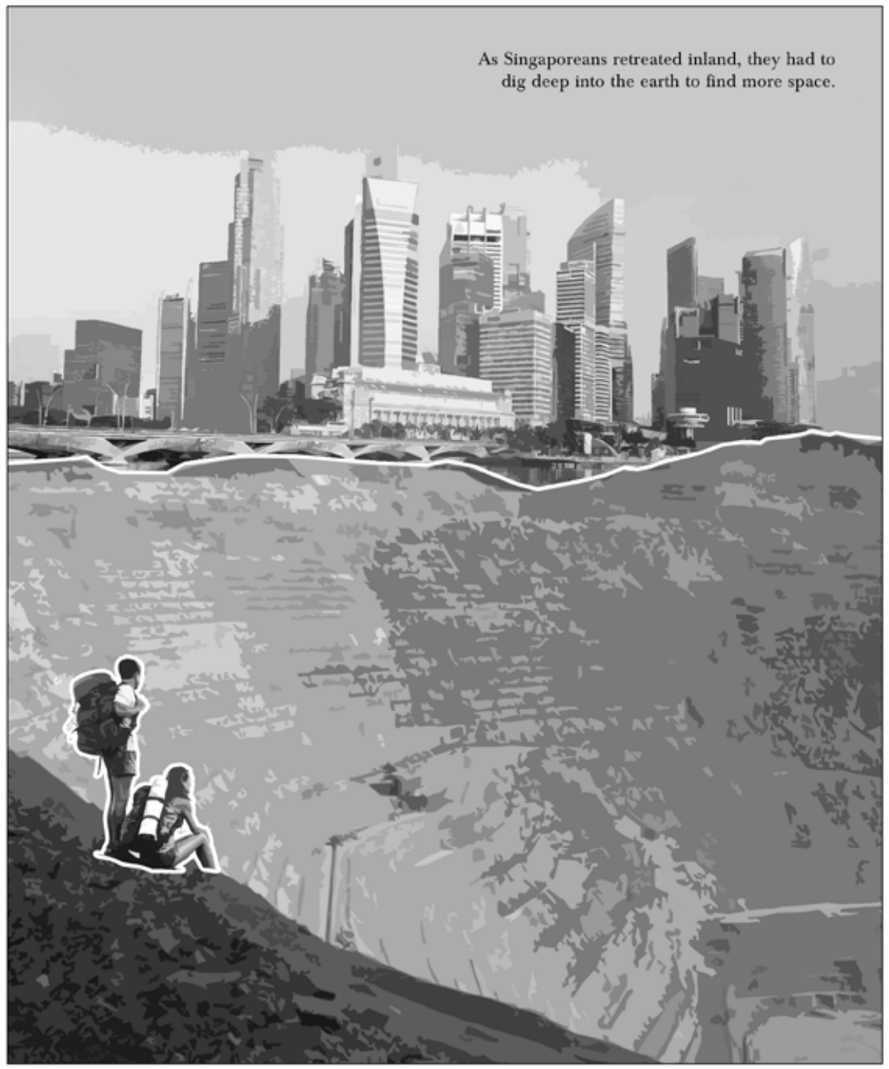
Research and Analysis
Category: Speculation

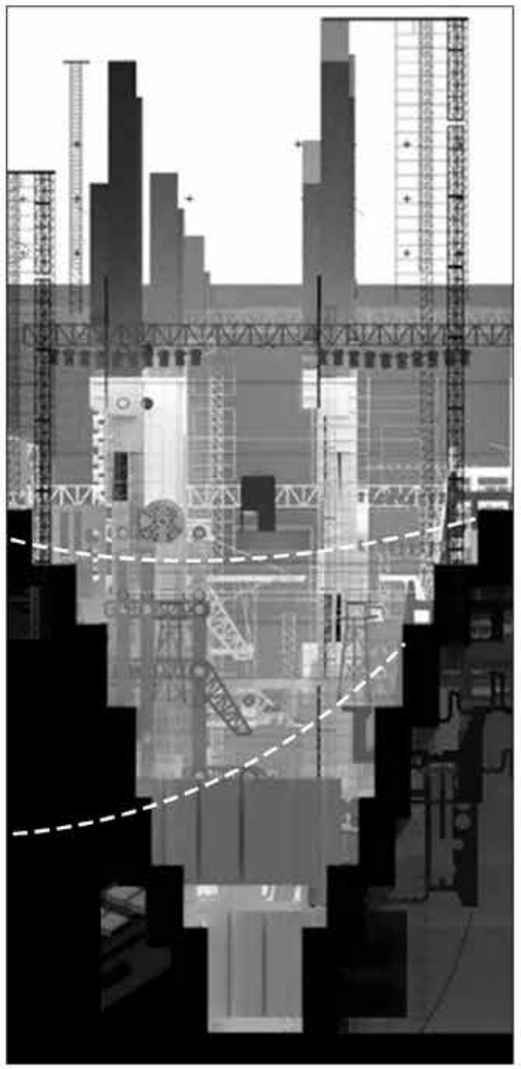
" We should allow Singapore to grow and plan for a much bigger population... like 10 milion people. "





The challenge of underground cities is their disconectivity.

Comunitites from an underground city might not find it worthwhile to comunicate and interact with other underground city comunities.



As Singapore grows into a more advanced and bustling city, the need for space in paramount. While we retreat from the ocean, we have to dig deep to secure more land surface for greater numbers of housing developments and business infrastructures. The earth dug up is stored as national reserves. Meanwhile, communities of work, live and play form within the underground cluster neighborhoods. Their amenities are within close proximity and plentiful. How would each neighborhood grow farther apart from each other culturally?

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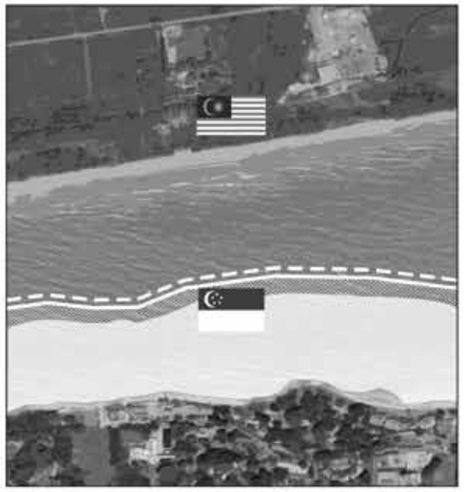
If Singapore Surrenders To The Ocean
Retreating inward, downward and upward –
A series of transformations following such a scenario

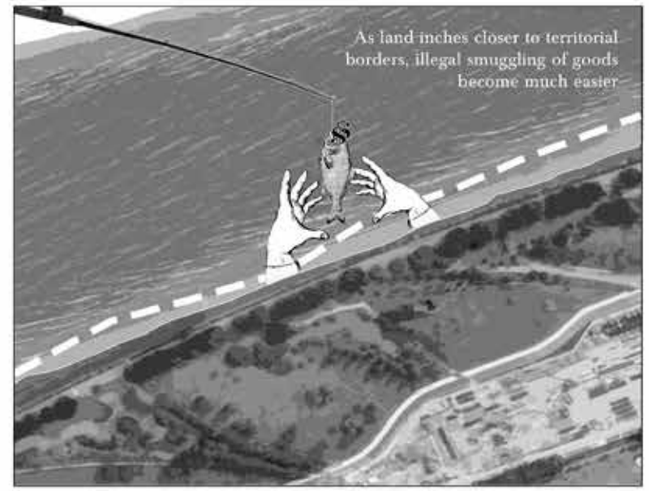
Research and Analysis
Category: Speculations

Government proposes further land reclamation as a solution to sea level rise, raising its terrestrial land from 51.8% to 74.6%.

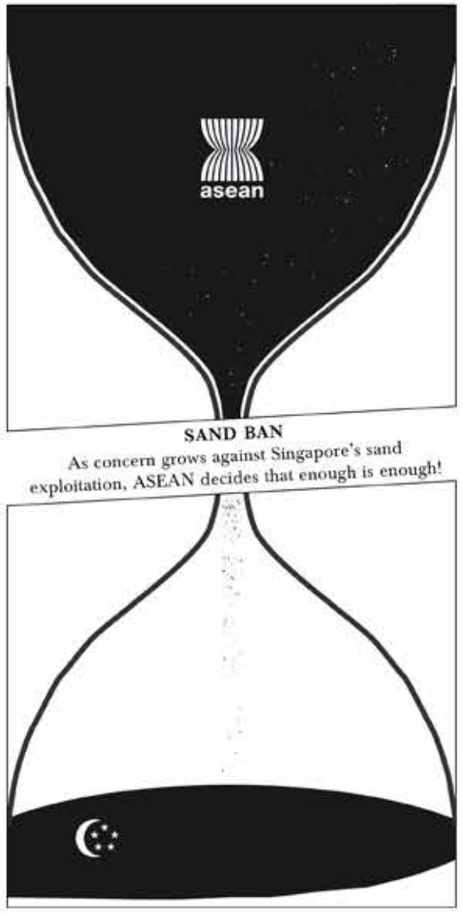
More concrete is used for land reclamation purposes. Singapore consumes more amounts of steel for rebars, aggregates for concrete and sand for land fills.



Reclaiming the city's northern region of the land would escalate existing tension between Singapore and Malaysia due to the close proximity between the two nations.



Needing to act on the nation's state of emergency, steel, sand and concrete are prioritised for land reclamation works, causing a growing scarcity of these materials. Singapore has to rethink their choices of material for domestic building construction.



SAND BAN

As concern grows against Singapore's sand exploitation, ASEAN decides that enough is enough!

Singapore concludes that aggressive land reclamation is the way to go. Adopting ideas from fellow victims of sea level rise, new methods of land reclamation begins, utilitising concrete to aid in substituting same amount of sand that is in scarcity. Malaysia actively calls Singapore out as it watches its neighbour inches closer with cautios eyes, pleading support from ASEAN nations to band their sand exports into Singapore. Meanwhile at home, local industries struggle to keep up with construction as precious sand and steel are prioritised for land reclamation projects under national emergency policies. As land draws closer towards water, smugglers seize the opportunity to increase their illegal trafficking activities.

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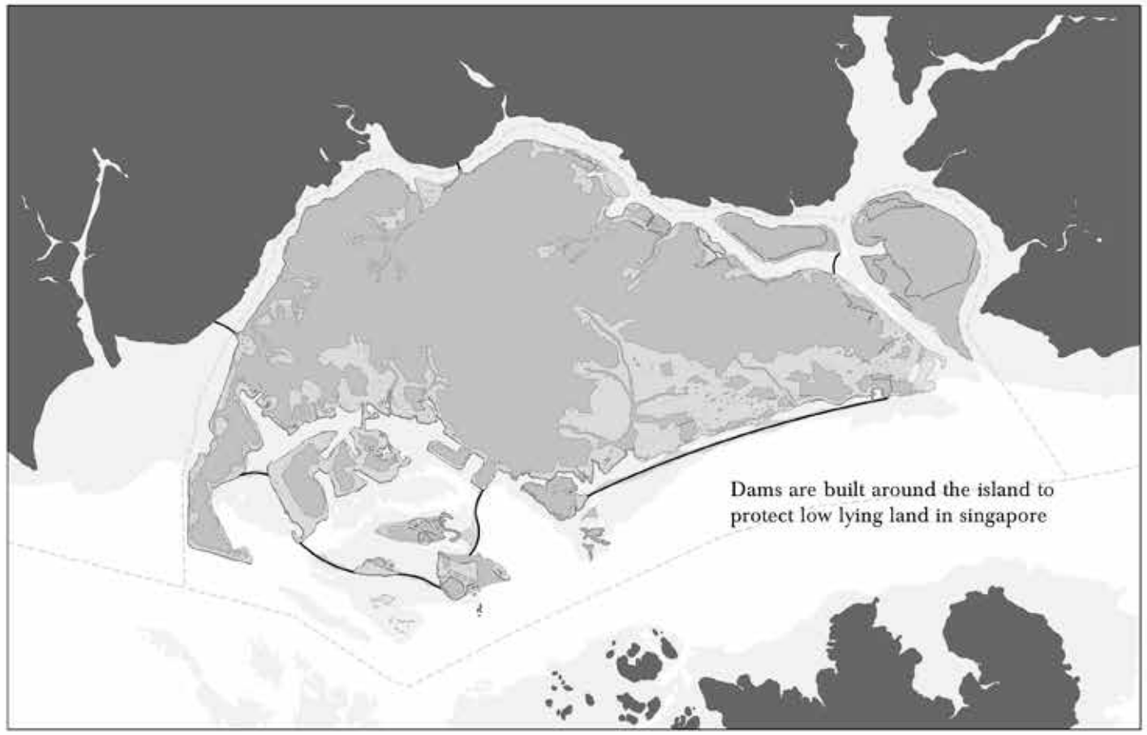
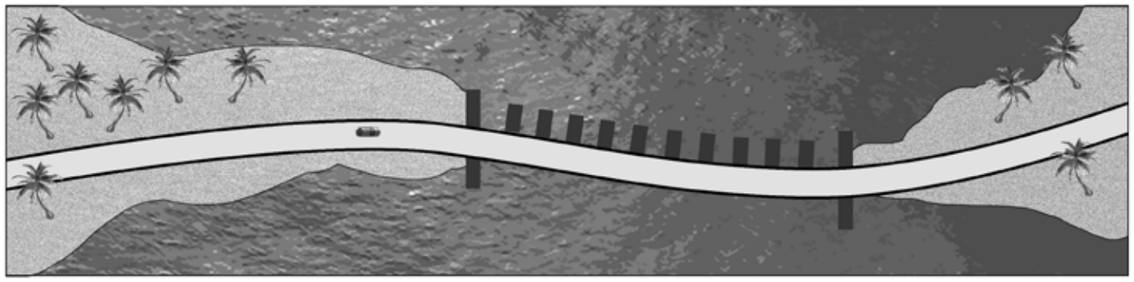
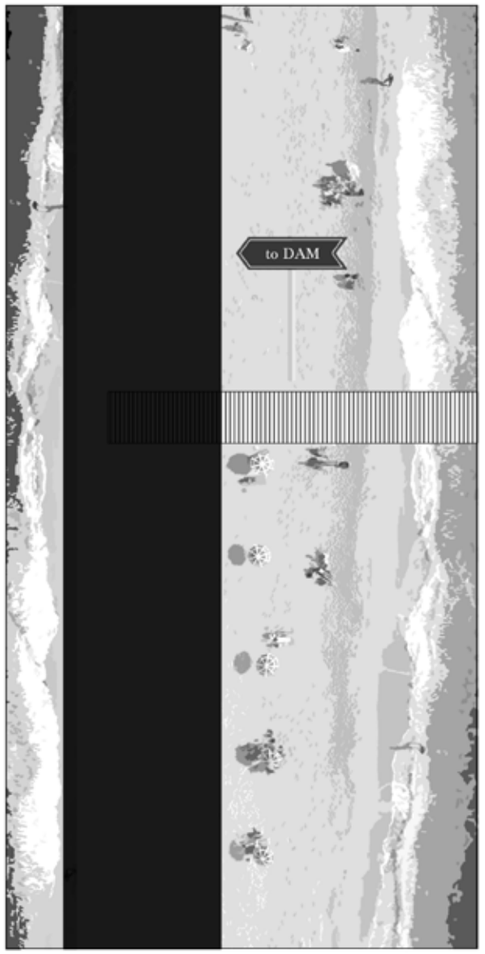
If Singapore Reclaims Land To Its Edges
Aggressive combat against sea level rise -
A series of transformations following such a scenario

