

Are Our Floods Getting Out Of Control?

A visualisation of Singapore's weather data to improve flood mitigation

Project 1 Presentation

DSIF-SG-9:

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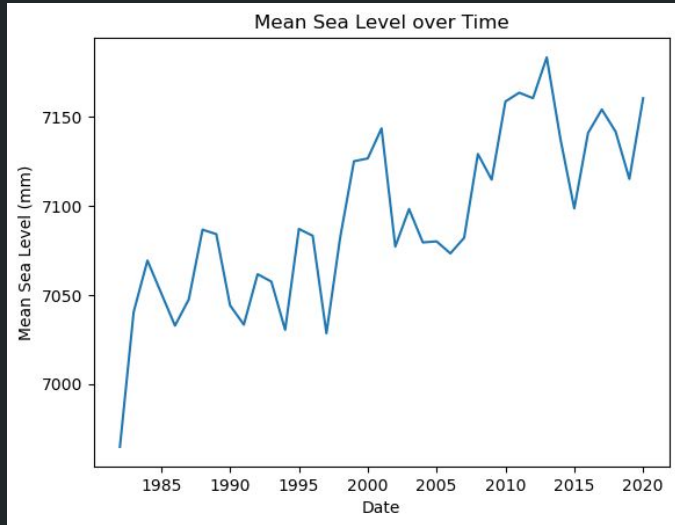
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Agenda

- Background
- Problem Statement
- Visualising Singapore's weather
- Implications of Erratic Weather
- Summary of Analysis
- Conclusions & Recommendations
- Q&A

Background

- Singapore's mean sea level: annual increase of 3-4 mm
- Global average surface temperatures are expected to increase 1.3°C-5.7°C
- More evaporation, more rainfall



Measures against rising sea level

- External defence: coastal protection
- Internal defence: drainage systems, water catchment facilities

Limitations of internal mitigations to manage floods

- Drainage sizing
- Rainfall unpredictability resulting in flash floods



Consequences

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graph TD; A[Consequences] --> B[Direct Cost]; A --> C[Indirect Cost]; B --> B1[- Flood Damages]; B --> B2[- Accidents & Injuries]; B --> B3[- Environment & Biodiversity]; C --> C1[- Business & Tourism]; C --> C2[- Productivity]; C --> C3[- Food Prices]; C --> C4[- Property Values]; C --> C5[- Quality of Life];
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Direct Cost

- Flood Damages
- Accidents & Injuries
- Environment & Biodiversity

Indirect Cost

- Business & Tourism
- Productivity
- Food Prices
- Property Values
- Quality of Life

Problem Statement

To examine the relationship between Singapore's mean sea level and its weather conditions to mitigate floods effectively

How can Singapore alleviate Floods ?

- Cost of flood damage in Singapore between 2000 and 2015 surpassed \$32 million.
 - Business, Tourism, Productivity costs
 - Instability of Food Prices and Property Values
 - Accidents & Injury Costs
 - Environmental Costs ie., Loss of Biodiversity etc.
 - Lower Quality of Life
- Ensure that the size of our internal defence system (storm drain, canals, water catchment areas) is large enough.
- Schedule periodic maintenance of the internal defence system.



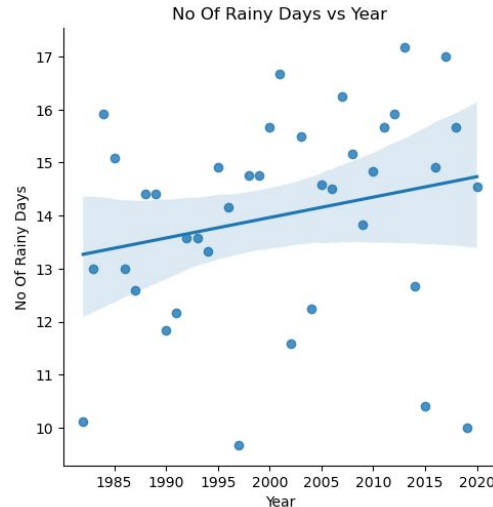
Visualising Singapore's Weather

No of Rainy Days over the Years

Since 1980s, the average number of rainy days has increased over the years.

While we had seen a lower total rainfall in the 2010s due to the El Nino effects, the El Nino did not result in a drop of the number of rainy days.

