

**SCJ Conference on Science and Technology for Sustainability 2011  
14 September 2011, Kyoto**

**Sustainability of Asia:  
Economic  
Development, Urbanization, Lowering  
Birth Rate/Aging and  
Climate Change**

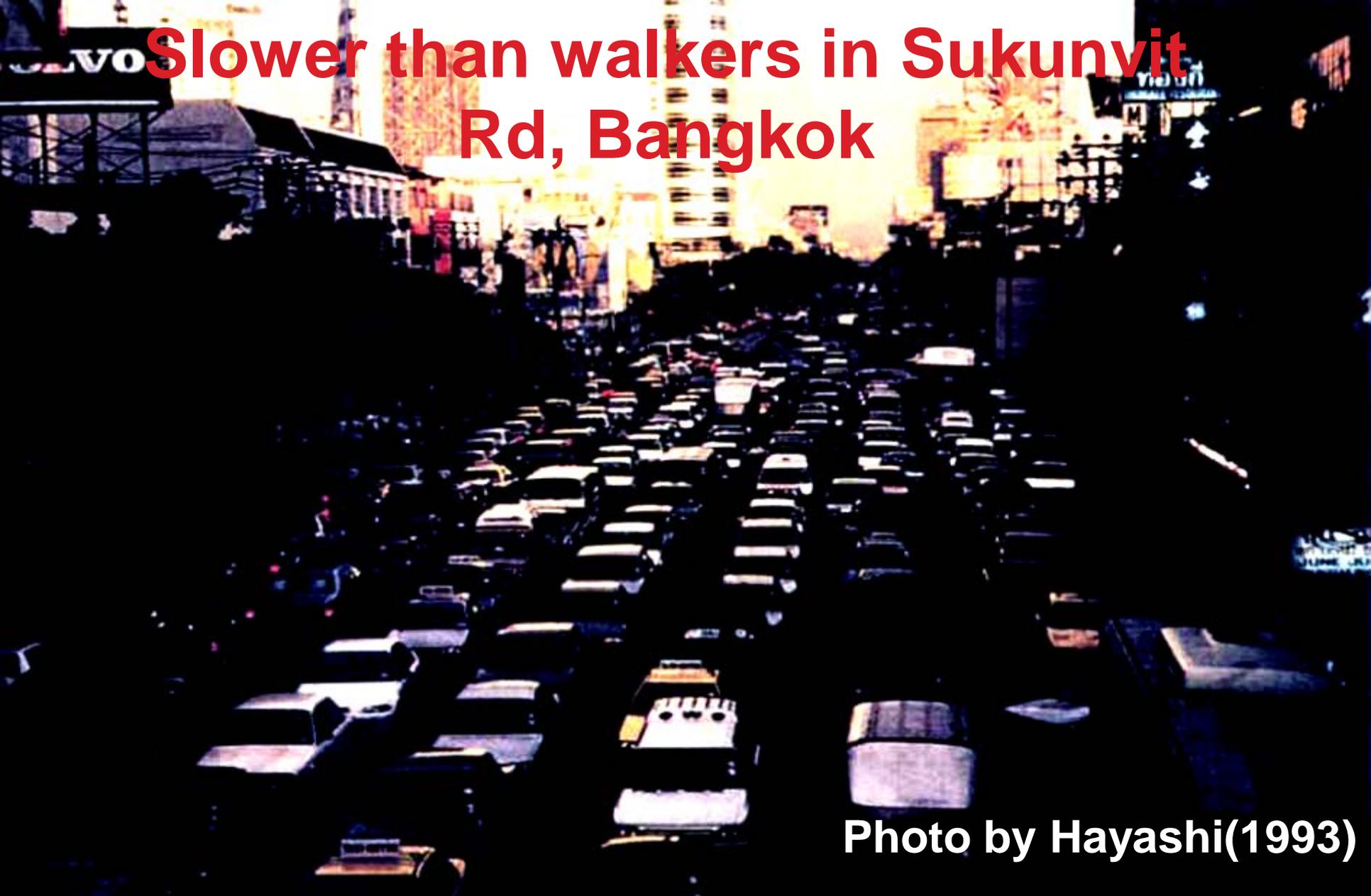
**Yoshitsugu Hayashi  
Director, International Research Center for Sustainable Transport and Cities  
Nagoya University**

# School boy waiting for bus at 4:30 am in Suburb of Bangkok



Yoshitsugu Hayashi, Nagoya University

Bangkok  
Post  
4 Sept  
1993 2



# Slower than walkers in Sukunvit Rd, Bangkok

Photo by Hayashi(1993)

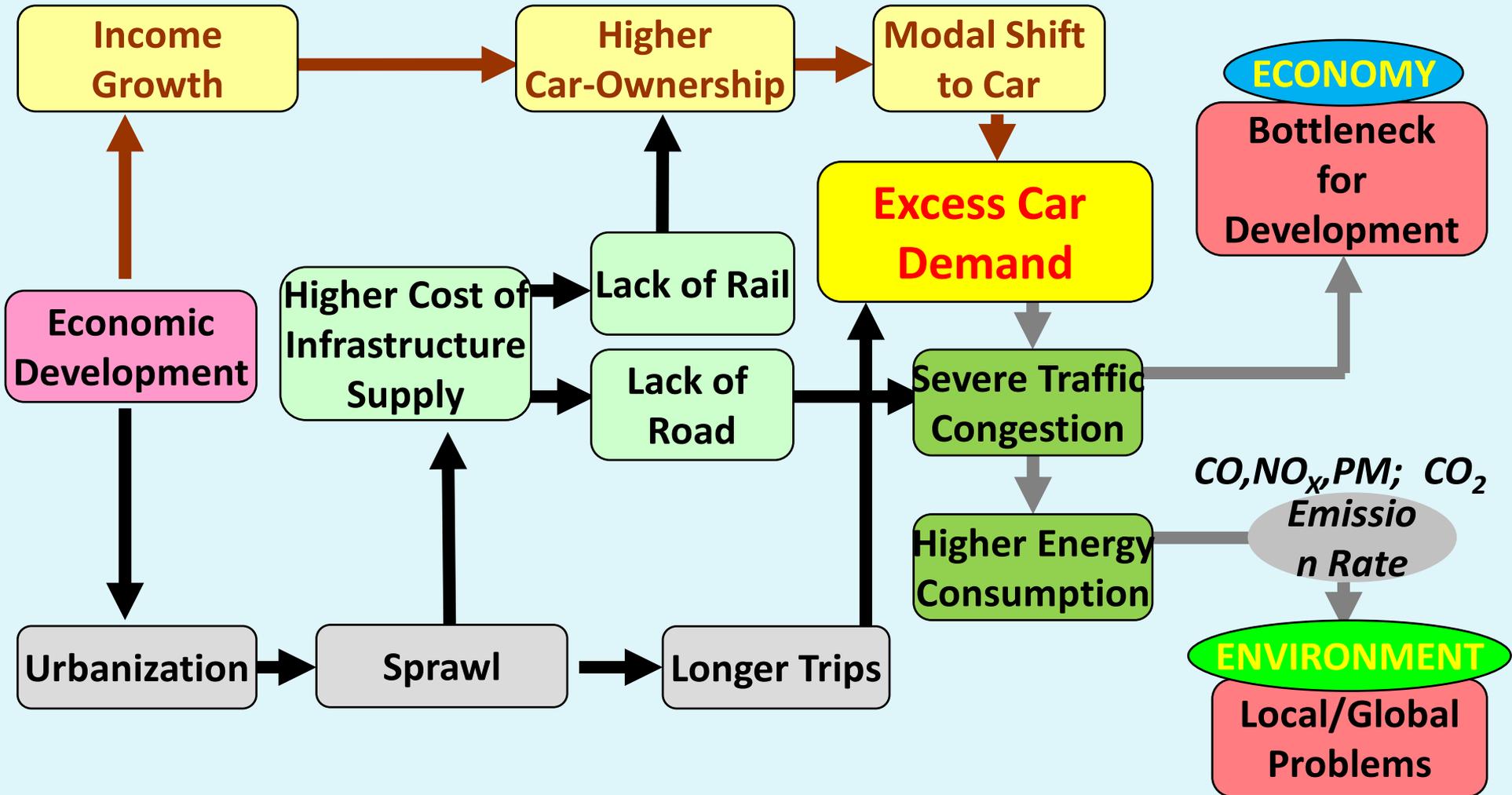
# Mumbai Suburban Train



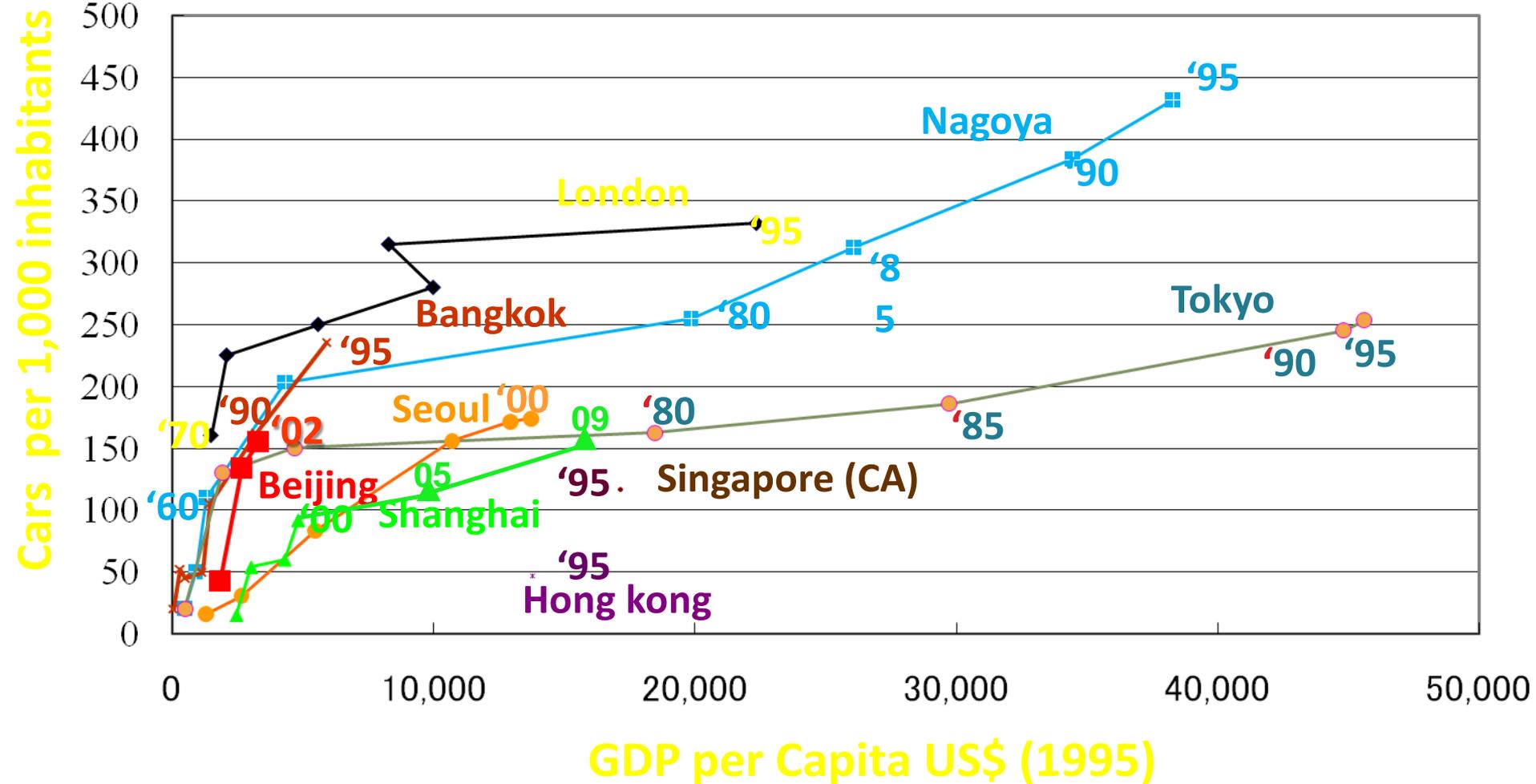
Photo by Krishna Rao

# Diagnosis of Interactions between Urbanisation and Motorization

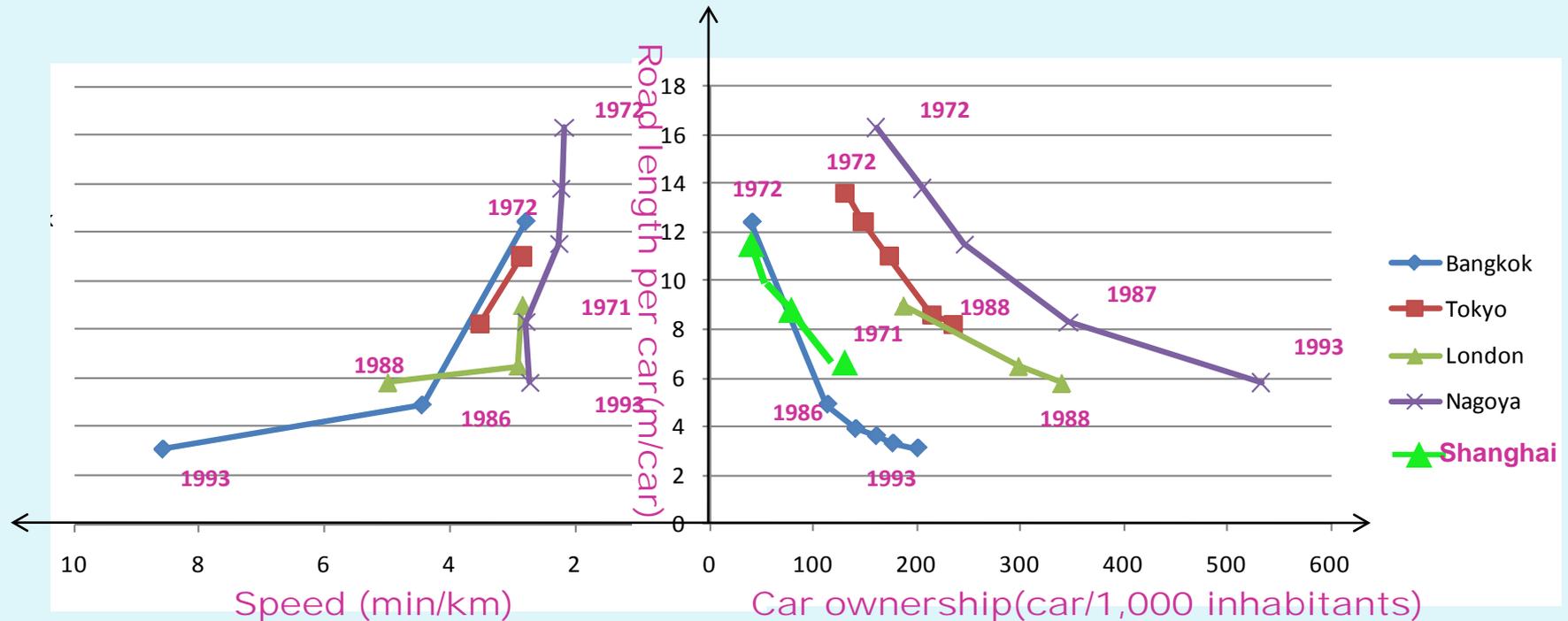
# Basic Mechanism of Urbanization and Motorisation



