Yoshitsugu Hayashi

Executive Committee Member, The Club of Rome

Ex-President, World Conference on Transport Research Society

Emeritus Professor, Nagoya University, Japan

Distinguished Professor, Tokai Gakuen University, Japan

Quality Road for Spatial Organization and Citizen's Sufficiency

Quality Road Conference

5 March 2025 @ United Nation University, Tokyo

G20 Principles for Quality Infrastructure Investment

① Sustainable Growth
- Job Creation, Tech-transfer, Virtuous Circle by Capacity Development,
- Connectivity enhancing SDGs

② Economic Efficiency / Life-Cycle Cost
- Value for Money, Innovative Technology

③ Integrating Environment
- Eco-system, Biodiversity, Climate conscious; Green Finance

④ Disaster Resilience
- Risk Management in Infrastructure Design, Insurance

⑤ Integrating Social Considerations
- Inclusiveness: Open Access, Safety, Gender, Vulnarables

⑥ Infrastructure Governance
- Openness, Debt Sustainability

Responsibility of Quality Road

(Alternative Conceptualization to G20 Principles, by Yoshitsugu Hayashi)

A) Robust Infrastructure Design: *Strength, Durability* and *Beauty*

B) Congestion Release and Economy Empowerment: Investment for *Efficient Connectivity* between Business and Daily Life *Facilities*

→ Pr② Economic Efficiency

C) Nation's and City's Life Stage Conscious: The later economic grows, the *Shorter Urbanization Cycle. Learning from Failures of preceding countries.*

D) Environmental Sustainability: *"Avoid-Shift-Improve"* Strategies for *De-carbonization (Urban Shape, Role share with Rail, Tech Innovation: EV,PHV,FCV)*

→ Pr③ Integrating Environment

E) Disaster Resilience: *Redundant Network Accessibility* considering Natural Hazards and Emergency

→ Pr④ Natural Disaster Resilience

F) Smart Growth/Shrink Conductor: *Healthy Urban Structuring* (Raumordnung) for Long-term Financing with *Value Capture* by *Integration* with *Land Use* for *Growing/Aging Society*

→ Pr② Life-Cycle Cost, → Pr⑥ Infrastructure Governance

G) Well-being Revolution: Replace GDP-based CBA (*Efficiency*) by QOL Accessibility Method (*Sufficiency*) to evaluate SDGs if *No one left behind*

→ Pr① Sustainable Growth, →Pr⑤ Social Considerations

Responsibility (A)

Robust Infrastructure

Strength, Durability and *Beauty*

Responsibility (B)

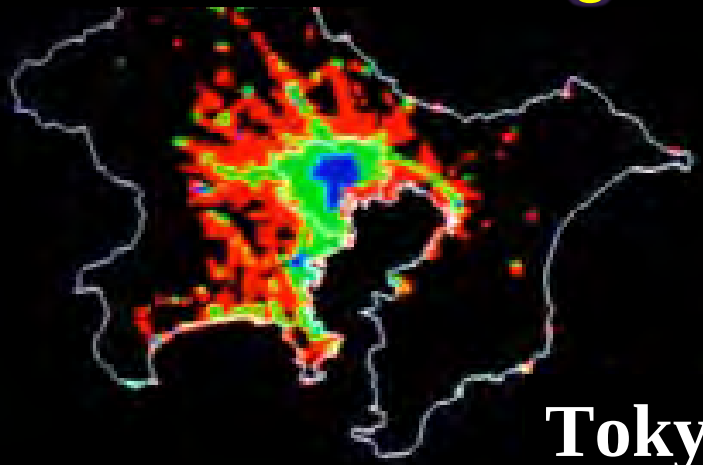
Nation's and City's Life Stage Conscious

The later economy grows, the *Shorter Urbanization Cycle*

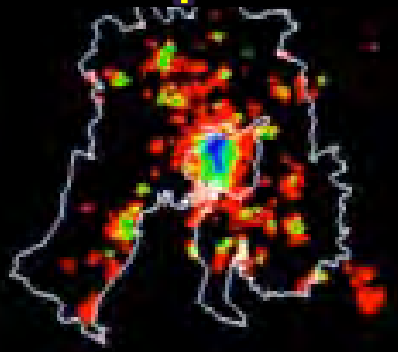
AVOID

Urban Sprawl

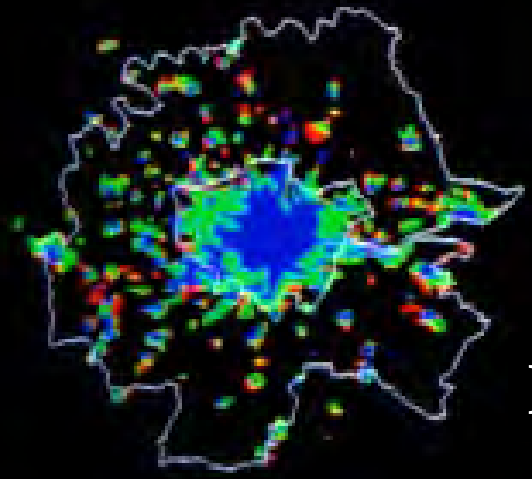
Changes in Built-up Areas



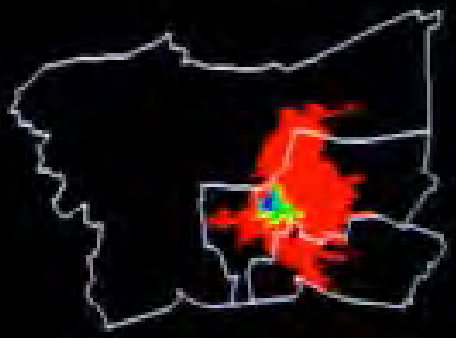
Tokyo



Nagoya



London



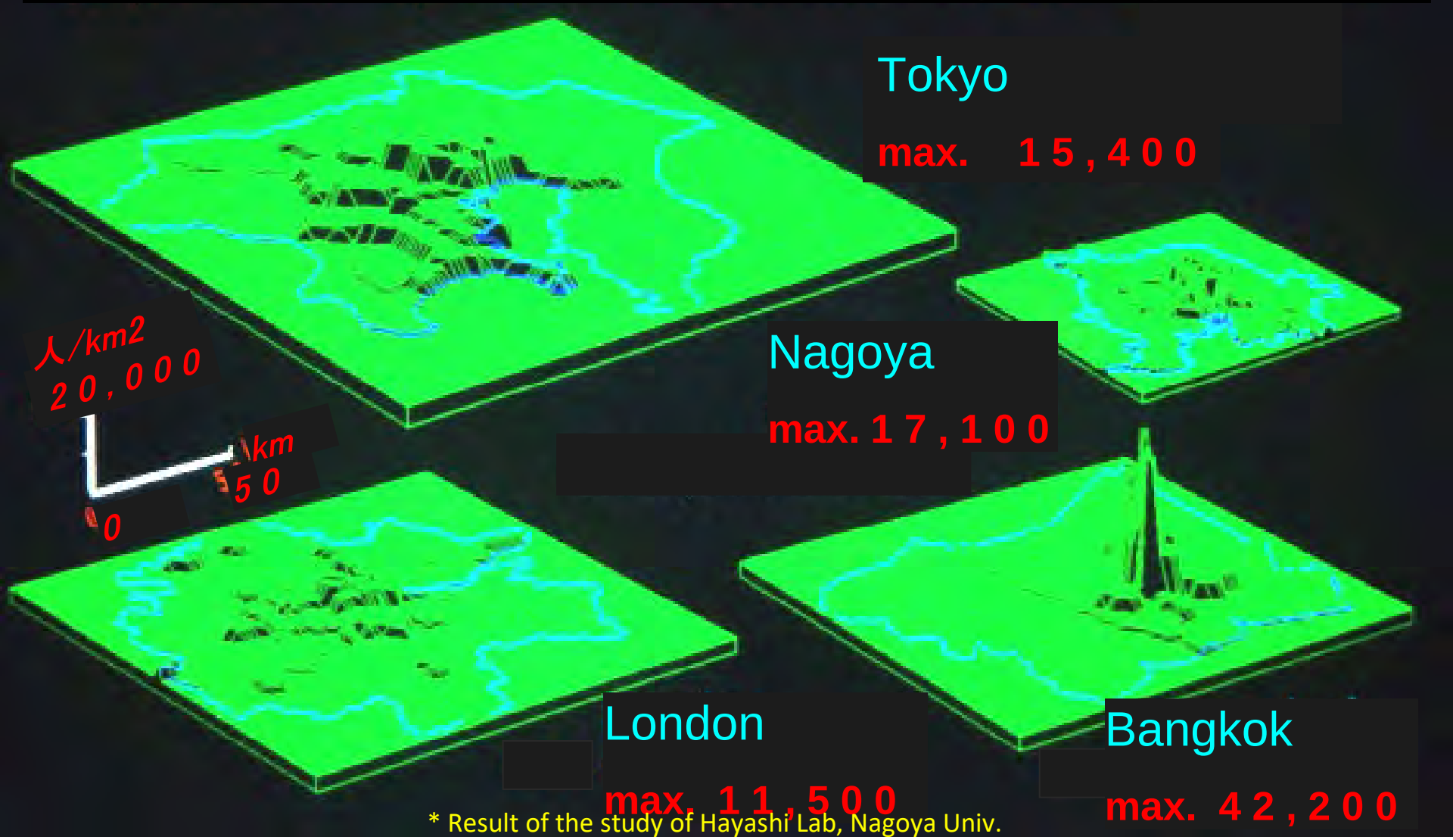
Bangkok

0 50 km

1910
1965
1985

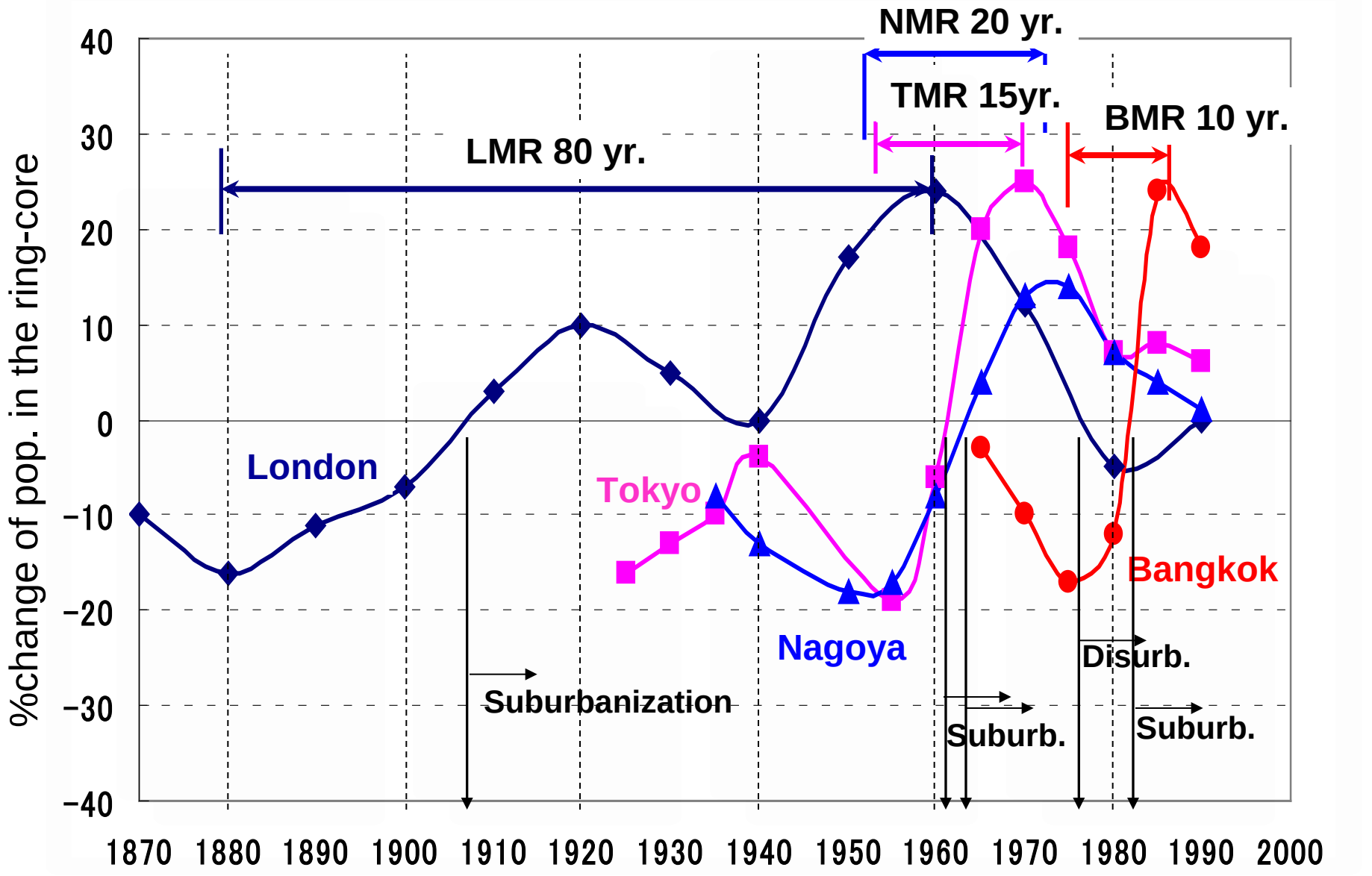
* Result of the study of Hayashi Lab, Nagoya Univ.

Population Density (1988)



* Result of the study of Hayashi Lab, Nagoya Univ.

Changes in stage of urbanization in the metropolises



* Result of the study of Hayashi Lab, Nagoya Univ.

Understanding "The Limits to Motorization" along Economic Development Stages

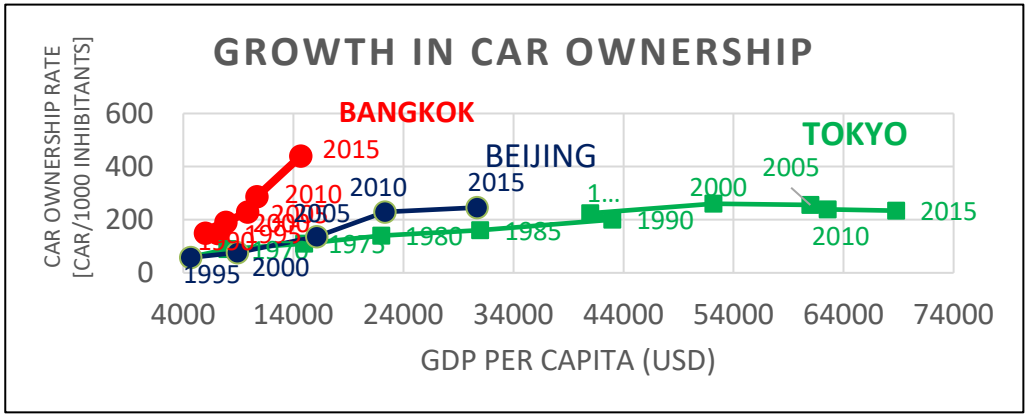
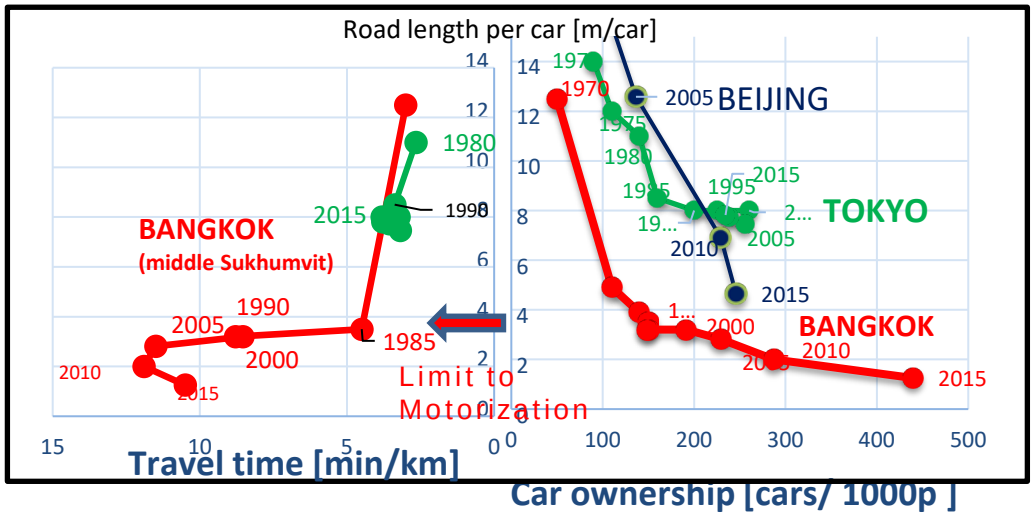