Research and Analysis
Category: Speculations



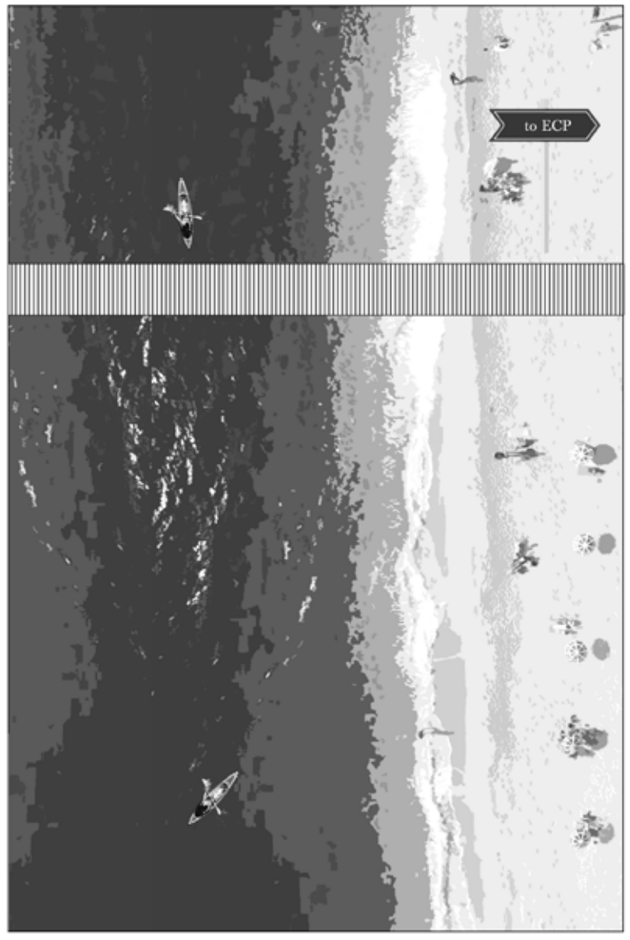


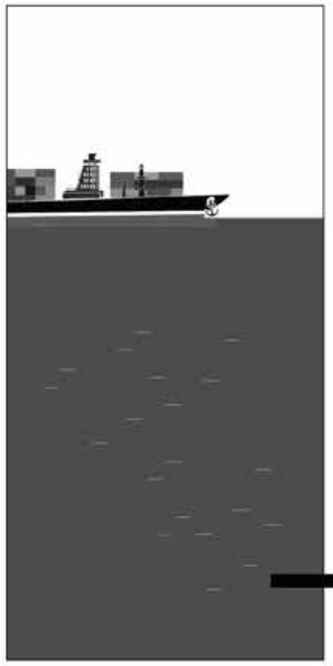
With the dam constructed, it serves as a new connector
along the southern edge of Singapore.

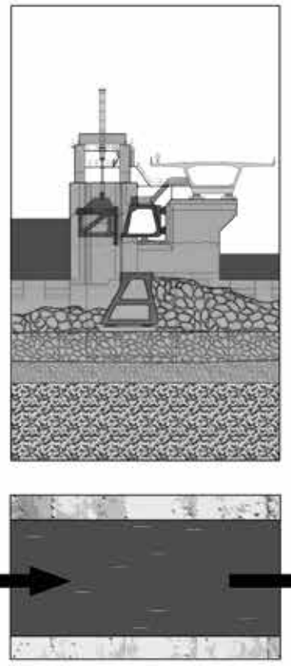


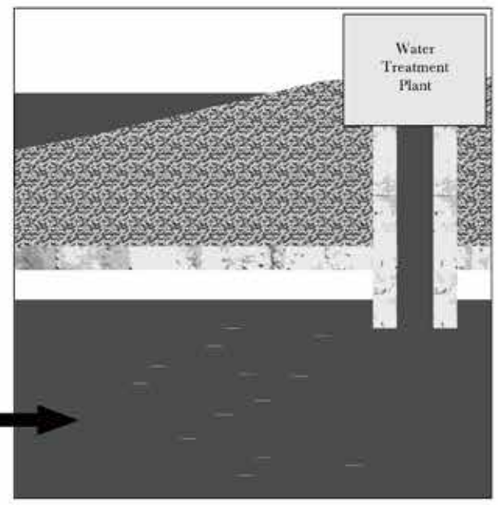
The dam becomes an offshore park -
A tourist attraction and a family
friendly hotzone in the weekends.

Low lying areas such as East Coast would
see new beach landscapes. Perhaps raising
property prices further in the region.









Storm water pipes are fitted within the dam infrastructure,
directing excess sea water inland through the DTSS towards
water treatment plants.

Conceding defeat to the scarcity and soaring prices of precious sand, Singapore decides to reinforce its coasts with dams and levees. Learning from the Dutch, these dams are rigged to the Deep Tunnel Sewerage System (DTSS) where excess sea water would be pumped away from the land towards desalination plants. Low lying areas like East Coast Park enjoy having an enclosed beach between land and the new dam. Dams would also become new forms of beaches further out into the sea, attracting locals to a bizaare man-made landscape. In addition to newly created beaches, dams also serve as accessible connectors along the southern edge of the island.

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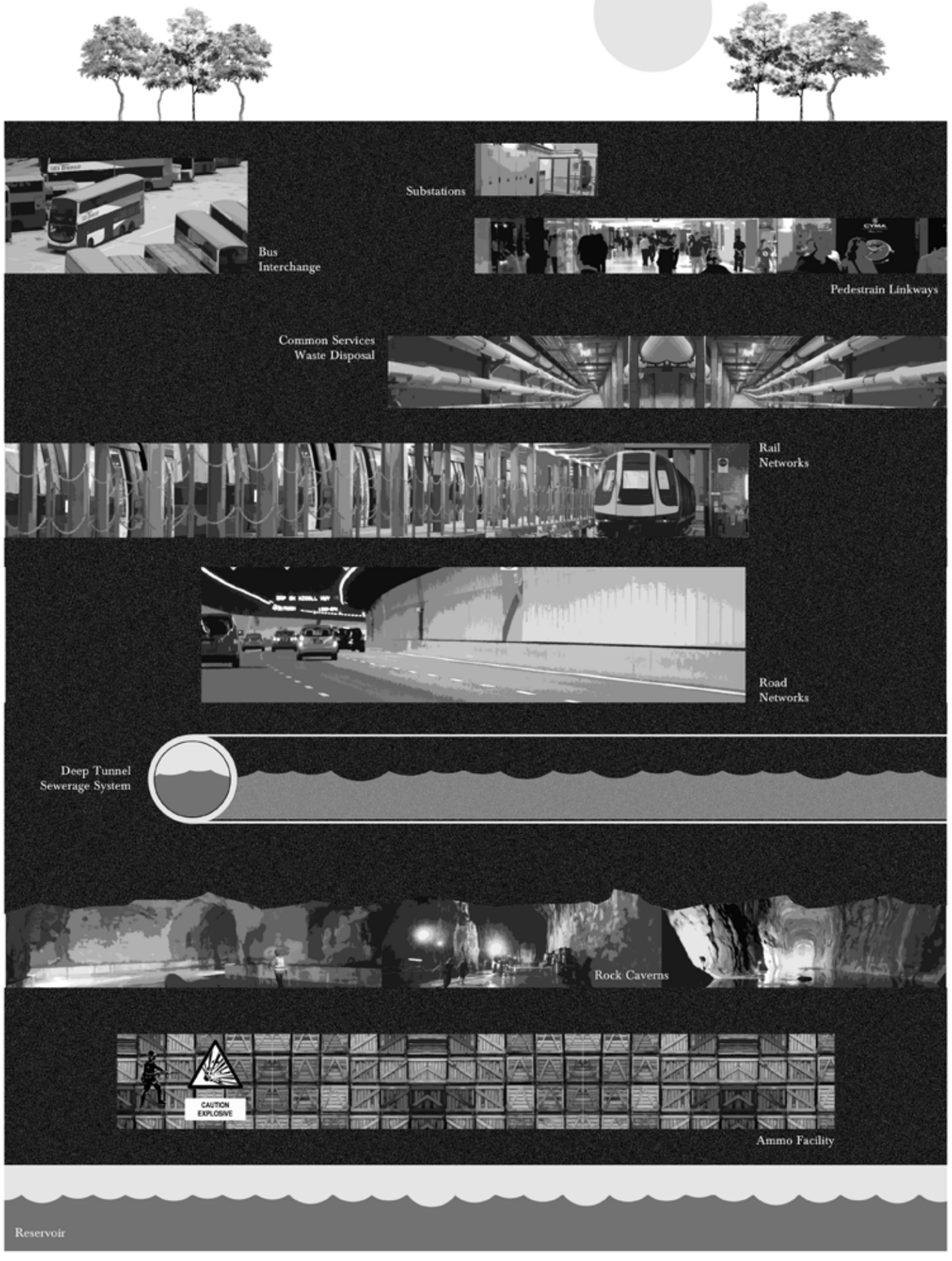
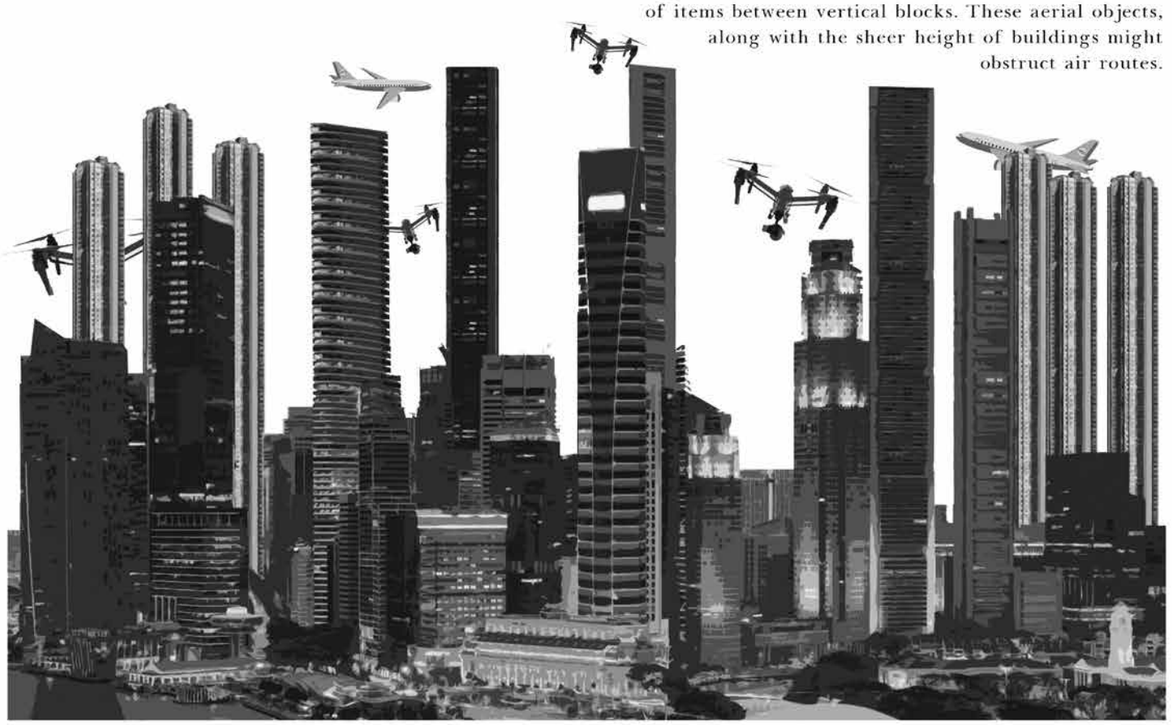
If Singapore Intensifies Flood Control Infrastructure
Aggressive combat against sea level rise -
A series of transformations following such a scenario

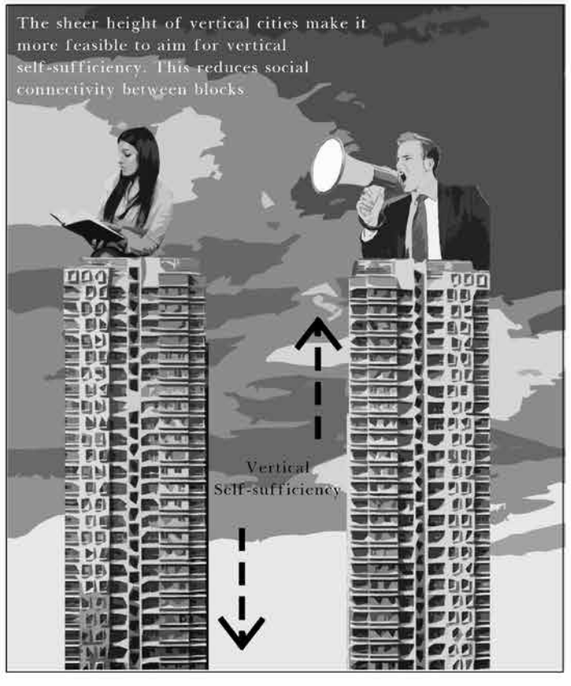
Research and Analysis
Category: Speculations



Underground City Plan
Singapore's subterranean proposals in search for more space

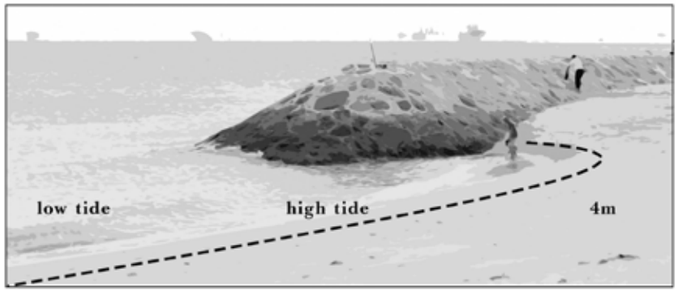
As cities densify vertically, there will be an increase in aerial obstructions such as drones. Drones will likely be required to ensure communication and transportation of items between vertical blocks. These aerial objects, along with the sheer height of buildings might obstruct air routes.