We can expect that when the El Nino effects are gone, we will be facing more intense rainfall in the future



More Frequent and Intense Rainfall

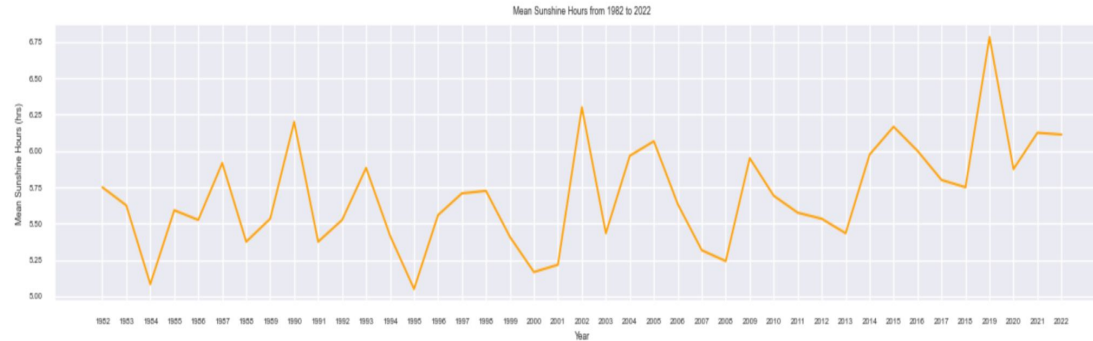


Total Rainfall (mm) fluctuate around the same average.

Maximum Rainfall in a Day (mm) did not increase over the years.

Number of Rainy Days (n) rising.

Water Cycle is Speeding Up

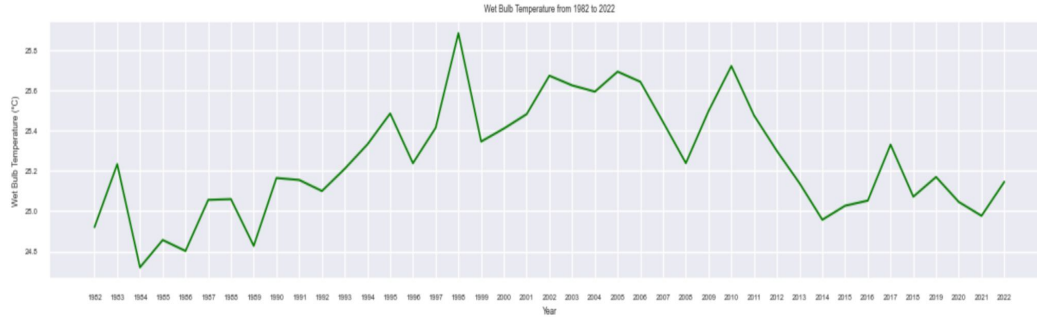


Mean Sunshine Hours (hr) has risen over the years.

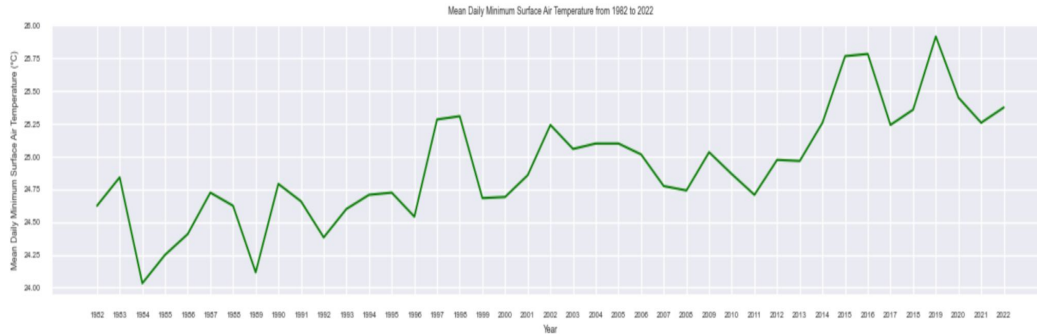


Mean Relative Humidity (%) has declined over the years.

