NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

Institute of Catastrophe Risk Management

Assessing Linkages between Urban Growth and Road Infrastructure for Major Southeast Asian Cities

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INTRODUCTION

The rate of urbanization in Southeast Asia (SEA) has been very rapid over the past years. In order to mitigate the risks of unmanaged urbanization, we need to understand the 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.

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 projected to reach 56% by the year 2030. The high urbanization rate poses numerous challenges including infrastructure design and resource management. A rapid and unplanned urban growth could threaten the sustainability of the SEA nations. 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 further is susceptible to heavy losses from natural catastrophes (e.g. 2007, 2013 floods in Jakarta, 2011 Thailand flood).

GOALS

- Modelling urban growth coupled with road infrastructure for major SEA cities.
- Urban growth prediction using SLEUTH (Cellular Automata model) and correlation with turning point maps; Bangkok case study.

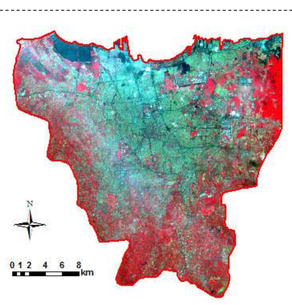
APPROACH AND RESULTS

- **Modelling urban growth coupled with road infrastructure:**

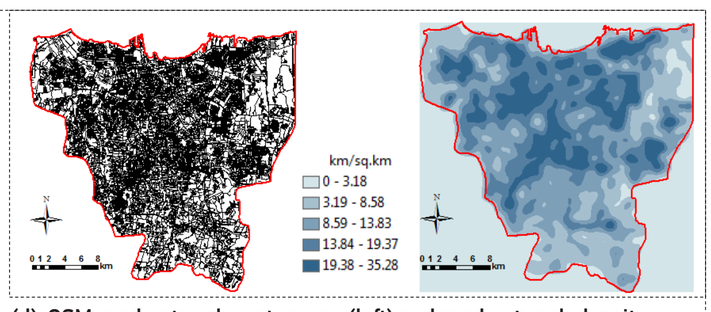
Used remotely sensed data (Landsat sensors) between 1987 and 2017 to generate spatio-temporal urban expansion maps (Land Use Land Cover - LULC) for SEA cities.

Used Open Street Map (OSM) road network data for SEA cities for 2017.

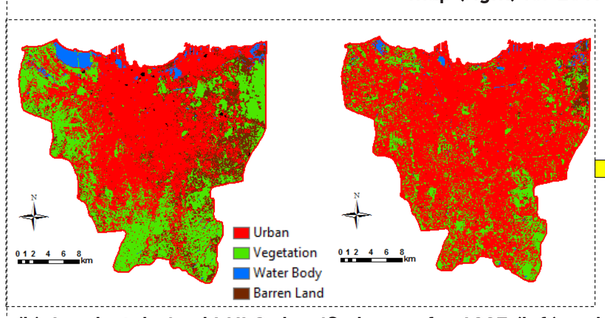
Jakarta case:



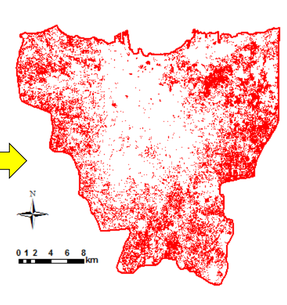
(a) Landsat - TM (FCC) data 1987



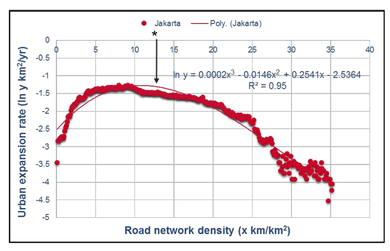
(d) OSM road network vector map (left) and road network density map (right) for 2017