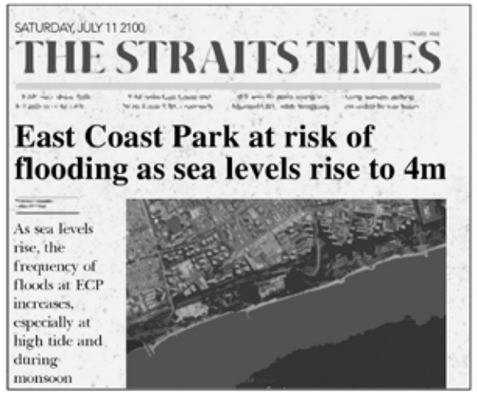




Vertical Densification
To accommodate for the expected 10million local population, we might need to build higher in addition to going underground. Advancements in construction and communication technology are required to enable this vertical growth. As each block aims to be self sufficient, it will be challenging to encourage social cohesion within neighbouring blocks.

East Coast Park lies 4m above sea level and there is a 3m rise between low and high tide

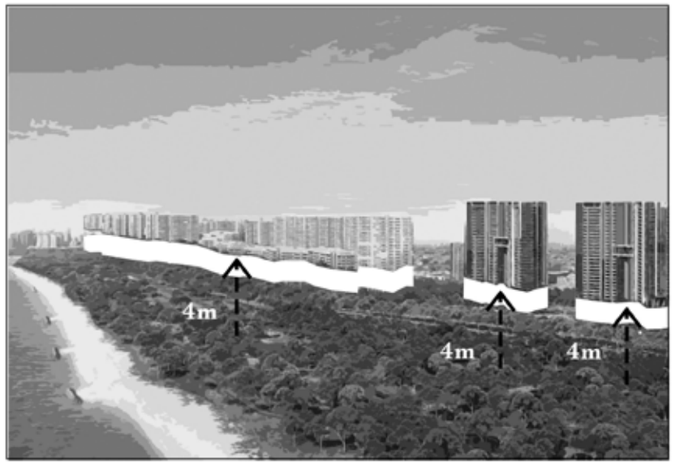



SATURDAY, JULY 11 2100

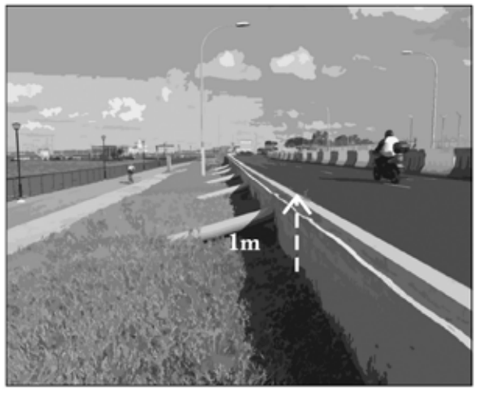
THE STRAITS TIMES

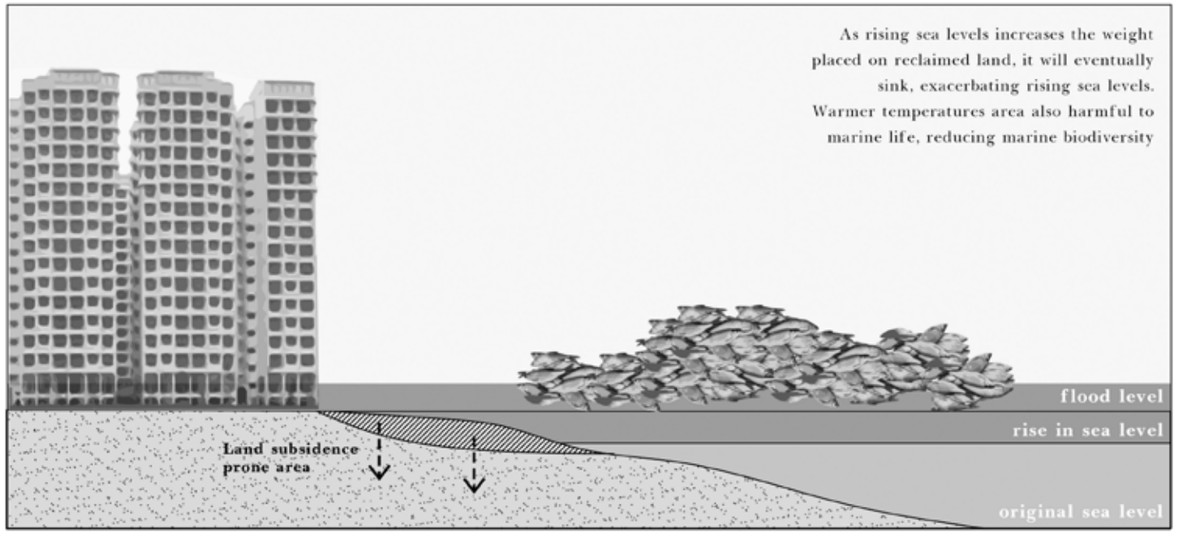
East Coast Park at risk of flooding as sea levels rise to 4m

As sea levels rise, the frequency of floods at ECP increases, especially at high tide and during monsoon



Existing infrastructure raised by 1m and all new buildings have to be built 4m above sea level





East Coast Park currently lies 4m above sea level. As waters continue to rise exponentially, we might hit or even surpass the 4m mark by 2100. This brings a set of consequences and warrants responses that are likely to change our coastal landform, most significantly Subsidence of the reclaimed land. As seen from other countries, hard measures such as seawalls and dykes will only take us so far, and a softer approach might be more successful in the long run. Embracing rising sea levels and incorporating the dynamics of water into our daily lives involves the erection of permeable gardens along the coast, as well as water squares and canals.

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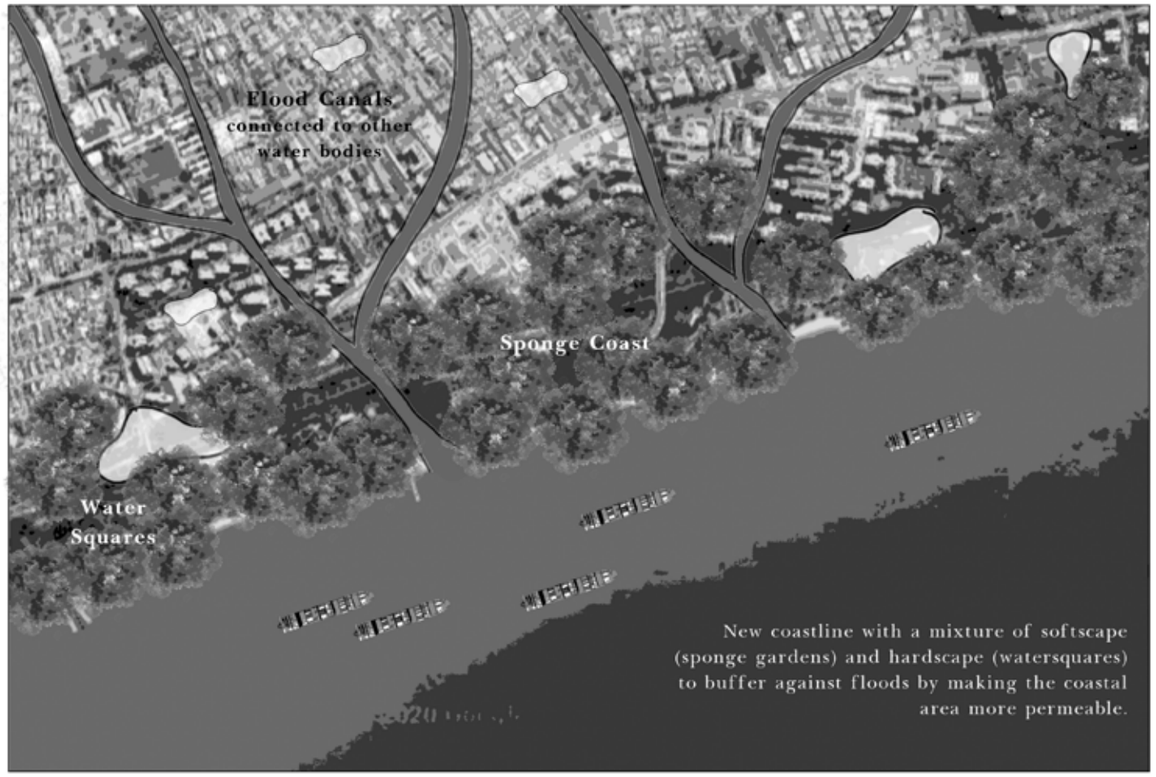


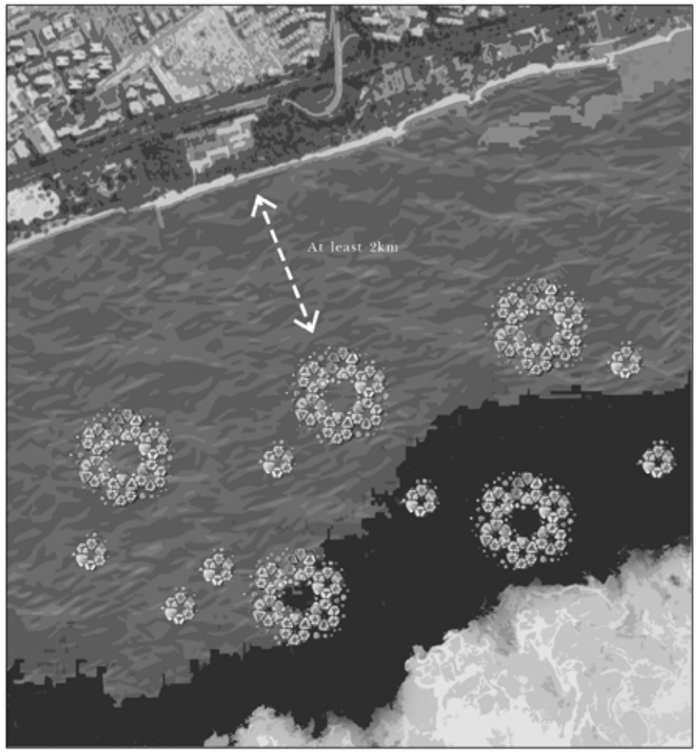
The new measures alter people's relationship with water. Previously, rain and floods were dreaded and considered disasters. With the water squares and flood cities, they are instead something to look forward to as it alters public facilities post-rain or flood.

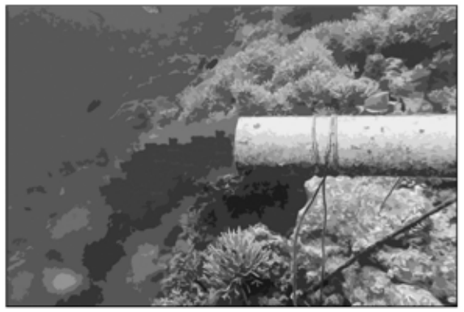
They also make the dynamics of water tangible and the flooded squares might even enhance the aesthetic value of these public spaces.

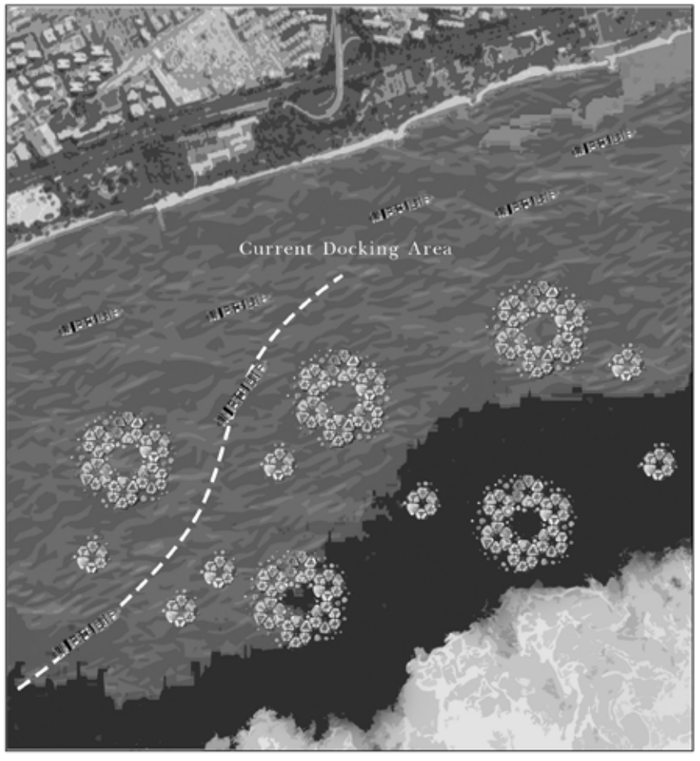
Buffered water could then be drained out into stormwater tanks or stored and filtered for future usage.