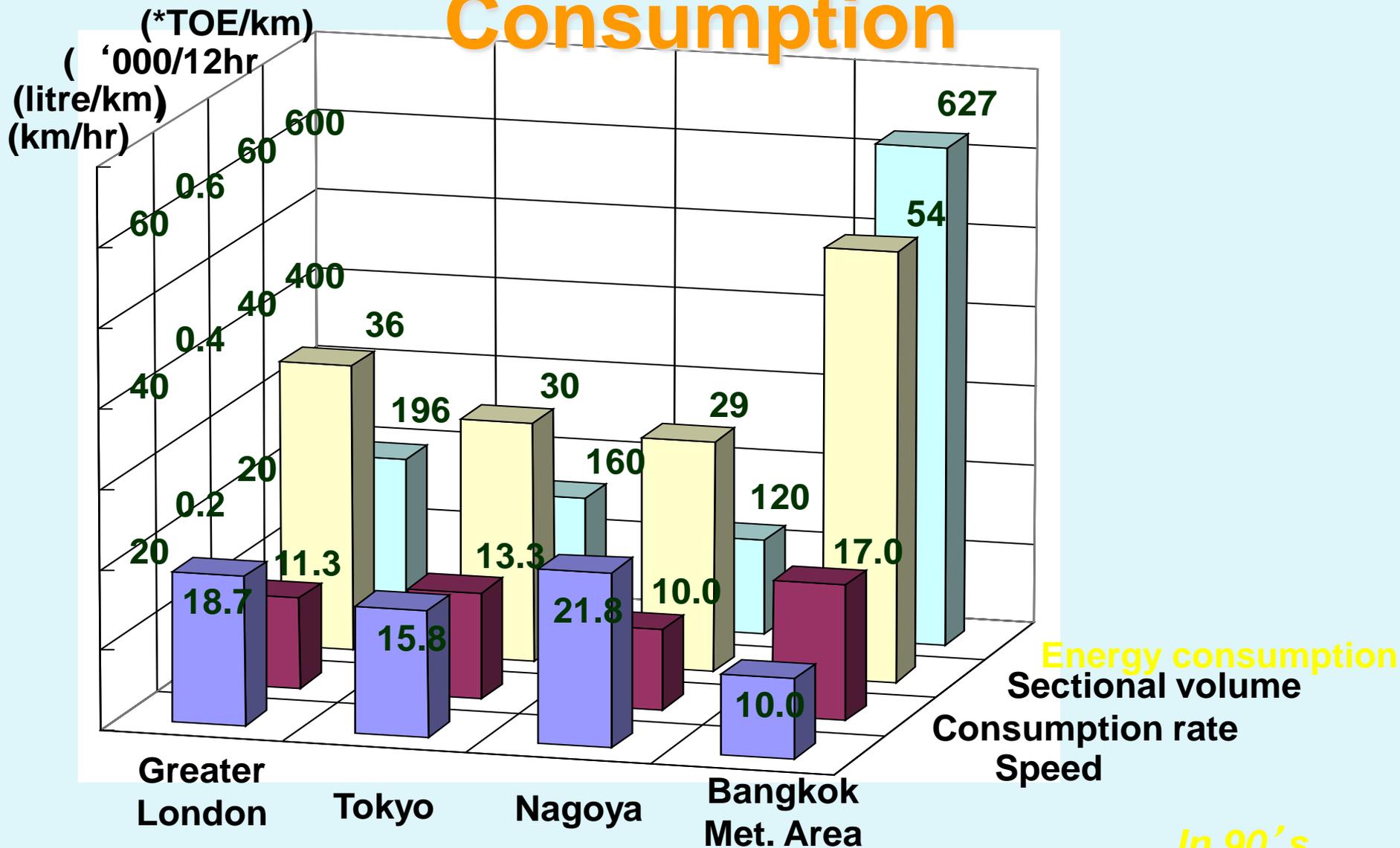
# Car Ownership



# Road Infrastructure Supply vs. Motorization Level vs. Peak Hour Speed

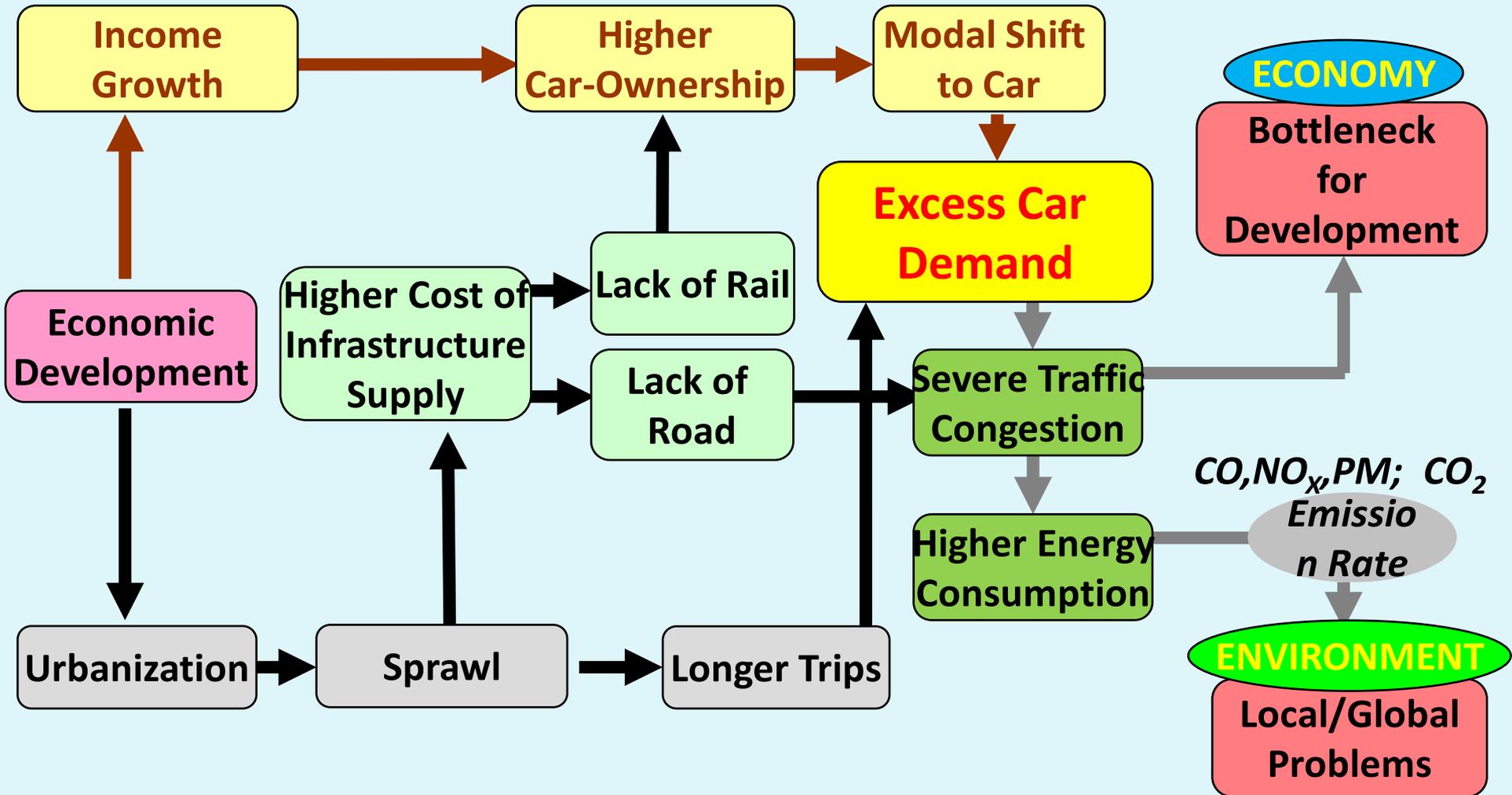


# Congestion and Energy Consumption

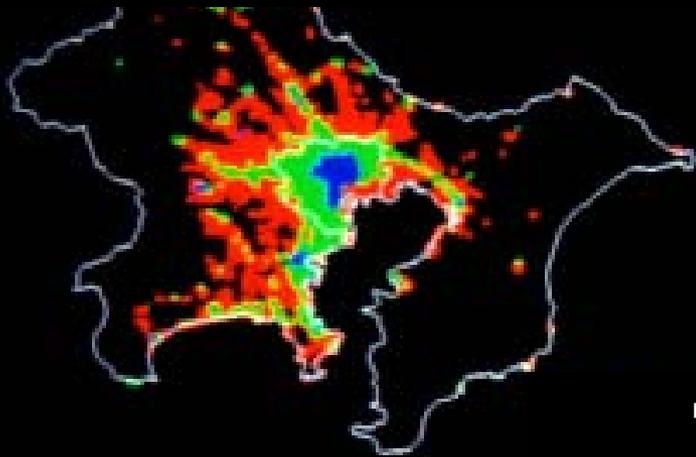


*In 90's*

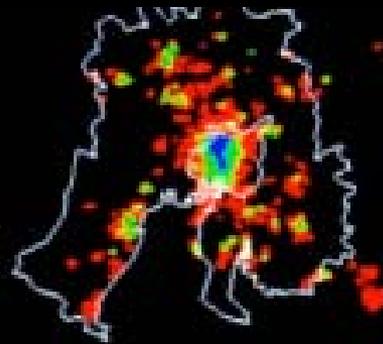
# Basic Mechanism of Urbanization and Motorisation



