NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE
Institute of Catastrophe Risk Management

Assessing Spatial and Temporal Urban Growth Patterns in Major Southeast Asian Cities

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INTRODUCTION

The rate of growth of urbanization over the past years has been very rapid. In order to tackle risks of urbanization, we have to understand spatio-temporal urban growth along with various aspects of urban infrastructure growth (e.g. power, transportation, water facilities), and evolution of land use/cover, economic activities and population.

Southeast Asia (SEA) has been going through a rapid rate of urbanization, with the urban population percentage increasing from 32% to 47% between 1990 and 2014, and is projected to reach 56% by the year 2030. The high urbanization rate poses numerous challenges including infrastructure design and resource management. With a population of 600 million people along with megacities such as Jakarta, Bangkok, and Manila and with many cities located along coastlines, in flood plains, or in active seismic zones, SEA is susceptible to heavy losses (e.g. 2007, 2013 floods in Jakarta, 2011 Thailand flood) during natural catastrophes.

GOALS

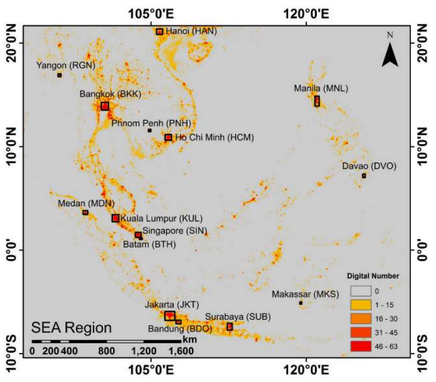
- Assessing spatio-temporal characteristics of urban growth in 15 major SEA cities to aid exposure and resilience analysis.
- Modelling urban growth coupled with road infrastructure for SEA cities.

APPROACH AND RESULTS

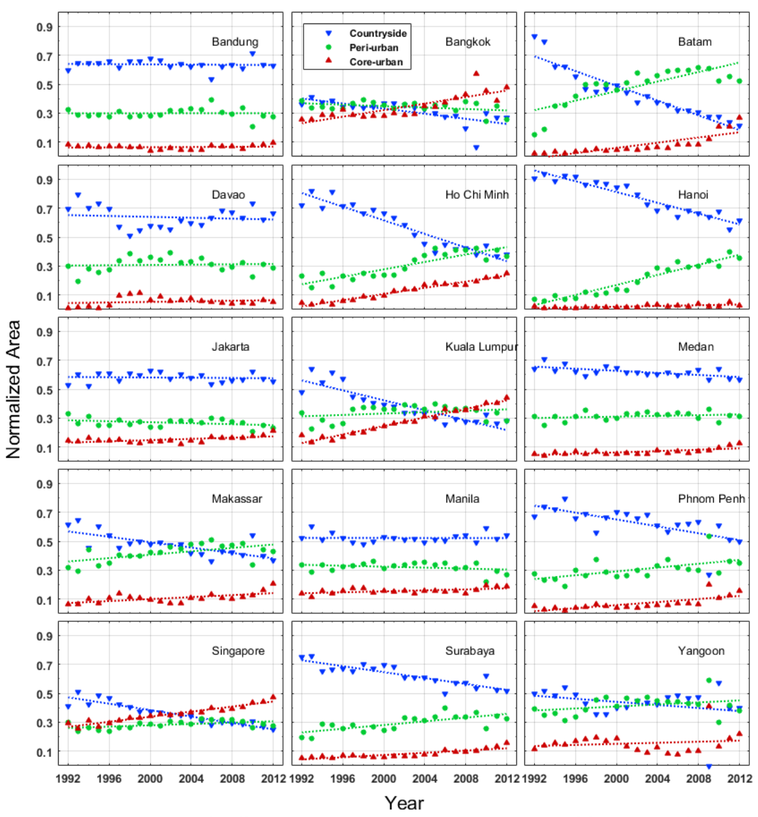
Assessing spatio-temporal urban growth:

Employed remotely sensed night-time light (NTL) data and spatial brightness gradient approach to extract different levels of urbanization. Calibrated NTL data (due to absence of on-board sensor calibration), assess efficiency using sum of normalized difference index (SNDI), and perform spatio-temporal analysis of urban growth.