Photo by Hayashi(1993)

Photo by Hayashi(2018)



S.Klug & Y.Hayashi_Infrastructure_Costs_and_Urban_Sprawl_WCTR Lisbon Proc_2010
https://www.dropbox.com/scl/fi/peser5nlukwsgoay712mw/S.Klug-Y.Hayashi_Infrastructure_Costs_and_Urban_Sprawl_WCTR-Lisbon-Proc_2010.pdf?rlkey=165ade5hcokocfwfk1ykxucbu&dl=0

Responsibility (C)

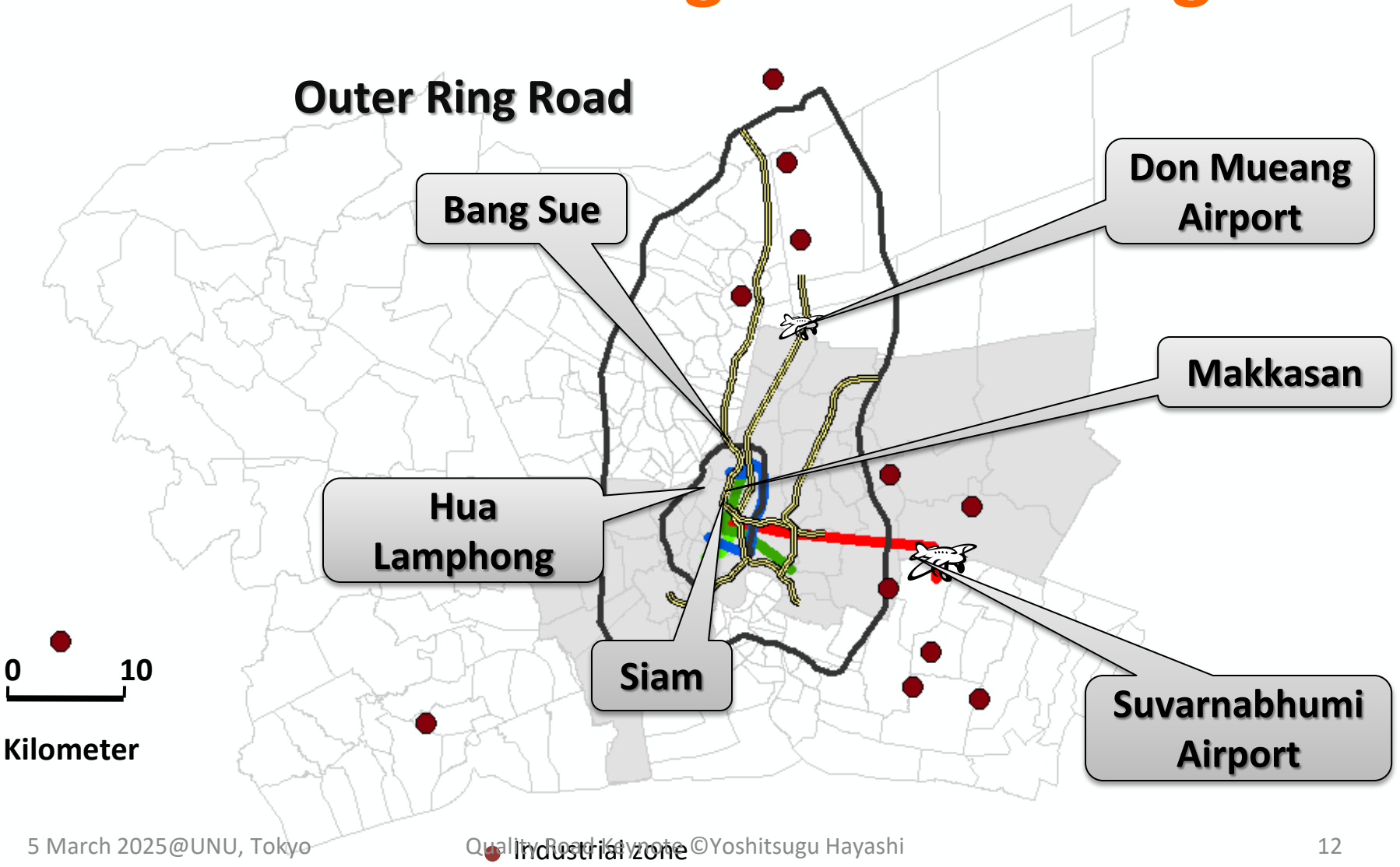
Congestion Release and Economy Empowerment

Investment for *Efficient Connectivity* between Business and Daily Life *Facilities*

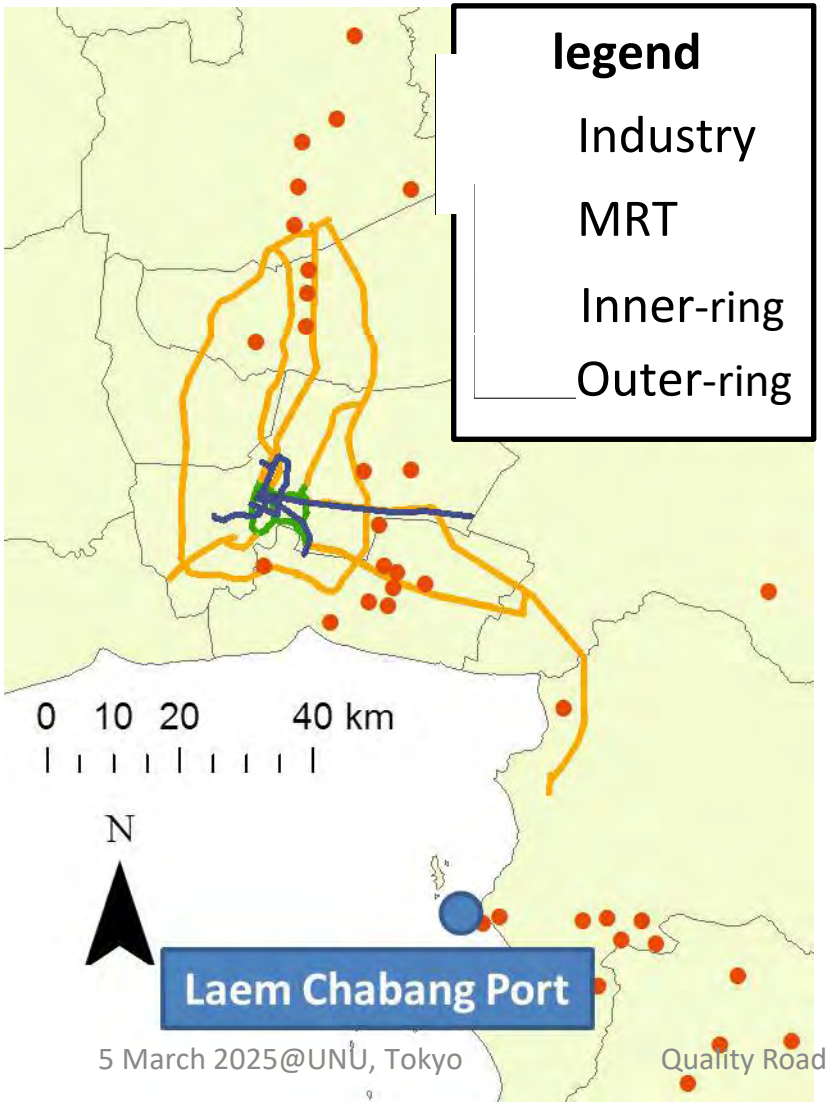
Factors for Drastic Improvement in Road Traffic Congestion in Bangkok

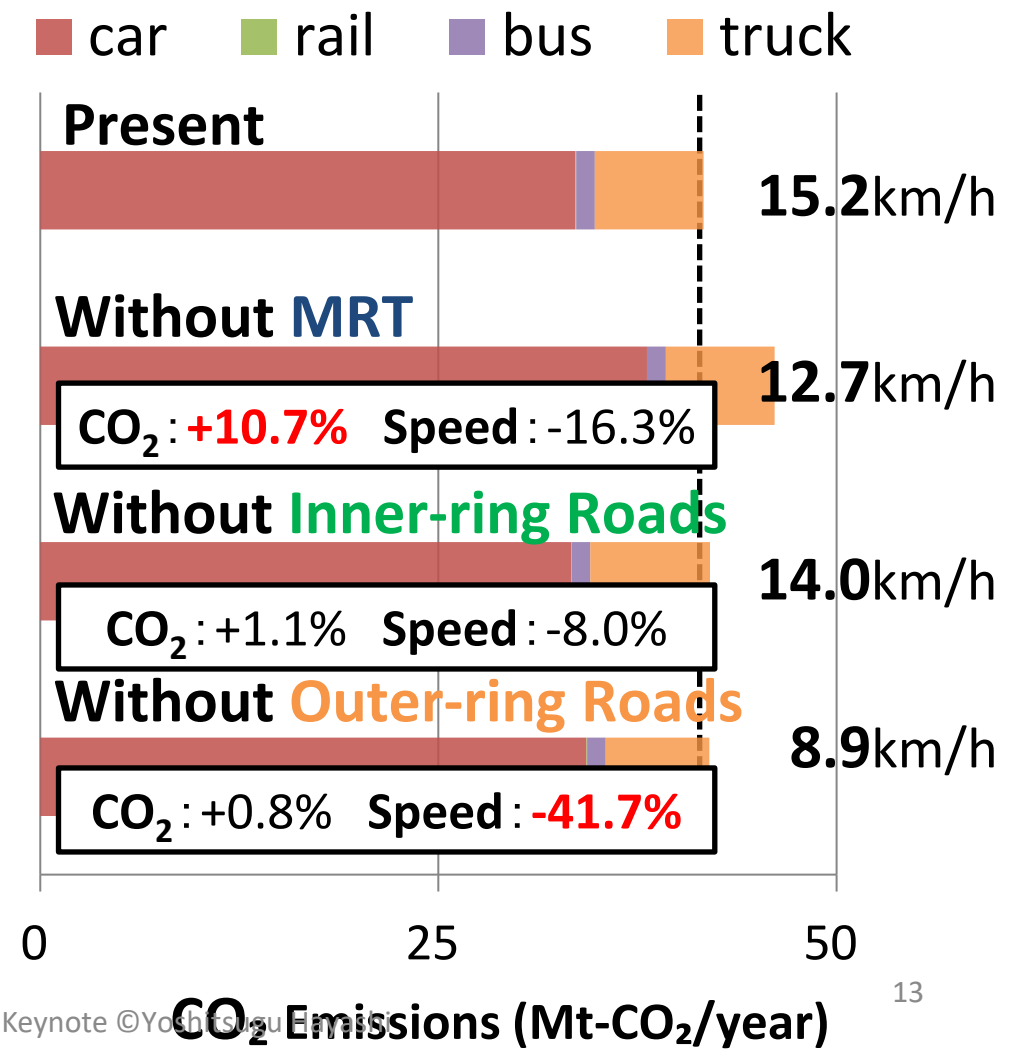
- Bangkok road congestion has been drastically improved by reduction of surface traffic due to 3 major network improvements:
  - New rail transit system has attracted car users
  - Urban expressway has converted car surface traffic
  - Outer ring road has diverted freight transport from industrial zones in north and south-west directly to Laem Chabang port

Factors for Drastic Improvement in Road Traffic Congestion in Bangkok



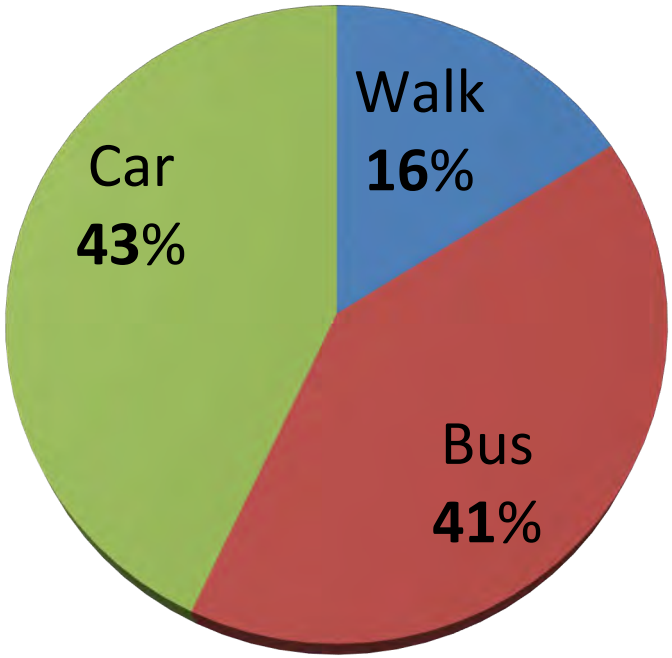
The Effects of Integrated Transport Systems on Traffic Congestion and CO_2 Mitigation