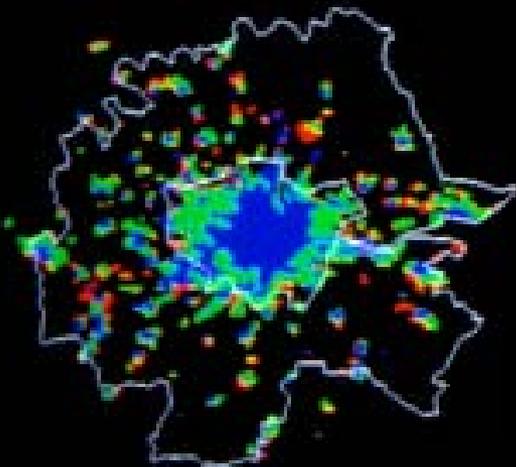
# Change in Built-up Areas



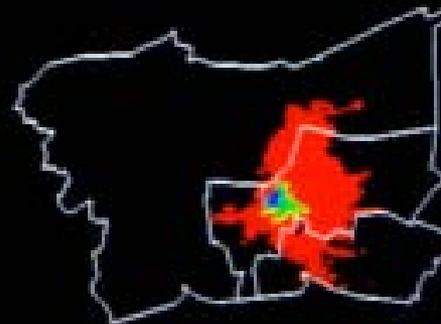
**Tokyo**



**Nagoya**



**London**



**Bangkok**



# Population Density (1988)

**Tokyo**

max. 15,400

**Nagoya**

max. 17,100

**London**

max. 11,500

**Bangkok**

max. 42,200

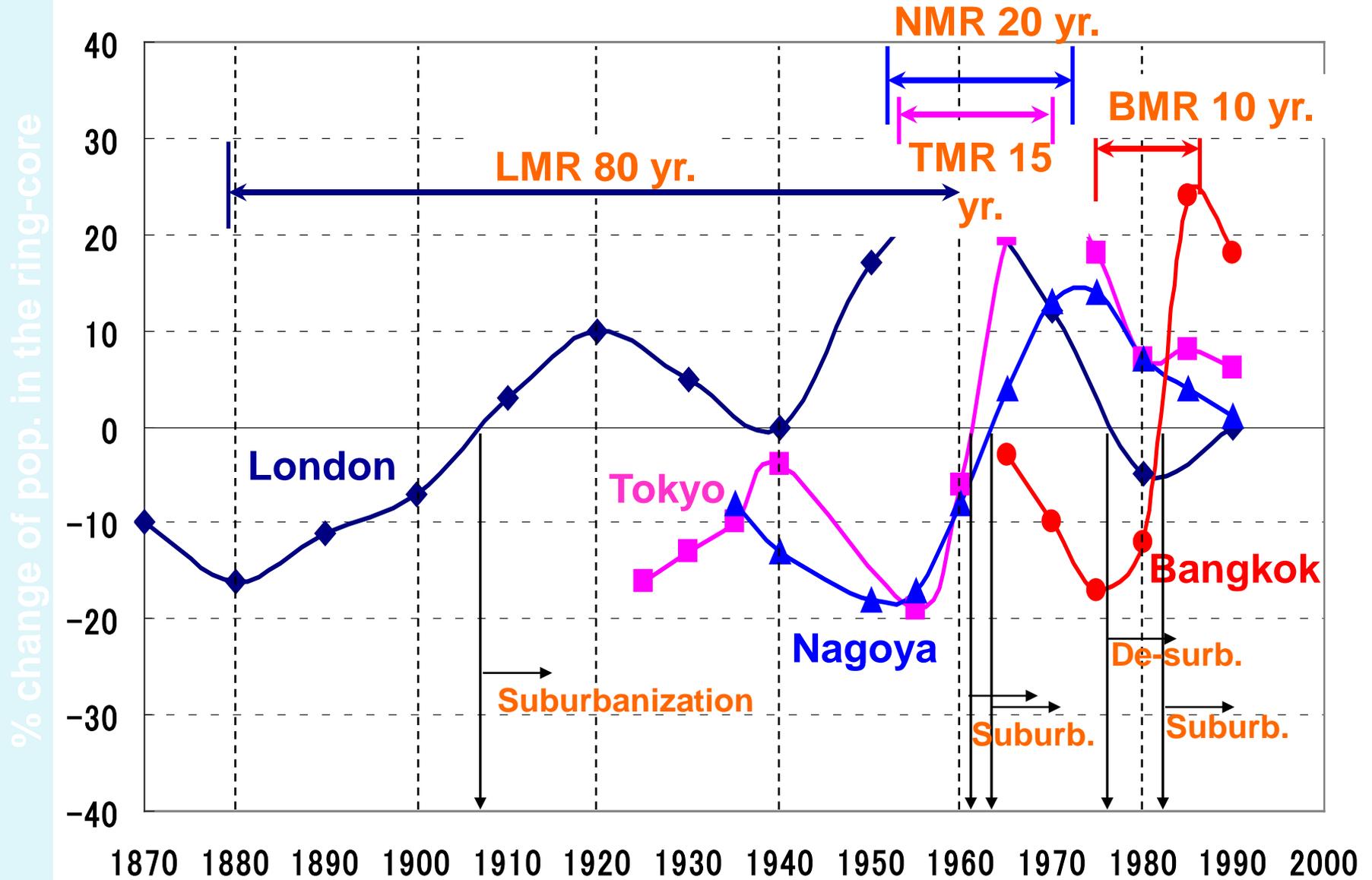
人/km<sup>2</sup>  
20,000

0

km  
50

0

# Urbanization Progress



How to manage the changing  
Eco-balance and Sustainability?  
-from Concept to Research Process-

# Earth is like “Cliff Top”

**Collapse of cliff**  
= **Excess human activities causing the environmental deterioration**  
(Decline in **Environmental Capacity**)

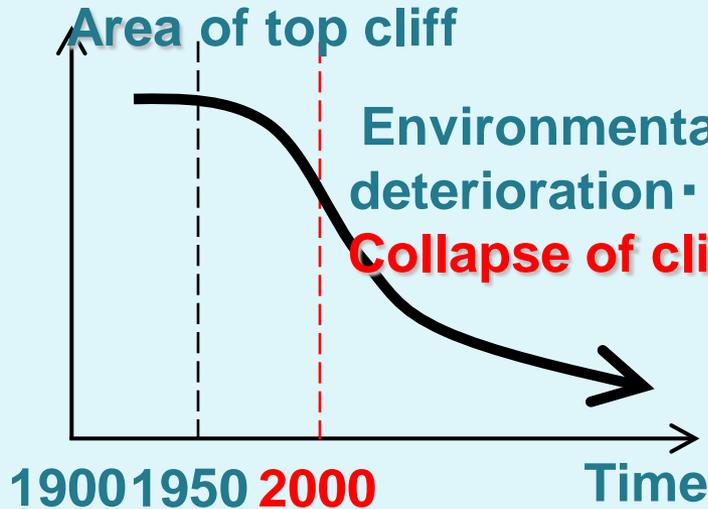
The area of cliff top  
= **Environmental Capacity**

**Taking position at the cliff top = Unfair usage of natural resources**  
Mankind having to survive at this narrow cliff top

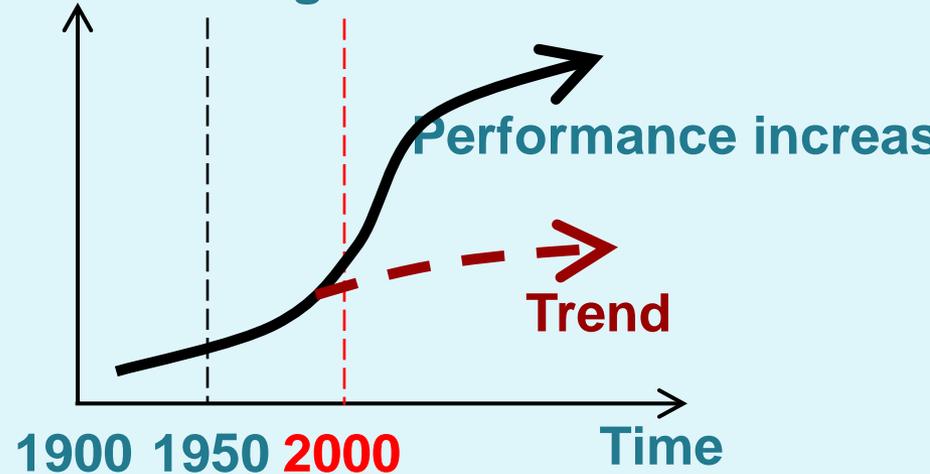
-> How to keep the cliff existing without collapsing (if possible, enlarging)  
= **Sustainability**

# Change in Balance between Resource and Living Environment

Remaining usable resources:



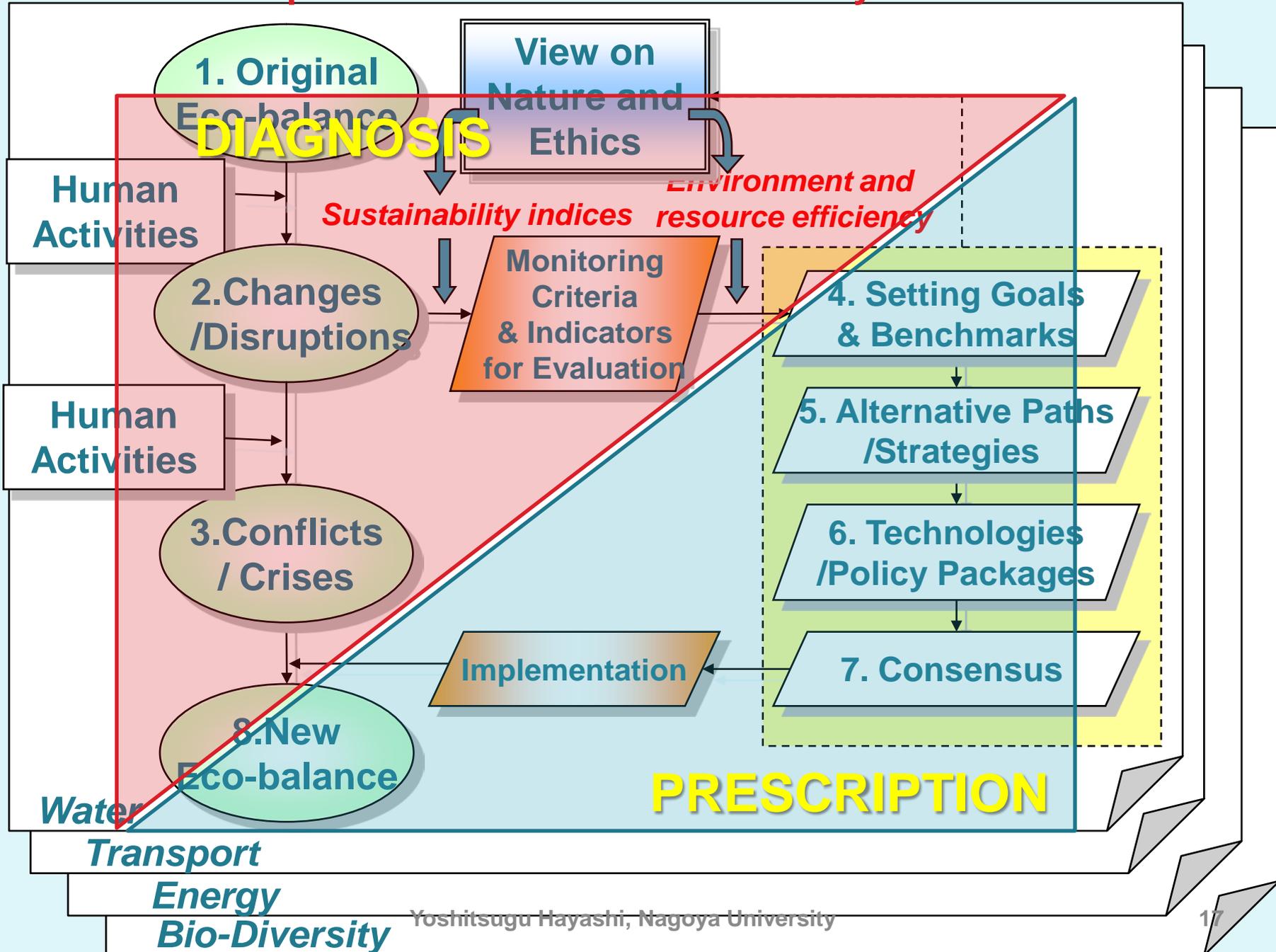
Resource change rate (=FACTOR X)