Water Cycle is Speeding Up

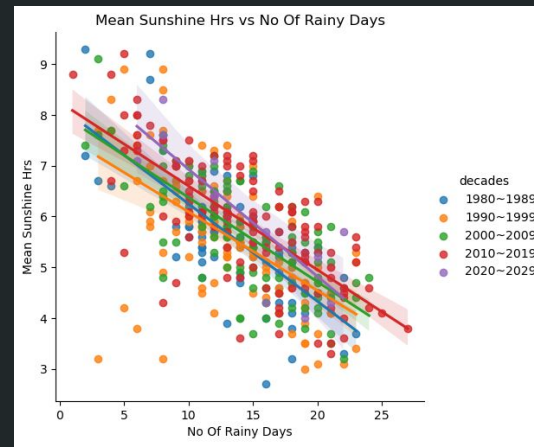
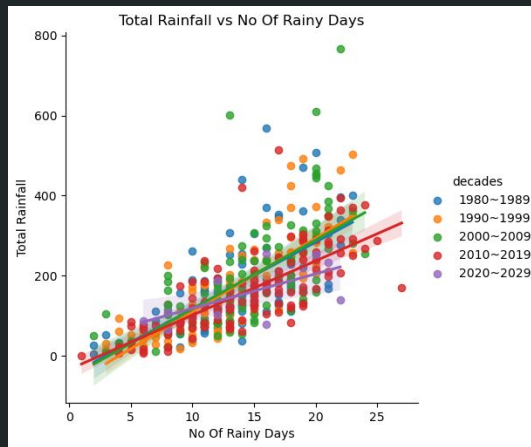
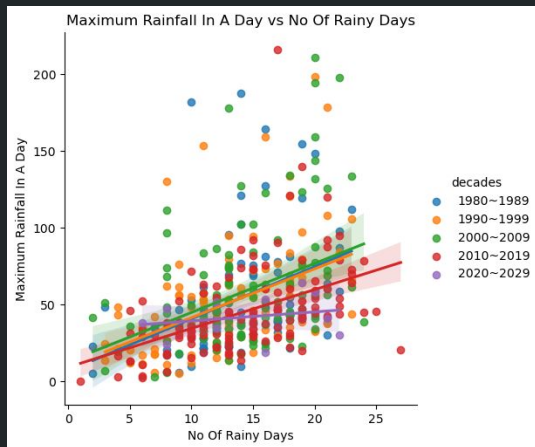
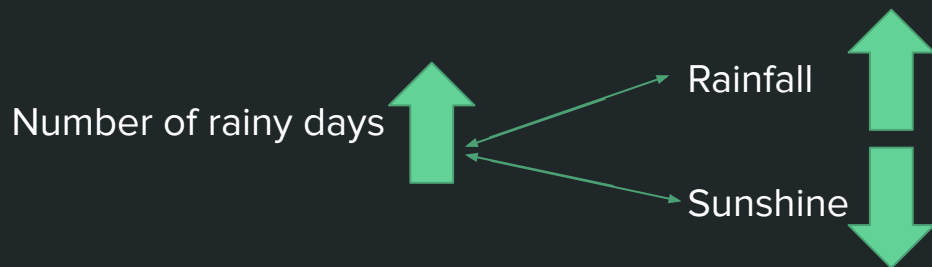


Wet Bulb Temperature has risen over the years.

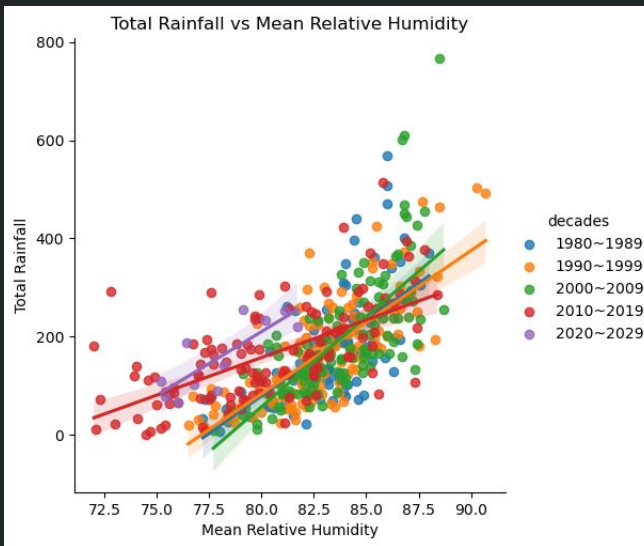
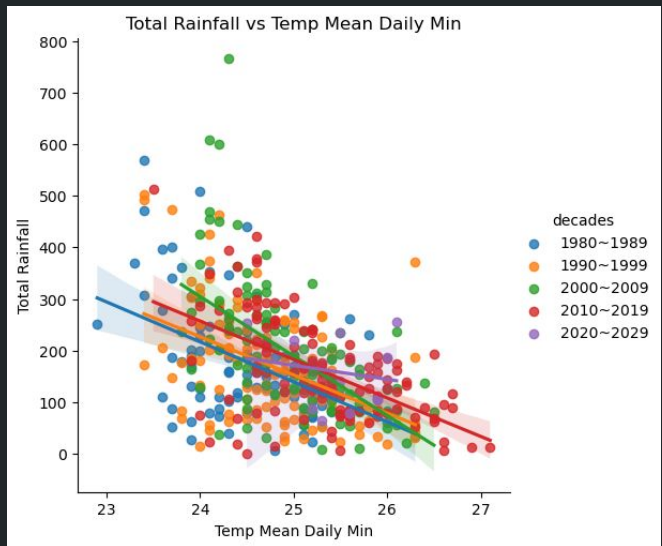
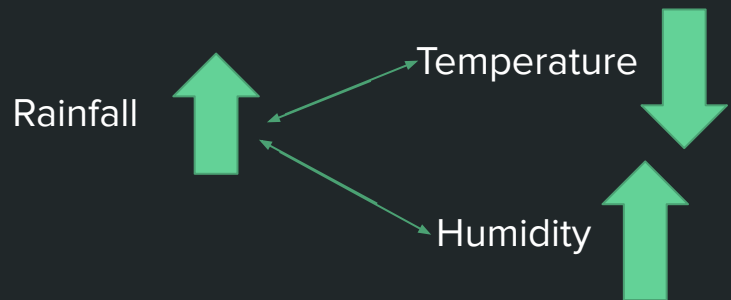


Mean Daily Surface Air Temperature has risen over the years.

