

# The Projected Economic Impact of Extreme Sea-Level Rise in Seven Asian Cities in 2030

## *Key Findings*

### Summary

Coastal cities across Asia are facing heightened flood risks due to rising sea levels and intensifying tropical storms. The Intergovernmental Panel on Climate Change warns that global mean sea level could rise by 0.43-0.84m by 2100 (IPCC, 2019). At the same time, throughout the twenty-first century, storms are on track to bring more damaging wind speeds, higher storm surges, and more extreme rainfall than in the past (Knutson et al., 2020).

We selected seven Asian cities that are economic centers and are located on or close to the coast to analyze how their gross domestic product (GDP) could be impacted by extreme coastal flooding in 2030 with the BAU (Business-As-Usual) carbon-emission scenario. Our analysis suggests how the climate crisis may affect the economies of the cities analysed in less than one decade unless we act immediately to achieve a rapid reduction in greenhouse gas emissions.

Currently climate action, including nationally determined contribution targets, is insufficient to avoid the risk of severe coastal flooding. Governments and corporations need to take concrete actions faster, e.g. halt coal-financing and transition to large-scale renewable energy, to keep the world's temperature rise within 1.5 degree celsius.

### Methodology

Three gridded datasets of extreme sea-level rise, population and GDP were used to calculate the potential impact of sea-level rise in seven Asian cities. This analysis is one of the first of its kind to use high spatial resolution data to suggest the areas of each city that may be affected by an increase in sea level, and to what extent the impact might be.

#### Data Sources:

- The projection of gridded sea-level rise and coastal flooding data is from Climate Central (Kulp and Strauss, 2019).
- The gridded global population density dataset is from the Socioeconomic Data and Applications Center of the U.S. National Aeronautics and Space Administration. The data used in this analysis are the most recent, 2020.

- The gridded global dataset for GDP (PPP, i.e. purchasing power parity) is provided by Dr. Matti Kummu, who previously published a paper using the same methodology. (Kummu et al., 2018). The data used in this analysis are from the year 2019.<sup>1</sup>

## Key Findings

- More than 96% of **Bangkok's** land area could be flooded should a 10-year flood<sup>2</sup> occur in 2030, including high density residential and commercial areas in the city center.
- **Jakarta** faces a dual threat from both sea level rise and sinking. Almost 17% of Jakarta's total land area is below the level to which sea water could rise should a 10-year flood occur in 2030, leading to a potential GDP risk of US\$68 billion.
- Low-lying areas in eastern **Tokyo**, including the Koto 5 Wards (Sumida, Koto, Adachi, Katsushika and Edogawa), are particularly vulnerable to rising sea levels. US\$68 billion in GDP is at risk from coastal flooding in Tokyo in 2030, or 7% of Tokyo's total GDP.
- In **Taipei**, Taipei Main Station, the most significant transport hub in northern Taiwan, is at risk of flooding, as is the historic Datong District. An estimated 24% of Taipei's total GDP could potentially be affected.
- Almost 87% of **Manila's** land area is below the level to which sea water could rise, should a 10-year flood occur in 2030. Up to 1.54 million people and a total of US\$39 billion could be affected.

City	Impacted area in km <sup>2</sup>	Impacted GDP (PPP) in US\$ billion (2019)	Impacted population in millions
Bangkok	1512.94	512.28	10.45
Hong Kong	27.36	2.24	0.09
Tokyo	79.28	68.19	0.83
Jakarta	109.38	68.20	1.80
Seoul	16.52	4.69	0.13
Taipei	46.93	29.64	0.43
Manila	37.29	39.24	1.54

*2030 projections for the impact of sea-level rise and flooding on GDP(PPP), population and affected areas of seven cities, listed in the order of total city size in km<sup>2</sup>.*

### Bangkok

- The city's vulnerability to flooding is exacerbated by the fact that the city is sinking due to soft soils, heavy urbanization and land subsidence.

<sup>1</sup> In this dataset, the constant '2019 international USD' was converted to constant '2015 international USD', the unit in which national GDP (PPP) from the World Bank was given for data consistency.

<sup>2</sup> In this report, a 'ten-year flood' is a coastal flooding event that is caused by storm surges and high tides. The flood's height above sea level has a 10% annual chance of being exceeded.

- More than 96% of Bangkok's land area is below the level to which sea water could rise should a 10-year flood<sup>3</sup> occur in 2030, according to our analysis using
- The Sappaya-Sapasathan, the new parliament house of Thailand, could potentially be flooded.
- A total of US\$512.28 billion and 10.45 million people could potentially be impacted by sea-level rise and coastal flooding in Bangkok in 2030.
- The impacted GDP (PPP) accounts for 96% of Bangkok's total GDP (PPP).

## Hong Kong

- The average number of tropical cyclones that affect Hong Kong is between 5 and 7 per year. Tropical cyclones cause storm surges, and the most extreme events in the past saw the sea level exceeding the tide level by more than 3 metres (Lee et al., 2010).
- About 2% of Hong Kong's land area is below the level to which sea water could rise should a 10-year flood occur in 2030, according to our analysis under projections under RCP8.5.
- Northwest Hong Kong, including Mai Po Nature Reserve, where a large portion of land is mangrove and wetland, is at very low elevation and is vulnerable to sea-level rise. On the path of the East Asian-Australasian Flyway, more than 80,000 waterbirds visit Mai Po each year (Wikramanayake et al., 2020).
- A total of US\$2.24 billion and up to 90,000 people in Hong Kong could potentially be affected by sea-level rise and coastal flooding in 2030.
- The impacted GDP(PPP) accounts for 0.4% of Hong Kong's total GDP(PPP).

