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Coastal Flood Risks in the Bangkok Metropolitan Region, Thailand: Combined Impacts of Land Subsidence, Sea Level Rise and Storm Surge

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Bangkok is one of the largest coastal mega-cities facing significant impacts caused by climate change. Two-dimensional flood inundation model is used to explore the exposure to potential flood risk areas.

1. Introduction

Due to the fast-changing climatic and anthropogenic conditions at coastal regions, many coastal mega-cities are becoming increasingly vulnerable to internal and external risks. The risk is particularly high for low-lying coastal cities in developing nations, with Southeast Asia recognized as a hotspot of vulnerability because of (i) the increasing population density, (ii) rapid change of natural landscape associated with urbanization and (iii) intensified hydrological and atmospheric conditions at the coastal front in an uncertain climate future. The Bangkok Metropolitan Region is one of the largest coastal megacities in Southeast Asia that are challenged by the potential impacts due to climate change and population growth in the coming decades. Climate-related risks in this region are associated with its relatively low-lying nature of the terrain and adjacency to the coast. Coastal inundation caused by high tides from the sea occurs annually in the area close to the seashore. This is set to increase given a projected rising sea level and the sinking landscape due to groundwater extraction and urbanization. The selected study site is the area located in the eastern part of the Chao Phraya River, which is identified as the most rapid industrialization in Thailand during the past decades.

Figure 1: Major floods occurred in Bangkok Metropolitan Region

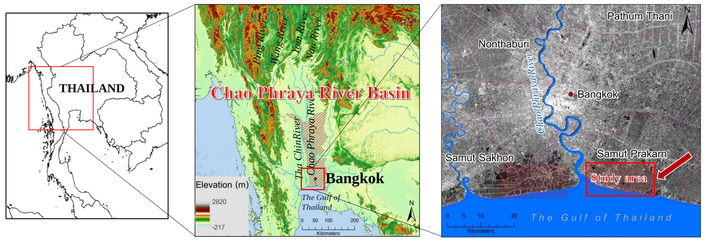

Figure 2: The study area is on the eastern part of Chao Phraya River Basin

2. Aims of the Study

- To evaluate the combined impacts of climate-related processes (e.g. sea level rise and storm surge) and anthropogenic factors (e.g. land subsidence) that affect coastal flood risks in the Bangkok Metropolitan Region, Thailand.
- To improve the understanding of potential impact of future flood risks on critical infrastructure and inform adaptation.

3. Methodology

This research investigates the coastal flood risks in Samutprakarn province, area located in the Bangkok Metropolitan Region. A two-dimensional flood inundation model (FloodMap, Yu and Lane 2006)[1] is used to derive inundation depth and velocity associated with each scenario. The input data for this model consist of hourly water level data, the topography of floodplain, and existing structural features such as flood defences. The Digital Elevation Model (DEM) was derived from Thailand National Spatial Data Infrastructure Committee, Geo-Informatics and Space Technology Development Agency, (GISTDA). The DEM was resampled to a 20-m resolution and then combined with the flood defences data derived from the Royal Thai Survey Department. The 2011 flood in Thailand is used as a baseline event. Scenarios were designed with projections of land subsidence[2], sea level rise[3] and storm surge[4] to 2050s, 2080s, and 2100s. The Quadratic summation of uncertainties method[5] is used to combine the impacts of key contributing factors and to estimate the high-end and low-end of the individual components. The critical infrastructure data are derived from Department of Public Works and Town & Country Planning, Ministry of the Interior. The impacts of coastal flood risk on critical infrastructures (e.g. power supply, transportation network, rescue centers, hospitals, schools and key government buildings) are evaluated.

(a) DEM resolution 20x20 m and flood defences (b) Land subsidence (c) Stage hydrograph for the simulation

Figure 3: Key datasets used in the modelling, baseline scenario is the event in 2011 (30th October, 2011)

4. Results

The maximum inundation extents and depths for all scenarios were processed using a Geographic Information System (GIS). The total flooded areas based on the projection of sea level rise and distributed land subsidence are illustrated below in Figure 4. The average maximum depth by 2050, 2080, and 2100 are 0.73 m, 1.0 m, and 1.21 m respectively. Results suggest progressively increasing, and non-linear risk of coastal flooding to key coastal infrastructures into the 2050s, 2080s, and 2100s. Figure 5 shows the total number of affected critical infrastructure and the percentage change of total affected building compared with baseline scenario. From this data, there are a growing number of temples, schools and government buildings at risk. Figure 6 presents the flood hazard map generated from the higher projection of sea level rise and distributed land subsidence by 2050.