Observations

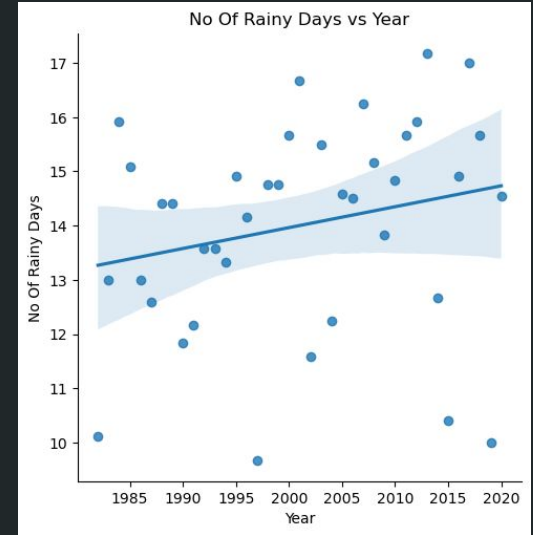
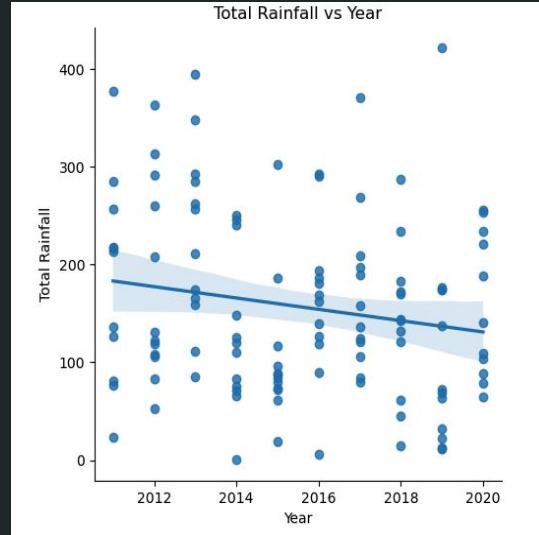
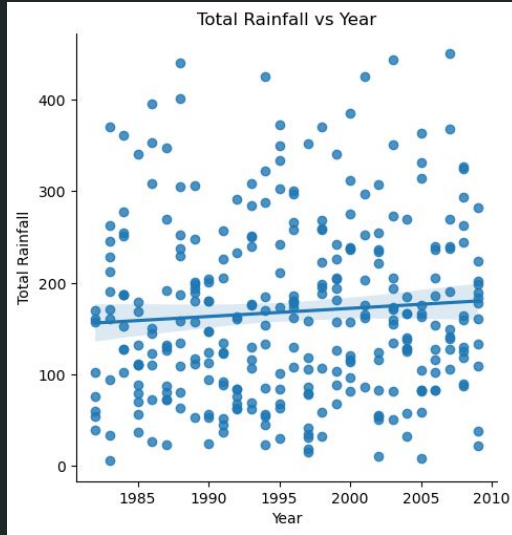


Observations



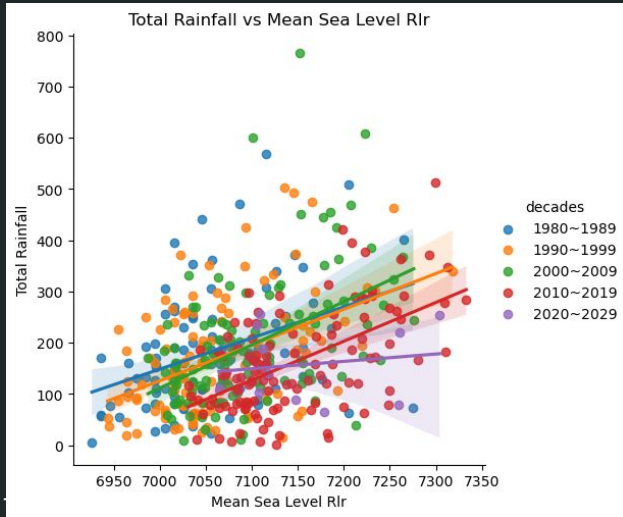
Observations

- Gradual increase from 1982 - 2010
- However downward trend observed past 10 years
- Steady increase in number of rainy days



Relationship between Mean Sea Level and Total Rainfall

- Positive correlation between mean sea level and rainfall



sea level and the total rainfall.