## Tokyo

- Although the average elevation of Tokyo is 40 meters above sea level, a number of low-lying areas with a high population density are still at risk of flooding.
- About 4% of Tokyo's land area is below the level to which sea water could rise should a 10-year flood occur in 2030, according to our analysis using projections under RCP8.5.
- The eastern part of Tokyo, particularly areas between Arakawa River and Edogawa River, could be affected by sea-level rise and coastal flooding in 2030, under the RCP8.5 scenario. In Edogawa City, 70% of land area is located below sea level, and the area has experienced devastating flooding in the past.
- Other areas that are at risk of flooding include Kasai Rinkai Park, which is built on reclaimed land on the shoreline of Tokyo Bay, and riverparks along the Arakawa River, which are popular destinations to watch the cherry trees bloom in spring.
- A total of US\$68.19 billion and up to 0.83 million people could potentially be affected by sea-level rise and coastal flooding in 2030.
- The impacted GDP(PPP) accounts for 7% of Tokyo's total GDP(PPP).

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<sup>3</sup> In this report, a 'ten-year flood' is a coastal flooding event that is caused by storm surges and high tides. The flood's height above sea level has a 10% annual chance of being exceeded.

## Jakarta

- Each year, Jakarta experiences flooding disasters following heavy rains, high river discharges, and high tides (Surya et al., 2019). In addition, excessive groundwater drainage is contributing to Jakarta's subsidence, which is on average 1 to 15 centimetres each year (Abidin et al., 2011). Some areas of Jakarta have sunk between 3 to 4.1 meters, especially in coastal areas (Rahman et al., 2018).
- Almost 17% of Jakarta's total land area is below the level to which sea water could rise should a 10-year flood occur in 2030, under an RCP8.5 scenario.
- The northern part of Jakarta is most at risk of flooding from sea-level rise because it has low elevation.
- Areas potentially affected by flooding include residential and commercial buildings, the National Monument and Jakarta City Hall, and shopping malls along the coast.
- A total of US\$68.20 billion and up to 1.80 million people could potentially be affected by sea-level rise and coastal flooding in 2030.
- The impacted GDP(PPP) is estimated to be 18% of Jakarta's total GDP (PPP).

## Seoul

- Approximately 3% of Seoul's land area is below the level to which sea water could rise should a 10-year flood occur in 2030, under an RCP8.5 scenario.
- Most of the areas that could potentially be affected by sea-level rise are in the western part of Seoul, mainly the Gangseo-gu on the Southern bank of the Han River and both banks of the Anyangcheon river.
- The northwestern edge of Gimpo International Airport could be slightly flooded. Gangseo Marsh Ecological Park could potentially be at risk of flooding. The Gangseo Marsh Ecological Park is a popular location to observe migratory bird species (Visitseoul, 2021).
- A total of US\$4.69 billion and up to 0.13 million people could potentially be affected by sea-level rise and coastal flooding in 2030.
- The impacted GDP (PPP) is estimated to be 1% of Seoul's total GDP (PPP).

## Taipei

- According to past century typhoon records from the Central Weather Bureau (CWB) in Taiwan, an average 4 typhoons make landfall on Taiwan each year, and the strength and scale of a Typhoon has been increasing in the past year (Hsu et al., 2017). Typhoons often cause severe flooding to coastal areas of Taiwan (Hsu et al., 2014).
- About 17% of Taipei's land area is below the level to which sea water could rise should a 10-year flood occur in 2030, under an RCP8.5 scenario.
- The western part of Taipei, particularly areas along the Tamsui River, would be affected more than other regions of the city if sea levels were to rise.
- Historic Datong District and Taipei Main Station could potentially be flooded.
- A total of US\$29.64 billion of GDP(PPP) and up to 430,000 people in Taipei could potentially be affected by sea-level rise and coastal flooding in 2030.
- The impacted GDP(PPP) accounts for 24% of Taipei's total GDP(PPP).

## Manila

- Some of the coastal areas of Manila are extremely low lying, with elevations less than two to three meters above mean sea level (Morin et al., 2016).
- In Manila Bay, the sea level is rising at 13.24 mm per year (Tseng, 2014).
- Metro Manila is sinking by a rate of 10 cm annually (Kramer, 2018), which is caused by the over extraction of groundwater (Clemente et al., 2001).
- Almost 87% of the City of Manila's land area is below the level to which sea water could rise should a 10-year flood occur in 2030, according to our analysis under an RCP8.5 scenario.
- Historical landmarks and popular tourist destinations such as Binondo, Intramuros, Malacanang Palace, and the Jose Rizal National Monument in Luneta Park could potentially be flooded. Luneta is one of the largest urban parks in Asia and home to a variety of wildlife (Gonzales & Magnaye, 2017).
- A total of US\$39.24 billion and up to 1.54 million people could potentially be affected by sea-level rise and coastal flooding in 2030.
- The impacted GDP(PPP) accounts for 87% of Manila's total GDP(PPP).