Land use scenarios: Trade-offs between benefits and risks

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European birth to death network dynamics

Birth and death location data of 120,211 notable individuals

Future transport network innovation scenarios are to be developed

(Murakami and Yamagata 2014, in prep.)
Future transport network innovation scenarios are to be developed

(Murakami and Yamagata 2014, in prep.)
SSP compatible Urban development scenarios

- **Difficult**
  - Dispersion
  - Urban form

- **Climate Change Mitigation**
  - Easy
    - Multipolar compact
    - Urban form

- **Climate Change Adaptation**

  - Easy
    - Property is diversified spatially

  - Difficult
    - Property is concentrated to high hazard area

(Yamagata, 2015)
Natural hazard risk index

The Munich Re 2002
(Reinsurance company)

1. Tokyo/Yokohama 710
2. San Francisco 167
3. Los Angeles 100
4. Osaka/Kobe/Kyoto 92
5. ......
Urbanization in the Tokyo metropolitan area

1888 to 1975  (Estimated from the GSI Regional Planning Atlas)

1888 to 1975

1888

1914

1946

1975

>> Urban expansion and agricultural contraction of paddy & crop lands.
Urbanization in the Tokyo metropolitan area
Urban land use scenarios in the future

Concentration or Dispersion?

2002 Landsat ETM+

Land use scenario

Compact city

Dispersion city
We have modeled economic behaviors of household, landlord and housing developer (nonlinear optimization model)

Hazard map (floooking inundation depth)
# Variables for the location choice model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unit</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ave. elevation</td>
<td>m</td>
<td>Average elevation</td>
<td>National land numerical information</td>
</tr>
<tr>
<td>Ave. slope</td>
<td>angle</td>
<td>Average slope</td>
<td>National land numerical information</td>
</tr>
<tr>
<td>Liquefaction risk</td>
<td>---</td>
<td>Risk index of liquefaction (from 0: no risk to 3: high risk)</td>
<td>Wakamatsu et al. (2006), Fig.***</td>
</tr>
<tr>
<td>Earthquake risk</td>
<td>---</td>
<td>Occurrence probability of earthquakes with ground</td>
<td>Japan seismic hazard information station</td>
</tr>
<tr>
<td>Building-to-land ratio</td>
<td>%</td>
<td>Building-to-land ratio</td>
<td>UDS Co., Ltd.</td>
</tr>
<tr>
<td>Floor area ratio</td>
<td>%</td>
<td>Floor area ratio</td>
<td>UDS Co., Ltd.</td>
</tr>
<tr>
<td>Residential</td>
<td>Ratio</td>
<td>Proportion of residential zone</td>
<td>UDS Co., Ltd.</td>
</tr>
<tr>
<td>U_C</td>
<td>Ratio</td>
<td>Proportion of urbanization control zone</td>
<td>UDS Co., Ltd.</td>
</tr>
<tr>
<td>Commercial</td>
<td>Ratio</td>
<td>Proportion of commercial zone</td>
<td>UDS Co., Ltd.</td>
</tr>
<tr>
<td>ln (area)</td>
<td>km²</td>
<td>Natural logarithm of the zone area</td>
<td>Nippon Statistics Center Co., Ltd</td>
</tr>
<tr>
<td>Office density</td>
<td>---</td>
<td># of office in 2006 / area</td>
<td>Establishment and enterprise census</td>
</tr>
<tr>
<td>W.Office density</td>
<td>---</td>
<td>Spatial weighted average of # of office in 2006 / area</td>
<td>Establishment and enterprise census</td>
</tr>
<tr>
<td>Office_W.Office density</td>
<td>---</td>
<td>(# of office + Spatial weighted average of # of office in 2006) / area</td>
<td>Establishment and enterprise census</td>
</tr>
<tr>
<td>Dist. sta.</td>
<td>m</td>
<td>Distance to the nearest train station</td>
<td>National land numerical information</td>
</tr>
<tr>
<td># commuters</td>
<td>---</td>
<td># of annual commuters of the nearest train station</td>
<td>National land numerical information</td>
</tr>
</tbody>
</table>

※ JMC: The Japan Meteorological Agency

Future Urban Land Use Scenarios

Current urban area

Dispersion scenario (BAU)
- Total number of each 7 types of households are statistically projected

Compact scenario
- Subsidized by 1200$ /y if moving to near urban centers (Zones less than 500 m)

Adaptation scenario
- Subsidized if moving to near urban centers, whose flood risk is not too high (< 5m)

Black: city centers
Sky blue: subsidized zones

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Mitigation and Adaptation Scenarios

**Mitigation**: compact city scenario along the railways. People use more public transport to achieve low carbon society.