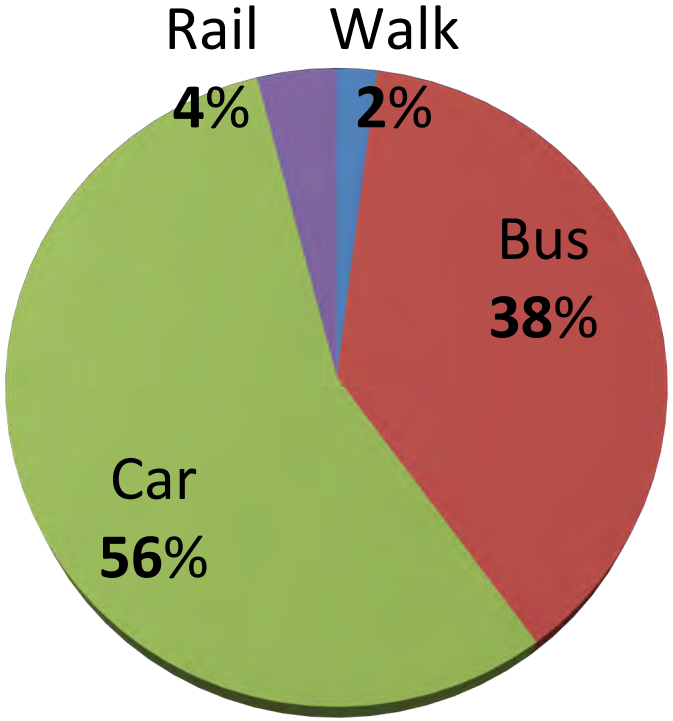
Change in Modal Share

- Modal share in 1989



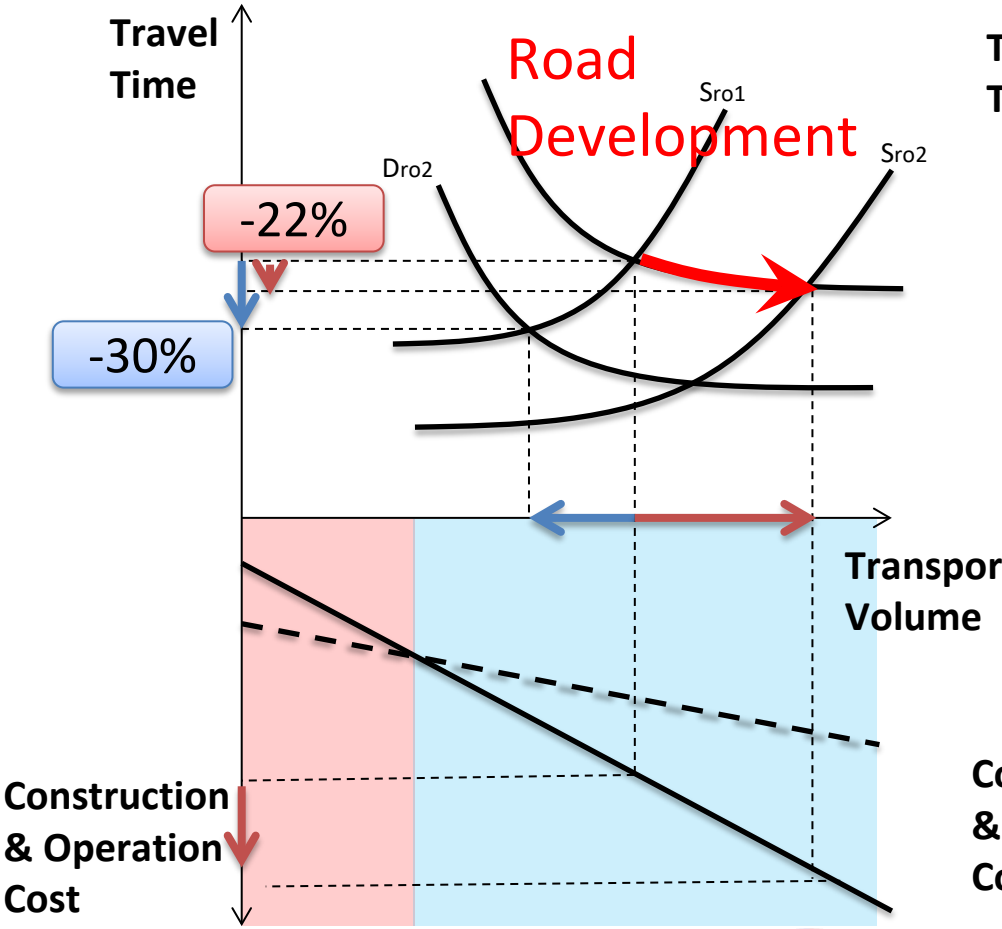
Source: JICA report

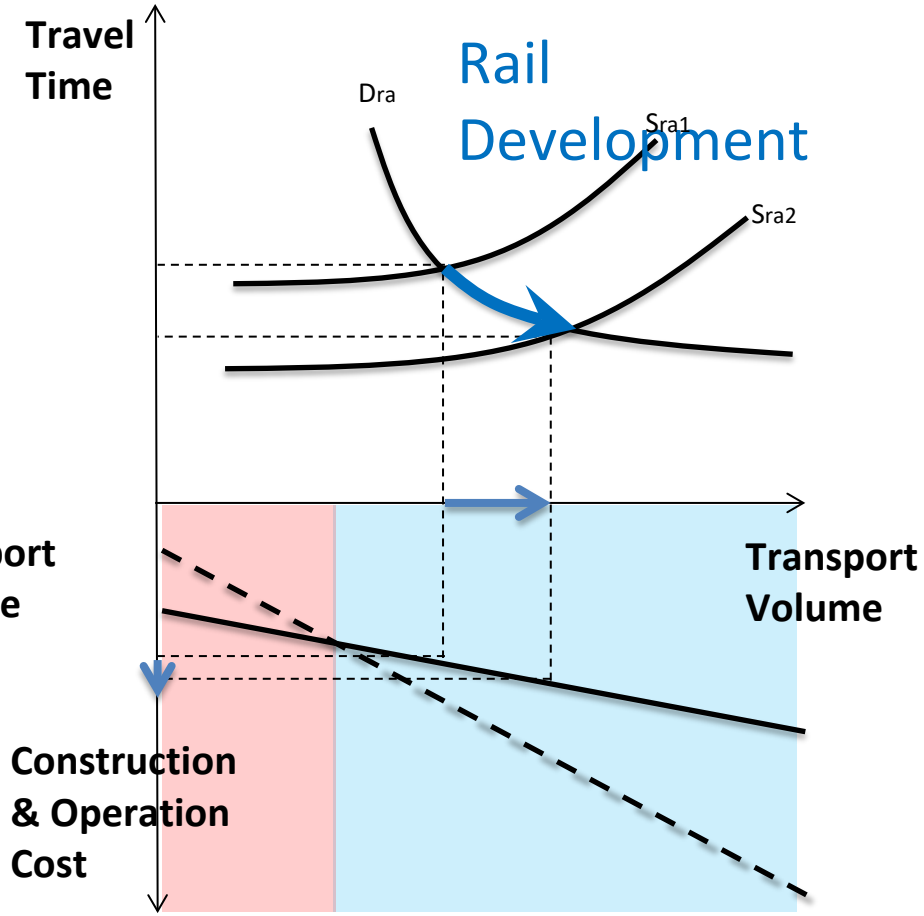
- Modal share in 2005



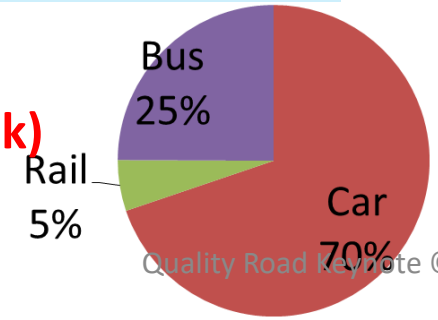
Source: ADB report

Road vs Rail
: which is more effective for calming traffic congestion?



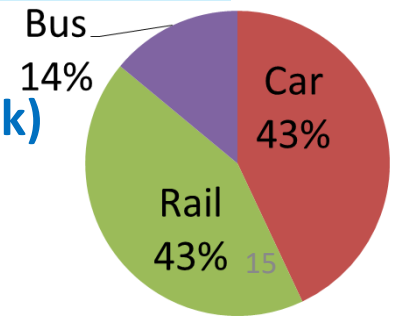


2050 Road-Oriented Development (Bangkok)



CO_2 Emissions: **-22%**

2050 Rail-Oriented Development (Bangkok)



CO_2 Emissions: **-45%**

Responsibility (D)

Environmental Sustainability

Best *Role Share* with *Railways*
for *De-carbonization* according to
"Avoid-Shift-Improve" Strategies

Mobility Transformation

- Emergence from 20 Century's Stupid Habits -

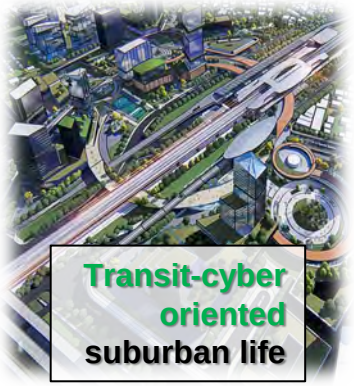
20th century Stupid Mobility → for Mass Economy with High Carbon

Car-oriented sprawling suburb

Over 90% of the time, cars are parked

Not walkable environment

Fixed time/destination commuting



Transit-cyber oriented suburban life

Cyber-support Sharing and Hierarchical transport network

Lively (*Sabai*) street built environment

Flexible workplace/ commuting timing

21st century Smart Mobility → for People with High QOL/Low Carbon

Damages caused by Mobility (World, Thailand)
- Effects on Mortality, Health & Well-Being -

1. Traffic Congestion

Average Travel Speed

Thailand **15** km/hr.

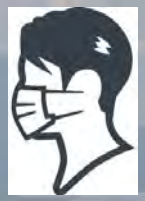
2. Road Accident

3 people die every hour

66 people die everyday from accidents

World **1.35 mil.** died (2020)

3. Air Pollution & health

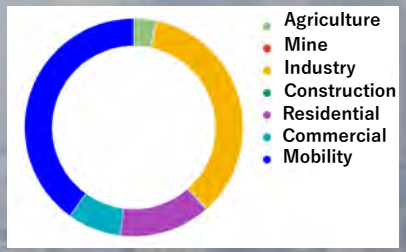


Asthma rate reaches **15-20%**

c.f. 5% in 1980

6.5 mil. died (2020)

4. Energy & GHG



Transport Energy Consumption **40%**

35%

Courtesy by Pawinee Iamtrakul

Policy/Technology Solution Options for De-Carbon & Anti-Pollution

(CUTE Matrix)

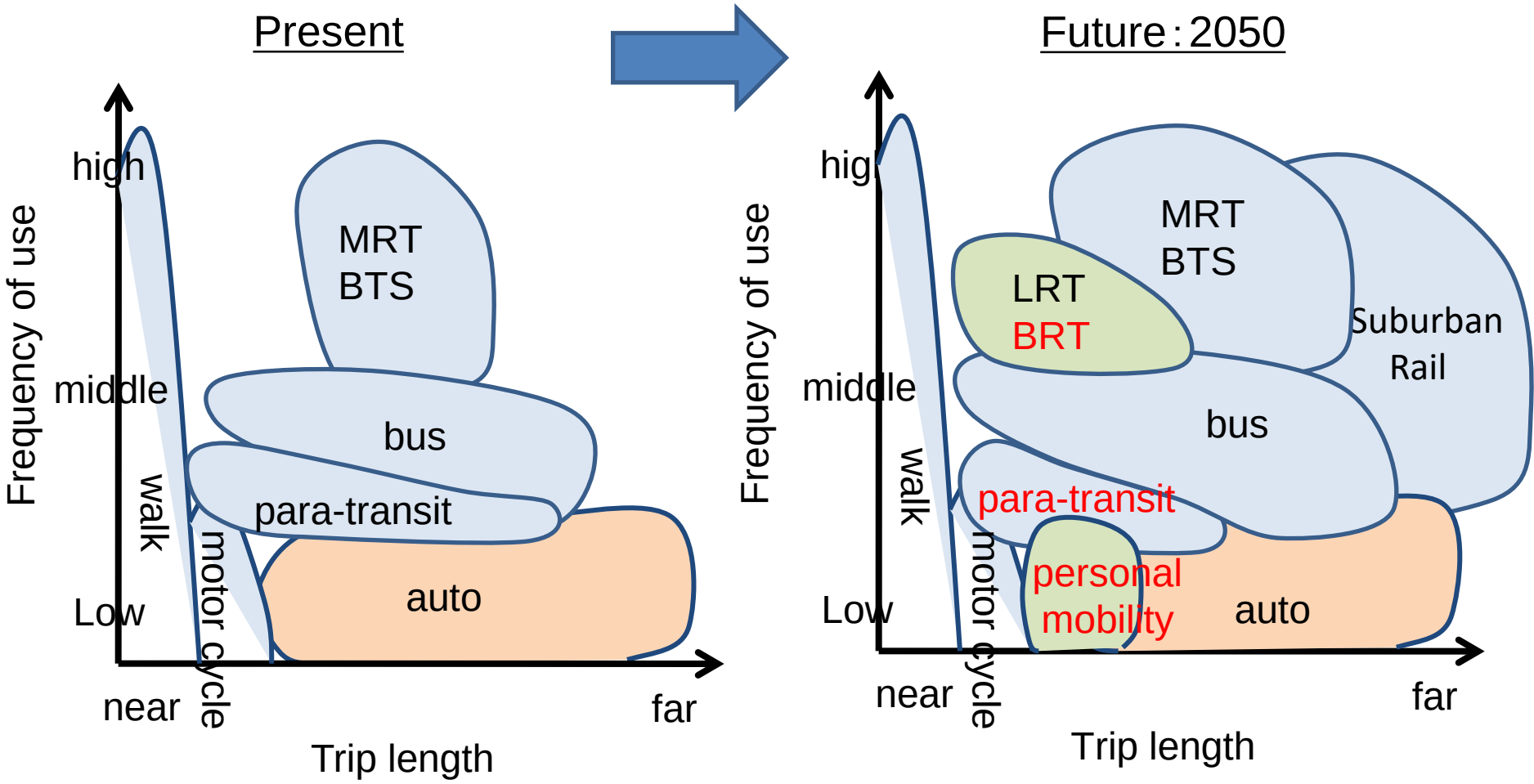
Strategies / Means	AVOID	SHIFT	IMPROVE
Technologies	• Transport oriented development (TOD) • **Poly-centric development** • Efficient freight distribution	• Railways and BRT • Interchange improvement among railway, BRT, bus and para-transit modes • **Facilities for small mobility and pedestrians**	• HB,PHB vechicle • E-vehicle • Fuel cell/Hydrogen vehicle • Biomass fuel • Autonomous driving • "Smart grid“ development
Regulations	• Land-use control	• Separation of bus/para-transit trunk and feeder routes • Local circulating service • Control on driving and parking	• Emissions standards • “Top-runner" approach
Information	• **Teleworking** • Online shopping • Lifestyle change	• **MaaS**	• "Eco-driving" • ITS traffic-flow management • Vehicle performance labeling
Economy	• Subsidies and taxation to location	• Park & ride • Cooperative fare systems between modes	• Fuel tax/carbon tax • Subsidies and taxation to low-emissions vehicles

Hideo Nakamura, Yoshitsugu Hayashi and Anthony D. May eds (2004)
Urban Transport and The Environment – An International Perspective, Elsevier

SHIFT

IMPROVE

Shift of Transport Mode



Para-transit would be a feeder for mass-transit

LRT/BRT & personal mobility would become more important

Goals for new Car Sales

	目標年度	目標	FCV	EV	PHEV	HEV	ICE
日本	2030	HV：30～40% EV・PHV：20～30% FCV：～3％	～3%	20-30%		30～40%	30～50%
	2035	電動車(EV/PHV/FCV/HV) 100%	100%				対象外 Not allowed
EU	2035	EV・FCV：100% (注) 欧州委員会提案	100%		対象外		Not allowed
米国	2030	EV・PHV・FCV：50%	50%			50%	
中国	2025	EV・PHV・FCV：20%	20%				
	2035	HEV50% EV・PHV・FCV：50% (注) 自動車エンジニア学会発表	50%			50%	対象外 Not allowed
英国	2030	ガソリン車：販売禁止 EV:50～70%		50-70%			対象外 Not allowed
	2035	EV・FCV：100%	100%		対象外		Not allowed
フランス	2040	内燃機関車：販売禁止	100%		対象外		Not allowed
ドイツ	2030	EV： ストック1500万台		ストック 1500万			

出典：公表情報を元に経済産業省作成

Stock:15mil cars

Stock:15mil cars

https://www.enecho.meti.go.jp/about/special/johoteikyo/xev_2022now.html

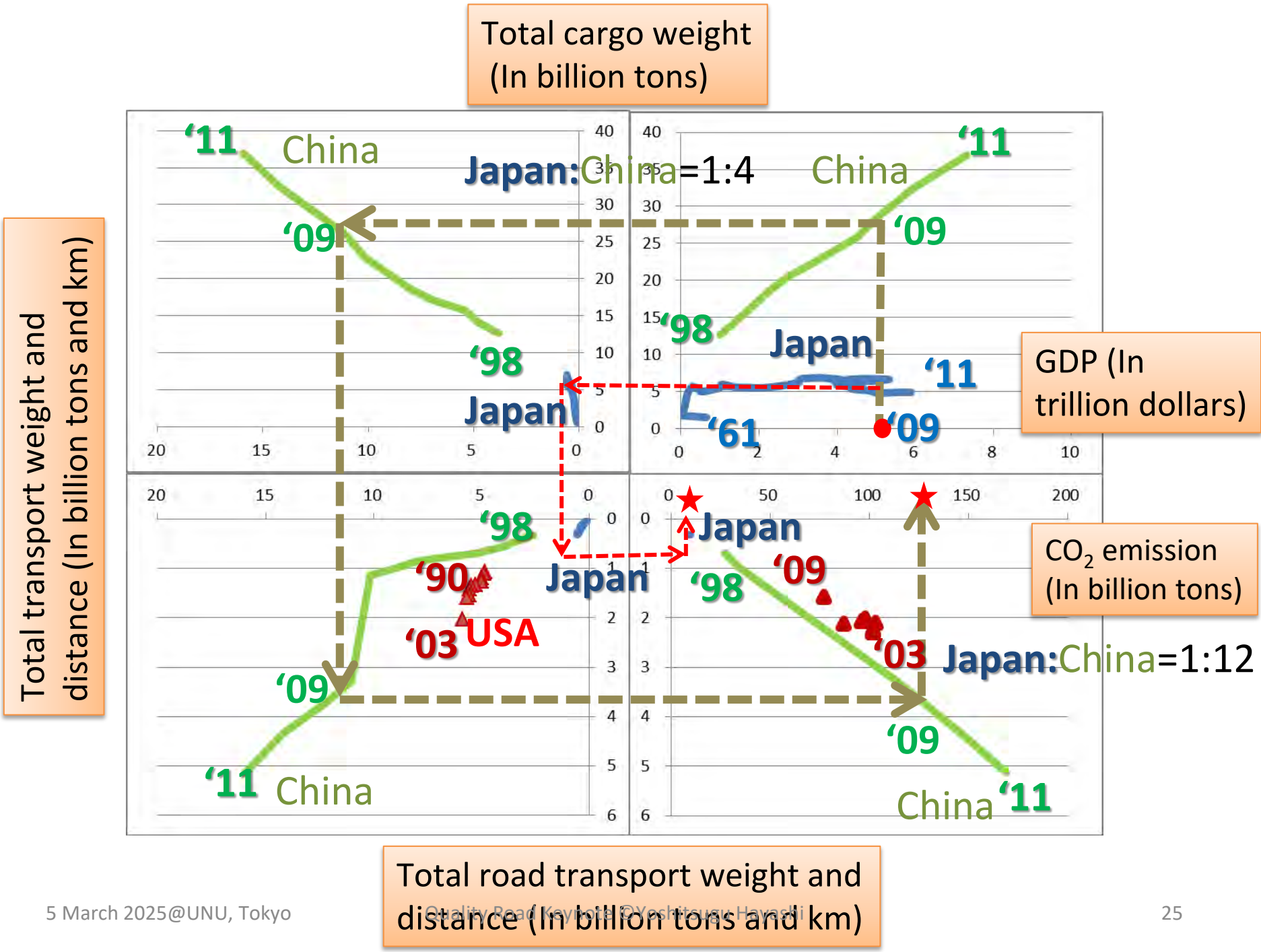
Importance of Shift to EV but The Barriers