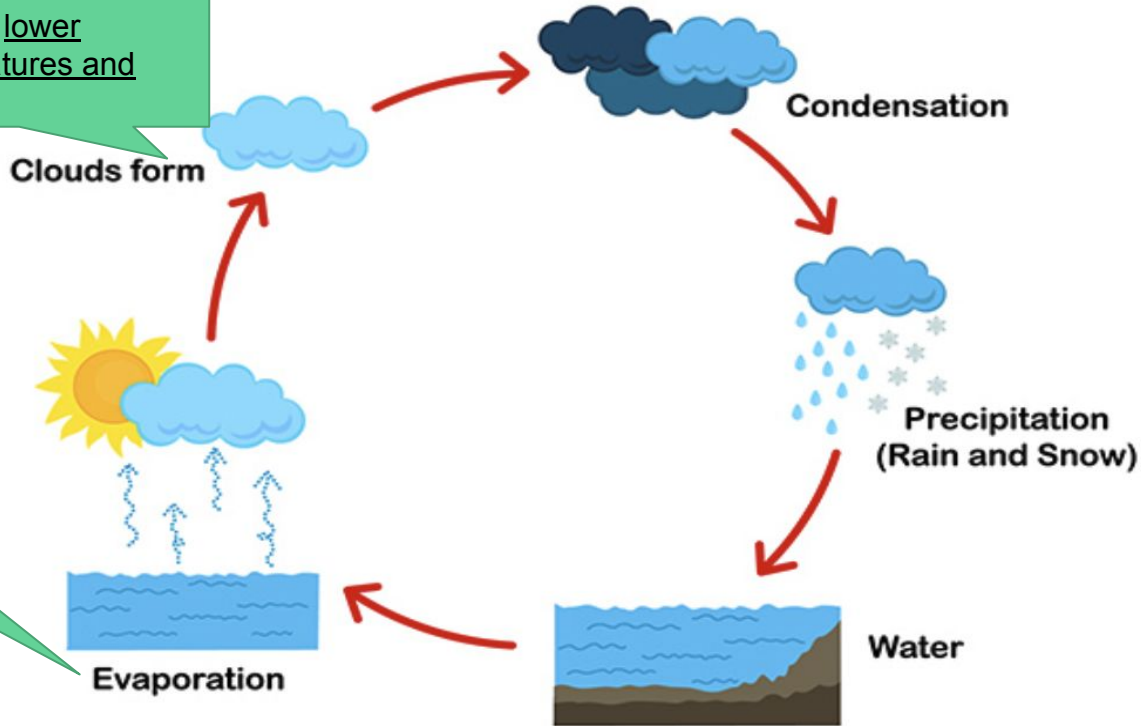
The trend is consistent for the 1980s up till the 2000s.

For 2010s onwards, which it seems that the total rainfall decreased, it was caused by the modulations of the 2015~2016 El Nino.

Before the Bad News: The Water Cycle Speeding Up

Cloud formation reflects solar and light energy from the sun, resulting in lower surface temperatures and less sunshine

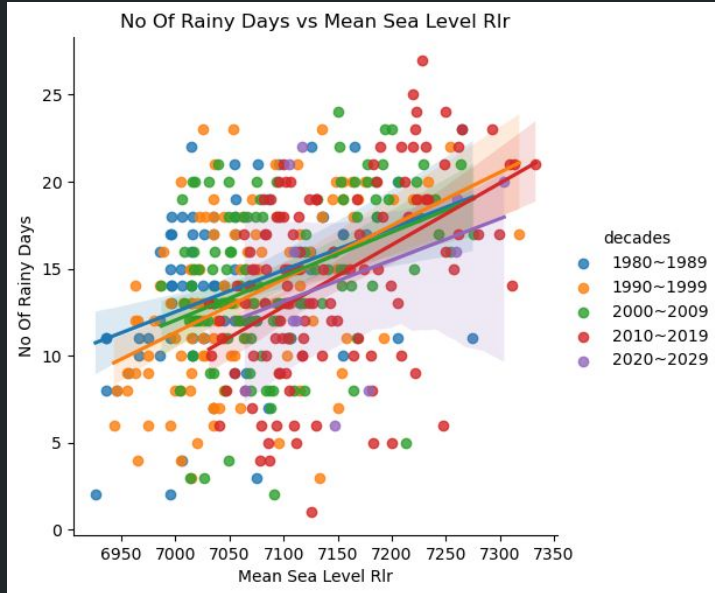
Water bodies trap heat and this speeds up evaporation, leading to increased relative humidity