Living environment of mankind



# Proposed Process for Sustainability Studies

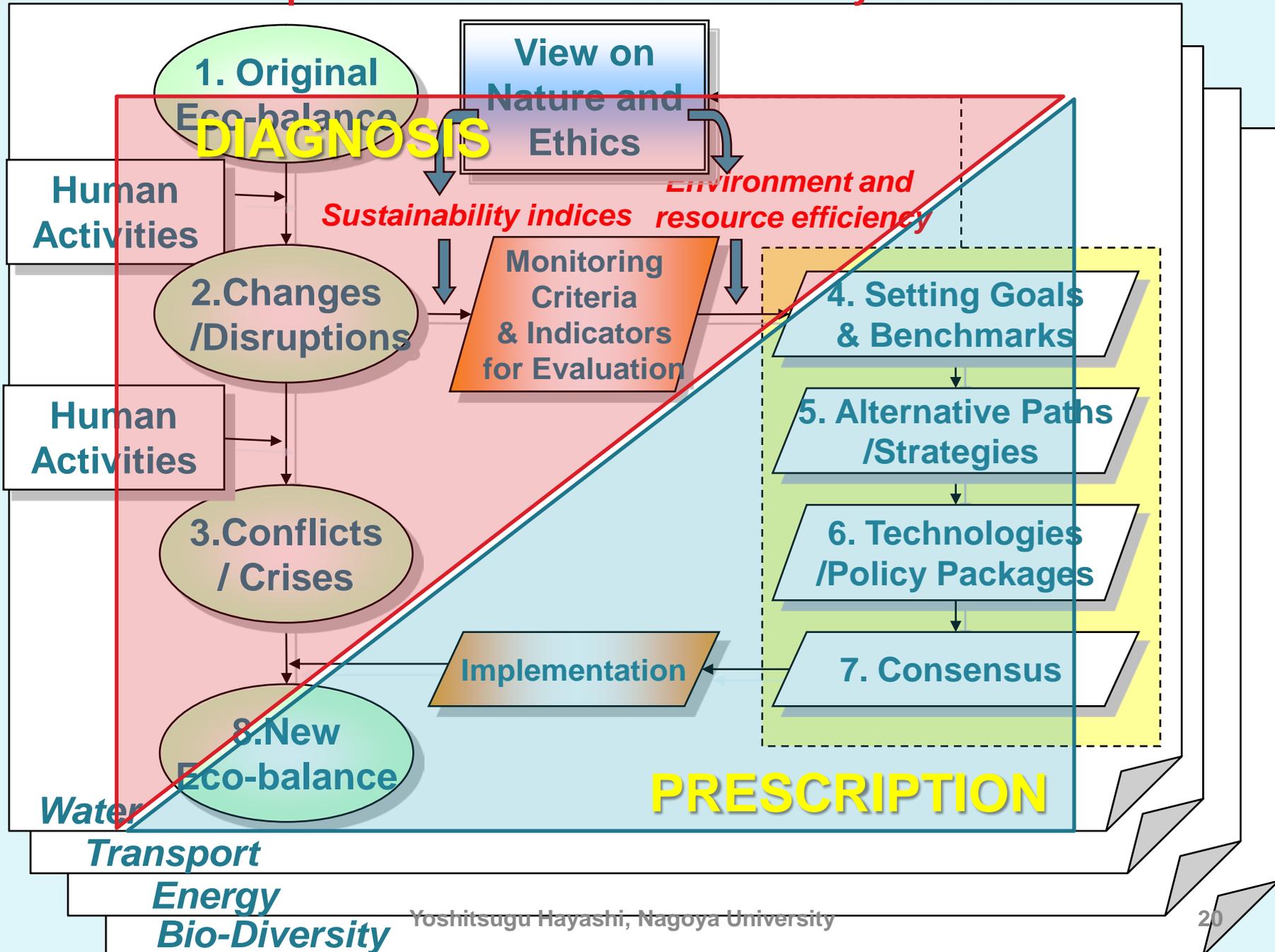


# Systematic Menu From Diagnosis to Prescription

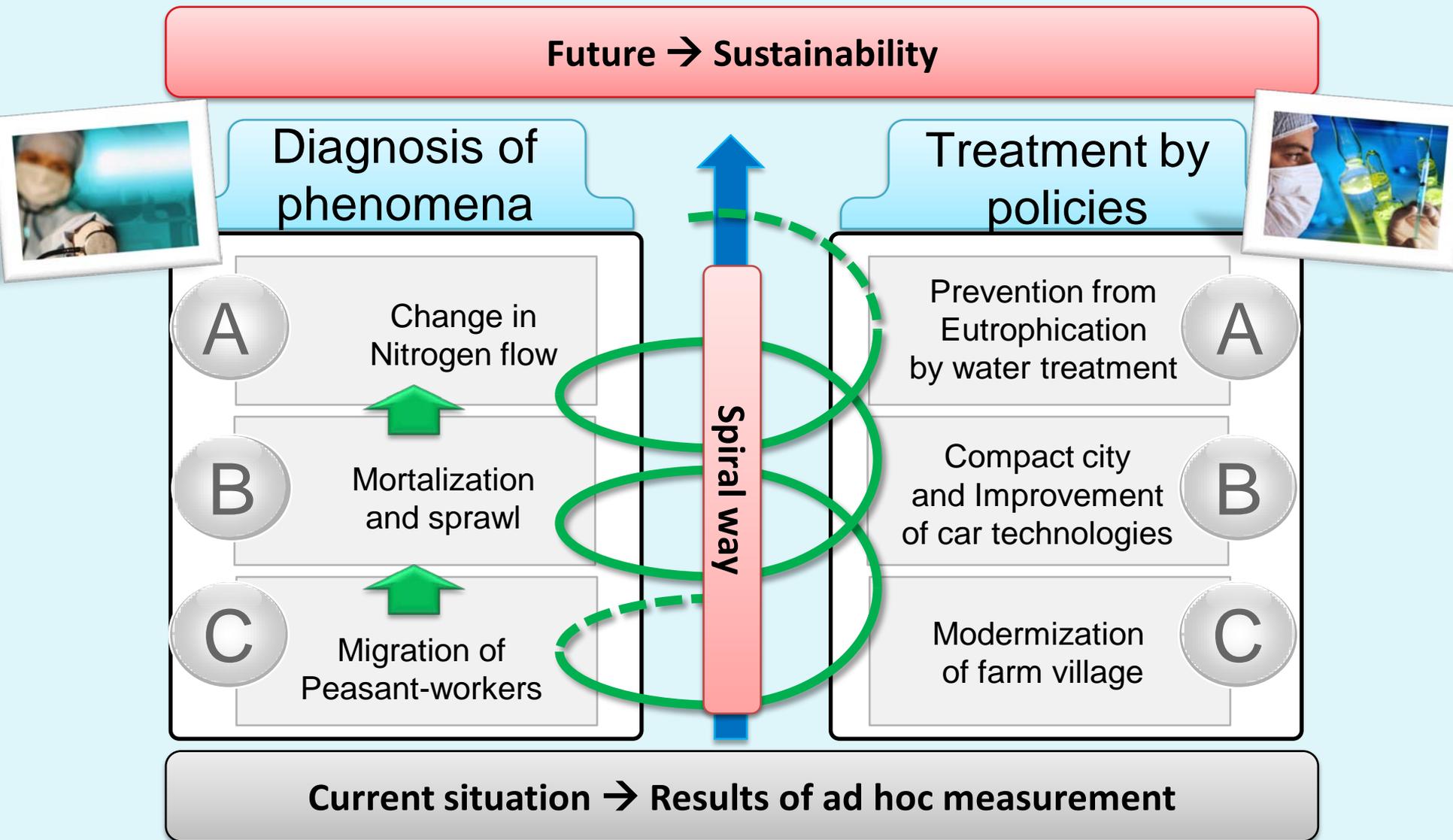
	<i>Water Environment</i>	<i>Sustainable Transport</i>	<i>Sustainable Energy</i>	<i>Bio-Diversity</i>
<b>1.Original Eco-balance</b>	Water environment balance; Eco-system balance	Non-motorized transport	Earth energy balance	Eco-system balance
<b>2.Changes / Disruptions</b>	Increasing in water use and pollution	Environmental load due to increased mobility and suburbanization	Human consumption of energy exceeding what is left	One species dies every 13 minutes
<b>Sustainability indicators</b>	"Virtual water"	Car ownership that can be sustained by earth	ECOSON (Population that can be sustained by earth resources)	Population Biology Index
<b>3.Confricts / Crises</b>	Lack of water; Health damage; Eco-system destruction	Global environmental load; Local pollution; Congestion; Traffic accident	Lack of energy	Unavailability of genetic resources / food crisis
<b>4.Goasl / Benchmarks</b>	Desirable balance between water circulation and land use	FACTOR X : More efforts to reduce environmental load than improve serviceability	Efficiency; Recycle energy use rate; Demand-supply scenario	Post 2010 target /2020 short term /2050 long term
<b>5.Alternative Paths / Strategies</b>	Securing resources; Improving water quality; Flood control, Verifying human and water engagement	EST: Improving vehicle and fuel technology; transport system and demand management	Alternative energy to petroleum, New energy use technologies	Eco-System approach For 12 strategy
<b>6.Technologies / Policy Packages</b>	Engineering, Landscape design	Vehicles; TDM; Land use; Public transport; Information	Energy business, Management, Low-energy consumption	Biotope network Satoyama ABS, L&R
<b>7. Consensus</b>	Public involvement in water catchment's area society	Mobility management; Solidarity and Cooperation	Post Kyoto Protocol	Nagoya Protocol

# Diagnosis of Interaction between Urbanisation and Nitrogen Circulation

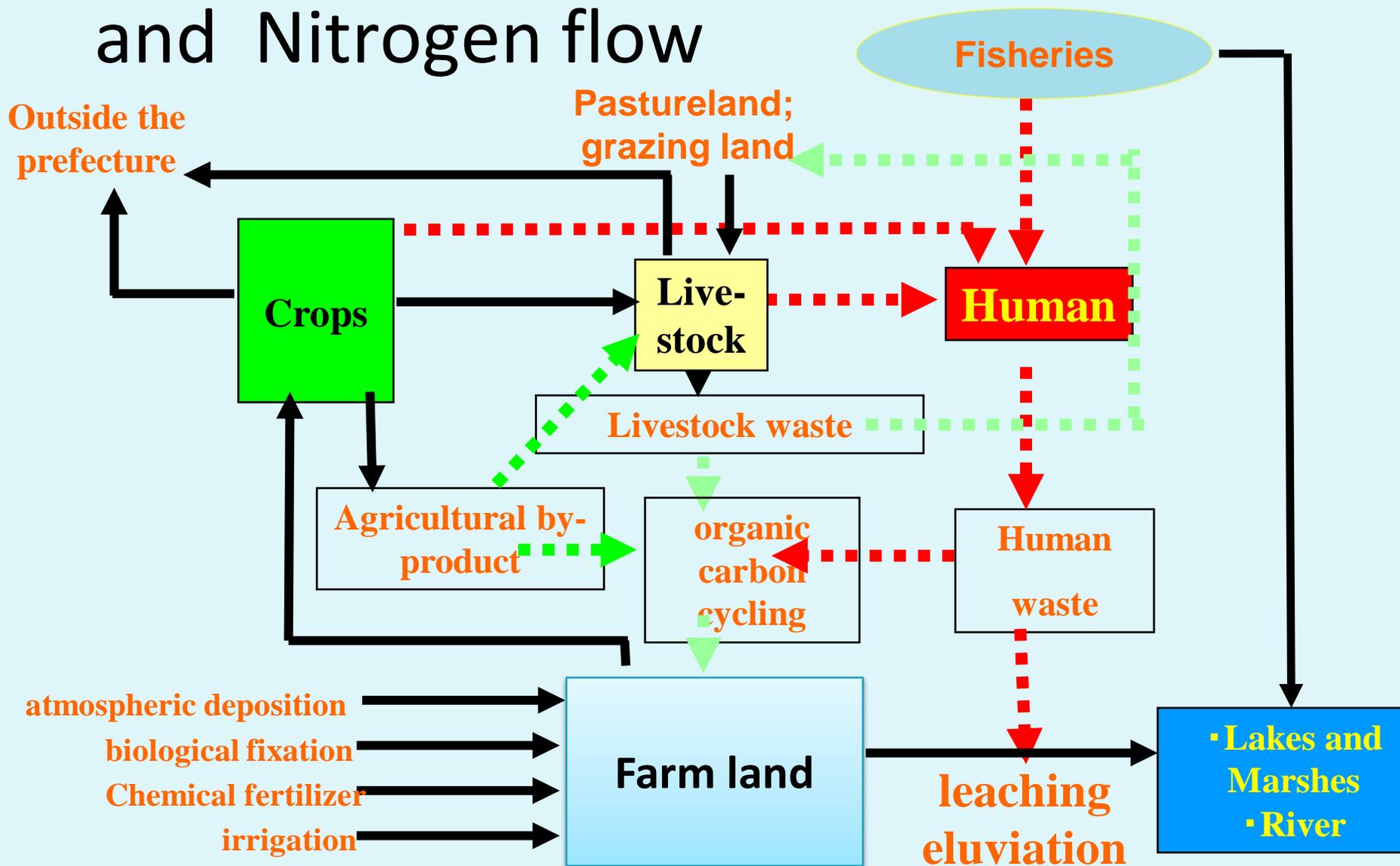
# Proposed Process for Sustainability Studies