- EV shift is important for decarbonization of road transport that shares 50% of world Oil consumption, 170EJ (exajoule=10^{18}J).
- Is EV the best solution?
- EV emit more emission till water, solar, wind electric generations will be dominant → From Well to Wheel Life-cycle Energy management
- 50% more total Electricity Demand if all vehicles are replaced by EV
- Can we build many more electricity generation, power storage and transmission systems?
- Competitor：Electricity demand for Data Center is estimated to be 100% more total electricity in 2030
- Waste of lithium-ion battery contains chemical and nuclear matters

→CO_2/km Fuel Efficiency based Regulation + Top Runner System

China: PM2.5 as outcome of a negative land-use transport interaction


China: PM2.5 as outcome of a negative land-use transport interaction


Total cargo weight
(In billion tons)
Total transport weight and distance (In billion tons and km)
GDP (In trillion dollars)
CO_2 emission
(In billion tons)
Total road transport weight and distance (In billion tons and km)
Japan:China=1:4
Japan:China=1:12
'11
China
'09
'98
Japan
'61
USA
'90
'03

Responsibility (E)

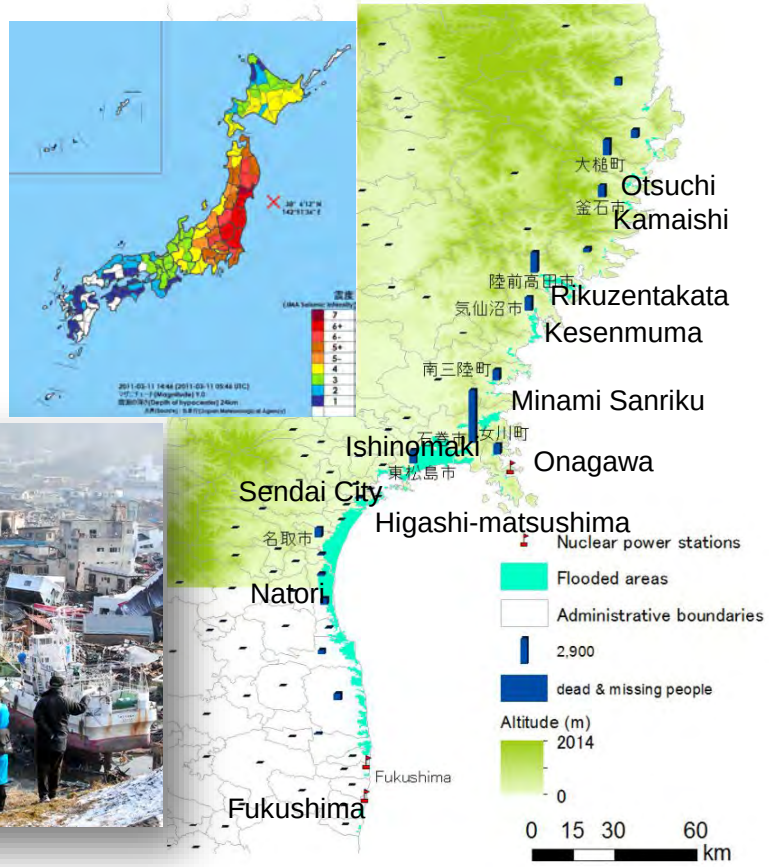
Disaster Resilience

Redundant Network Accessibility

considering Natural Hazards and Emergency

Damages by
The Great East Japan earthquake, 2011

Source : asahi.com

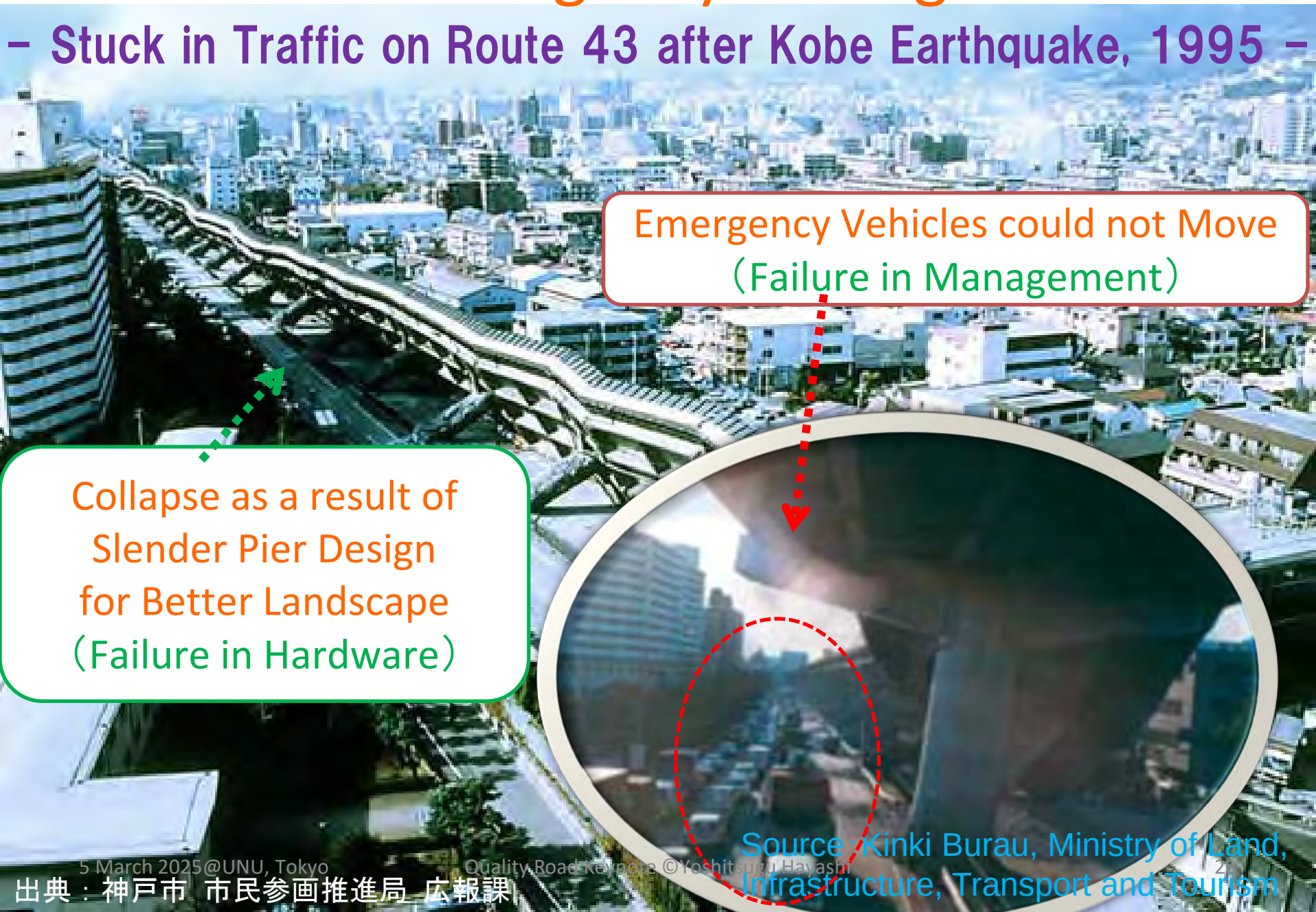


Time & Date	14:46 11/03/11
Magnitude	9.0
Earthquake type	Undersea mega-thrust
Death	14,907 (19/05/2011)
Missing	9,041
Injuries	4,799
evacuees	160,672
Tsunami area (km2)	561
Completely destroyed residential buildings	91,150

(Source: Ministry of Internal Affairs and Communications, Statistics department, Japan)

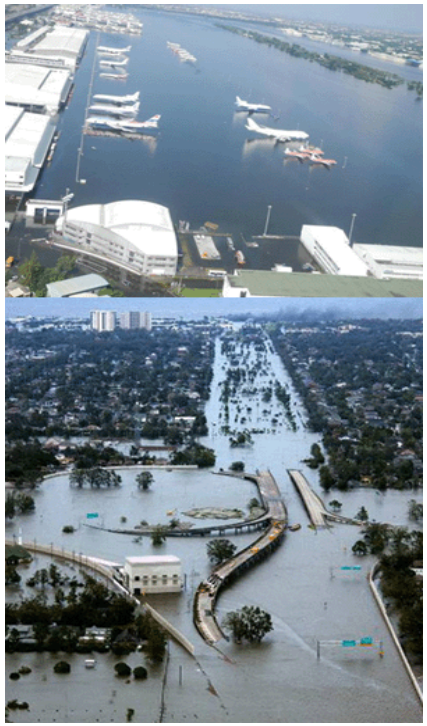
Lack of Emergency Management

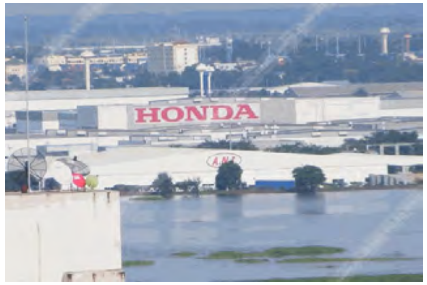
– Stuck in Traffic on Route 43 after Kobe Earthquake, 1995 –



Disaster Resilience

2011 Bangkok Flood
Central Region and Industries Submerged for Months

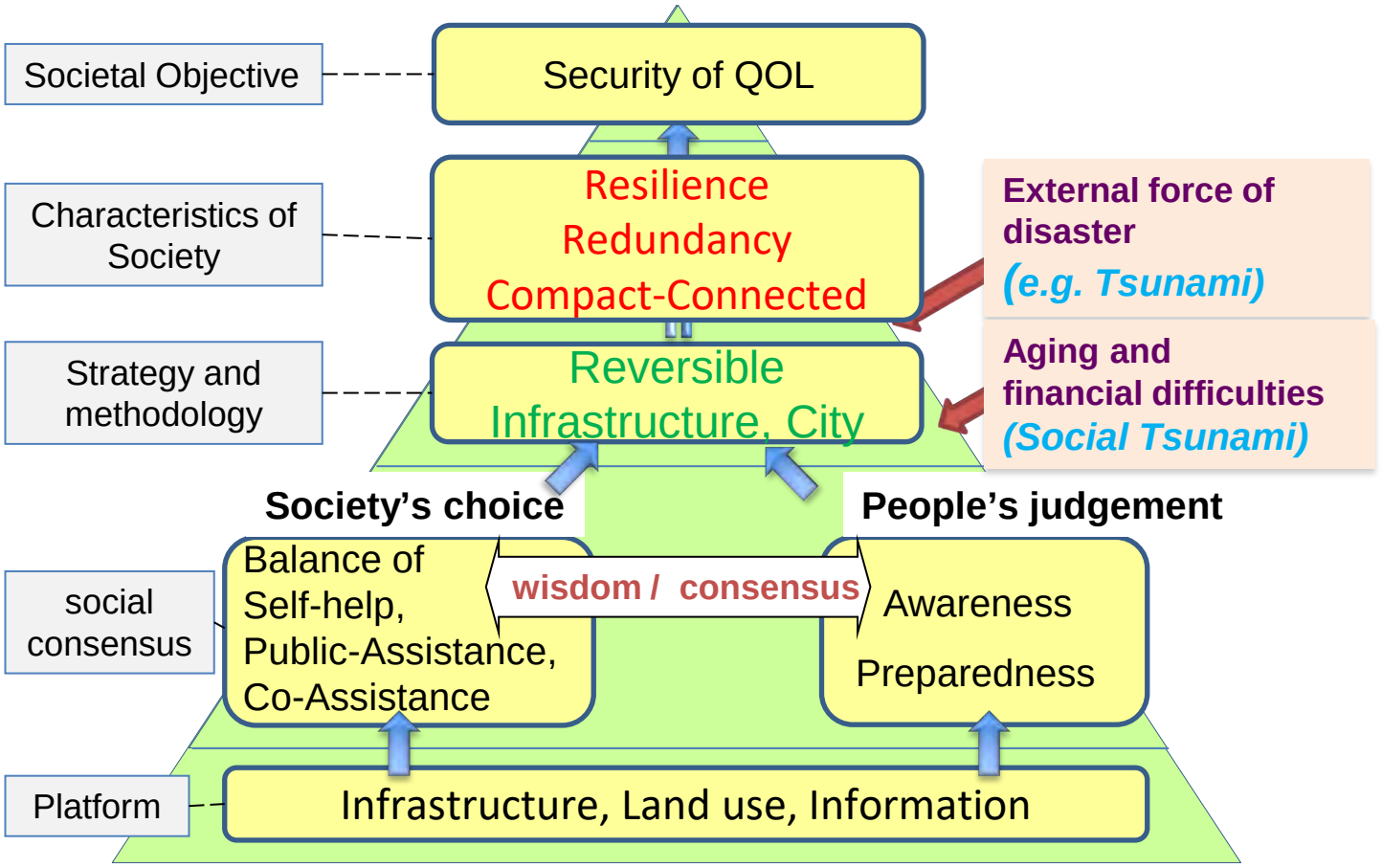




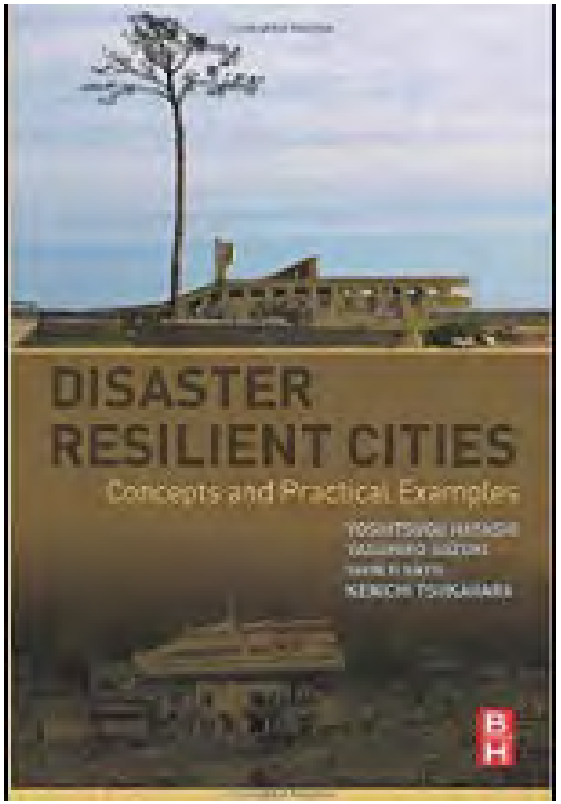
Duration: 149 days
Life Loss: 813 deaths
Economic Loss: 48,185 mil US$
Elevated/Underground Rails Roads are Resilient