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



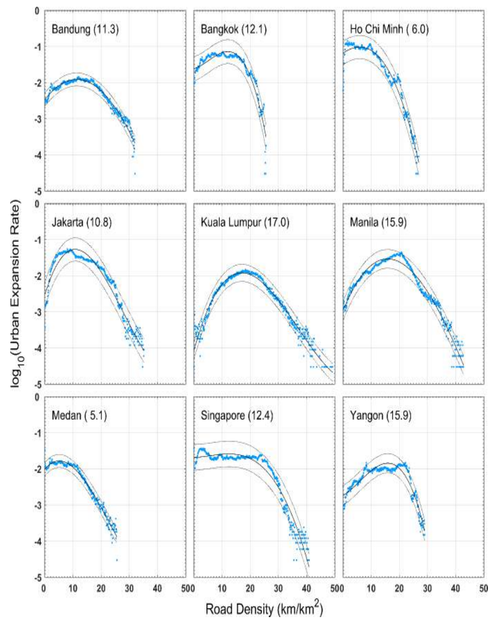
(c) Urban land expansion 1987-2017



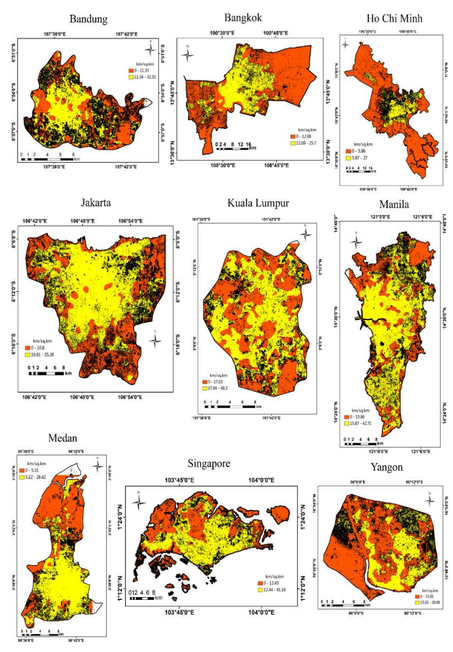
(e) Fitting curve of road network density and urban expansion rate (* - Turning Point)

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



(f) Fitting curve of road network density and urban expansion rate for major SEA cities (Turning Point values in km/km2)



(g) Zoning maps derived from turning point results

- **Urban growth prediction using SLEUTH (Cellular Automata model) and correlation with turning point maps; Case study of Bangkok city**

Data inputs for SLEUTH : Landsat derived LULC maps for Bangkok city for 4 time periods (1987,1997,2007,2017), Slope, Hillshade, Road networks (1987, 2017) and Exclusion layer.

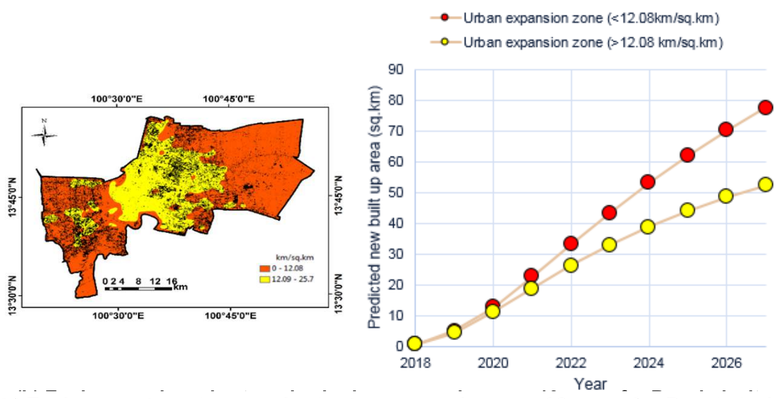
SLEUTH model characteristics

- Captures spatial and temporal complexity
- 2 dimensional (lattice) – cells/units
- Every cell interacts with corresponding neighbour cells
- Behaviour of Cellular Automata (CA) is controlled by five coefficients: diffusion, breed, spread, slope and road
- Four growth types can take place: spontaneous, diffusive, organic and road influenced
- Future growth simulation based on transition criteria/rules

Bangkok case study:

- Urban growth predicted for 10 years from 2017
- Growth rules criteria adopted for this study: "continuation of historical urban growth without changing current conditions"
- Urban prediction patterns were further categorized and analyzed based on turning point zoning maps

(a) Growth prediction results for Bangkok city for 2018 and 2027
Note: Yellow colour : Seed urban footprint pixels (2017)
Green colour : Predicted urban growth pixels



(b) Zoning map based categorized urban expansion over 10 years for Bangkok city

CONCLUSIONS AND FUTURE WORK

- Turning point useful for urban expansion vs road network density analysis; helps to identify rapid urban expansion zones within each city
- Helps to improve rationality of spatial urban planning as necessary for developing economies such as SEA cities
- The urban growth prediction patterns were categorized based on the turning point map; where it is observed that the cumulative urban expansion area vary between the zones of the turning point zoning maps and are correlated with its trends
- SLEUTH can be a highly useful tool for urban planners for investigating likely outcomes of city development plans, supporting the development of necessary actions for sustainable and resilient urban planning
- SLEUTH results are further being assessed w.r.t socio-economic indicators such as population and GDP
- Land use change prediction work is in progress to identify and quantify spatio-temporal dynamics such as infrastructure demand in Bangkok city

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