# Diagnosis and Treatment of Urbanization (DTR) for sustainability

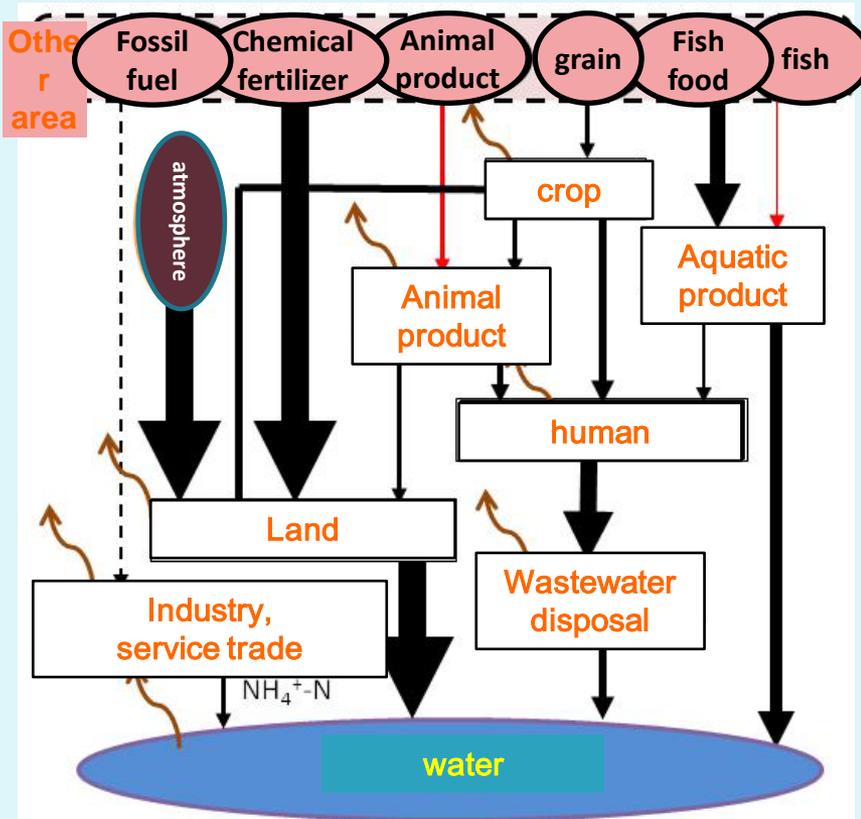


# Basic Mechanism of Urbanisation and Nitrogen flow

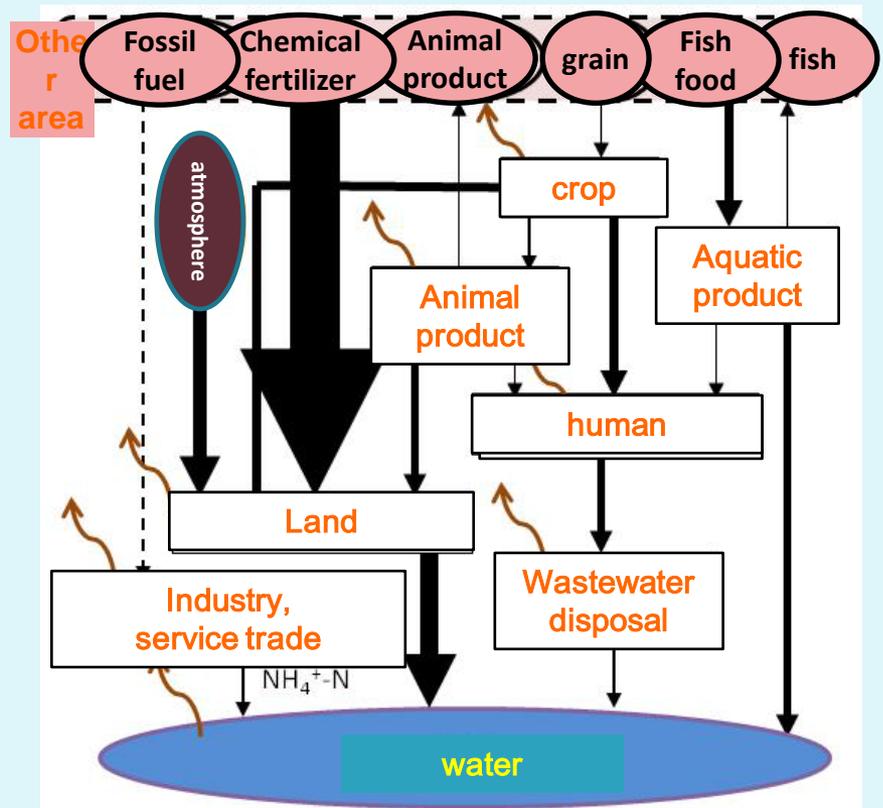


# Change of Nitrogen flow in Shanghai

1980

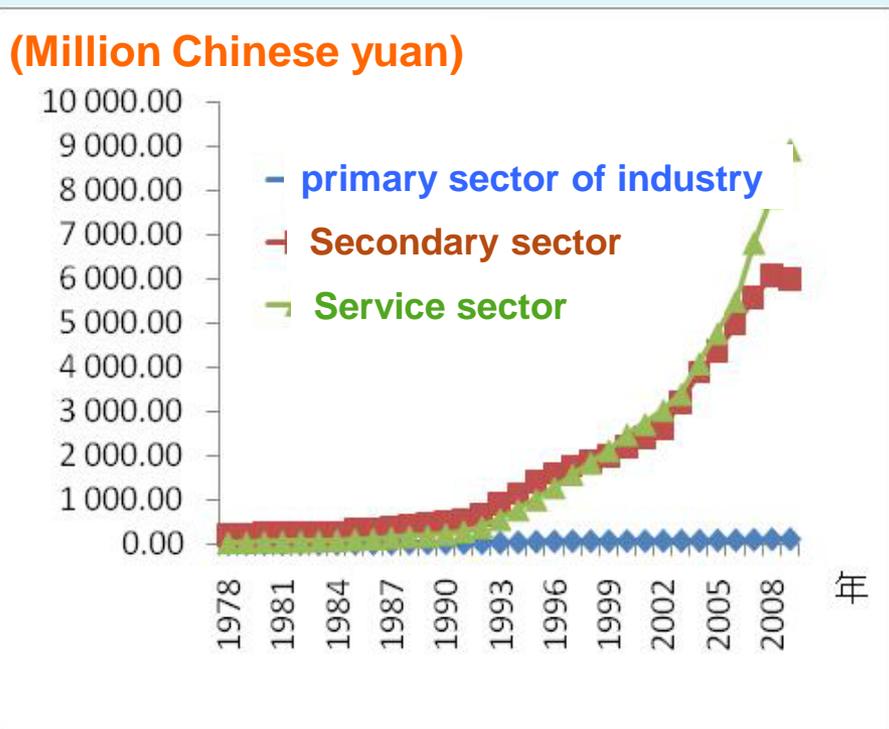


2008

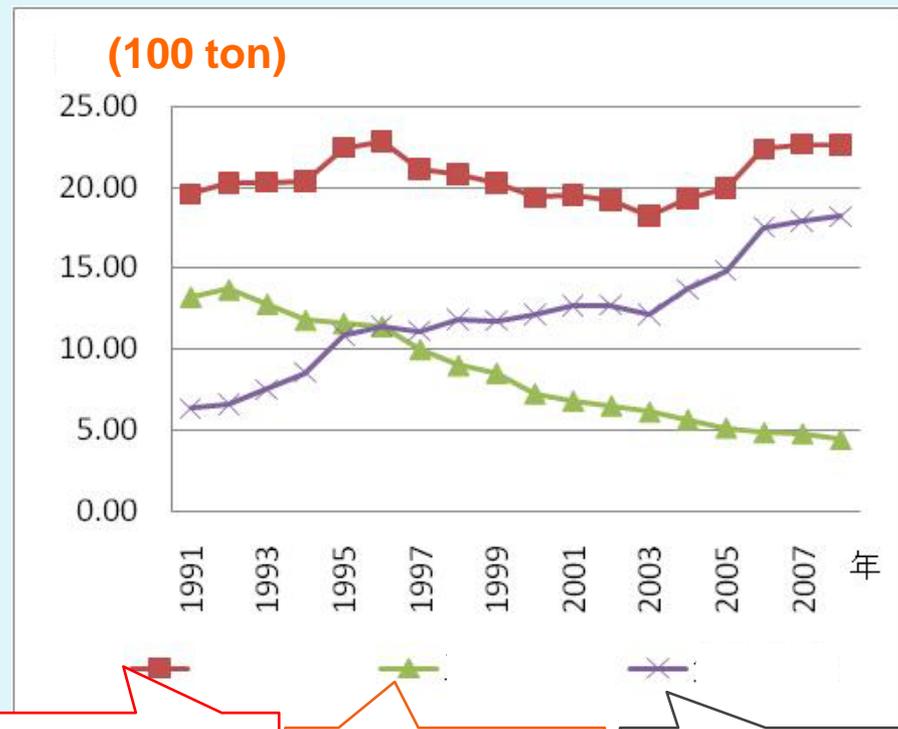


# Water environmental problems in Shanghai : Change from “Industrial pollution” to “Urban pollution”

## Change in GDP Composition



## Change in Sewage Discharge

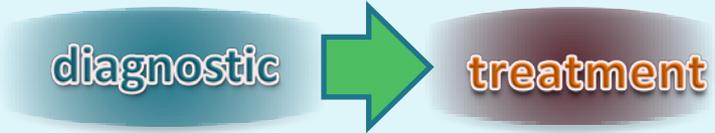
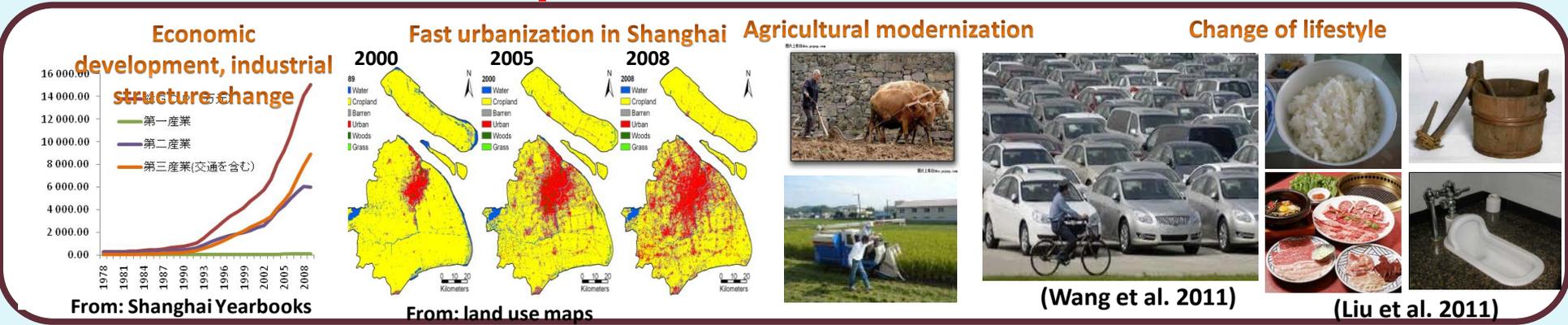


**Total amount of sewage discharge**

**Industrial discharge**

**Household discharge**

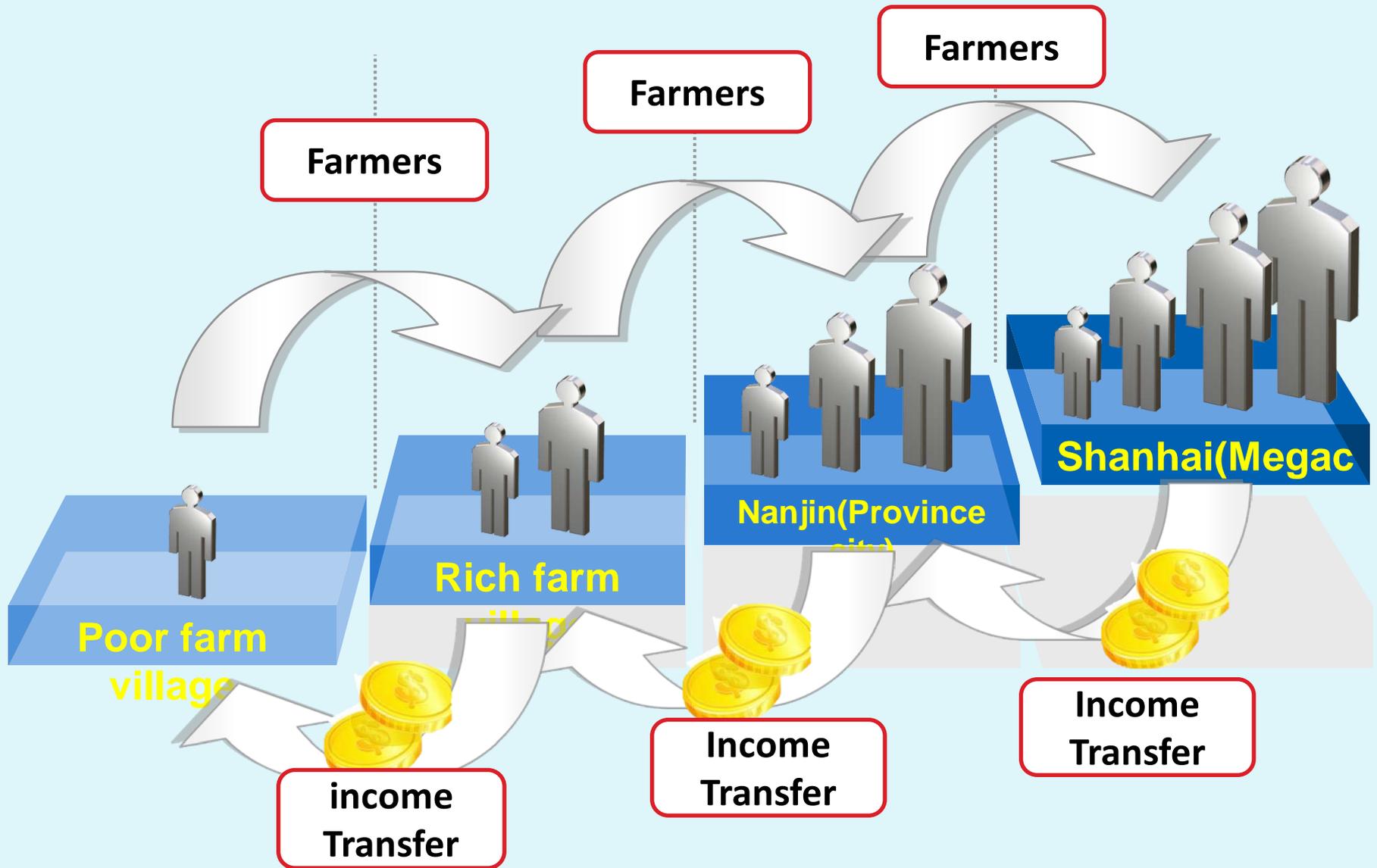
# Severe eutrophication in Yangtze River Delta induced by rapid economic development and urbanization → solutions?



■ Pollution abatement in urban areas  
Positive aspect: government implements effective measures (pollutants removal based on investment in environment, fishery regulation, ecological compensation, etc.)  
Negative aspect: shift of pollution (expansion of air pollution), top-down environment policy

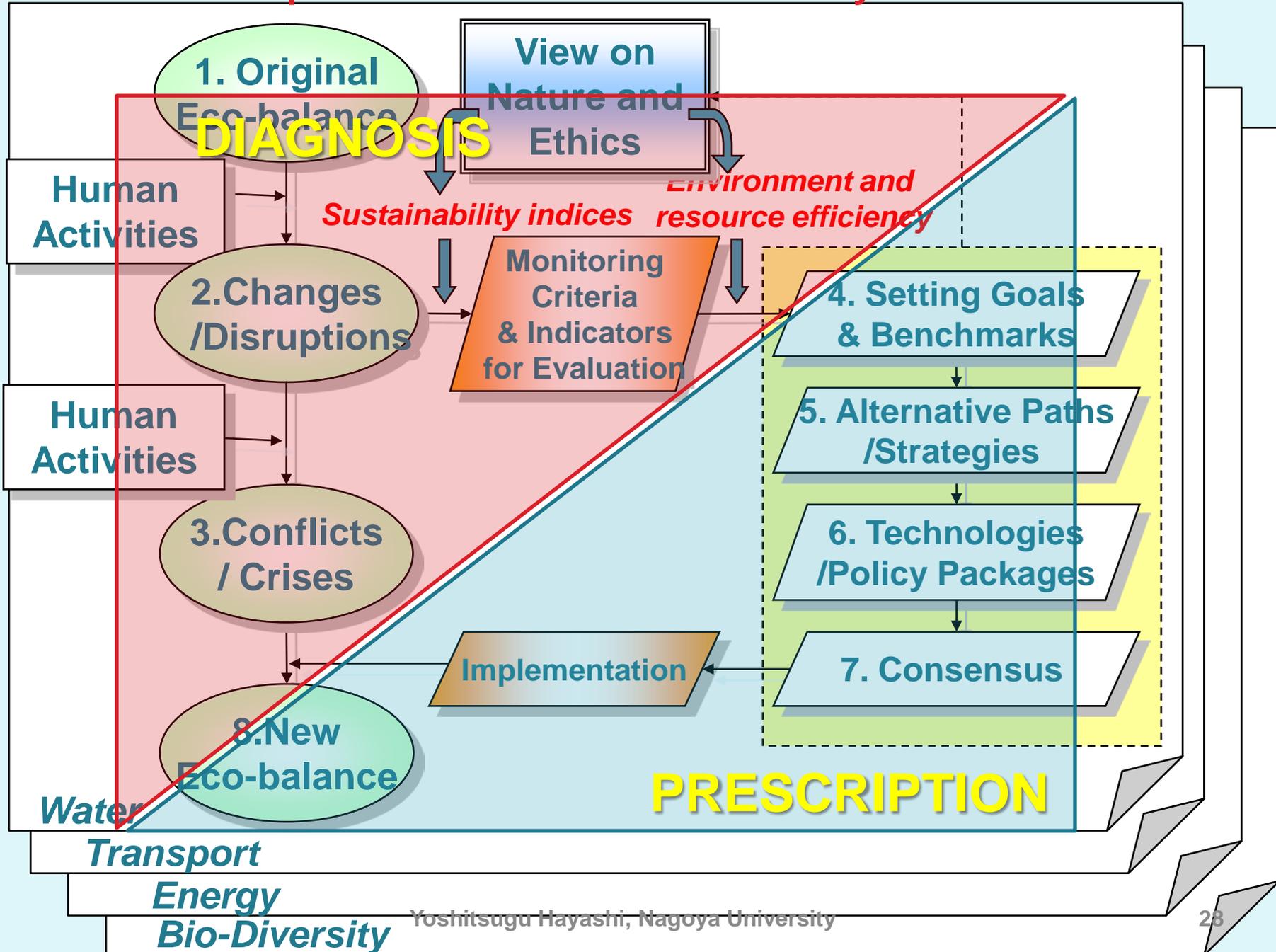
- Effective solutions aiming at material cycles in large-scale
- **Integrated catchment management** - prevention of 'transfer of pollution' -
    - **Nitrogen & Phosphorus intensive sewage disposal**- technological treatment
  - **Citizen participative society** - Importance of environmental education
    - **Local recycling orientation society**
    - **agriculture free from Chemical fertilizer**