Courtesy by Varameth Vivhiensan

Resilient Cities and Communities



Books: Disaster Resilient Cities



Elsevier, 2016

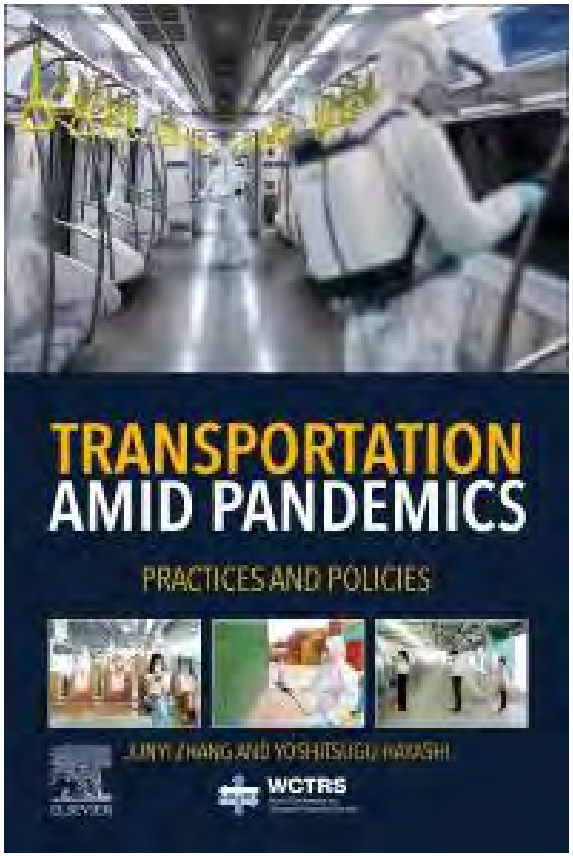
Akashi 明石書店, 2015

Tsinghua University Press, 2015

https://www.dropbox.com/scl/fo/6hvsztkbb3a3i6aqf3rr4/AJpJ1DPZc3fB-cwIm68QzMk?rlkey=8dha1cu0wh9kvlovwd7q8j2vx&dl=0

Pandemic Resilience: Learning from COVID-19

COVID-19 Handbook



- **Lockdown → 2 hr-City** life is **not resilient** in emergency
- People **trust** whole metropolitan society less and **local community** more
- Need for **last mile** convenient mobility
- Need **3rd place** for co-working
- Need for **accessibility to service facilities** such as hospitals, shops, etc.

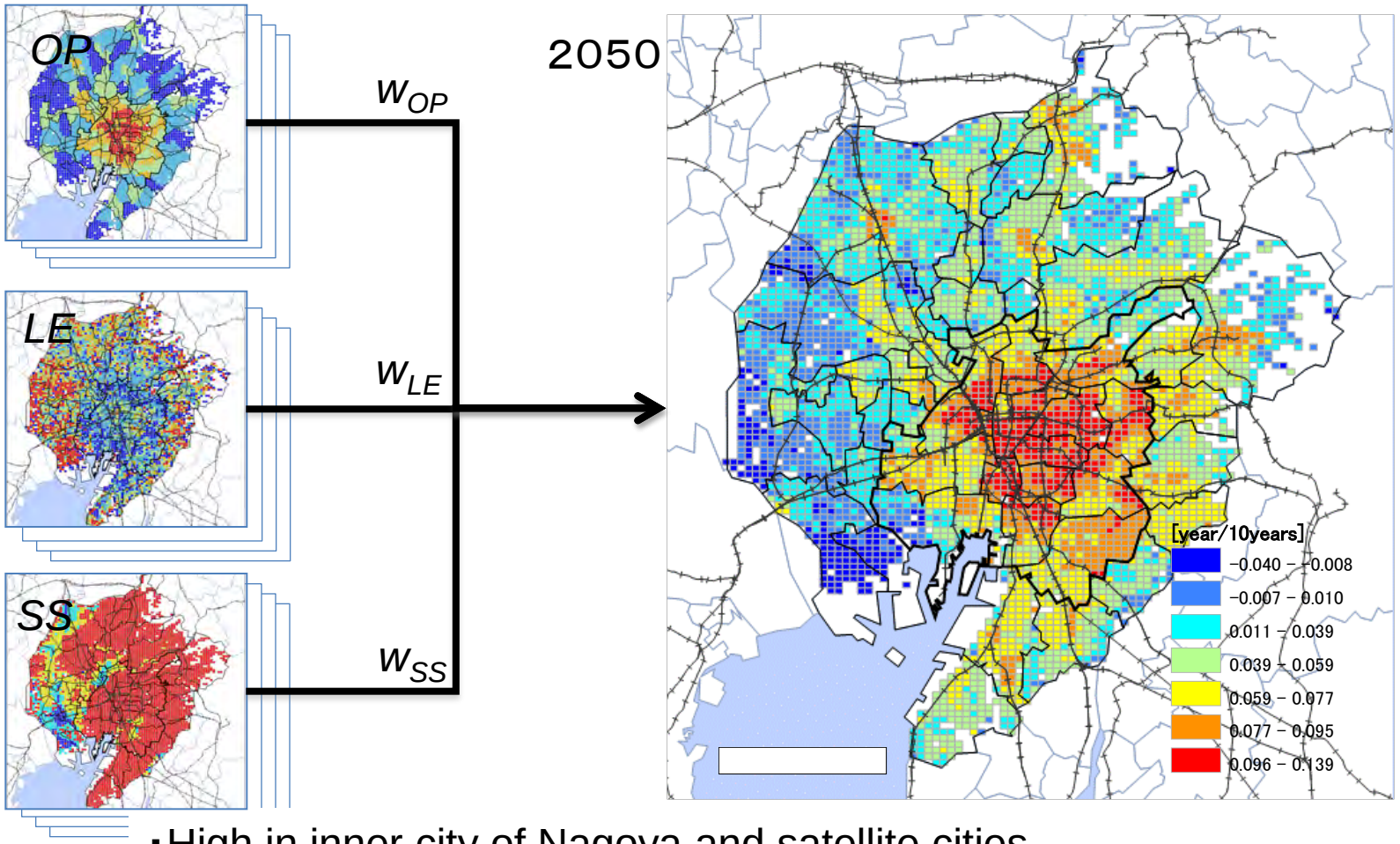
Junyi Zhang & Yoshitsugu Hayashi eds, WCTRS-Elsevier Book Series, 715 pages

Responsibility (F)

Smart Growth/Shrink - Value Capture Conductor

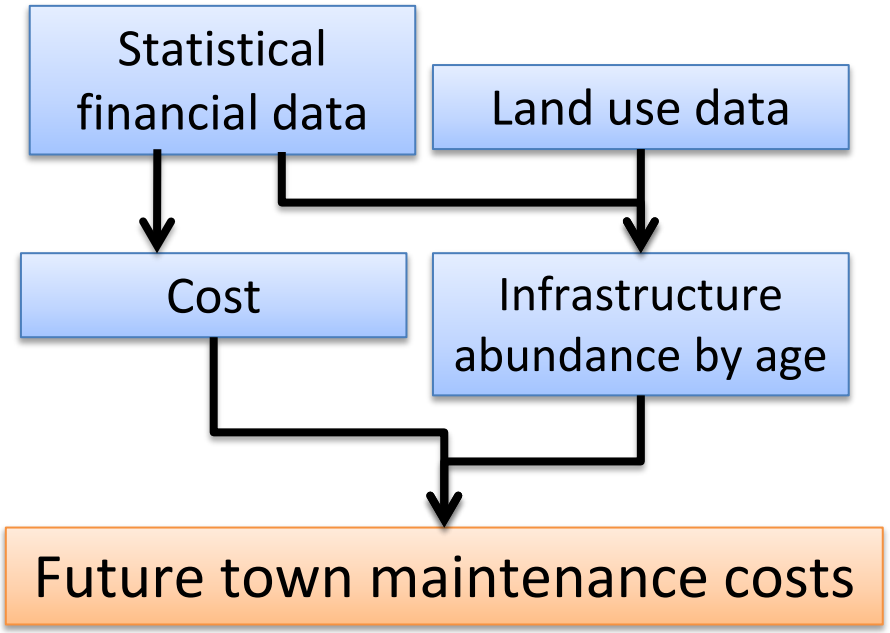
Healthy Urban Structure by *Integration* with *Land Use* for *Growing/Aging Society*

QOL（for average citizen）

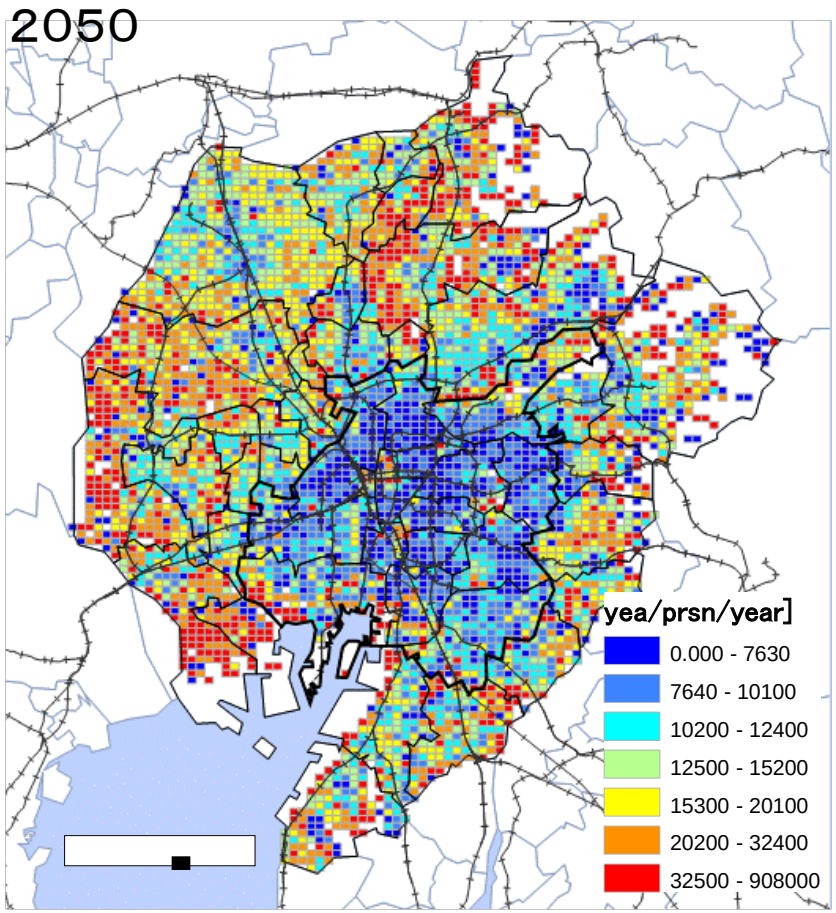


- High in inner city of Nagoya and satellite cities
  → influenced by transport accessibility
- Low in West and High in East
  → influenced by earthquake and flood risk

Per capita Future Social Cost (Infrastructure Maintenance)



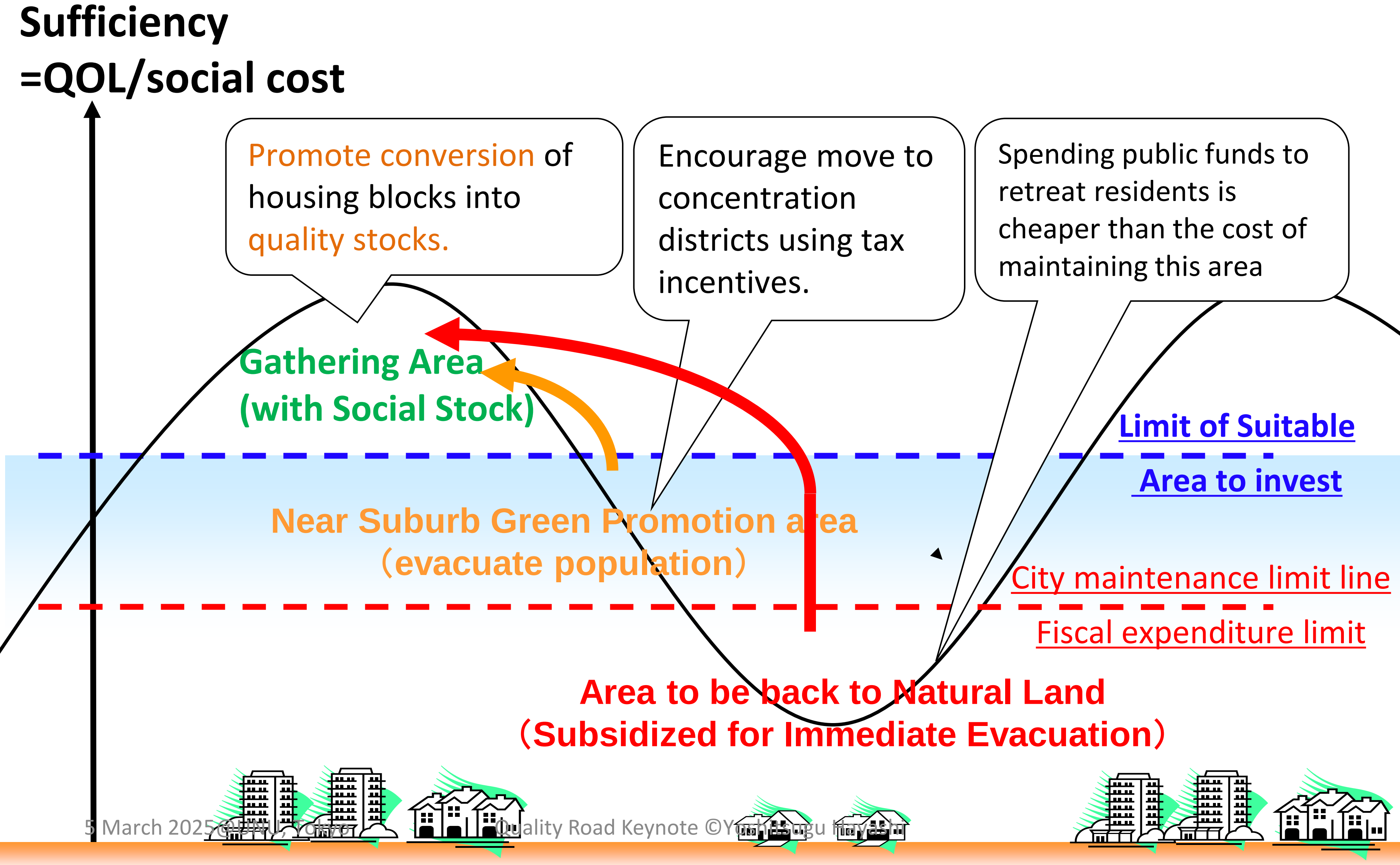
Targets of estimation:
Municipal roads, water supply, sewerage, agricultural community drainage, joint treatment and septic tanks



- Low in densely populated areas, such as Nagoya City and the center of its peripheral cities
- In 2050, cost will be particularly higher in the western area where population is drastically decreasing

Setting criteria for Smart Shrink (retreat + re-concentration)