Embracing water
Chronicles the change in landform from present times to a potential 4m rise in sea levels

Research and Analysis
Category: Speculation



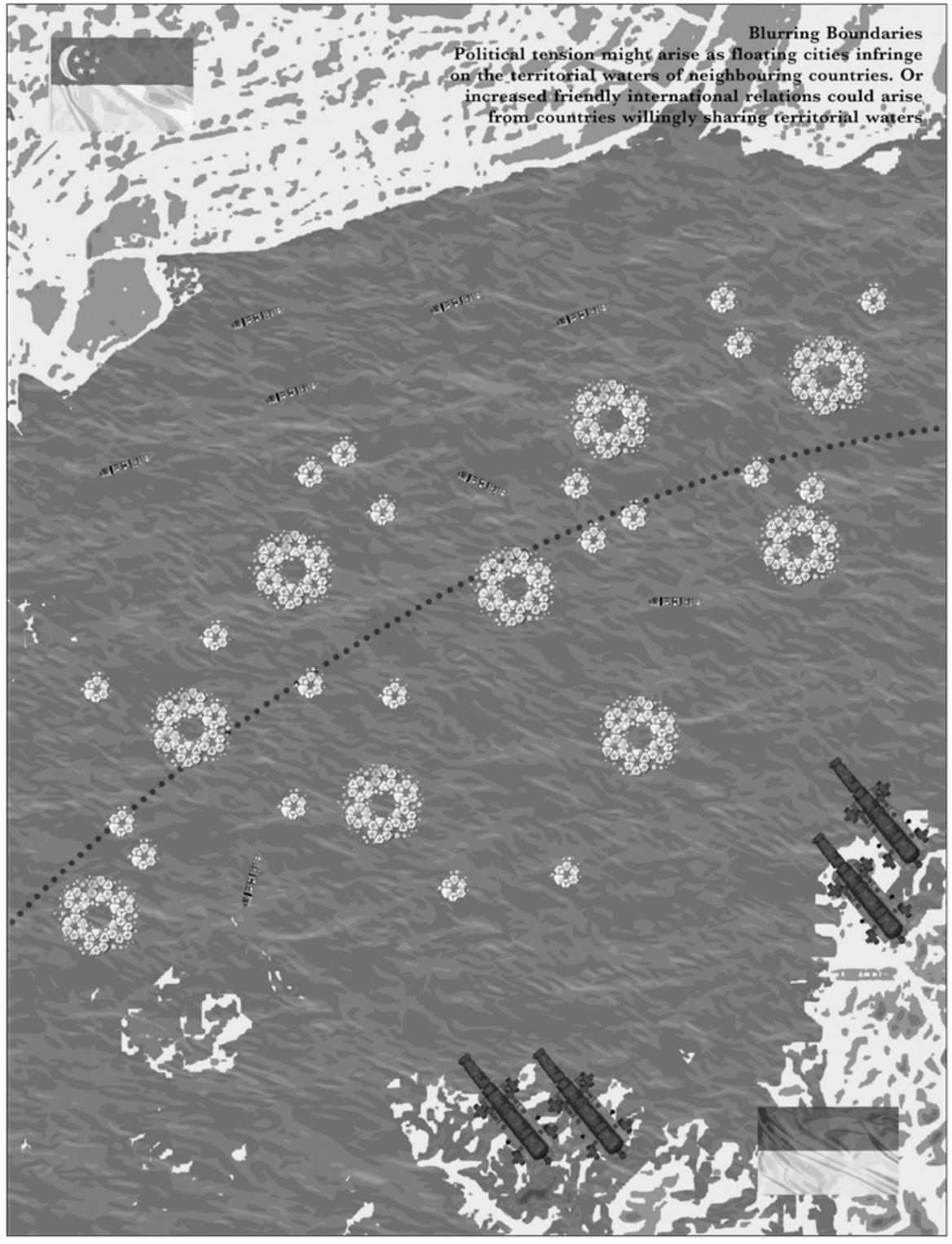




Floating cities are built in very deep waters, which are experienced approximately more than 2km away from Singapore's coast. This leads to people being isolated from the local community.

It also interferes with current trading routes as there is a docking area for ships off East Coast Park.

The construction of floating cities also has to be accompanied by advancements in deepwater construction technology. Advancements also have to be made in sustainable technology for waste disposal to reduce the harmful effects of living in such close proximity with marine life.



As we run out of space on land, a potential idea might be to start colonizing water. At the rate our technology is developing, leaps in construction technology to build large scale offshore cities has been deemed possible. However, political and environmental issues still persist. Would these floating colonies be independent states? Or would territorial water boundaries be blurred internationally? Problems such as underwater noise pollution, waste disposal and the effect our structures have on marine biodiversity also have to be addressed.

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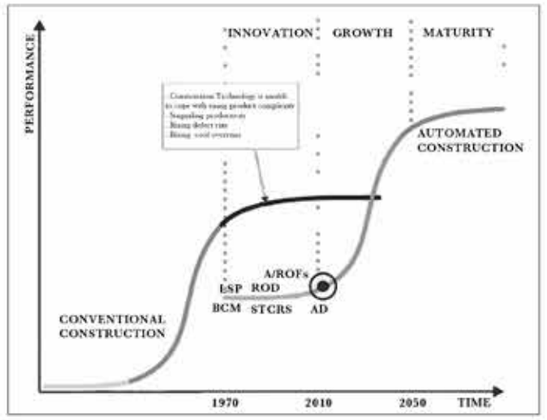
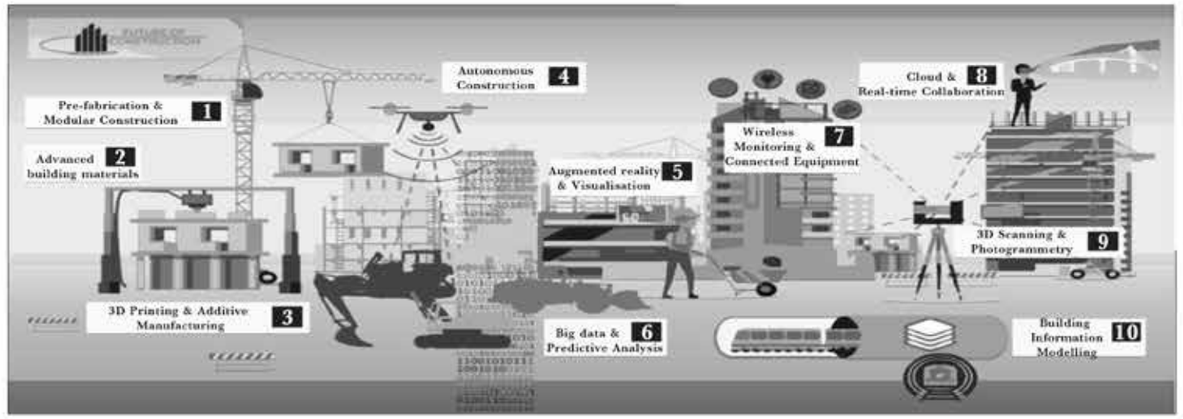
Floating Cities
As rising sea levels are a long term problem, floating cities might be a more adaptable solution

Research and Analysis
Category: Speculation

"We need to make best use of how digitalisation can enable us to be more productive and more efficient."
- DPM Heng Swee Keat
May 28, 2020






Construction


Marine


Wholesale Trade


F&B Services


Heavy Vehicles Transport Drivers


Public Transport Operators


Petroleum, Chemicals

SECTORS

1 MIL. FOREIGN MIGRANT WORKERS WORKFORCE

2.3 MILLION LOCAL WORKFORCE

PRESENT

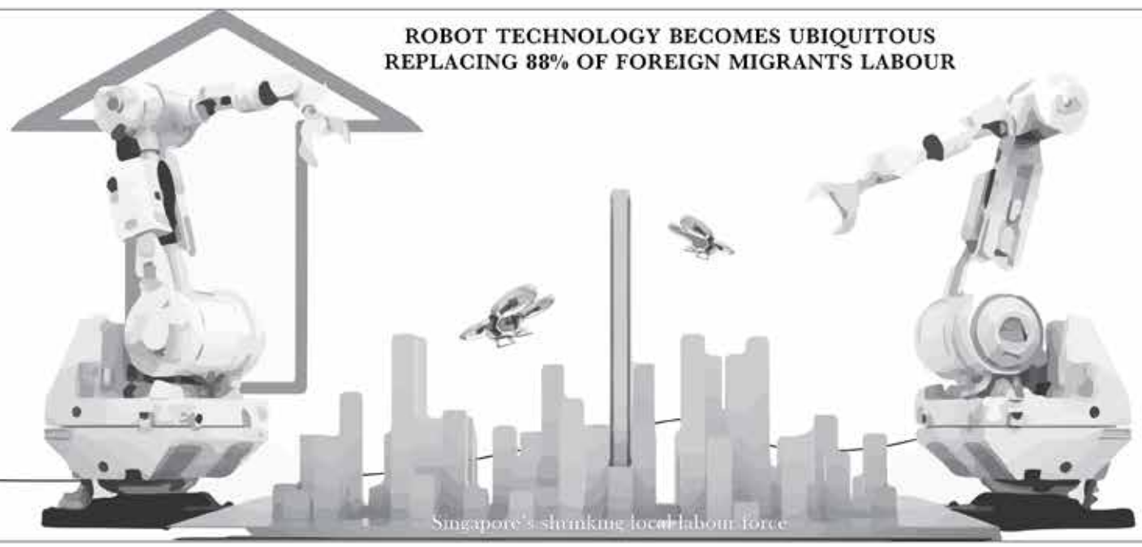
THE GOVERNMENT'S MAJOR DRIVE TO SLOW THE INFLOW OF FOREIGN WORKERS
TO RAISE PRODUCTIVITY IN ECONOMY THROUGH USE OF ADVANCED TECHNOLOGIES

FUTURE

88%

COMPETITIVENESS AT STAKE

ROBOT TECHNOLOGY BECOMES UBIQUITOUS
REPLACING 88% OF FOREIGN MIGRANTS LABOUR



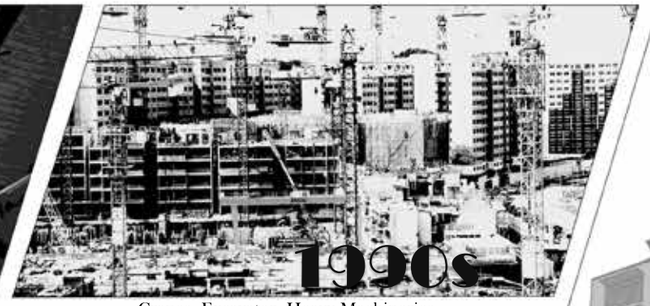
The disruptive future construction massively shift the demand of construction to the use of advanced construction technologies, stakes are high as livelihood of foreign workers will be at risk. Not only will the reduction in foreign workers not hamper the speed of Singapore's redevelopment, rather it accelerates and inadvertly impact Singapore's economy and business vitality. Is the longer-term interest of Singaporean jobs and the economy better secured?

If Singapore reduce reliance on foreign workers with technological advancements
Men v.s Machines in Digital Age -
A series of transformations following such a scenario

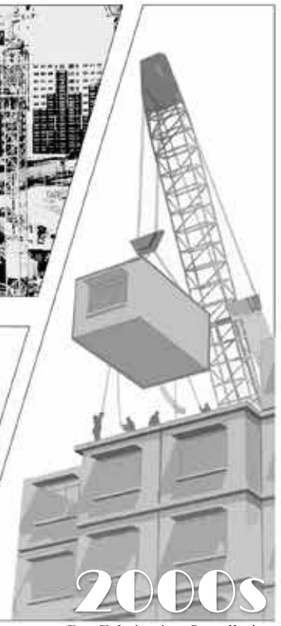
Options Research Studio AY 20/21 Semester 1
Studio Tsuto Sakamoto

Research and Analysis
Category: Speculations

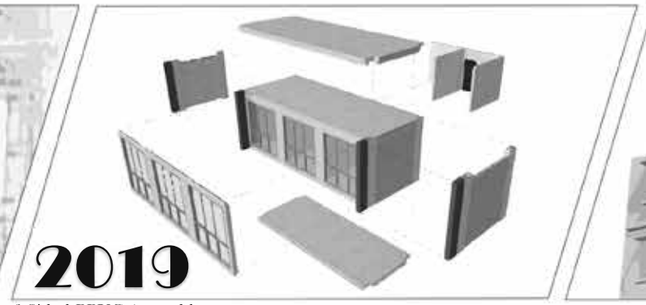
Bamboo Scaffolding



Cranes, Excavator, Heavy Machineries



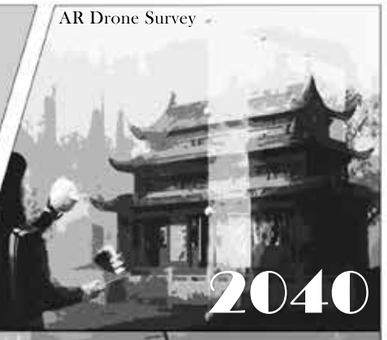
Pre-Fabrication Installation



6-Sided PPVC Assembly

BIM Augmented Reality (AR)

Superstructure 3D Printing

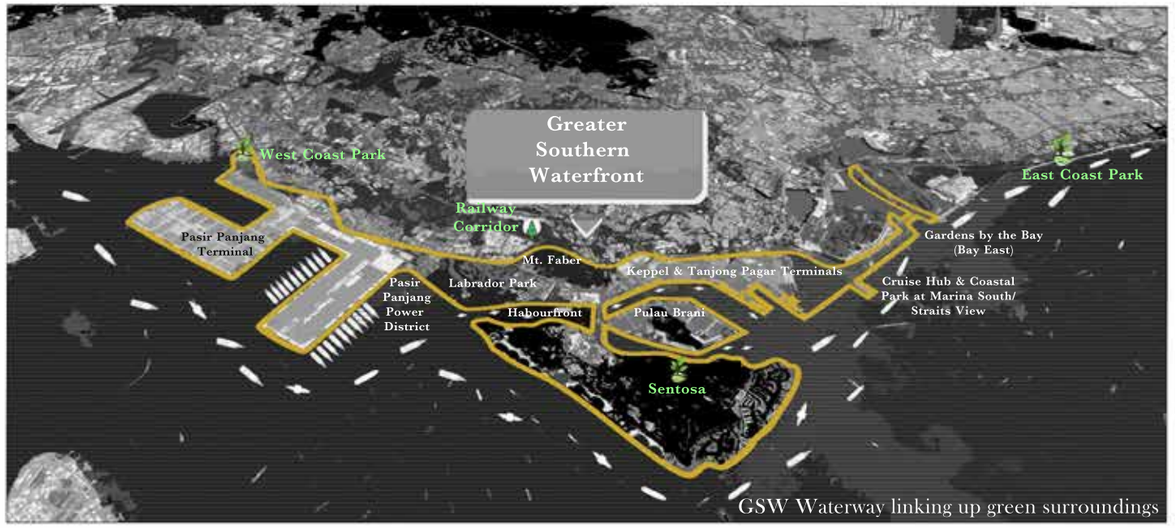


As construction technologies advances, new jobs opportunities are created while others are left behind. Will the integration with Artificial Intelligence unleash the power of a smart, connected, and vibrant nation?