# Migration of Farmers in China

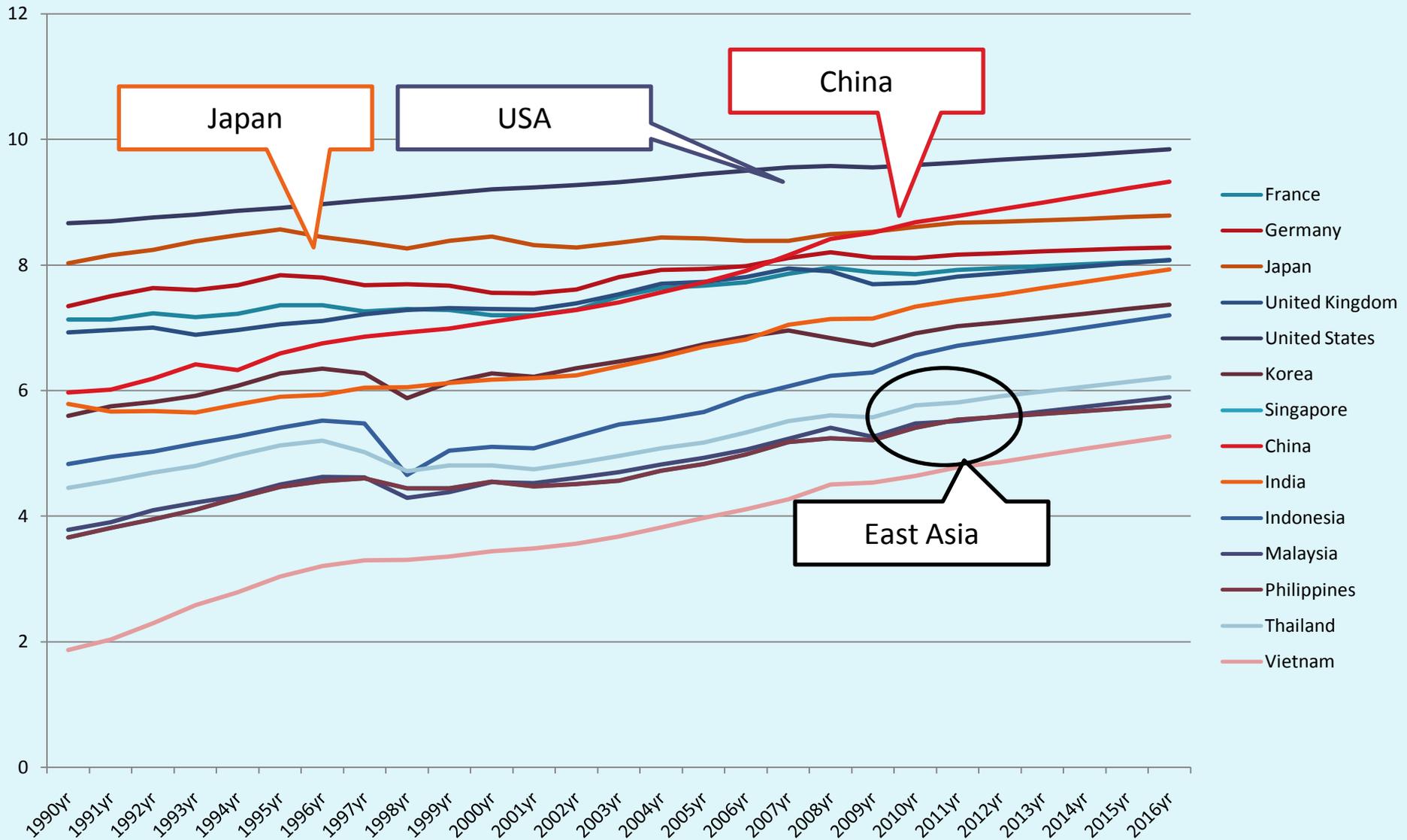


# Prescription for Motorisation & Climate Change

# Proposed Process for Sustainability Studies



# GDP Growth (1990-2016), $\times$ natural logarithm

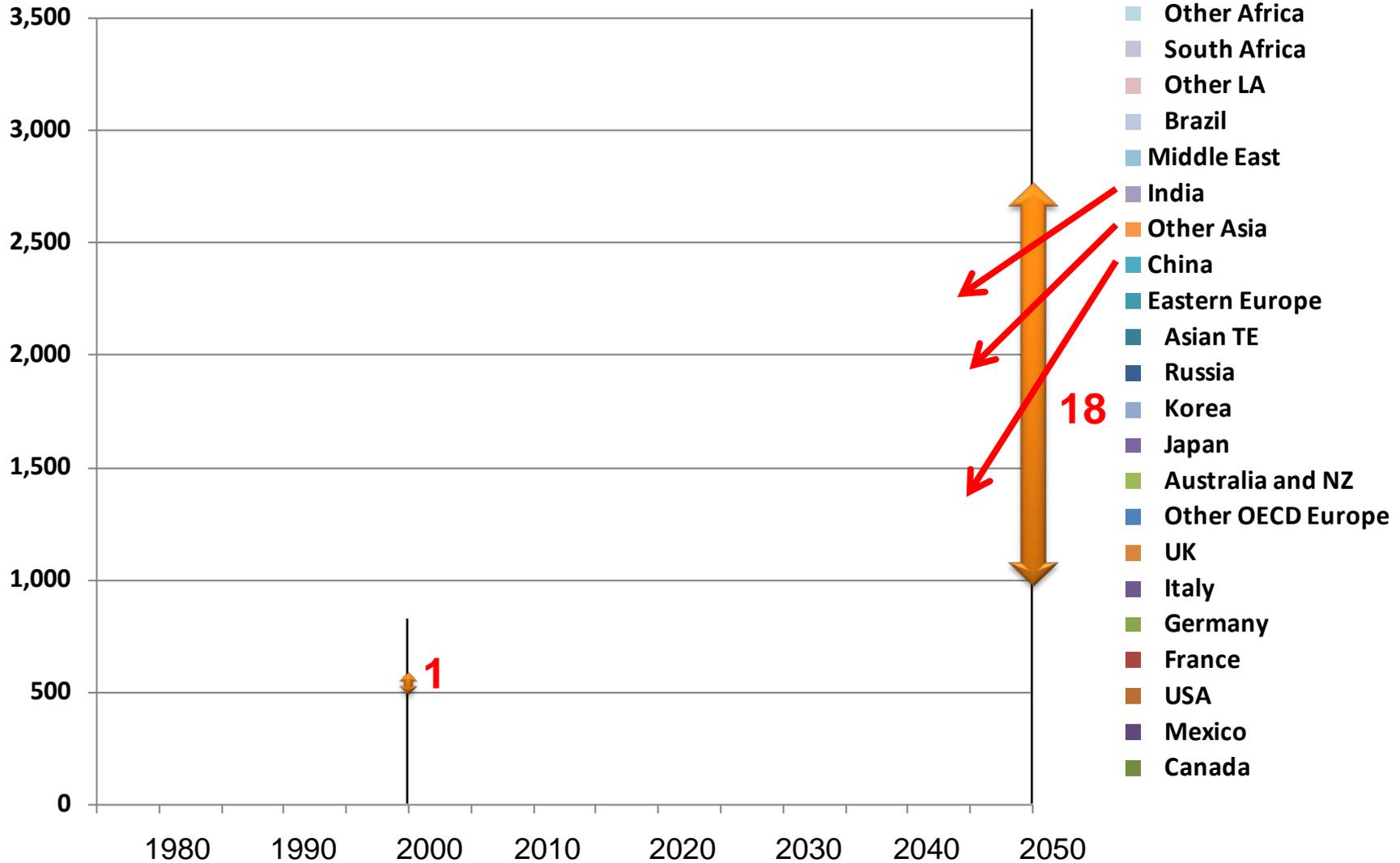


Data source:

IMF (World Economic Outlook Database, April 2011)

# IEA Vehicle Ownership Projections

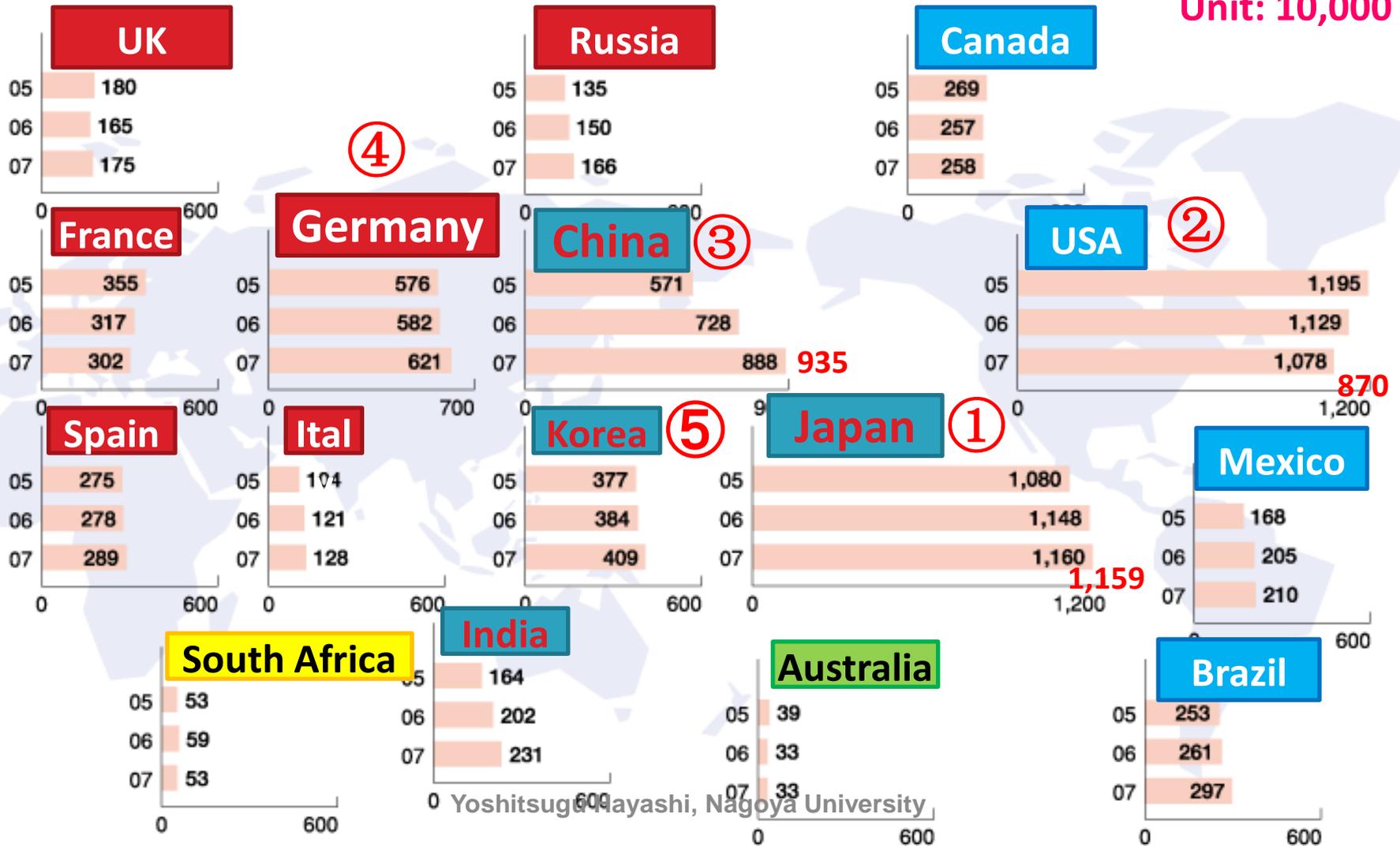
## Where Will These Cars Fit?