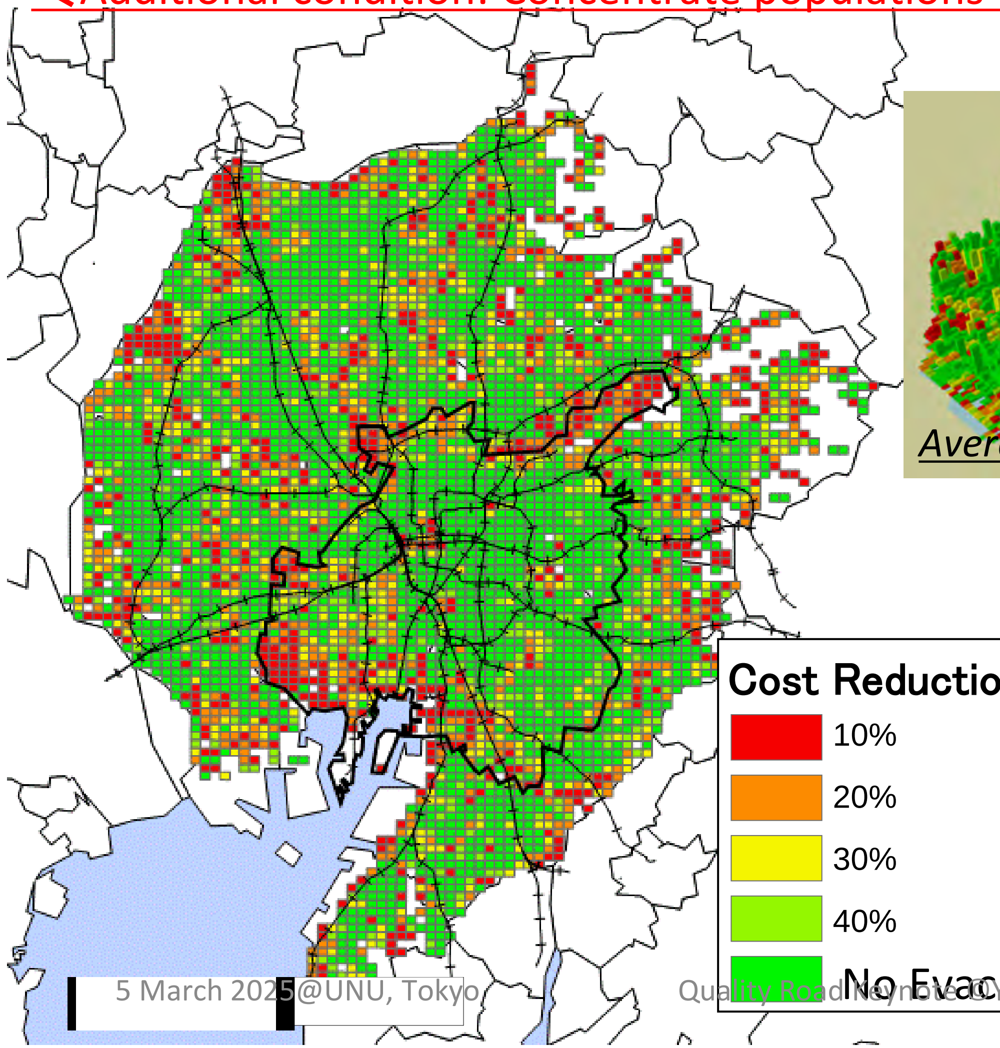
"Classification based on social value / social cost of land"



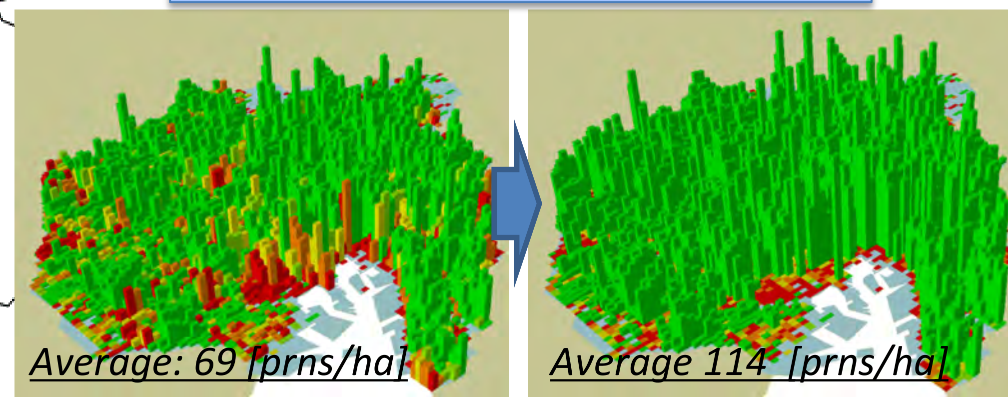
Smart shrink: Selection of districts for retreat

- Select retreat districts necessary to achieve the maintenance cost reduction target.
- Retreat from districts with low-cost efficiency (QOL/cost)

＜Additional condition: Concentrate populations within the boundaries of municipalities＞



Change in Population Distribution

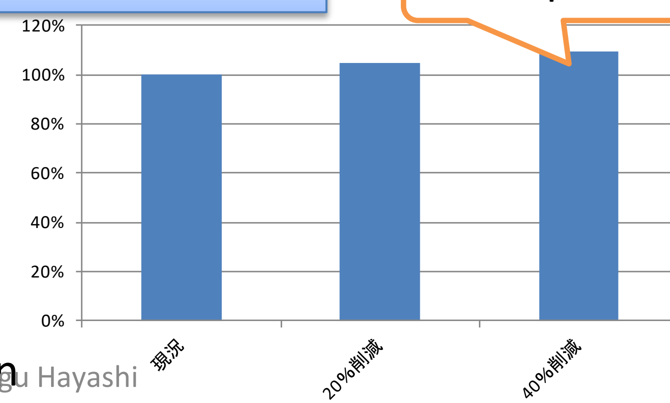


Current

Case of 40% Reduction

Impact on QOL

8% improvement



※Improvement rate compared to Current(100%)

Land use – transport integration and value capture

- Integrated urban and regional management of land use with transport and value capture are crucial, but the reality has been reverse.
- In developing countries, metropolises have been sprawling. This will create future huge debt for the country and city, burdening on the next generations.
- Aging has already started in several Asian countries.
- The future generations, who may become poorer, cannot bear.

→ *Stefan KLUG, Yoshitsugu HAYASHI (2010)* ***Infrastructure Costs and Urban Sprawl – An International Case Study****, 12th WCTR, Lisbon*

https://www.dropbox.com/scl/fi/w3ak3n7cabyzxz7t0zytz/S.Klug-Y.Hayashi_Infrastructure_Costs_and_Urban_Sprawl.pdf?rlkey=kcdeoqzvdx1kymm43oxgl9g6l&dl=0

Responsibility (G)

Well-being

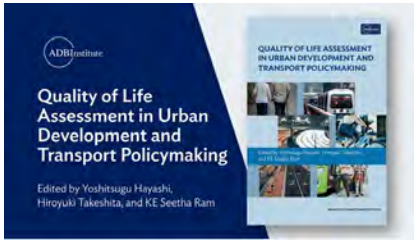
Replace GDP-based CBA (*Efficiency*)
by QOL Accessibility Method (*Sufficiency*)
to evaluate SDGs if *No one left behind*

QOL Mainstreaming in Transport Planning

- From Mass Economic **Efficiency**
  to Individual's **Sufficiency**
- From **Cost-Benefit Analysis**
  to **QOL Accessibility Model**
  - by different Age, Gender, Income level
- Towards **SDGs**: No one left behind

From Economic Efficiency (GDP) to Personal Sufficiency (QOL)

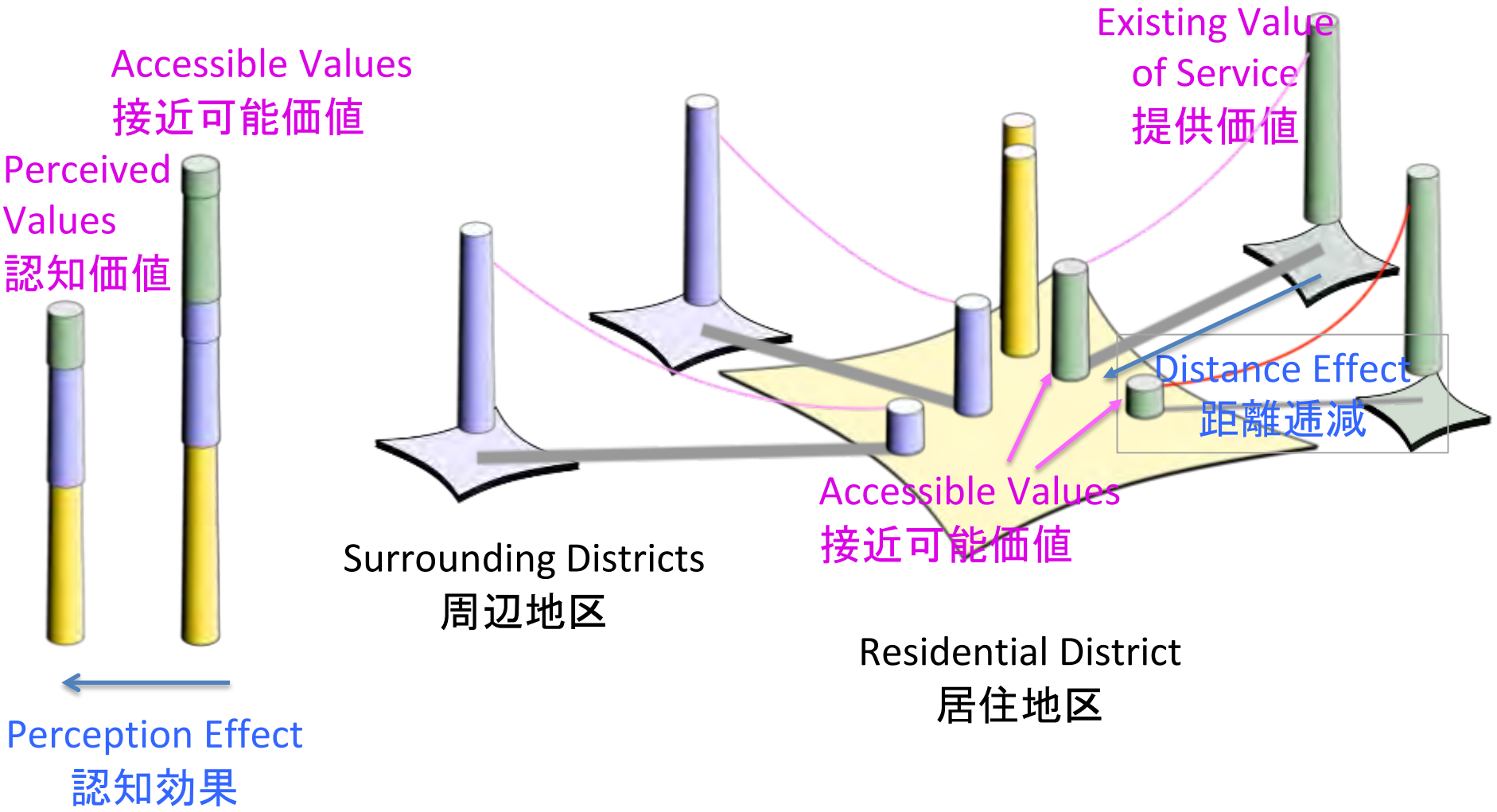
- Conventional Cost-Benefit Analysis (GDP/Construction and Maintenance Cost) is still used.
- GDP is an indicator to show only the mass economic (money) flow passing in a country/region during a year.
- GDP indicator does not tell anything about if "No one left behind", which is the most important view point of SDGs.
- GDP seeking has not made people happy but is Galapagos of 20th century. Today in 21st century, we should seek for happiness (Quality of Life) for differently attributed each citizen.
- Evaluation for Sufficiency (QOL/Direct+Social Cost) is required.
- QOL Accessibility Model is proposed



→ *Hayashi, Y., H. Takeshita and KE. Seetharam eds. (2023) Quality of Life Assessment in Urban Development and Transport Policymaking, ADBI Press (e-Book free download)*

https://www.adb.org/publications/quality-of-life-assessment-in-urban-development-and-transport-policymaking

Hayashi's QOL Accessibility Model



QOL Accessibility Model

Accessible Value

$$A_{ij}^{m} = V_{j}^{m} \cdot e^{-\alpha c_{ij}}$$

- ***m***: QOL factor
- ***i***: Mesh block with residents living in
- ***j***: Mesh block with objective value of QOL factor ***m***
- α^{m}: Impedance parameter for traveling from mesh block ***i*** to mesh block ***j***
- c_{ij}: Travel cost between mesh block ***i*** and mesh block ***j***
- ***Vjm***: Existing value of QOL factor ***m*** exists in mesh block ***j***
- ***Aijm***: Accessible Value of ***Vjm*** for residents living in mesh block ***i***.

Perceived Value

$$QOL_{i}^{k} = \sum W^{mk} A_{ij}^{m}$$

- ***k***: Population group ***k*** with certain social-economic attributes
- ***Wmk***: Weight of QOL factor ***m*** for person ***k*** among all factors
- ***QOLik***: Perceived Value=Quality of life for person ***k*** living in mesh block ***i***

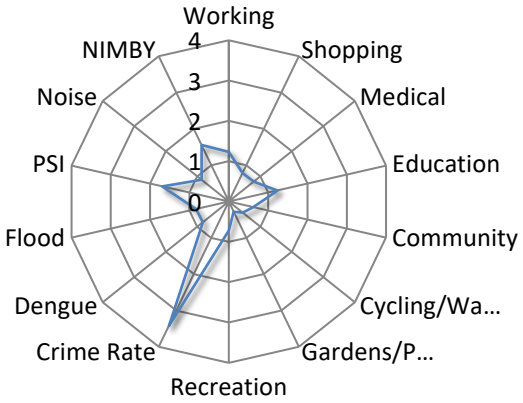
Gross Regional Happiness

$$GRH^{k} = \sum_{i} P_{i}^{k} \cdot QOL_{i}^{k}$$

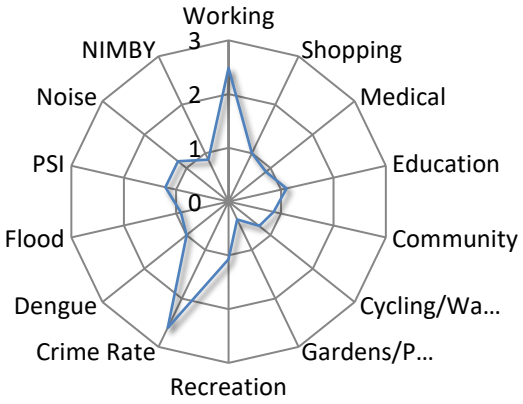
$$GRH = \sum_{k} GRH^{k}$$

Weights between QOL Factors (Singapore)