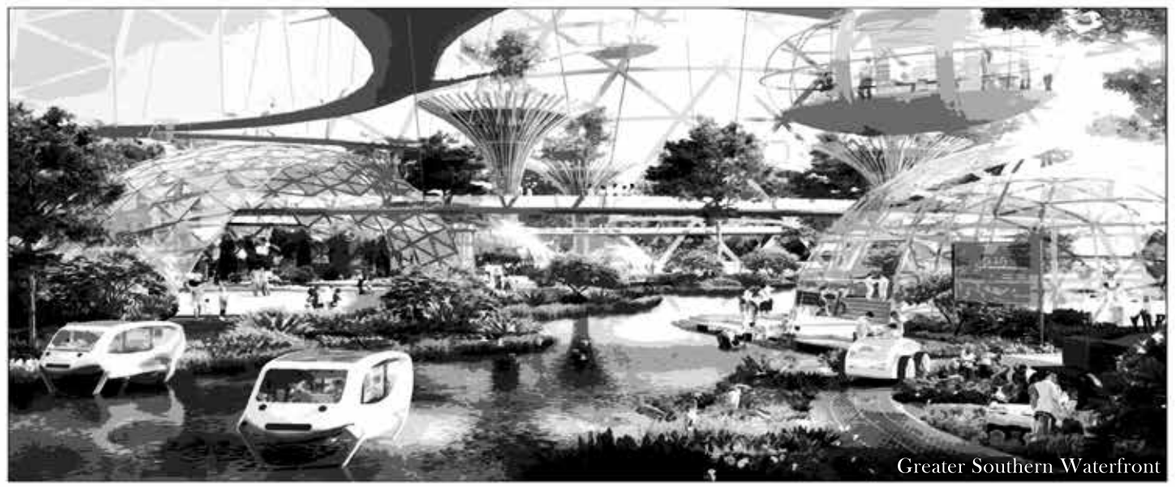
The Evolution of Construction Advancements
Men v.s Machines in Digital Age -
A series of transformations following such a scenario

Options Research Studio AY 20/21 Semester 1
Studio Tsuto Sakamoto

Research and Analysis
Category: Speculations



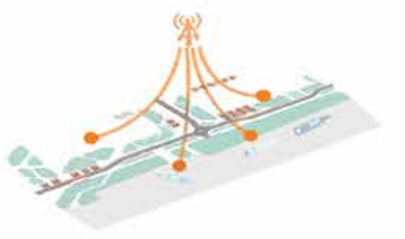
GSW Waterway linking up green surroundings



Greater Southern Waterfront

Water Taxi System

Activate Coastal Waterfront



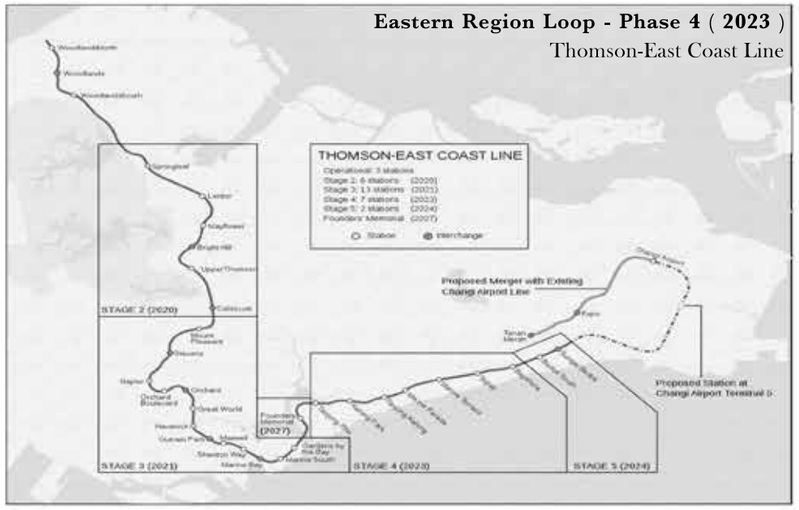
5G Connectivity

Strategically located along the coastlines of the Greater Southern Waterfront, will East Coast Park activate into a vibrant waterfront for the Eastern Region of Singapore? Improve accessibility linking Green and Blue, is this yet another urban redevelopment gimmick, or a true attempt to integrate the socio-ecology treasures of the East?

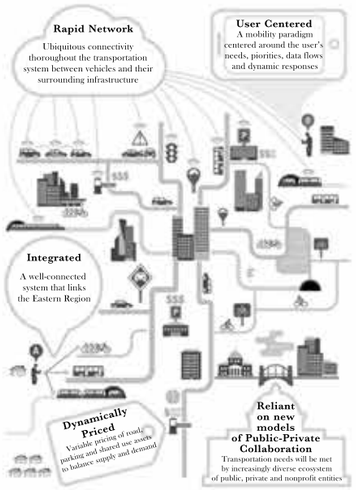
If Singapore leverage on 'Water' as new means of Transport
Future Mobility (Water Transport) in Digital Age -
A series of transformations following such a scenario

Options Research Studio AY 20/21 Semester 1
Studio Tsuto Sakamoto

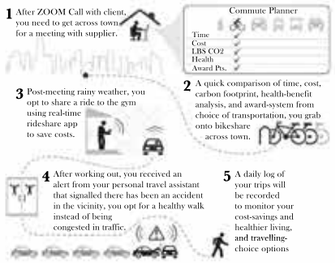
Research and Analysis
Category: Speculations



Digital-age Transportation Systems



Social Transport-Sharing



Battling Urban Gridlock

There is no silver bullet solution to the problem of gridlock - next generation urban transport systems will connect transportation modes, services, and technologies together in innovative new ways that pragmatically address a seemingly intractable problem.

Hub for Future Economy
with flexibility spaces and active programming that caters to different business and lifestyle needs, It will have a sizable residential population so that people can work closer to home.

New Paradigm of Mobility
with 90% walk-cycle-ride mode share target. With a comprehensive public transit network, more spaces will be dedicated to pedestrians and cyclists.

Smart and Sustainable District
by adopting a combination of district-wide infrastructure, innovative building designs, green technologies and data to inform planning decisions.

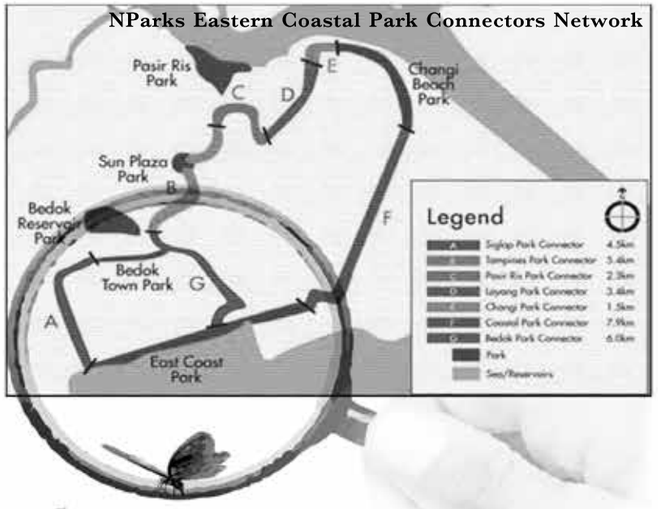
District of Gardens and Waters
with more than 185 hectares of parks and waterbodies, and direct connections to wider Round-Island-Route and Coast-to-Coast Trail to promote healthy living for all

Today's mobility system cannot meet future transportation demand without increasing congestion and pollution. The future mobility network for the movement of people and goods provides vital access to jobs, education, healthcare and trade. Will the new applications of transport technology bring work closer to home?

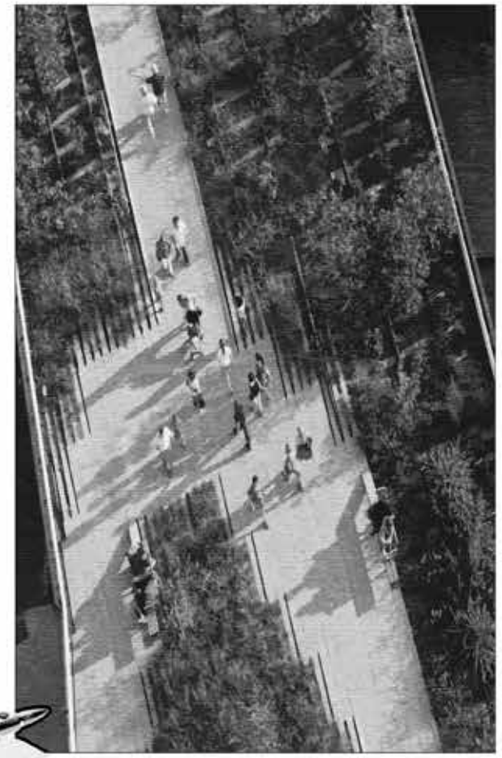
If Singapore leverage on Autonomous Traffice Network
Future Mobility (Public Transport) in Digital Age -
A series of transformations following such a scenario

Options Research Studio AY 20/21 Semester 1
Studio Tsuto Sakamoto

Research and Analysis
Category: Speculations



Bayshore Residential District
(East Coast)



Eastern Park Connector Network

5G Eastern Region Planning

Smart Living . Green . Blue. Transport .

Augmented Reality Park Experience

Connecting a wide variety of green, blue and play spaces creates an integrated network within the Eastern Coastal Park Connector Network (NParks). Can the revitalised and increased recreational spaces develop into a new typology of co-existence in the "Publicliness" and "Segregated" Public, Social Spaces in a Post-Pandemic nation?

If Singapore leverage Green Connectivity
Future Mobility (Park Connectors) in Digital Age -
A series of transformations following such a scenario

Options Research Studio AY 20/21 Semester 1
Studio Tsuto Sakamoto

Research and Analysis
Category: Speculations

MASTERPLAN - INTERIM

Studio Works

01 SEA LEVEL RISE + RAINFALL

Resilience through the process of inundation over time

Singapore, an island state located near the equator is more susceptible to the climate change threats of rising sea levels and extreme torrential rains altering our urban landforms and social-scape. Rather from a 'hindrance perception', many see the potentials to create a more "waterproof" urban environment and utilising the massive abundance of increased saline and freshwater supply.

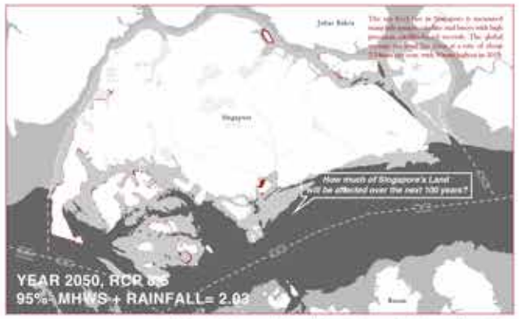
Projected Annual Rainfall Totals

Dynamical downscaling of extreme rainfall annual projection beyond 2050 from days with rainfall accumulations greater than the 95th percentile value (30mm per day based on wet days in Singapore) from the Northeast Monsoon (Dec – early March) and Southwest Monsoon (June - Sept) seasons.