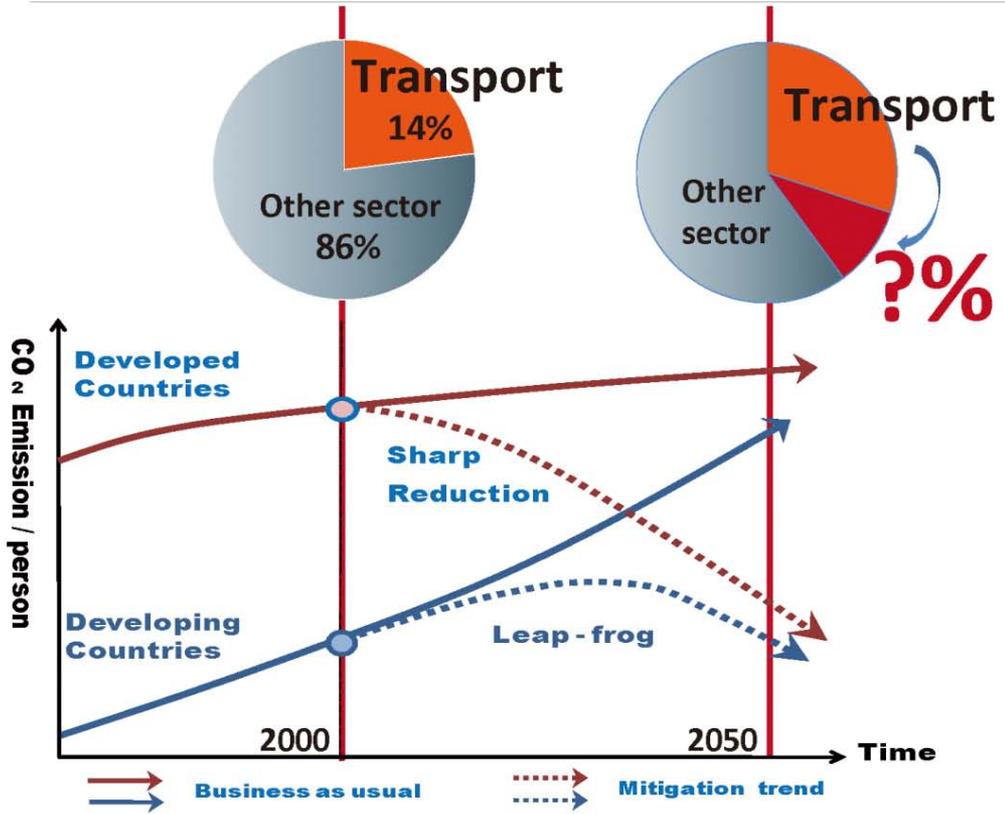
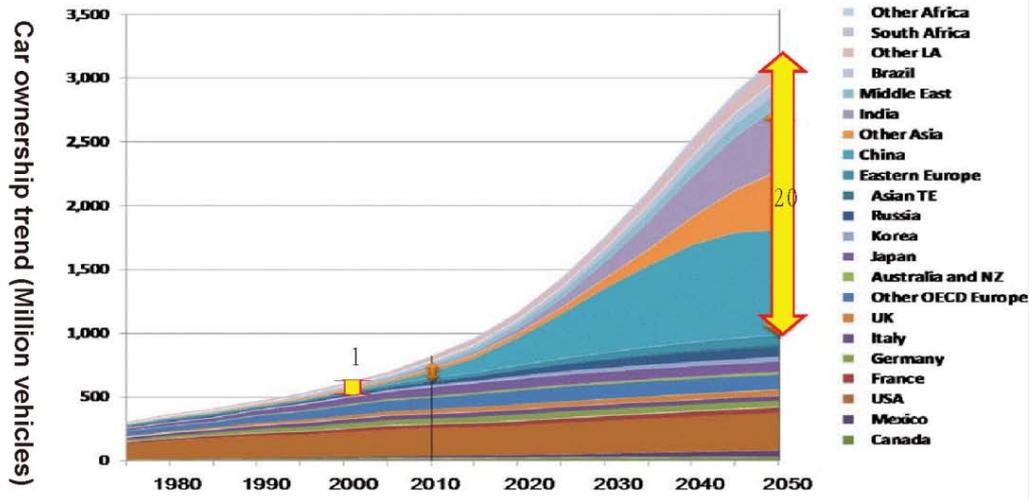


# Increasing Use of Automobile

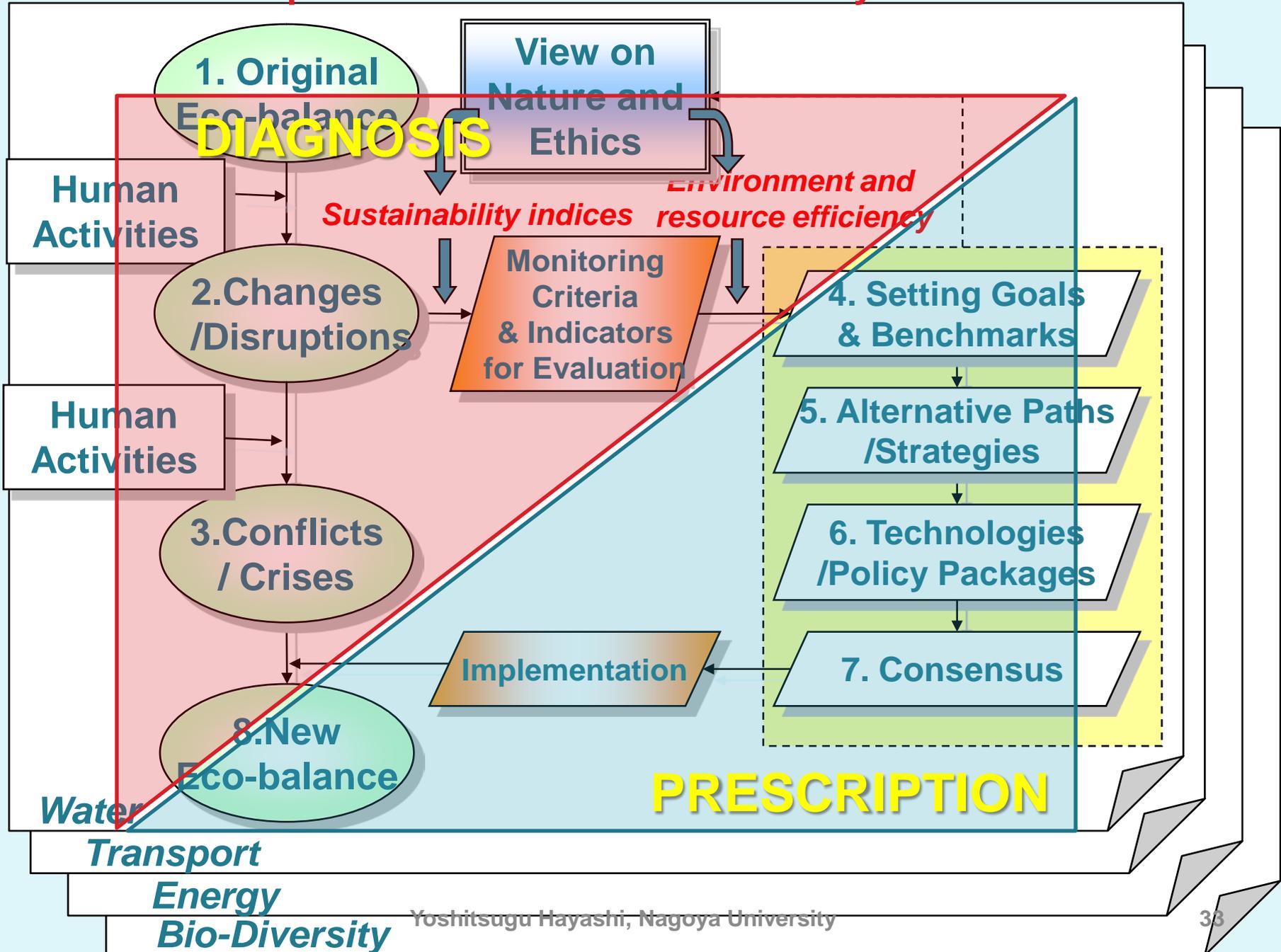
*Automobile Production in the world (2005, 2006, 2007)*

Unit: 10,000





# Proposed Process for Sustainability Studies



# Factors to Setup Future Vision of Low-carbon Transport System in Asia

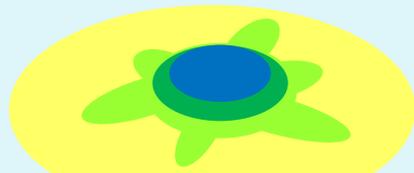
## 1. Urban Structure



A. Wide spread



B. TOD

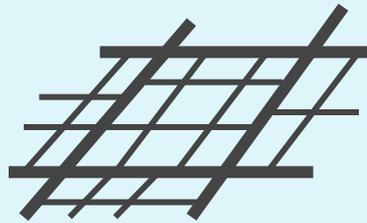


C. Centralized

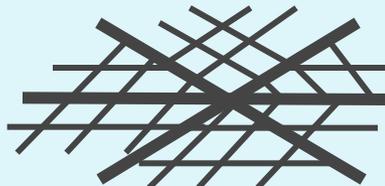


D. Multipolar

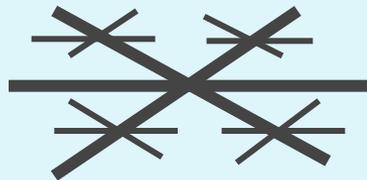
## 2. Network



a. Grid



b. Hybrid



c. Radial

## 3. Hierarchy among modes

1) Urban Rail  
|  
Bus

2) Urban rail  
|  
Para-transit

3) BRT  
|  
Bus

4) BRT  
|  
Para-transit

## 4. Technology by mode

Technological Innovation



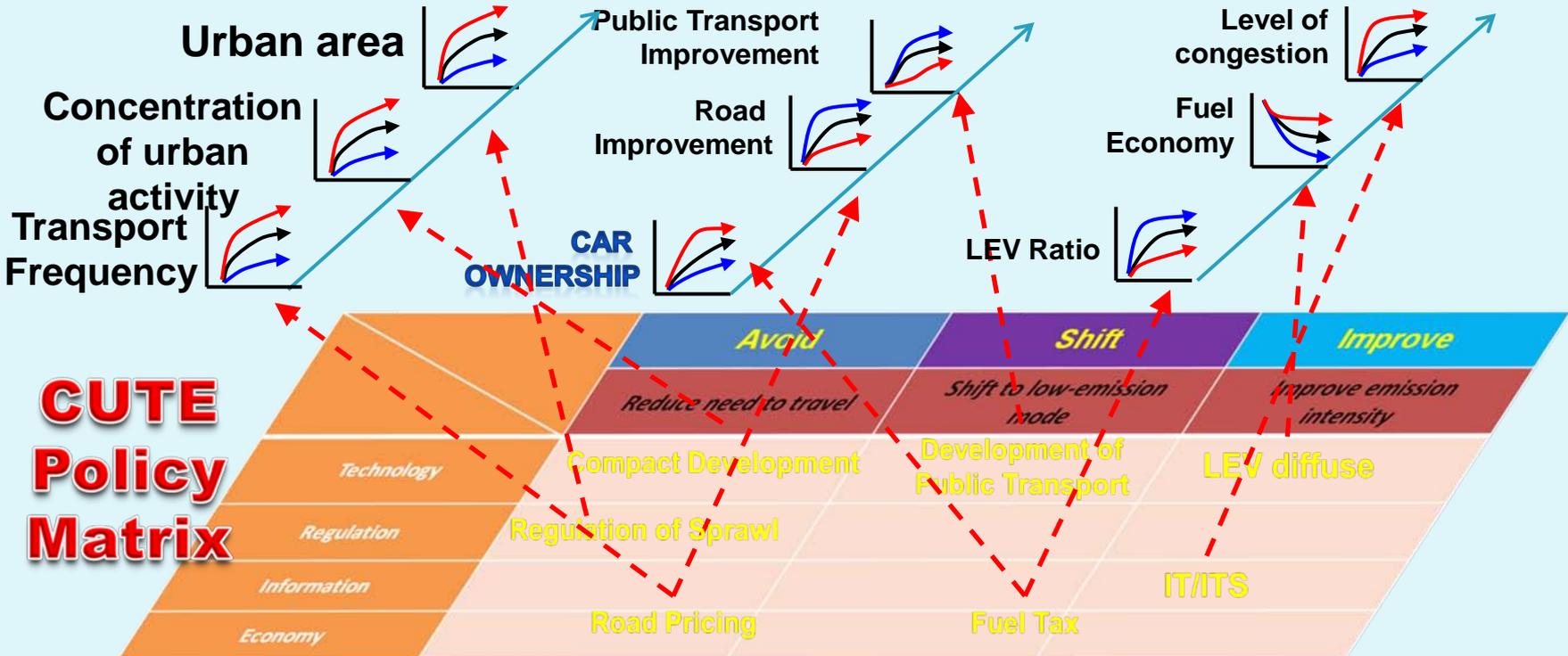
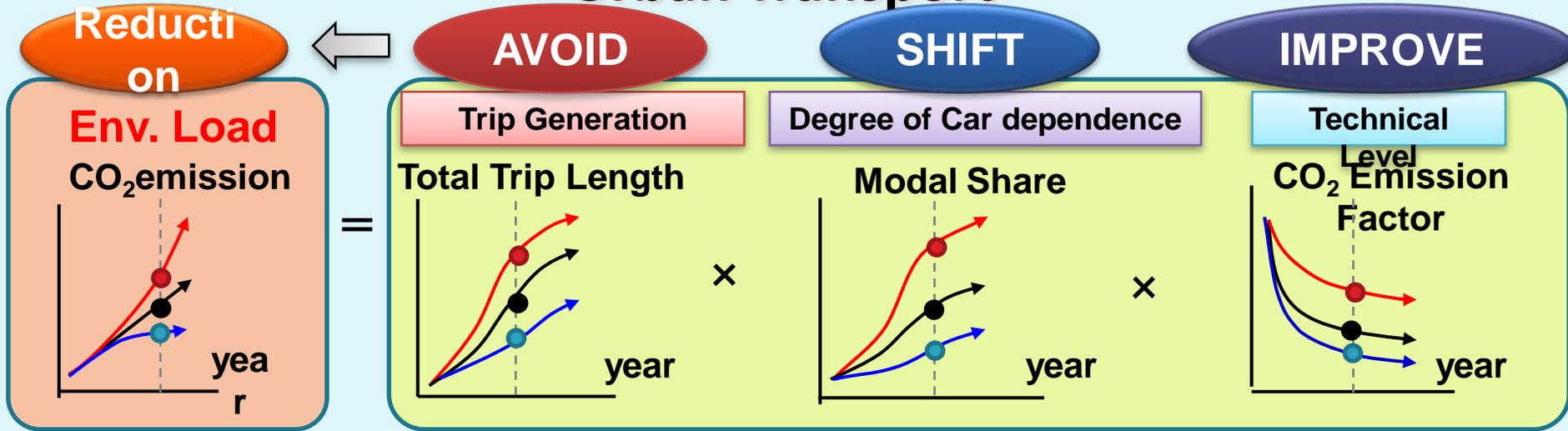
New system