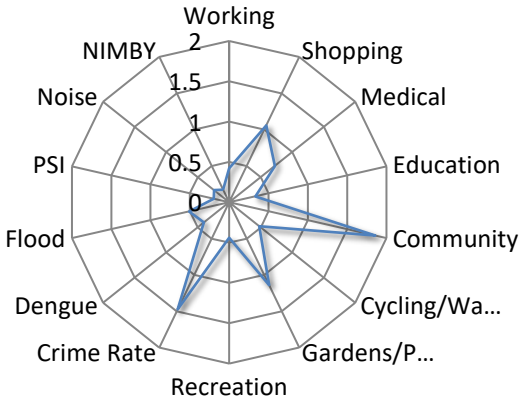
Young / Female



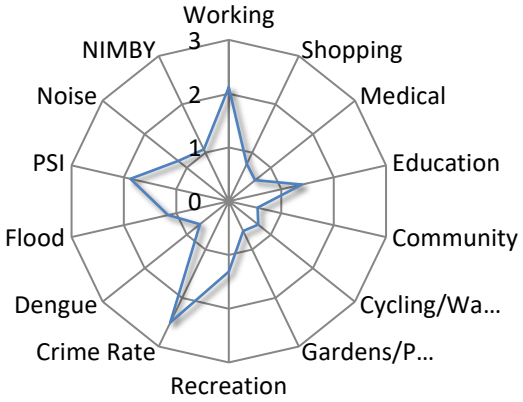
Middle-aged / Female



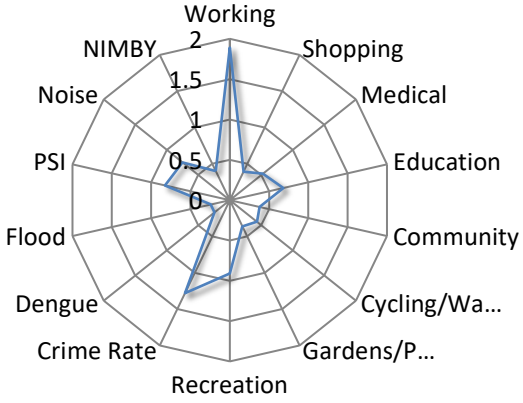
Aged / Female



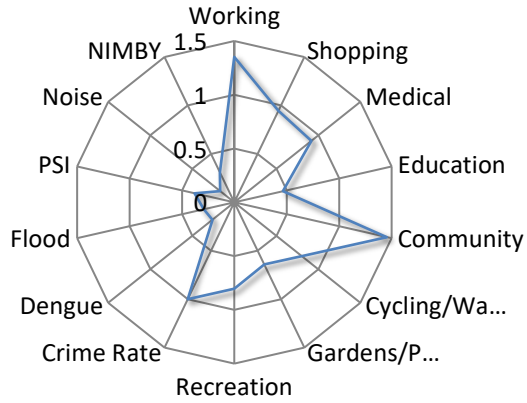
Young / Male



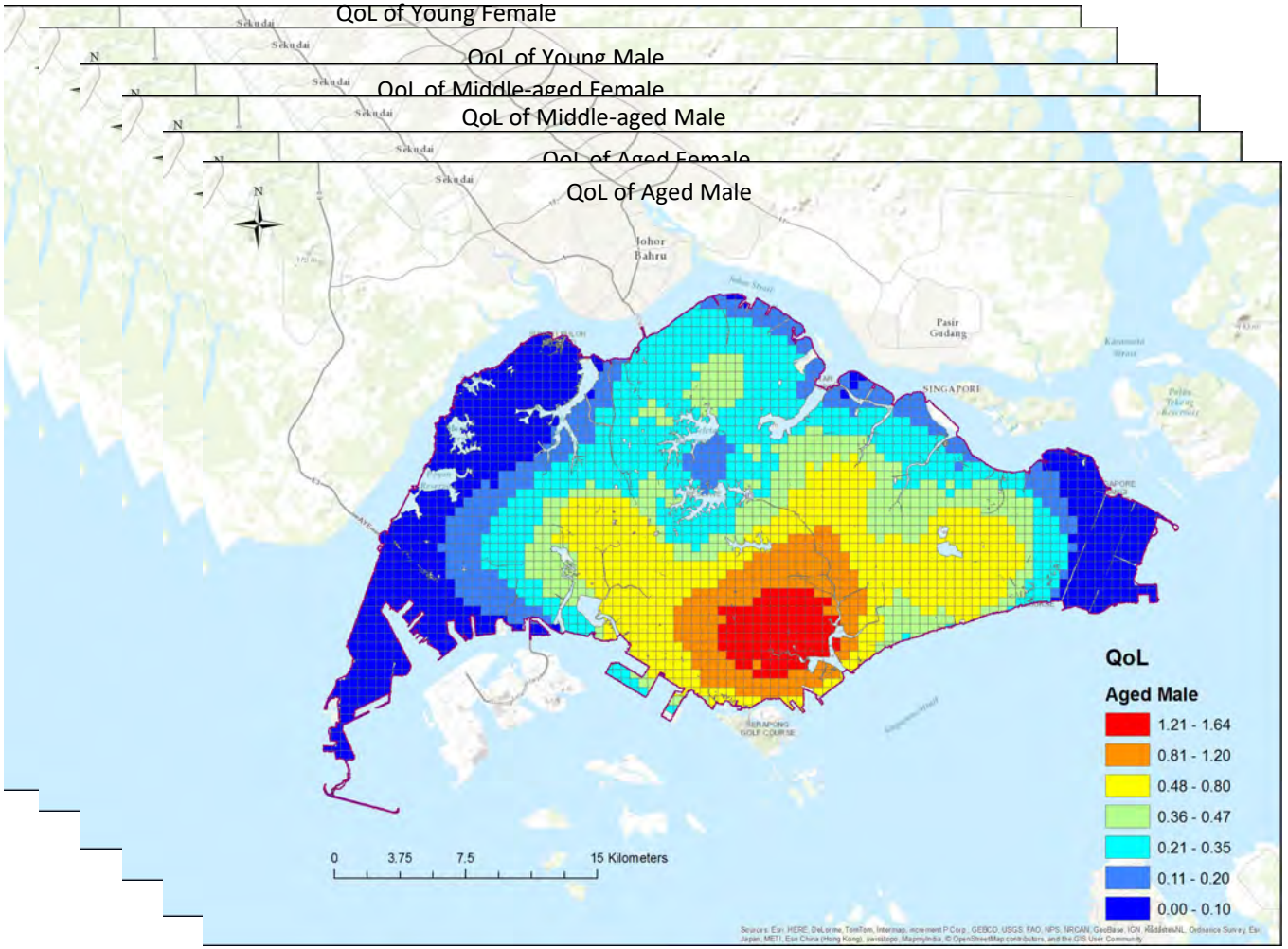
Middle-aged / Male



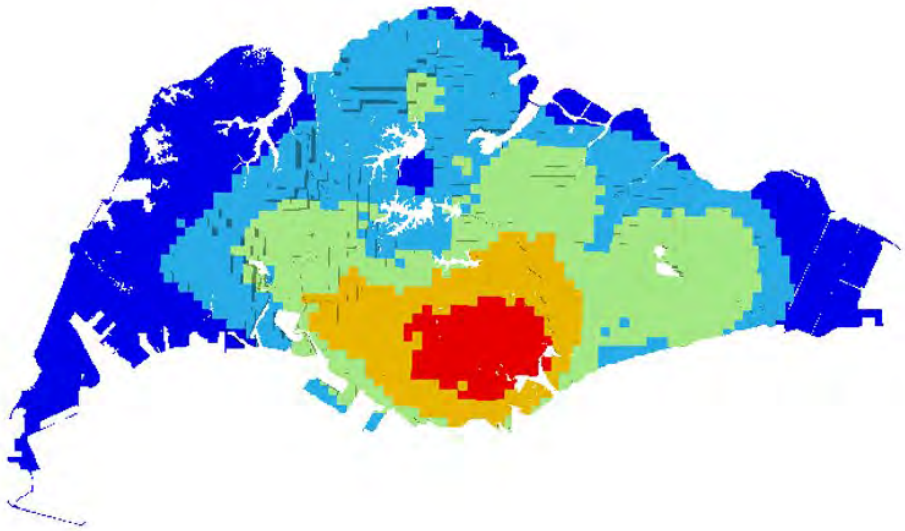
Aged / Male



QOL Spatial Distribution in Singapore
(by age, gender)



Policy Options
- Transport Network or Compact City –

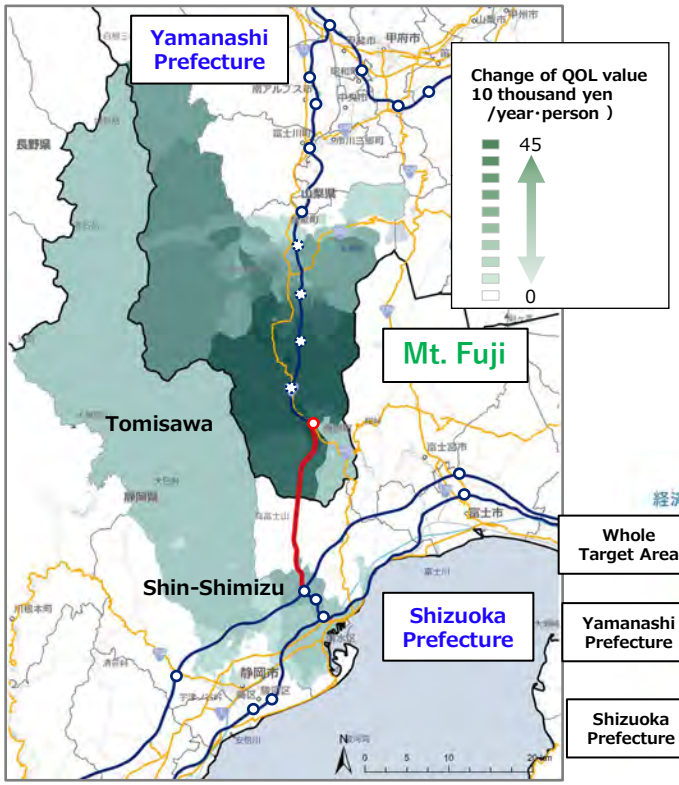


Total Volume = GRH (Gross Regional Happiness)

Source: Master Thesis of Yong Jian Khoo,
supervised by Yoshitsugu Hayashi, Graduate School of Environmental Studies, Nagaya University, 2015

Case study: Chubu-Odan Motorway
(near Mt.Fuji)

Increase in QOL Value by New Motorway Opnening



Average Value per capita in Target Area

9,700 yen/person･year

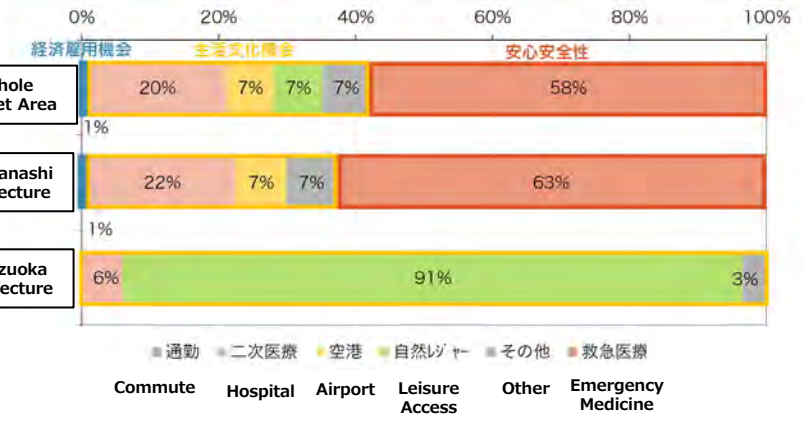
×

Population in Target Area

About 250 thousand

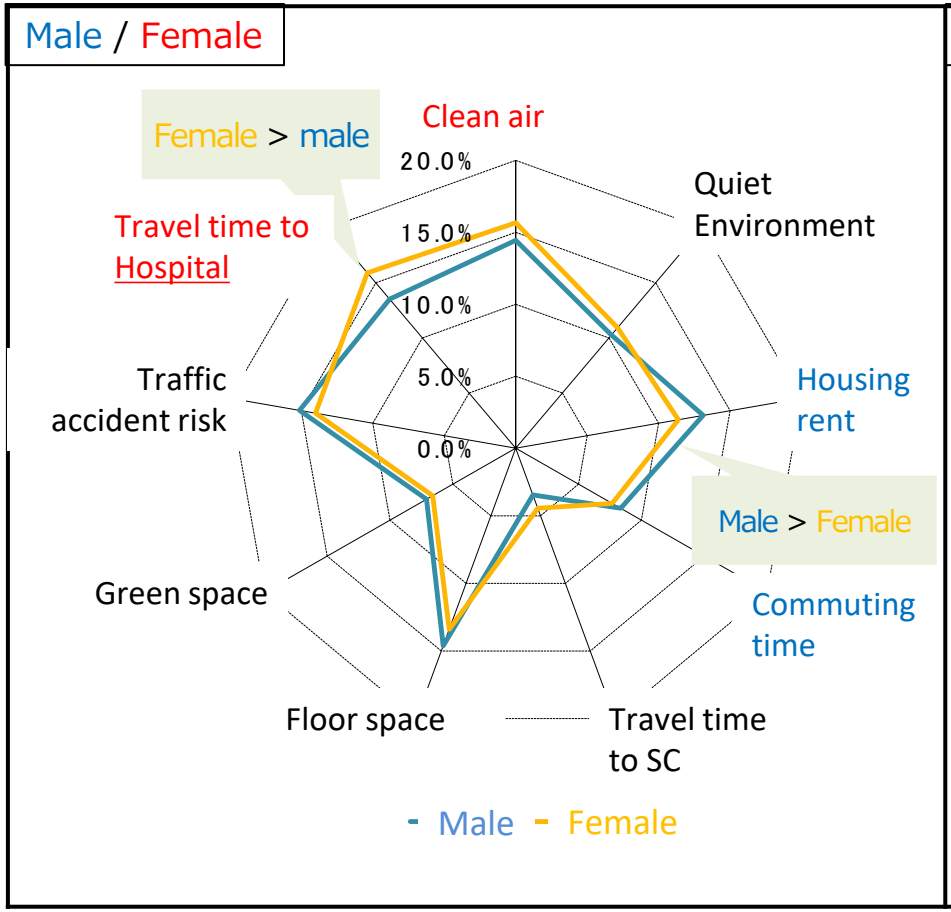
=

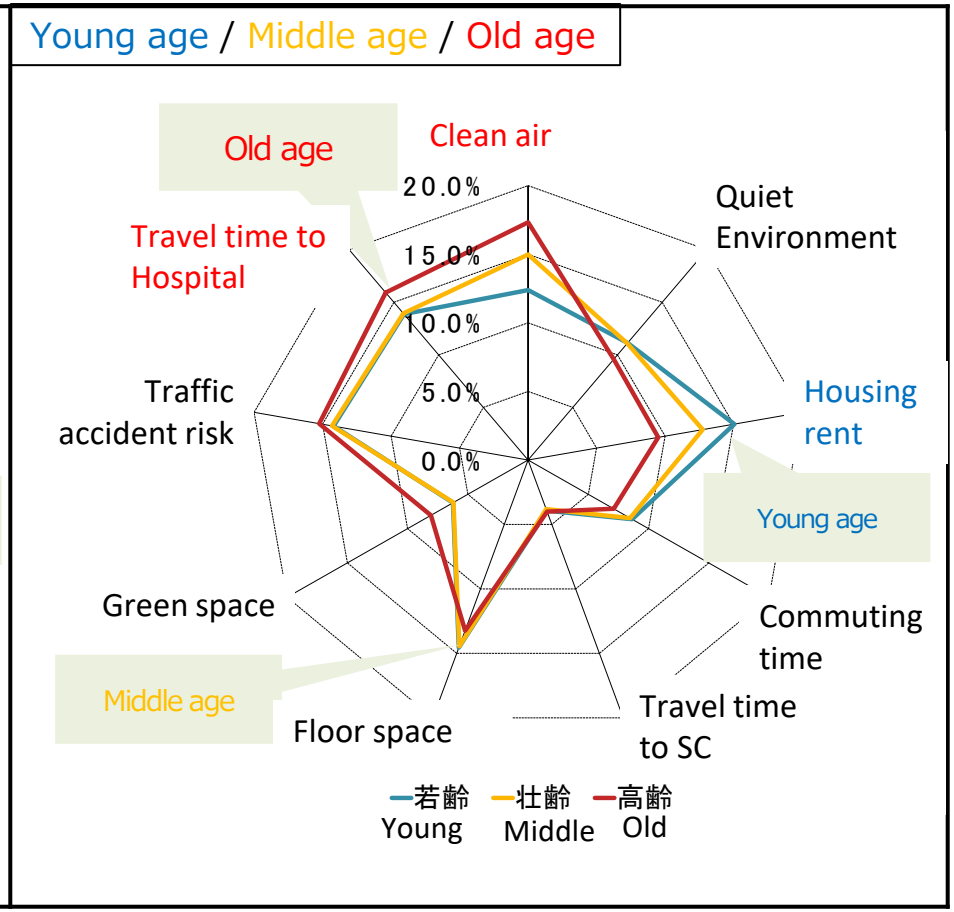
24.4 billion yen/ year



Difference in Individual Perception by QOL factor in Across Chubu Motorway project