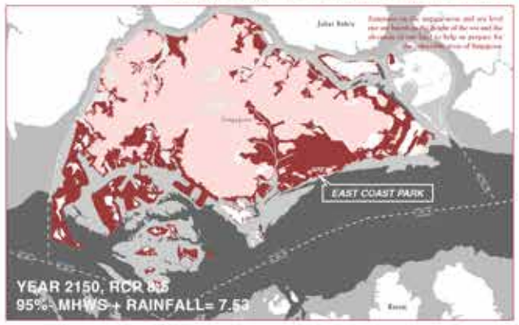
Projection Factors

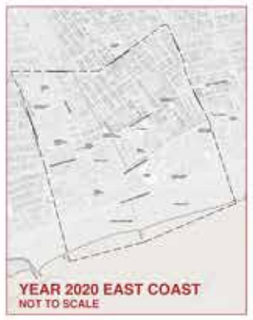
Extreme Sea Level :
Waves
Swell
Storm surges
+
Regional Sea Level Rise:
Scaling of global mean sea level rise
Ocean density
Atmospheric pressure
Glacier adjustments
+
Global Mean Sea Level Rise:
Thermal expansion
Antarctic and Greenland ice dynamics
Glacial melt
Land water storage

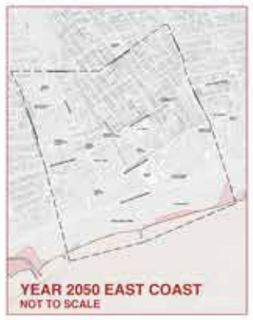
+
Extreme Torrential Rain
Extreme Temperatures
Extreme Winds

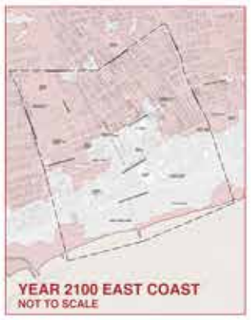


Evolving of Singapore's Coastal Land with sea level rise and rainfall



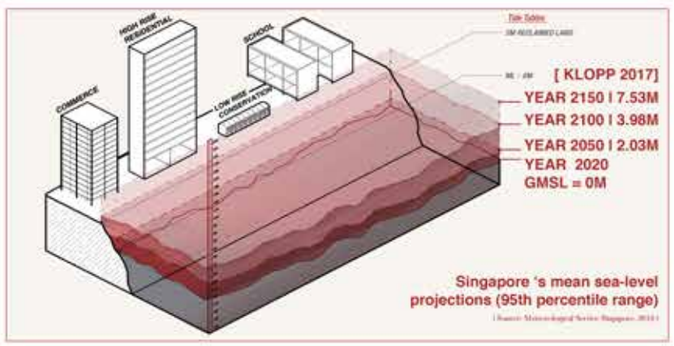






Displacement of occupants in buildings

Existing buildings as East Coast Park are not built to withstand extreme sea level rising due to climate change. In turn this creates opportunities for users to re-examine and explore new ways to address inland flooding and land subsidence issues into current and future conservation, low-rise buildings, high-rise residential, commerce and school's typologies due to biuform strategies.



Singapore 's mean sea-level projections (95th percentile range)

02 PROBLEMS ARISING FROM WATER LEVEL INCREASE

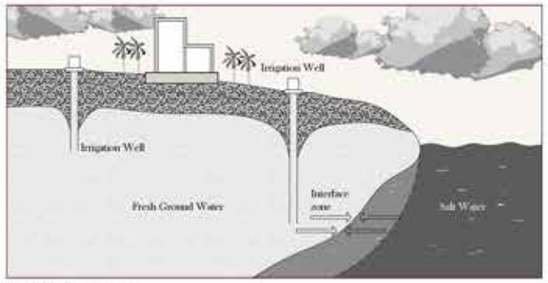
Sea level rise are causing more than just flooding

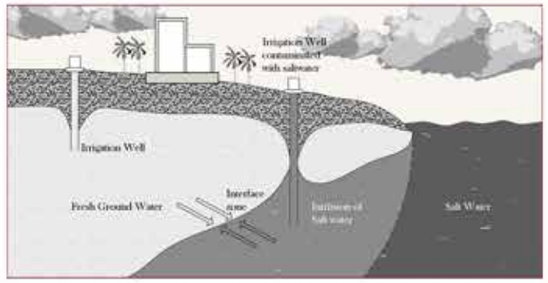
Rising sea levels can bring about a slew of issues that will greatly affect civilisation. These issues stretch across a broad spectrum, ranging from social, ecological to economical aspects.

Urban Habitat Issues

Rising sea levels will threaten coastal homes as they will be in a constant threat of being submerged in the event of a deluge.
The constant threat of being flooded is currently weighting on coastal residence's value, as both buyers and developers are starting to be weary of purchase estates along the shore.

Inland nations too face the similar issue as well, as more land is consumed by the rising sea levels. This problem then leads the islanders to question do they wish to continue staying in their native islands or relocate elsewhere.





Economical Issues

The increase of groundwater abstraction, combined with rising sea levels is causing a phenomenon known as Saltwater Intrusion.

This intrusion brings a bundle of issues, such as contaminated fresh water which would require increased treatment costs for desalination plants or in worse case scenarios, render ground water undrinkable at all.

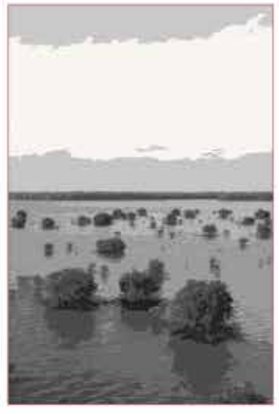
Additionally, tourism in countries that are near coast fronts would be in severe danger as the nation faces threat of being flooded from time to time. Places like Venice or Halong Bay would be avoided by tourists as water levels constantly rise.

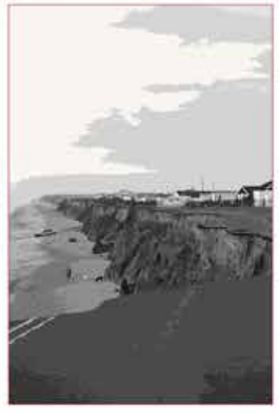
Ecological Issues

Rising sea levels would affect coastal flora and fauna alike, as many species risk losing their nesting and mating grounds. An increase in salinity in fresh water areas would also result in habitat loss for plants as contaminated waters would dehydrate plant roots causing them to die, destroying natural vegetation.

Increase in soil salinity would also result in coastal erosion, further limiting the amount of available land.

Rising sea levels result in an increase of both severity of tropical storms as well as their rate of occurance. This means that coastal





03 CURRENT STRATEGY + CRITIQUE + COUNTER

"How much will it cost, to protect ourselves against rising sea levels?"

To create an integrated and adaptive disaster-relief framework. The masterplan strategies aims to break down a potentially destructive calamity into smaller, manageable disturbances in the district in an attempt to conserve and build upon the deep heritage of East Coast, along with taking advantage of the abundance of water resource as a subsidiary means of sustenance

National Day Rally 2019 Climate Change : Coastal Defence Proposal

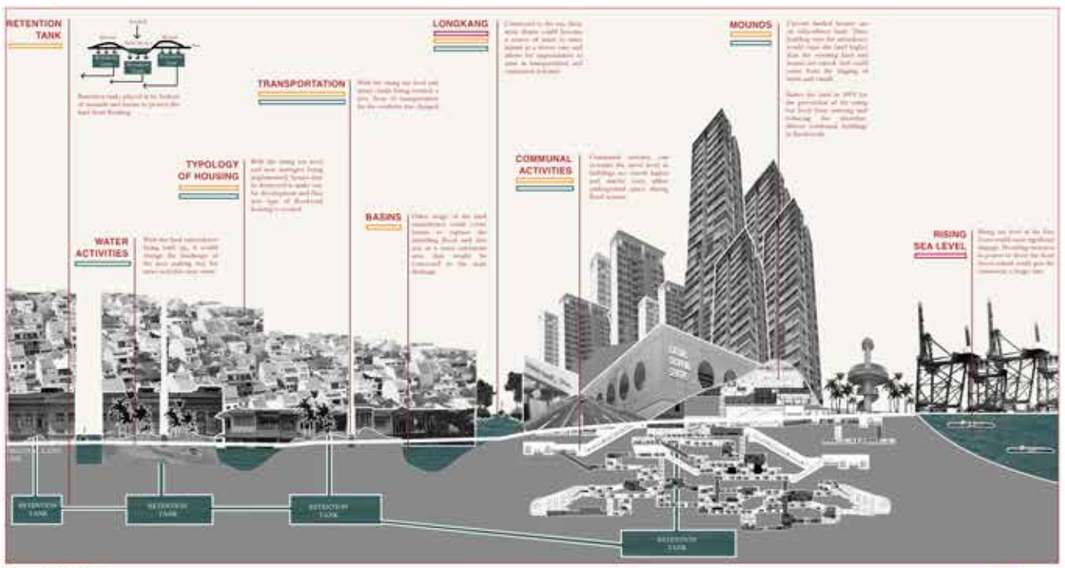
The announcement of the $100 Billion budget to counter sea level rise comes as both a reliefe and a whammy, from different perspectives. While the capital the authorities are willing to invest is heartening, the speculated strategies announced to develop across the century is questionable. These strategies of phased poldering, reclamation, and sea-walling, coupled with the introduction of new residential typologies along the coast across time, can be argued as excessively expensive, short-sighted, and potentially as a secondary mean to increase Singapore's land value at the expense of the East Coast district's community and culture. The large scale strategies bring about little to no impact to the lifestyle, community, and future proofing of East Coast beyond year 2100.

Coastal Defence Proposal : Reclamation of Islands

Reclamation of islands from Marina to Changi - residential typology built upon the reclaimed land, allows for more channelling of extra water

Coastal Defence Proposal : Poldering along the Shore

Dikes are built higher than the reclaimed land, and excess water is pumped out into the sea. The lower ground creates opportunities for farming and water activities due to its moist nature.



New Strategies

Mounds and Basins are used to create a more organic landscape in East Coast, allowing a slow and gradual flooding inland with the rising sea level. This improves culture of living with water and a sprout of a new typology of land use.

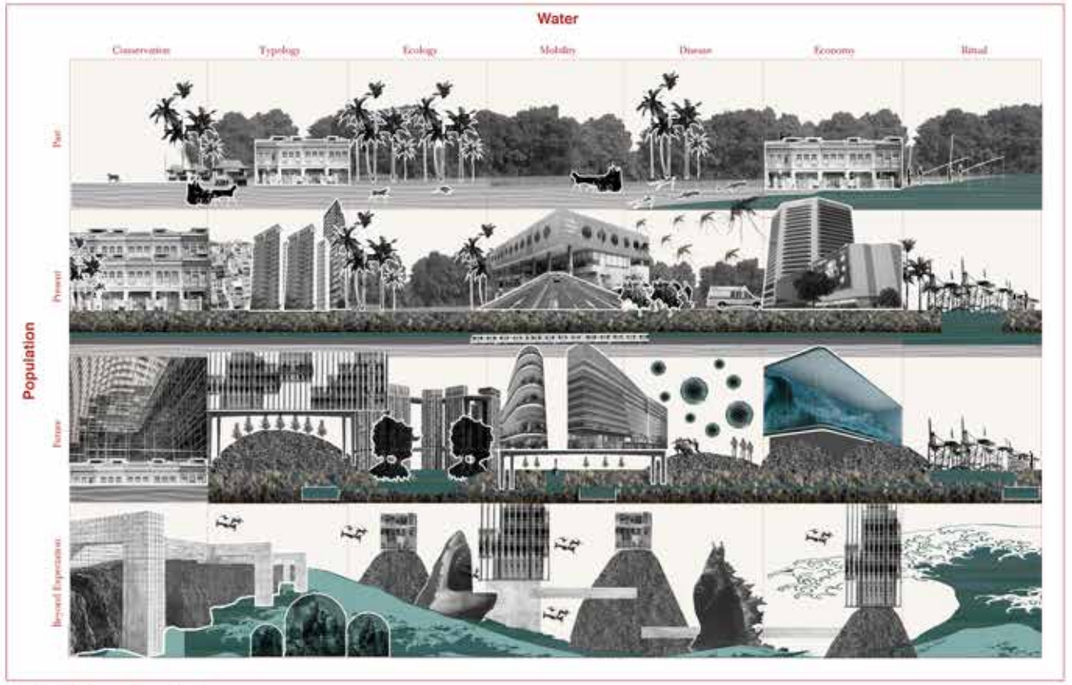
04 SPECULATION + PATTERNS + SCENARIOS

"History is written, but culture and heritage constantly evolves"

Given the unpredictable nature of disasters, there will be an inherent need to relocate affected residents from time to time, starting from the lowest lying flood prone areas. Flood patterns become increasingly destructive and erratic as climate change take a turn for the worse, thereby increasing the frequency and inconvenience of relocation.

Enomenos of East Coast

Places of gather in the East Coast that creates a sense of familiarity for the residents. However, with the rising sea level and the spaces sinking, this makes way for a new form of gathering

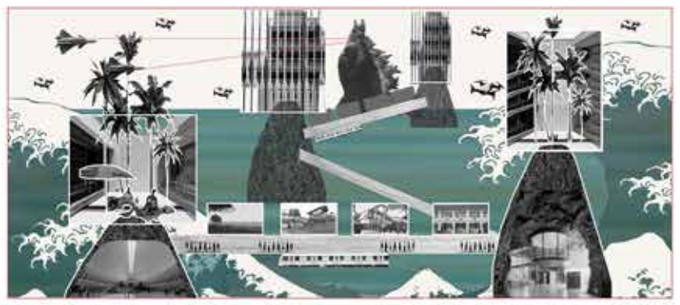


Culture Patterns Over the Years

Water has always been a key element in defining the culture of East Coast. However, with the rise of sea level, residents would need to start preparing living one with water. Therefore, slowly introducing water inland would help residents to assimilate with water before it overtakes the whole landscape beyond the years of 2100.