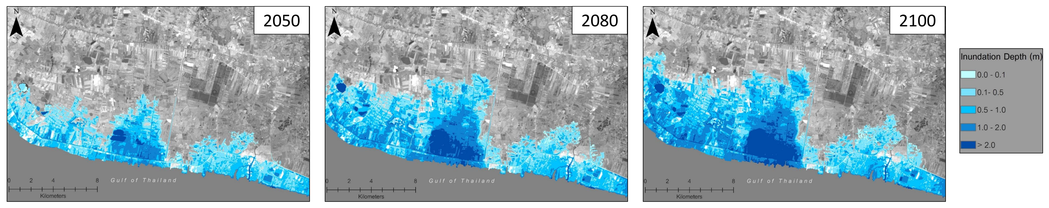

Figure 4: Maximum inundation extents and depths for different scenarios

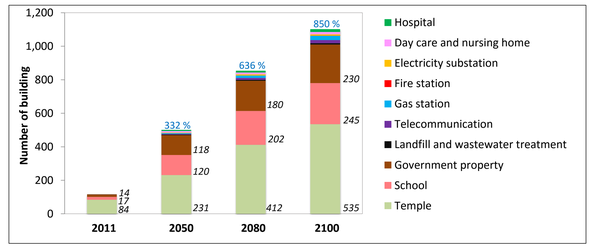

Figure 5: Comparison of affected critical infrastructure for different scenarios

5. Conclusions

This study adds to knowledge about the potential impacts of climatic and anthropogenic processes on coastal cities in Southeast Asia, which are particularly vulnerable to coastal flood risks due to their fast changing climatic and anthropogenic conditions. Our work highlights the parts of the urban fabric of coastal Bangkok that are most at risk and will help the authorities to prioritise then take action to defend key infrastructure and assets.

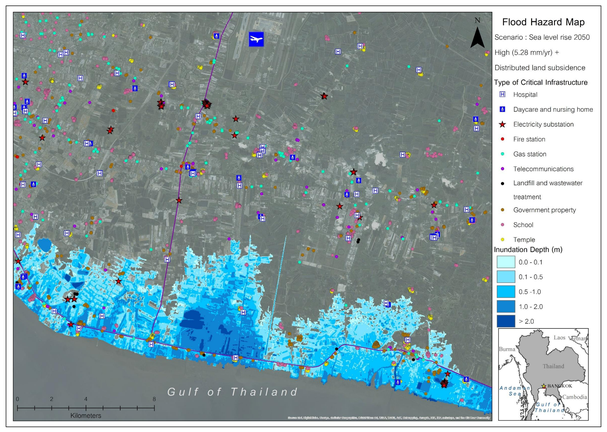

Figure 6: Flood hazard map based on the projection of sea level rise and land subsidence by 2050

6. Acknowledgements

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References

1. Yu, D., and Lane, S. N. (2006). Urban fluvial flood modelling using a two-dimensional diffusion-wave treatment, part 1: Mesh resolution effects. *Hydrological Processes*, *20*(7), 1541–1565.
2. Aobpaet, A., Cuenca, M. C., Hooper, A., and Trisirisatayawong, I. (2013). InSAR time-series analysis of land subsidence in Bangkok, Thailand. *International Journal of Remote Sensing*, *34*(8), 2969–2982.
3. IPCC (2013). *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley(eds.)] Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.
4. World Bank. (2009). Climate Change Impact and Adaptation Study for Bangkok Metropolitan Region: Final Report. Retrieved 30 October, 2012, from https://openknowledge.worldbank.org/handle/
5. Katsman, C. A., Hazeleger, W., Drijfhout, S. S., Oldenborgh, G. J. and Burgers, G. (2008). Climate scenarios of sea level rise for the northeast Atlantic Ocean: a study including the effects of ocean dynamics and gravity changes induced by ice melt. *Climatic Change*, *91*(3-4), 351–374.

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