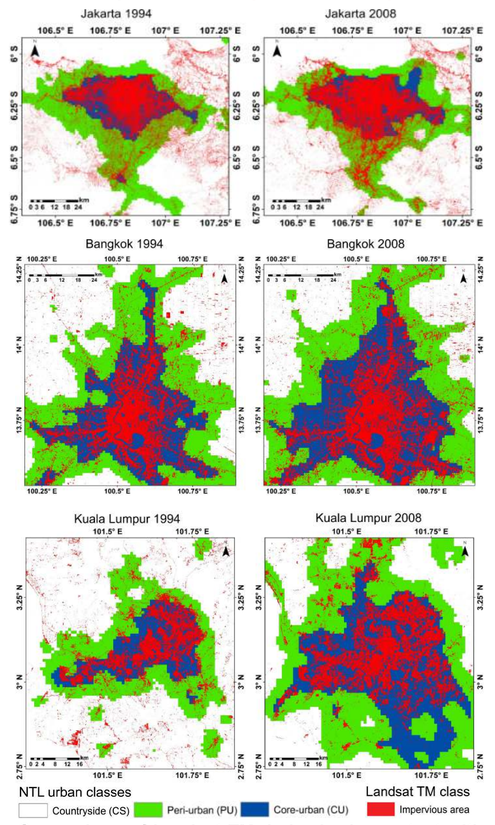
SEA night-time light image (Source: NASA)



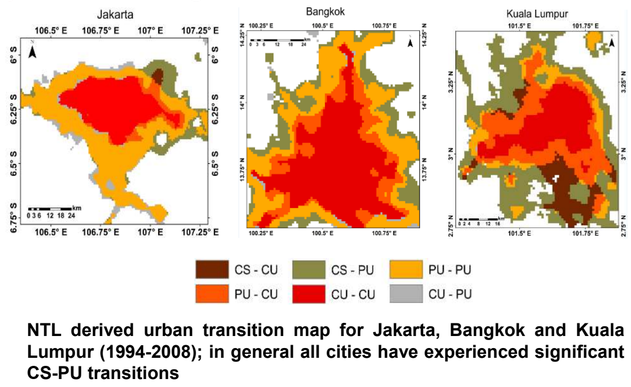
SEA NTL composite (6-bit radiometric resolution) for year 2012 with 15 major cities; later calibrated and used to extract countryside (CS), Peri-urban (PU) and Core-urban (CU) categories using Brightness Gradient approach



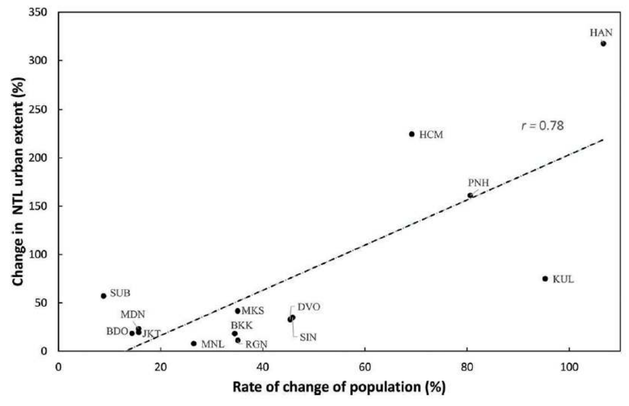
Temporal change of different NTL-derived urban categories (CS, PU and CU) and linear trends for 15 SEA cities; the decreasing (increasing) trends in CS (CU) categories are stronger compared to the PU category, which is an indication of increasing urbanization; Bangkok, Singapore and Kuala Lumpur have a stronger urbanization trend compared to other cities since the CU category crosses the PU and CS



Comparison of Landsat TM derived urban extent with NTL derived urban categories for Jakarta, Bangkok and Kuala Lumpur; NTL-derived CU category is in good agreement with the Landsat TM derived urban land cover map with the NTL CU region consistently enveloping the Landsat TM urban extent