Implications of Erratic Weather

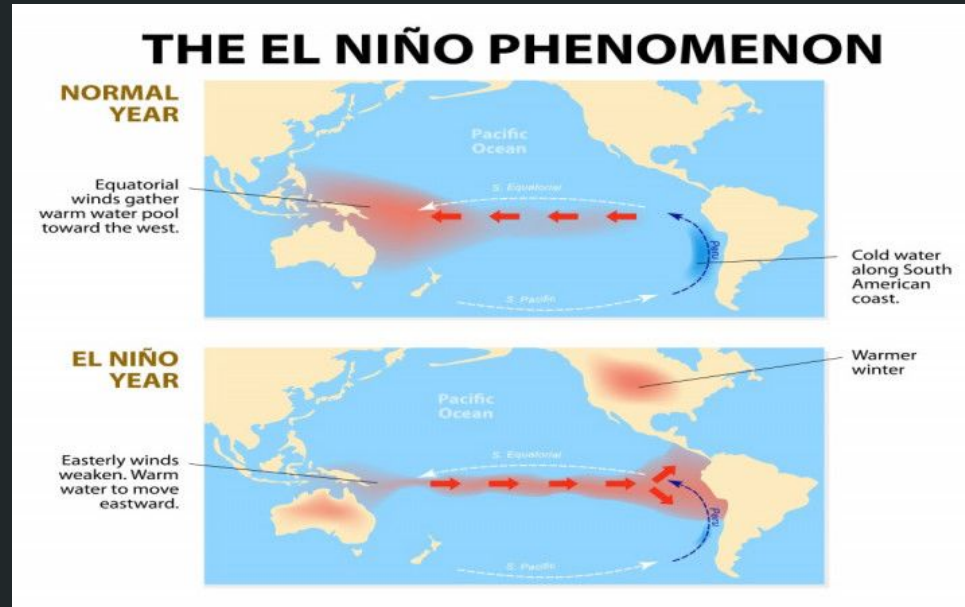
Relationship between Mean Sea Level and No of Rainy Days

- Positive correlation between mean sea level rise and number of rainy days.
- Throughout the decades, this had been consistent. This is in line with the earlier observation of number of rainy days increasing over the years.
- Coupled with the water cycle, we can now see that higher mean sea level results in a larger volume of water to evaporate and promote cloud formation



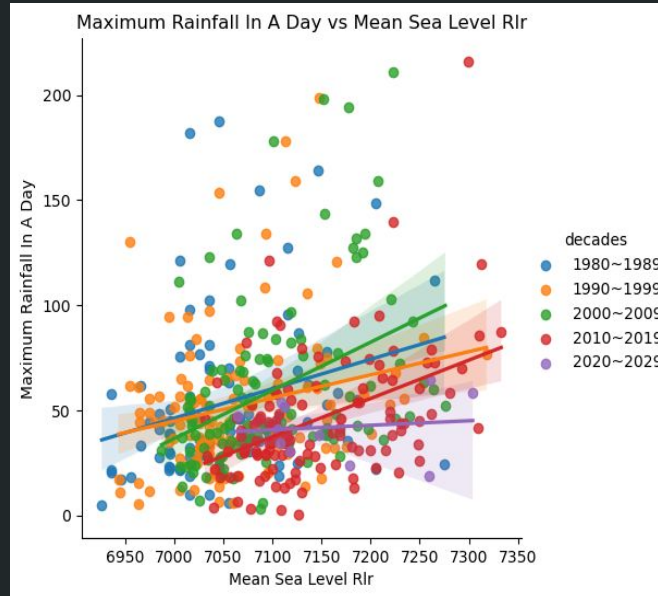
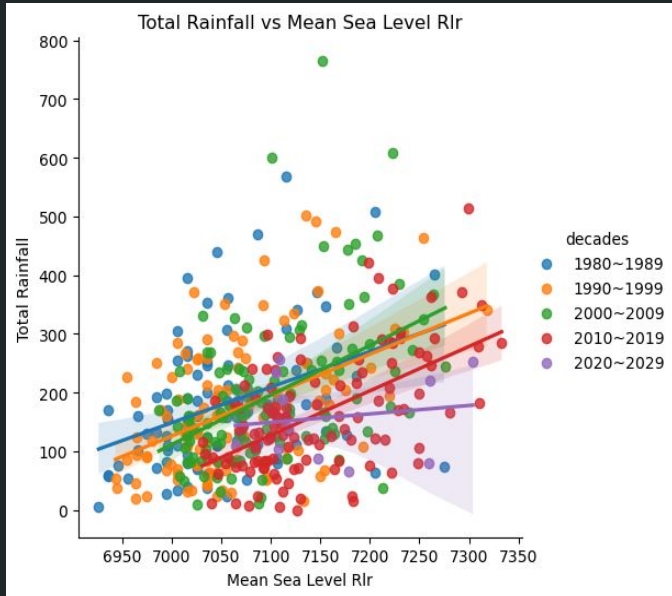
New Terms - El Nino

- There is a counter clockwise ocean current swirl
- During El Nino years, the warm water currents counter the swirl, taking away raincloud from Asia, leaving us drier
- El Nino can last for 2~7 years