**Adaptation**: move houses from low-land areas that are potentially vulnerable to floods and coastal disaster.
Compact city scenario which also consider adaptation against flooding risks.

Risk reduction: $-7.2B$

Risk reduction: $-30.4B$
Revised Act on Special Measures Concerning Urban Renaissance (August 1, 2014)

• Compact cities with multipolar networks

It is recommended to avoid the high Tsunami and/or sediment disaster areas when designate the resident-attracting districts.
Some key questions for new Project

• We need to understanding dynamics of Urbanization to project the future of cities
• Mega-cities can shrink sustainably?
  – Downsizing to multi-polar structure might be an effective strategy to manage the risks
• New life styles for the Well-being
• Future intra/inter city transport systems
• Mitigation and adaptation integration as “Urban Resilience”
Increase of flood risks

• **Flood risk in 21C.** (Hirabayashi et al., 2013)

![World map showing flood risks](http://flood.firetree.net/)

- Blue: Flood increases
- Red: Flood decreases

• **Sea-level rise**
  - Some recent studies predict that the sea-level rise can be 1m by 2100 (e.g., Robert et al., 2011).
  - The cost of sea-level rise is substantially underestimated (Michael, 2007)

![Maps of Tokyo, Nagoya, Osaka metropolitan areas after 1m sea-level rise](http://flood.firetree.net/)

Tokyo  
Nagoya  
Osaka  
Metropolitan areas after 1m sea-level rise (source: http://flood.firetree.net/)
Flood risk and urban design

• In Japan, it seems that the flood risk is not reflected to urban design sufficiently.
  – **Right figure**: Elevation and location of thermal plans.

• **Underestimation of the flood risk**
  – **Normality bias**
    ✓ People tends to underestimate the possibility of suffering from disasters.
    ✓ People tends to be too optimistic even under disaster.

→ Even if flood risks are perceived, person still prefers living nearby the ocean partly due to the underestimation.
Urban management for flood risk

- Hazard risk management is needed to take proper action under flood disaster.

- Risk management in Yokohama
  - A web-GIS system of showing hazard maps is opening on public.
  - If this system works well, the flood prone area must be perceived as a dangerous area, and it would decrease property values.

Source: http://wwwm.city.yokohama.lg.jp/select_map.asp
Hedonic analysis

- The impact value of the flood risk is evaluated by quantifying their impacts on **condominium unit prices** in the 7 wards in Yokohama city.

## Summary statistics of the unit prices

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Value (million JPY)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>40.87</td>
</tr>
<tr>
<td>Median</td>
<td>39.20</td>
</tr>
<tr>
<td>Maximum</td>
<td>320.0</td>
</tr>
<tr>
<td>Minimum</td>
<td>10.90</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>11.82</td>
</tr>
<tr>
<td>Sample size</td>
<td>694 / 27,446</td>
</tr>
</tbody>
</table>

Average condominium prices
Explanatory variables relating the ocean

- **O-dist**
  - Distance to the ocean.

- **O-view**
  - 3D view to the ocean.
  - It is calculated using ArcGIS 3D analyst.

- **Depth**
  - Estimated inundation depths under the Nankai Trough Earthquake.

✓ 23 other explanatory variables (not shown here) are also introduced to control these influences.
Estimation result

• O-dist
  – Proximity to the ocean has a positive economic value (although the impact is not statistically significant).

• O-view
  – Only scenic ocean view has significant positive economic value.

• F-risk
  – Flood risk has positive economic value.

→ While O-dist and O-view have positive value as expected, the negative value flood risk is not reflected adequately at all.
Estimated marginal benefit from the ocean

**Red**: Greater positive benefit from the ocean ($O_{-}\text{dist} + O_{-}\text{view} + F_{-}\text{risk}$)

- Flood prone area attracts persons

There are several options to mitigates the flood risk

- A landuse regulation
- Embankment construct

- Policy must be chosen considering their possible influences on, e.g., human amenity, hazard risk, and natural environment.

→ Scenario analyses are needed
Research plan

• We plan to proceed scenario analyses to design sustainable urban development.

**Developer/Policy maker**

- Design proposal
- Visualization
- Co-design
- Take action toward the implementation
- Development of an urban design support tool

**Researcher**

**Micro-scale (3D urban space; 0.5m grids)**

- Building scenario (Material; Structure...)
- Greening scenario (Allocation, volume...)

**Coarser-scale (1km grids)**

- The landuse-transportation-energy model-based scenario analysis (e.g, regulation...)
- Example: A scenario of installing a green belt on flood prone areas.

**Quantification**

- Amenity
- Hazard risk
- Environ. efficiency
- Econ. impact