NTL derived urban transition map for Jakarta, Bangkok and Kuala Lumpur (1994-2008); in general all cities have experienced significant CS-PU transitions

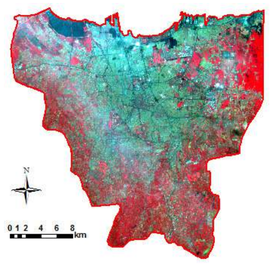


Rate of change in NTL urban extent from 1995 to 2010 (normalized w.r.t 1995) with rate of change in population; strong correlation with the population growth for the SEA cities with inland cities showing an unrestrained spatial growth with population

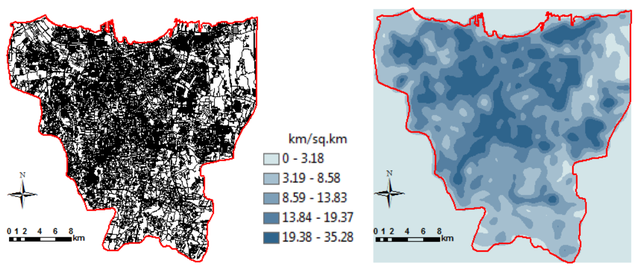
Modelling urban growth coupled with road infrastructure:

Used remotely sensed data (Landsat sensors) between 1987 and 2017 to generate spatio-temporal urban expansion maps (Land Use Land Cover - LULC) for SEA cities.
Used Open Street Map (OSM) road network data for SEA cities for 2017.

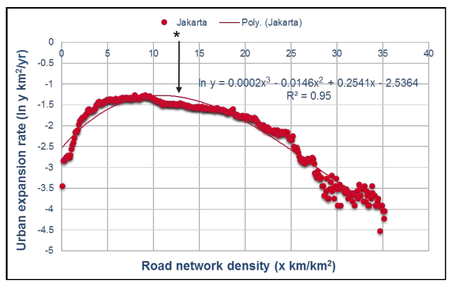
Jakarta case:



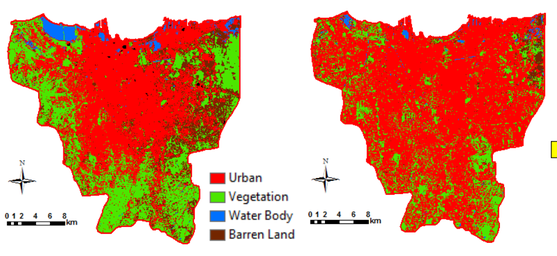
(a) Landsat - TM (FCC) data 1987



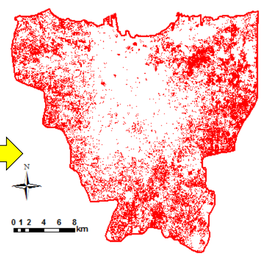
(d) OSM road network vector map (left) and road network density map (right) for 2017



(e) Fitting curve of road network density and urban expansion rate (* - Turning Point)



(b) Landsat derived LULC classified maps for 1987 (left) and 2017 (right)



(c) Urban land expansion 1987-2017

Key observations:

- Investigated the relationship between road networks and urban expansion in SEA cities
- It is observed that the logarithmic urban expansion rate with road network density follows an inverted concave pattern
- Turning point (TP): Position at which the degree of the effect of road network density on urban expansion changes
- TP serves as a resilience and sustainability indicator in terms of promoting proper urban and infrastructure planning

CONCLUSIONS

- Results show strong spatio-temporal trends in urbanization for all 15 SEA cities analysed
- Medium and high urban categories were generally found to increase over time whereas low urban category decreased with time
- These trends were found to vary for each city with their differing socio-economic and geographic characteristics
- The urbanization trends showed strong correlation with the population growth
- Turning point useful for urban expansion vs road network density analysis; helps to identify rapid urban expansion zones within each city depending on past data analysis
- Helps to improve rationality of spatial urban planning – necessary for developing economies such as SEA cities

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