Beyond Expectation

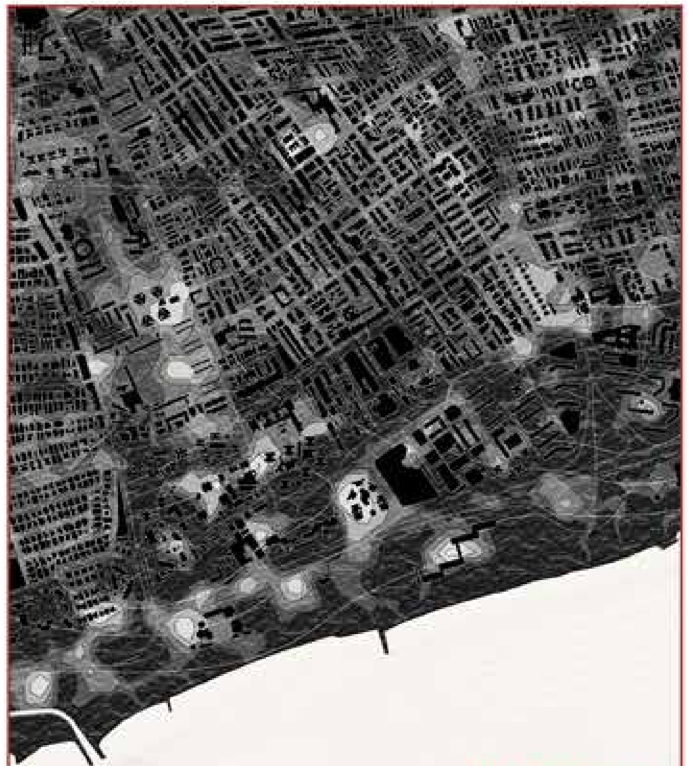
Mounds and Basins are used to create a more organic landscape in East Coast, allowing a slow and gradual flooding inland with the rising sea level. This improves culture of living with water and a sprout of a new typology of land use.



05 WATER FLOW ANALYSIS + STRATEGIES

Identifying Areas for Intervention

The first step is to identify where are the specific areas that will be most affected by sea level rise as well as unpredictable flooding. We can use two mappings to locate them: water flow and sea-level rise. For water flow, we use a mixture of topography and urban density to identify the direction in which water flows during a storm. For sea-level, we are taking the Kopp 2017 RCP8.5 prediction of 2100. Overlapping the two datasets will show us problem areas that require intervention, which will ultimately shape our masterplan.

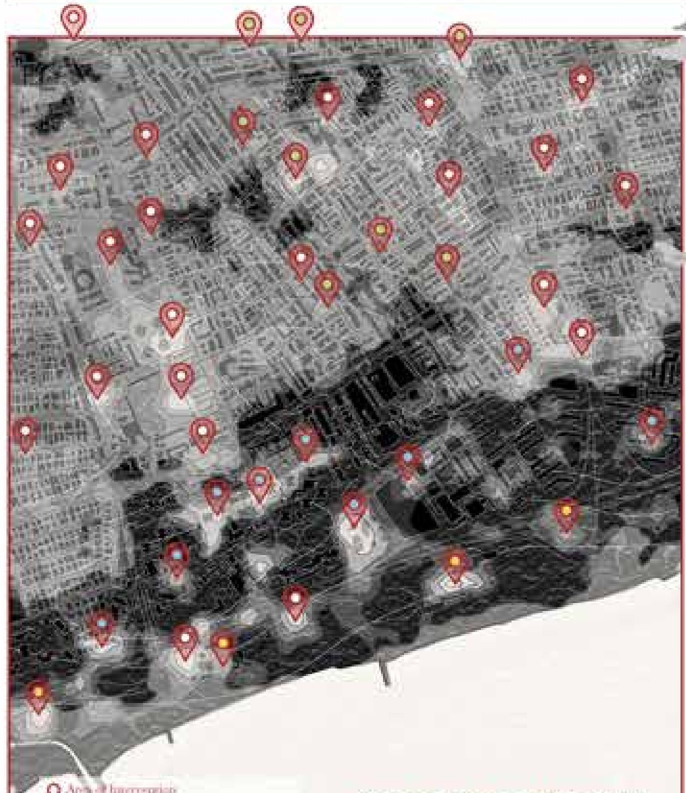


Water Flow Diagram

Water flows from darker shades to lighter shades. Based on topography and urban density.

Sea-Level Rise in Year 2100

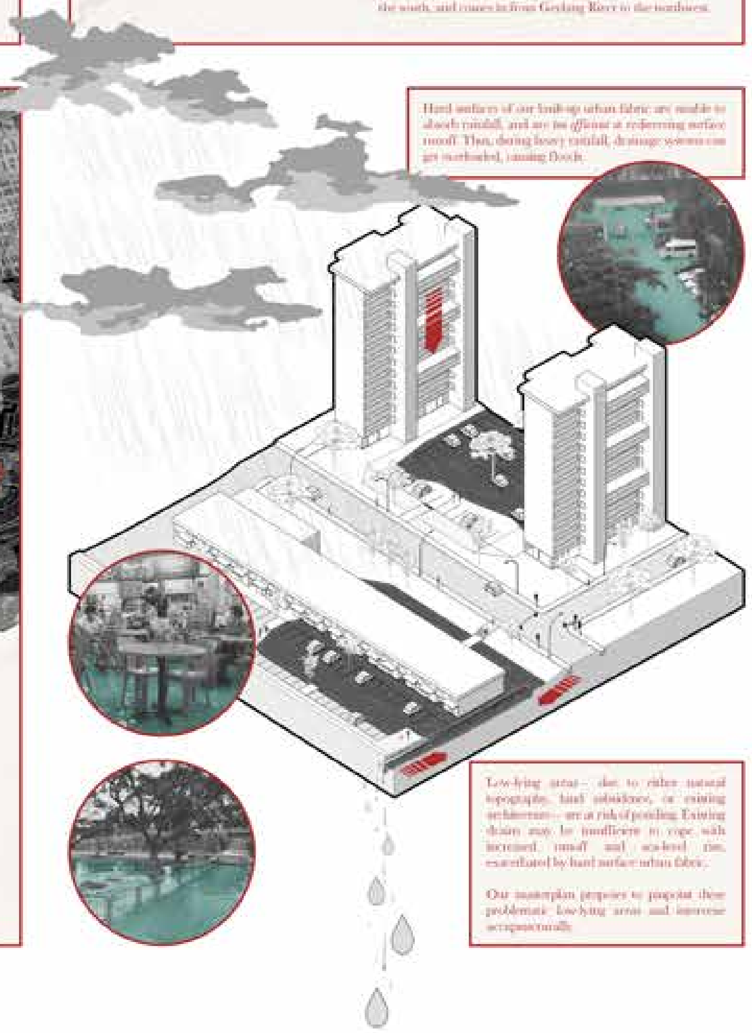
Represented by the lighter shade. Sea rises from the East Coast to the south, and comes in from Geylang River to the northwest.



- Area of Intervention
- Intervention + Bay Area
- Intervention + Land Subsidence
- Intervention + Architectural Conservation

Combined: Areas of Intervention

Overlayed water flow and sea-level rise diagrams. We can derive from this specific areas that require intervention.



Hard surfaces of our built-up urban fabric are unable to absorb rainfall, and are too *efficient* at redirecting surface runoff. Then, during heavy rainfall, drainage systems can get overloaded, causing floods.

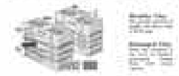
Low-lying areas – due to either natural topography, land subsidence, or existing architecture – are at risk of ponding. Existing drains may be insufficient to cope with increased runoff and sea-level rise, exacerbated by hard surface urban fabric.

Our masterplan proposes to pinpoint these problematic low-lying areas and intervene acupuncturally.

06 MOUNDS, BASINS + LAND SUBSIDENCE

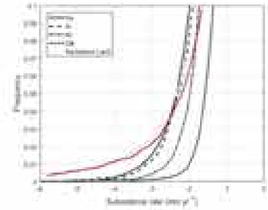
Displacement

In response to land subsidence, basins are created with retention and recharging tanks underneath to buffer against subsidence. The earth dug out to create basins then form mounds to relocate residents. This creation of basins and mounds seek to buffer against land subsidence and to protect people from floods.