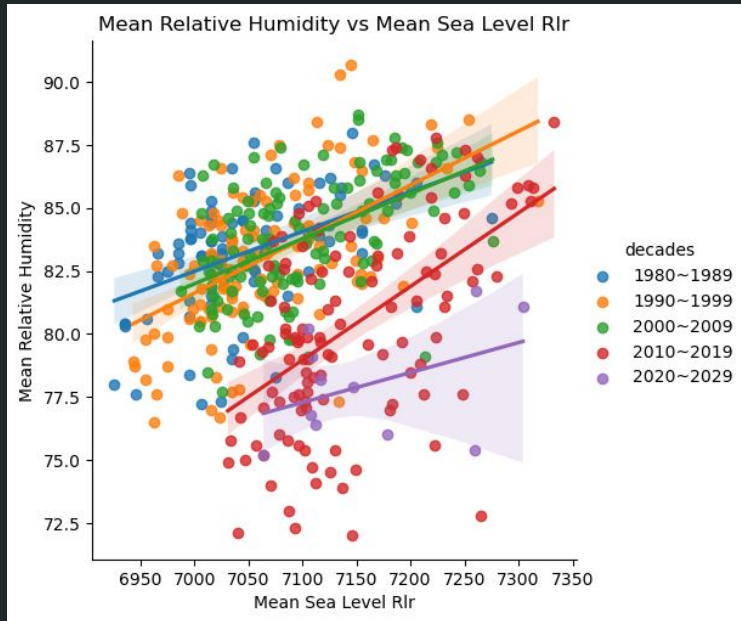
Relationship between Mean Sea Level and Rainfall

- Positive correlation between mean sea level rise and rainfall
- Up to 2010s, the pattern has been consistent. With the disruption by the El Nino in 2015-2016, the general in the past decade had fallen, but we expect this to be temporary
- When the El Nino's effects wear off, we can anticipate a continue rise in rainfall (erratic), which is inline with the rainfall data over the years



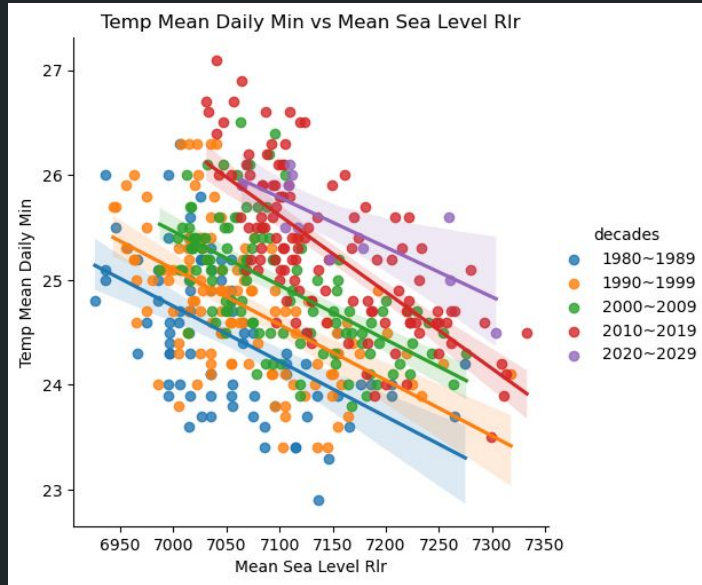
Relationship between Mean Sea Level and Humidity

- Positive correlation between mean sea level rise and humidity
- Up to 2010s, the pattern has been consistent. With the disruption by the El Nino in 2015-2016, the humidity in the past decade had fallen, but we expect this to be temporary
- When the El Nino's effects wear off, we can anticipate a continue rise in humidity, which promotes cloud formation and eventual rain



Relationship between Mean Sea Level and Surface Temperature

- Negative correlation between mean sea level rise and surface temperature
- We can note that with global warming, the daily minimum temperatures had risen over time
- However, with the combined effects of the humidity, and increasing number of rainy days, it is not unreasonable to expect higher rainfall in the future