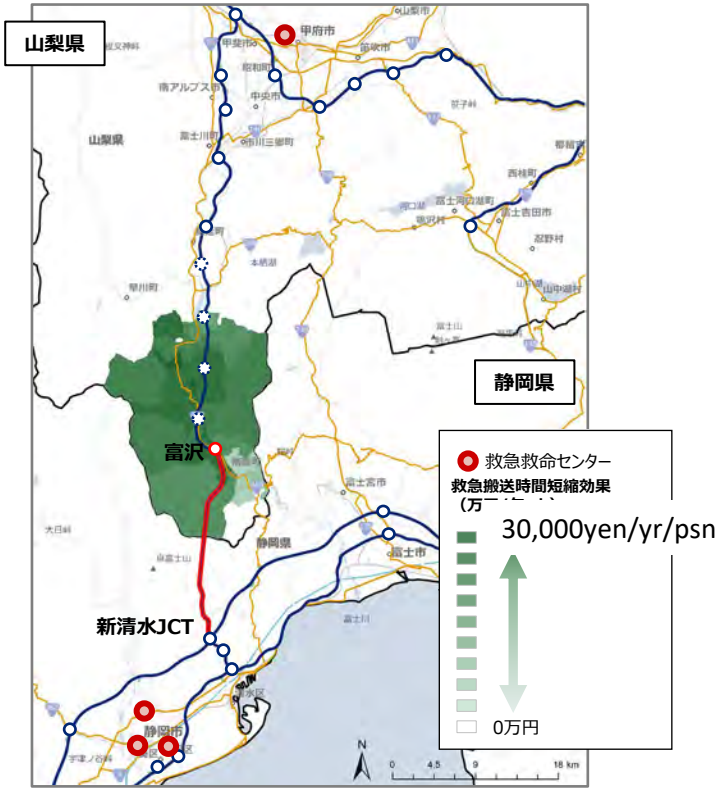
QOL differences by gender, by age group



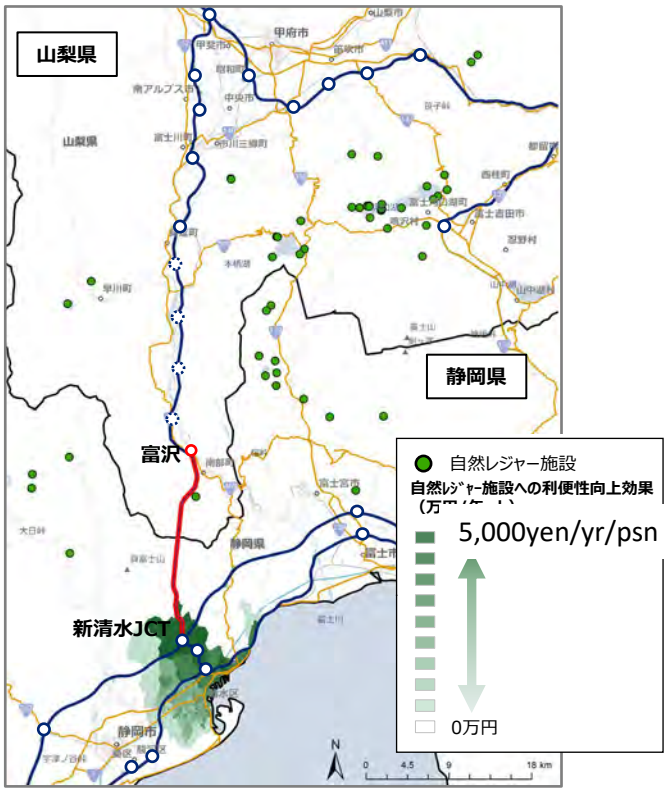


Chubu-Odan Motorway
(Difference in Reasons for QOL Increase by Opening)

Emergency Medical Service

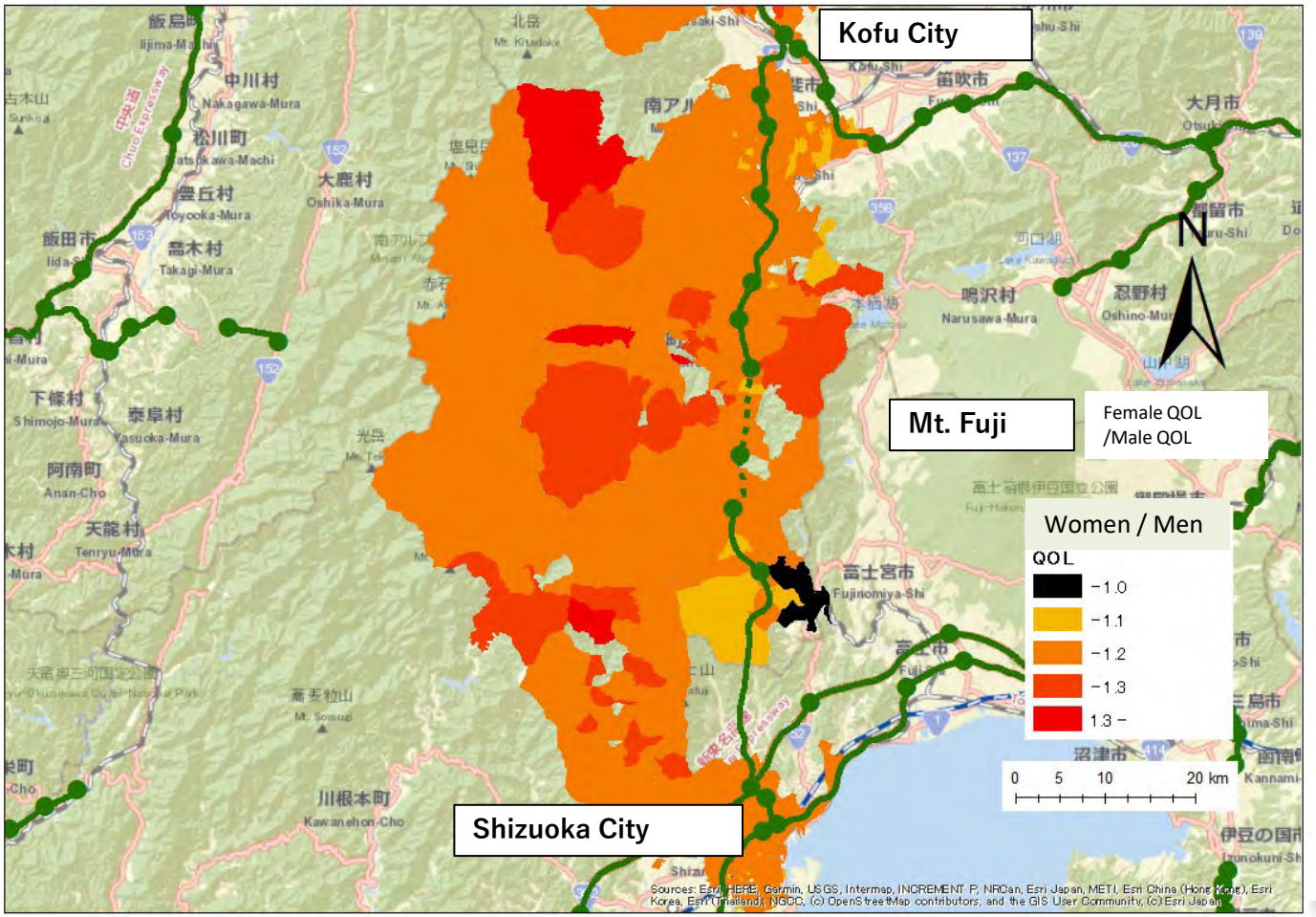


Leisure Access



QOL Comparison (Female vs. Male)

Men



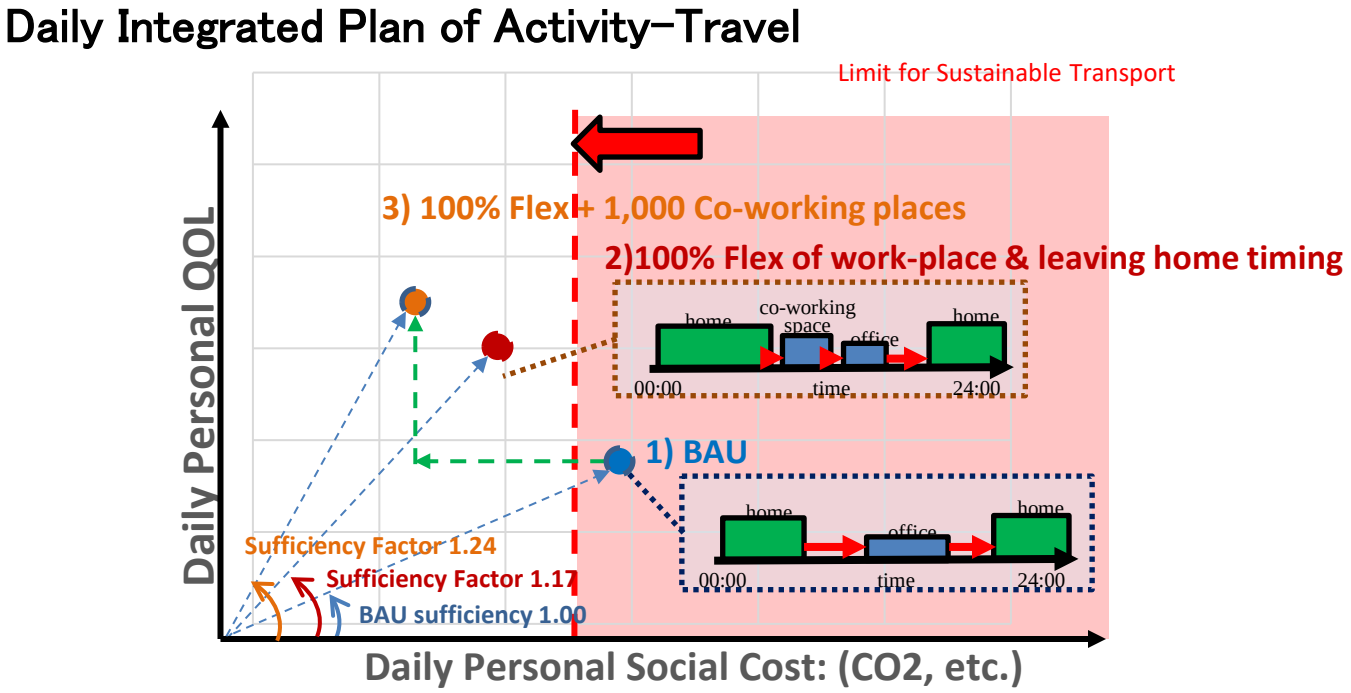
A pathway to Better Mobility for a Better Bangkok

- The Sukhumvit model -

Principal Investigator
Yoshitsugu Hayashi
Project Director
Thanaruk Theeramunkong

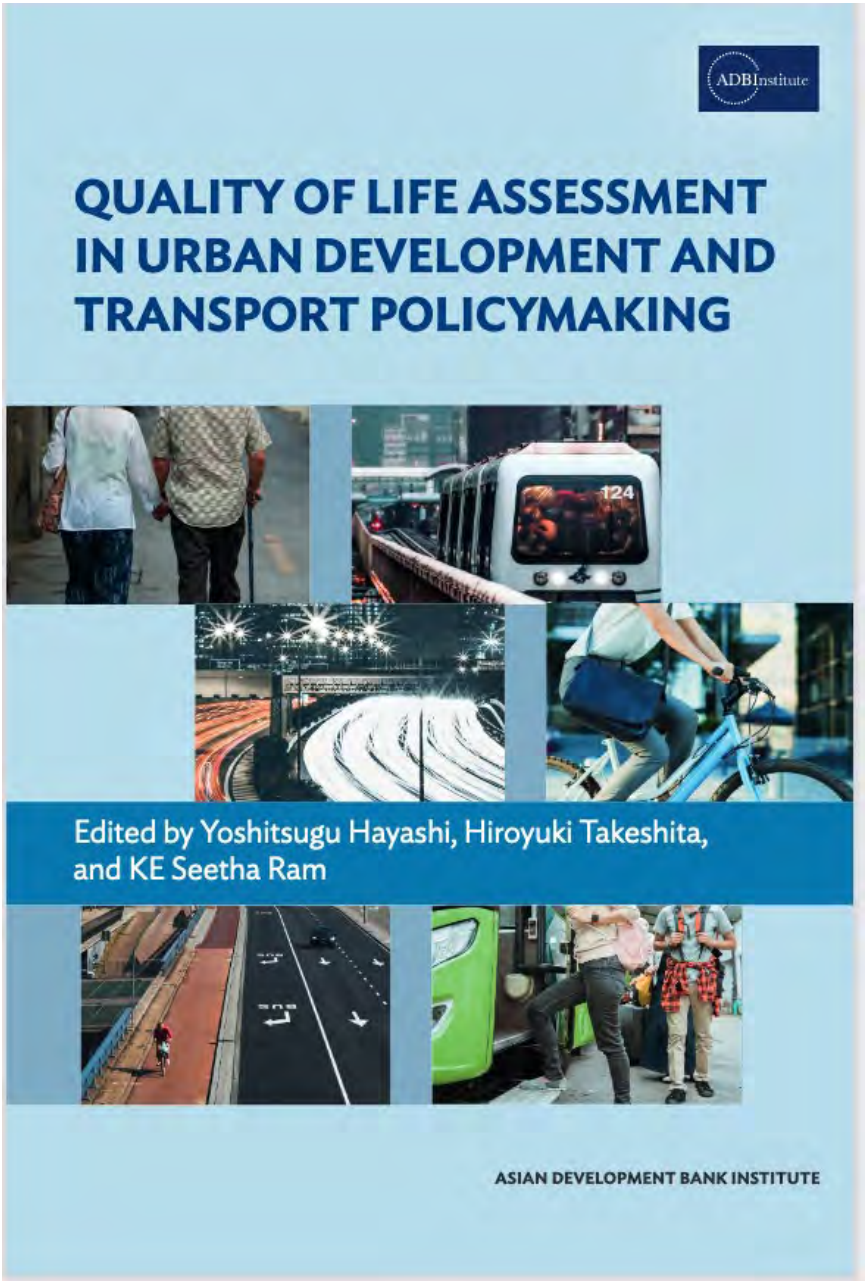
JICA SATREPS - JCC
1 February 2024
Sukosol Hotel, Bangkok

"Sufficiency" Factor X



From JICA/JST SATREPS Project 2018-2024"Smart Transport for Thailand 4.0" (Chair: Yoshitsugu Hayashi)

https://www.dropbox.com/scl/fi/d1f7eq0putevthth8yoj0/2024-02-23_SATREPS-Brochure-wide-_compressed.pptx?rlkey=486ct935eu3c6up809oihc9ea&dl=0



QOL New Book

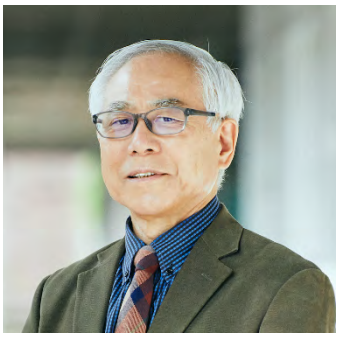
- Just Published, July 2023
- Asian Development Bank Institute Press
- e-Book: free download

- Editors: Yoshi Hayashi, Hiroyuki Takeshita, K.E.Seetharam
- Authors: include Yoshi Hayashi, Werner Rothengatter, Roger Vickerman, Yves Crozet, Jamie Leather

Quality Road
Sufficient and Inclusive
Better for Everyone !

Thank you for your attention !

Brief CV of Prof. Dr.-Eng Yoshitsugu Hayashi



Professor Hayashi is Emeritus Professor, Nagoya University and Distinguished Professor, Tokai-Gakuen University.

Prof. Yoshitsugu Hayashi is Executive Committee Member elected from 130 Full members of The Club of Rome, a well-known Think-Tank for its 1972 Report "The Limits to Growth"

He is Immediate Ex-President (2013-2019) of WCTRS (World Conference on Transport Research Society), gathering over 1,000 members from 70 countries.

He is a well-known international research Leader in transport – land use interactions, and their impacts on Planetary Sustainability, Climate change, Disaster redilience, Value capture, socio-economic impacts of COVID-19 Pandemic, and Quality of Life. Their results have been published in over 50 books and 200 journal papers.

He has contributed also to real Project Assessment including a) Tokyo Bay Bridge project in 1970's, b) Bangkok urban railway development since 1992, b) Japanese Maglev high speed rail since 1999, c) Indian high-speed rail since 2017, etc.

[just for reference]
50 books includs:
"Intercity Transport and Climate Change" (Springer, 2014),
"Disaster Resilient Cities" (Elsevier, 2016),
"Balancing Nature and Civilization" (Springer, 2019),
"Transportation Amid Pandemics - Lessons Learned from COVID-19" (Elsevier, 2022)"
"Quality of Life Assessment in Urban Development and Transport Policymaking" (e-Book for free download, Asian Development Bank Institute Press, 2023).