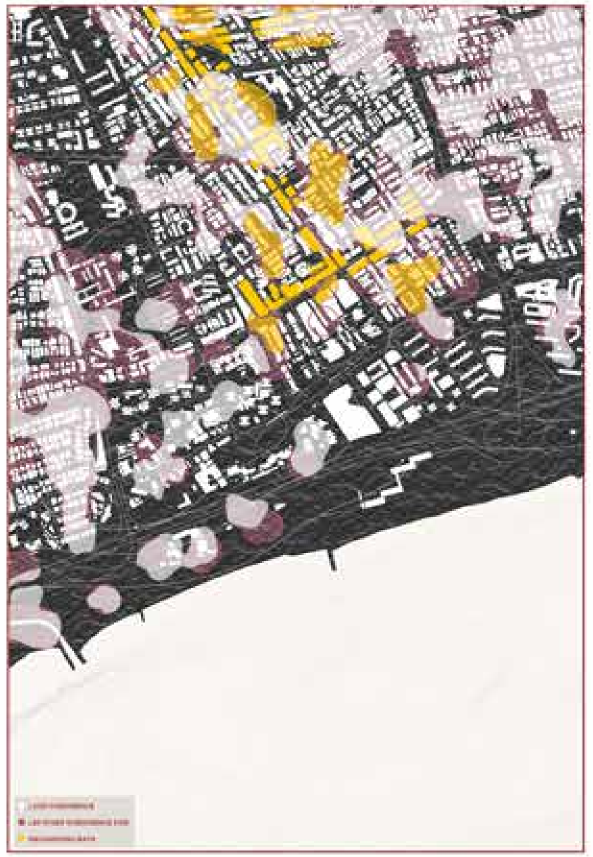


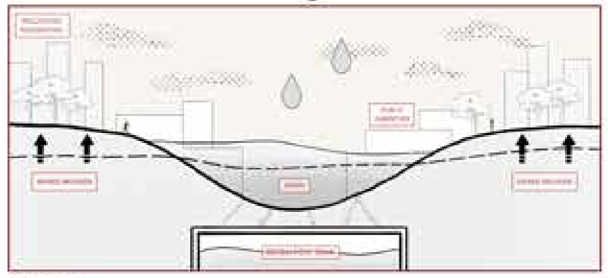
Land Subsidence

Retention Tanks and Recharging

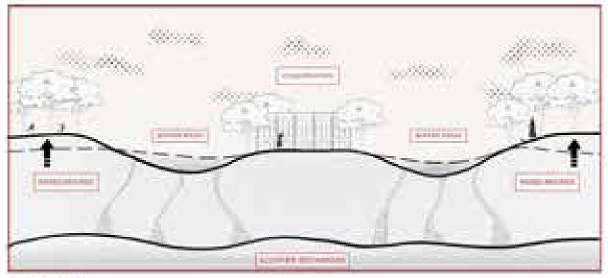


Land Subsidence at Marine Parade

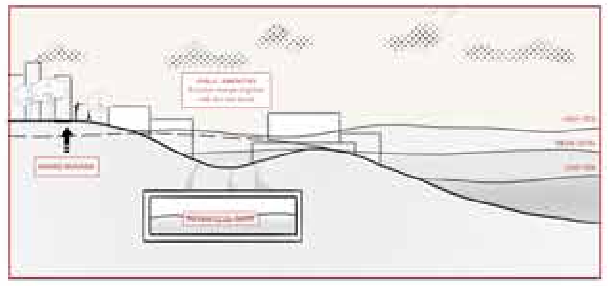




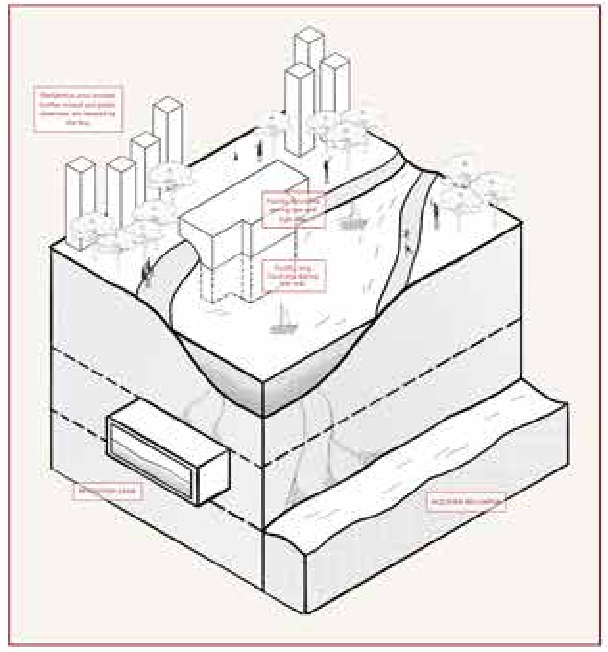
STRATEGY 01
LOW-LYING AREAS



STRATEGY 02
CONSERVATION AREAS

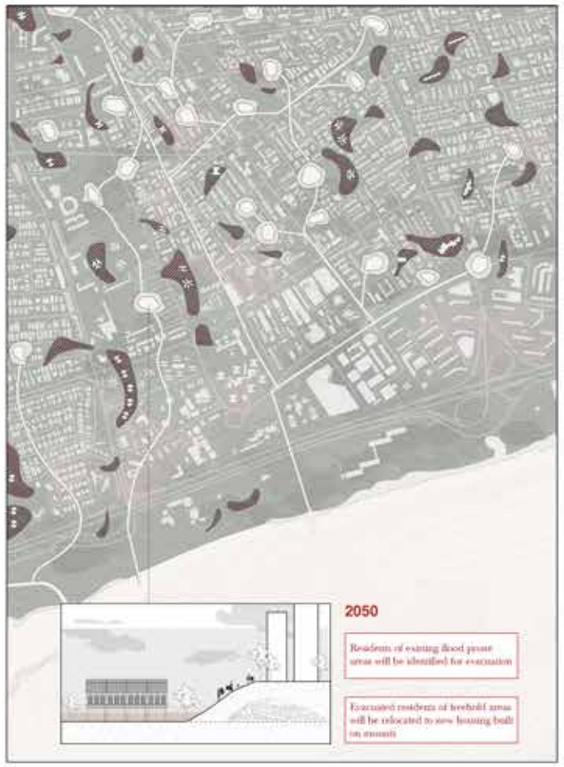


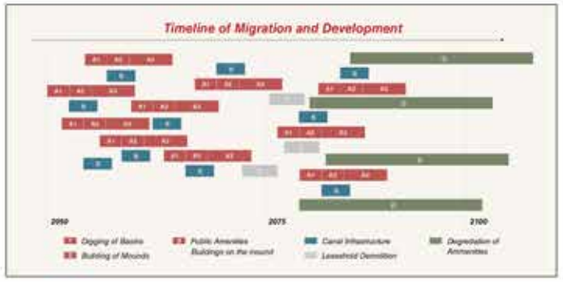
STRATEGY 03
BAY AREAS

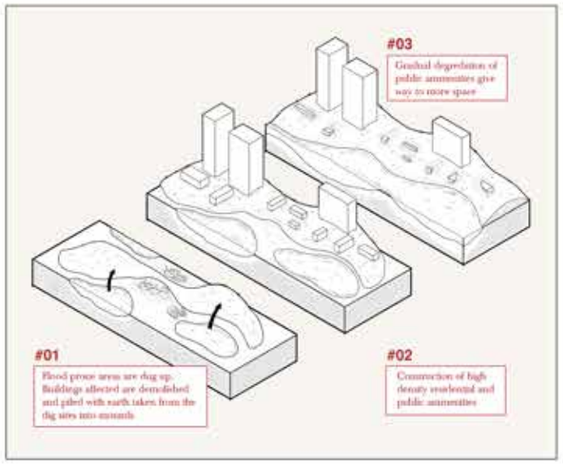


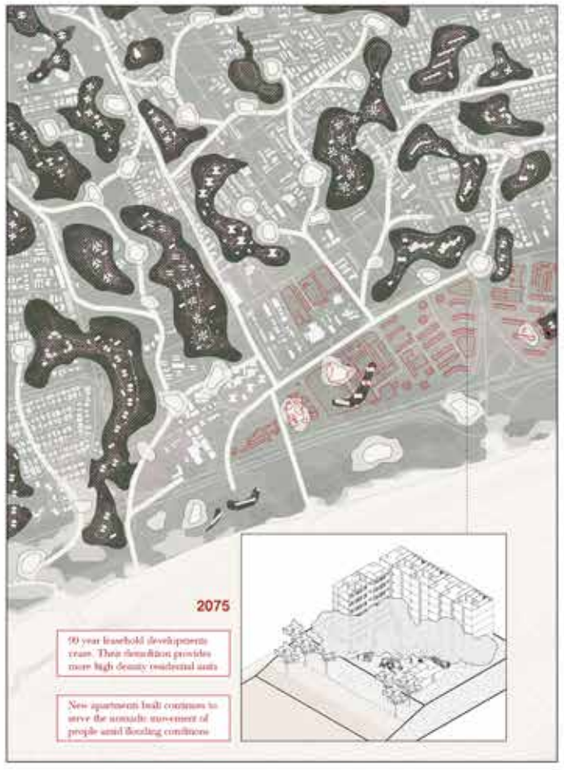
ISOMETRIC OF BASIN AND MOUNDS

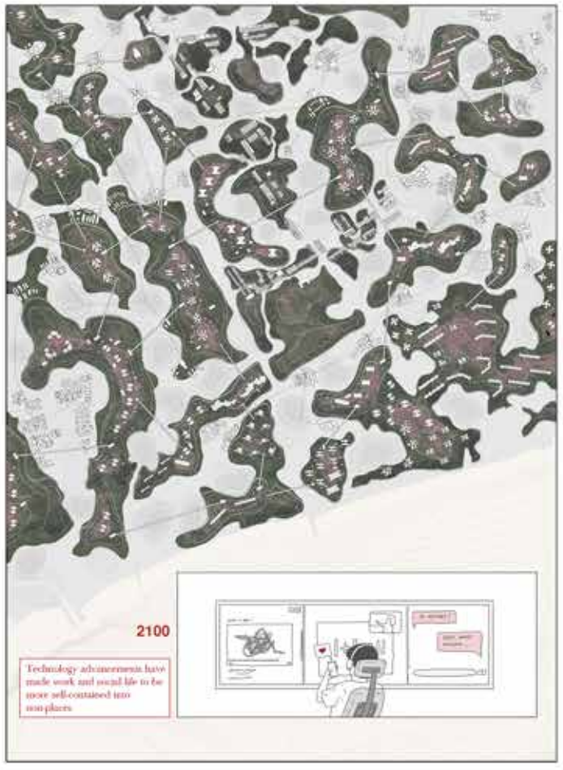
07A MASTER PLAN DEVELOPMENT ACROSS TIME (YEAR 2050 - 2100)





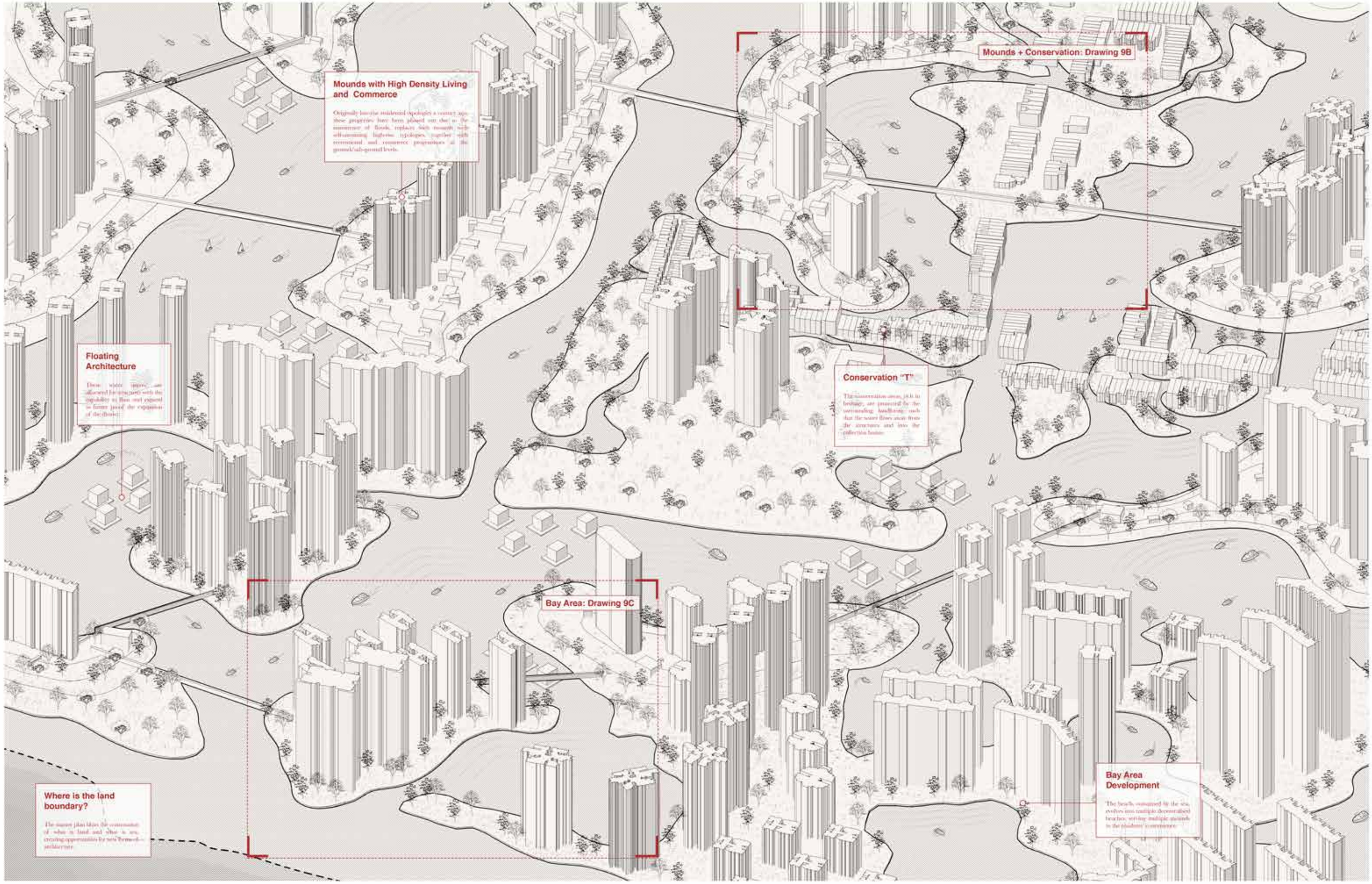




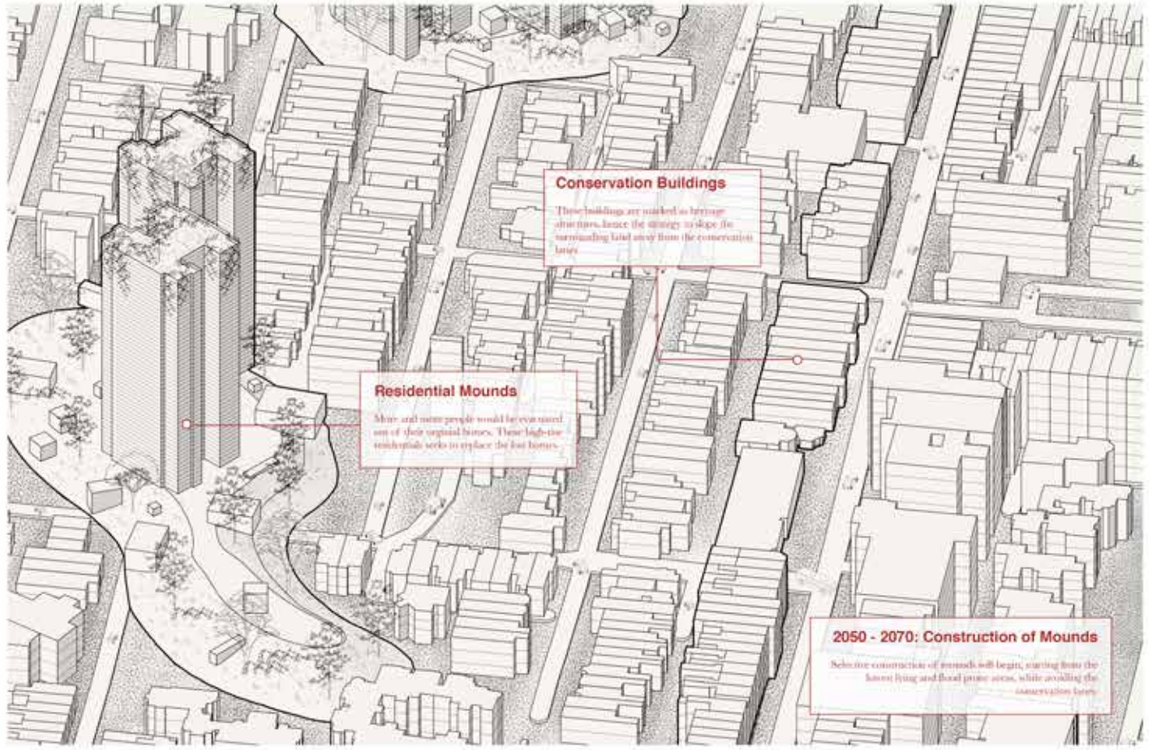


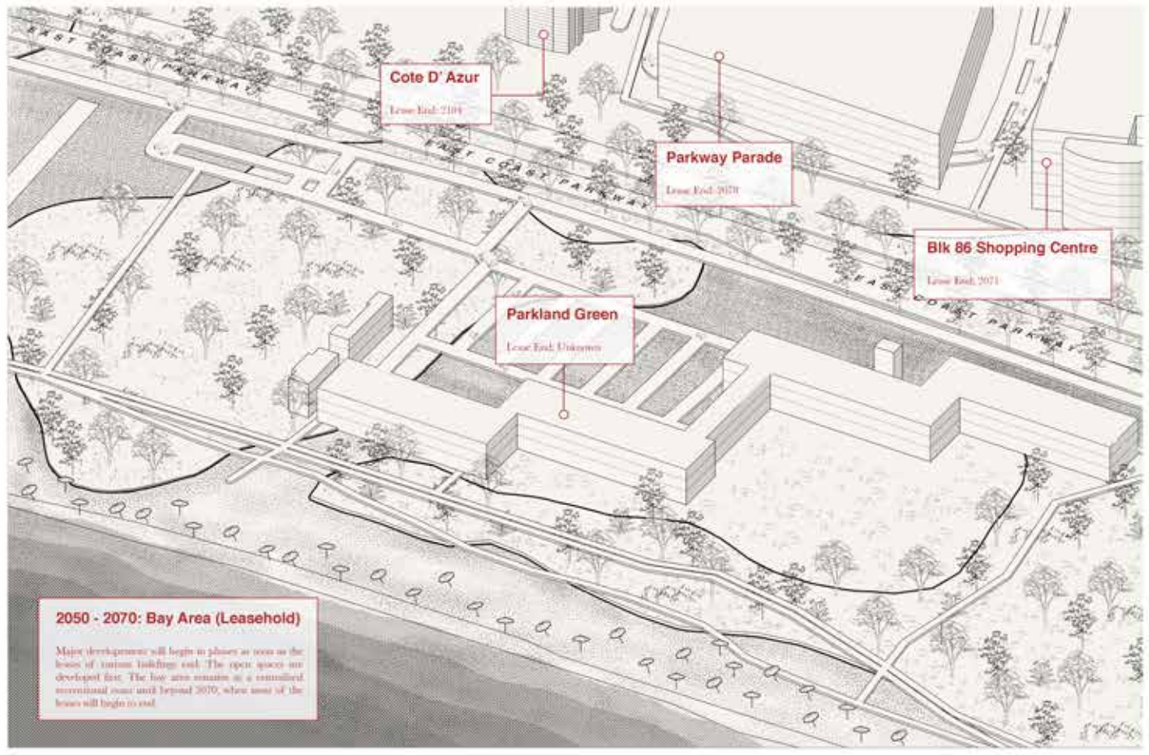
08 EAST COAST MASTER PLAN: BEYOND 2100

09A EAST COAST BEYOND 2100: MASTER PLAN AXONOMETRIC



07B MASTER PLAN DEVELOPMENT ACROSS TIME (YEAR 2050 - 2100)





09B EAST COAST MASTER PLAN BEYOND 2100 (INTERFACES)