Summary of Analysis

Analysis Summary

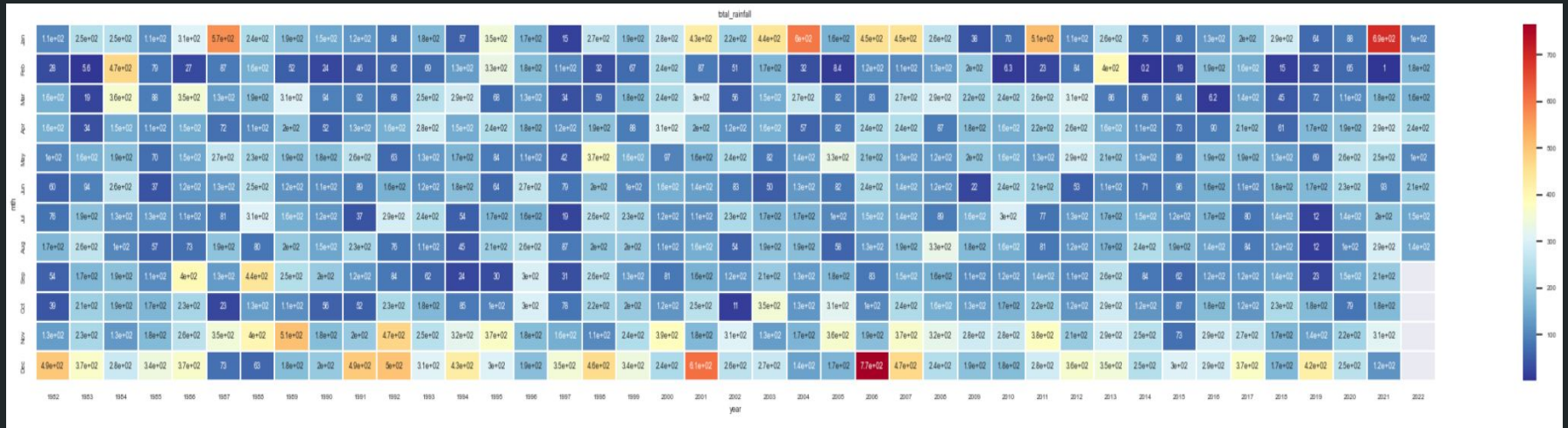
- Rising mean sea levels gels well with Singapore's weather data.
- From the water cycle, rising mean sea levels contribute to a higher volume of seawater, which has excellent heat storage capacity.
- This increase in temperature promotes evaporation and cloud formation, eventually resulting in rainfall.

Conclusions & Recommendations

Conclusion

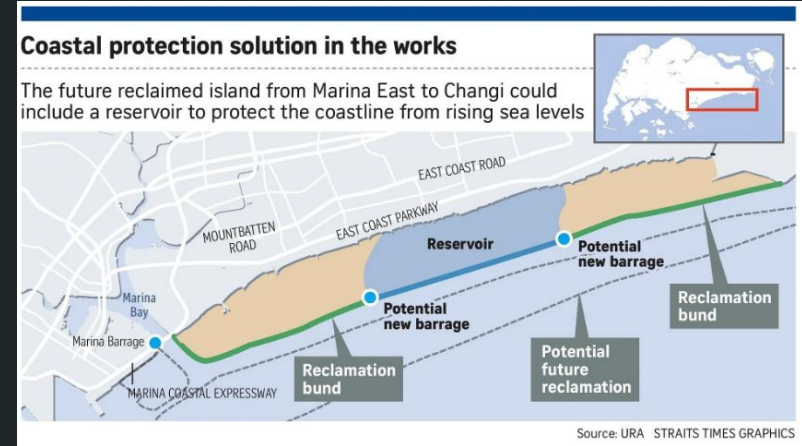
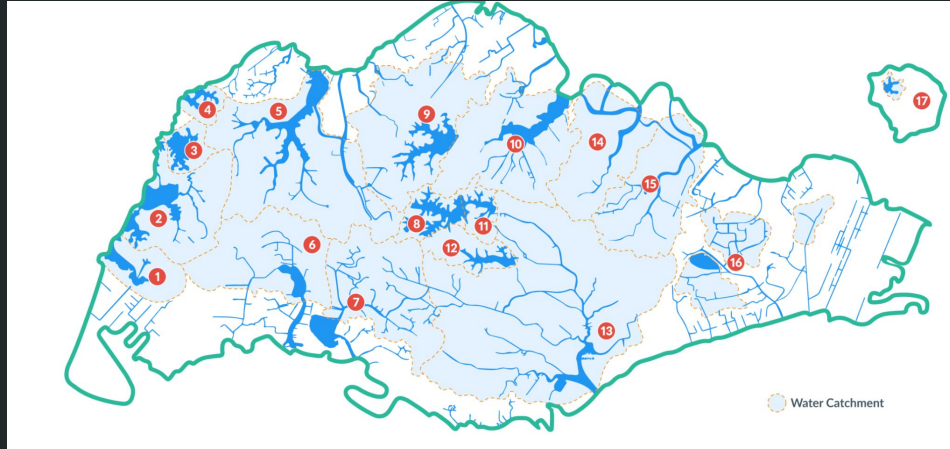
- Singapore is able to address rising mean sea levels through strengthening our external defences, such as the use of seawalls.
- However, this also implies that rainfall will increase over the years and eventually overwhelm our internal control measures.
- Therefore, more proactive measures need to be taken to bolster our internal defences to mitigate flooding.

Recommendation



- Utilising rainfall data from December-January timeframe (coinciding with the North East Monsoon) to size up our internal defences (storm drain, water catchment, etc)
- Drier months (eg. February) can be used for periodic maintenance of the internal defences

Recommendation



We need to increase the capacity of our water catchment:

- Enlarging existing water catchment (such as Seletar and Peirce) thru land acquisition of land nearby
- Speed up the construction of the Long Island along East Coast Park

Q&A