Combination considering characteristics of each city

Seeking future image of low-carbon transport

# Structural Formula for Environmental Load from Urban Transport



# Transport Strategy - Techno/Policy Instruments

		Strategy		
		Avoid	Shift	Improve
CUTE Matrix		Reduce traffic demand	Reduce emissions per unit transported	Reduce emissions per kilometer
Instruments	Tech nology	<ul style="list-style-type: none"> <li>■ Pedestrian Ort Dev't</li> <li>■ Bicycle Ort Dev't</li> <li>■ Transit Ort Dev't</li> </ul>	<ul style="list-style-type: none"> <li>■ Integrated Public Transport System (BRT+ParaTransit)</li> <li>■ Highly Competitive Railway</li> </ul>	<ul style="list-style-type: none"> <li>■ LEV, EV</li> <li>■ Alternative Energy</li> <li>■ Advanced Infra- Tech</li> <li>■ Logistic Efficiency</li> </ul>
	Regula tion	<ul style="list-style-type: none"> <li>■ TDM</li> <li>■ Parking Regulation</li> <li>■ Compact/Mix Land Use</li> </ul>	<ul style="list-style-type: none"> <li>■ Bus/Tram Priorities</li> <li>■ Non-MT</li> <li>■ Smarter Modal Evolution</li> </ul>	<ul style="list-style-type: none"> <li>■ Emission Standard</li> <li>■ Top Runner Program</li> <li>■ Eco-Drive</li> </ul>
	Informa tion	<ul style="list-style-type: none"> <li>■ ICT</li> <li>■ Telework</li> <li>■ Smart Choices for Workplace and Schools</li> </ul>	<ul style="list-style-type: none"> <li>■ Awareness Campaign</li> </ul>	<ul style="list-style-type: none"> <li>■ Knowledgebase</li> <li>■ ITS</li> <li>■ Labeling of Vehicle Performance</li> </ul>
	Econo mic	<ul style="list-style-type: none"> <li>■ Fuel Tax</li> <li>■ Road Pricing</li> <li>■ Car Charge / Fee</li> <li>■ Location Subsidy</li> </ul>	<ul style="list-style-type: none"> <li>■ Fuel Tax</li> <li>■ Road Pricing</li> <li>■ Car Charge / Fee</li> </ul>	<ul style="list-style-type: none"> <li>■ Fuel Tax</li> <li>■ LEV Preferential Tax</li> </ul>

# Bangkok in 2002



Photo by Hayashi

# Bangkok



# Mass-transit Network of Future Bangkok

2010 84.8km

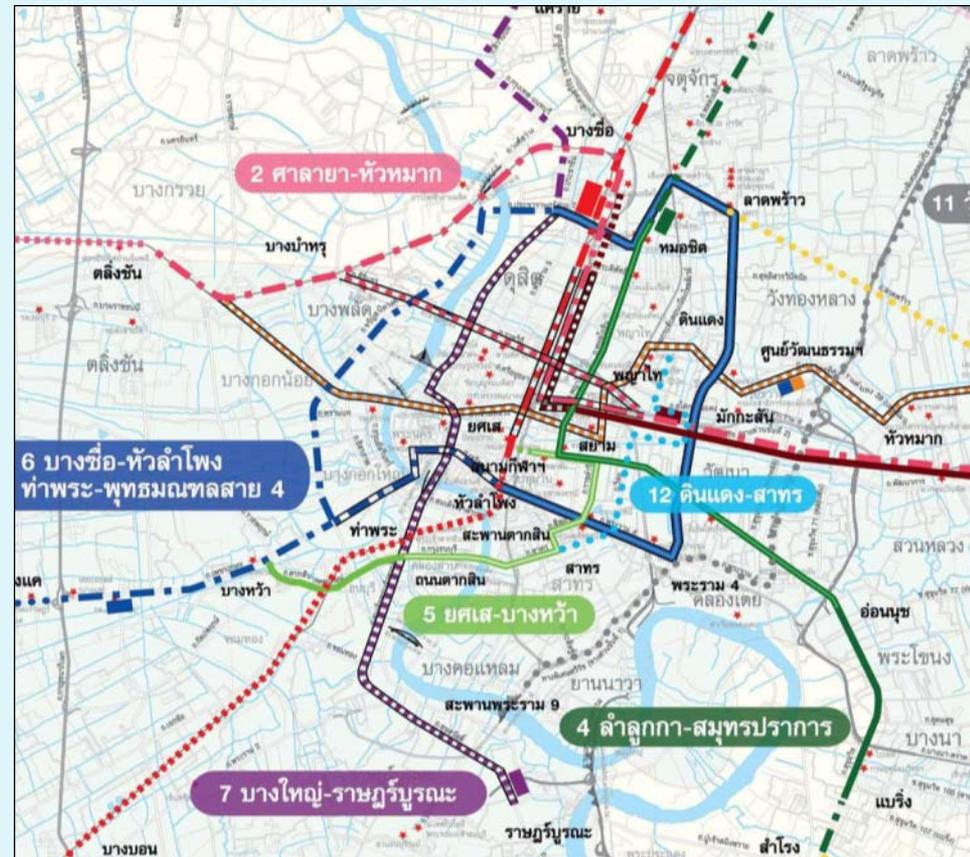
planning:

2016 236km

2019 391km

2029 509km (12lines)

Master Plan Study to adjust rail mass transit system in Bangkok and its vicinity(2010)



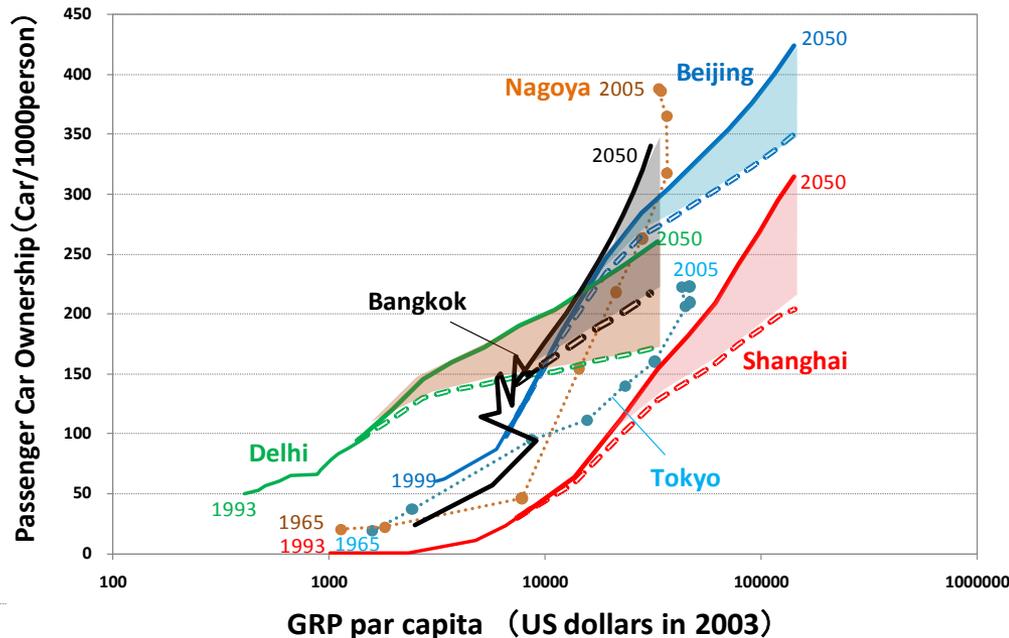
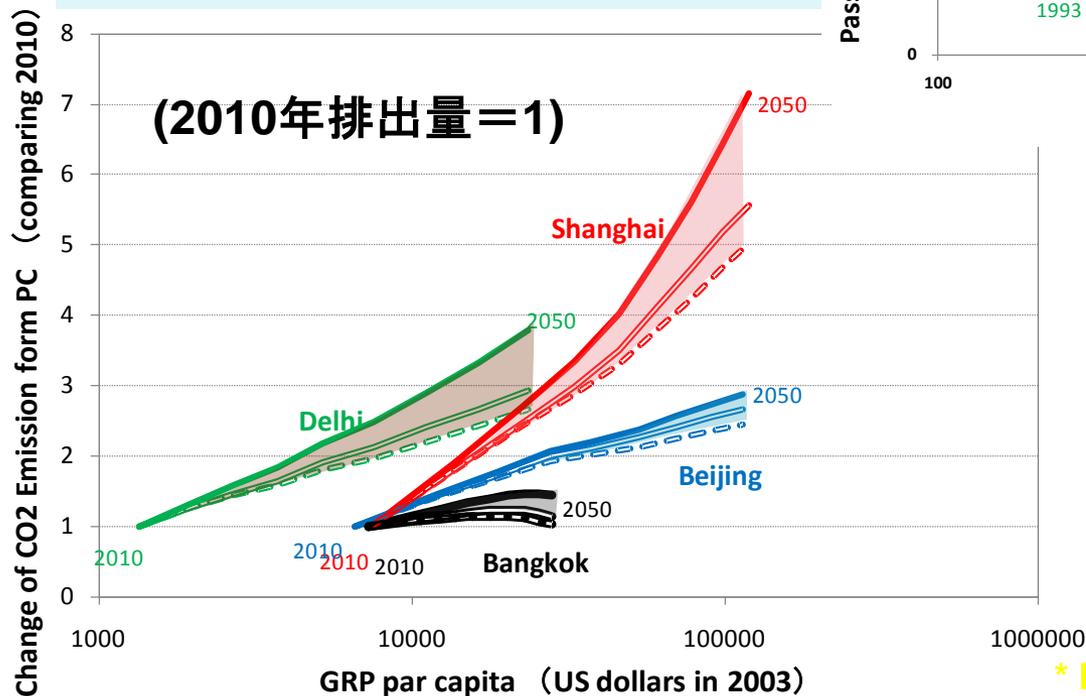
# CO2 Emission Reduction from Passenger Car by Railway Development

By 2050, railway will be developed as same level in Tokyo in 2005.

Without Railway

Development during mature stage  
(2030~2050)

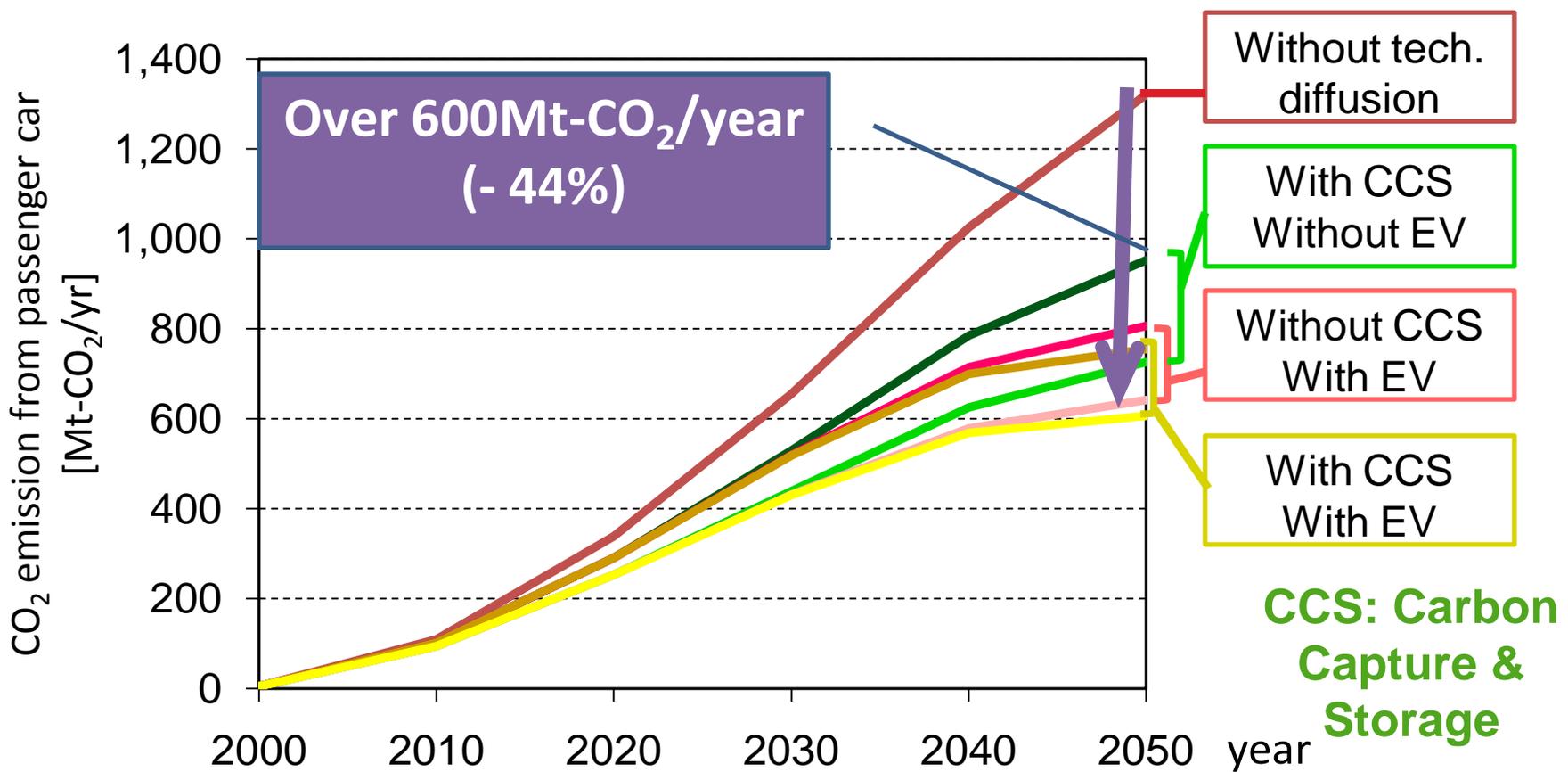
Developed during early stage  
(2010~2030)



If railway might be developed during early stage, 36% of CO2 can be reduced. If including technological innovation, around 80-86% of CO2 can be reduce.

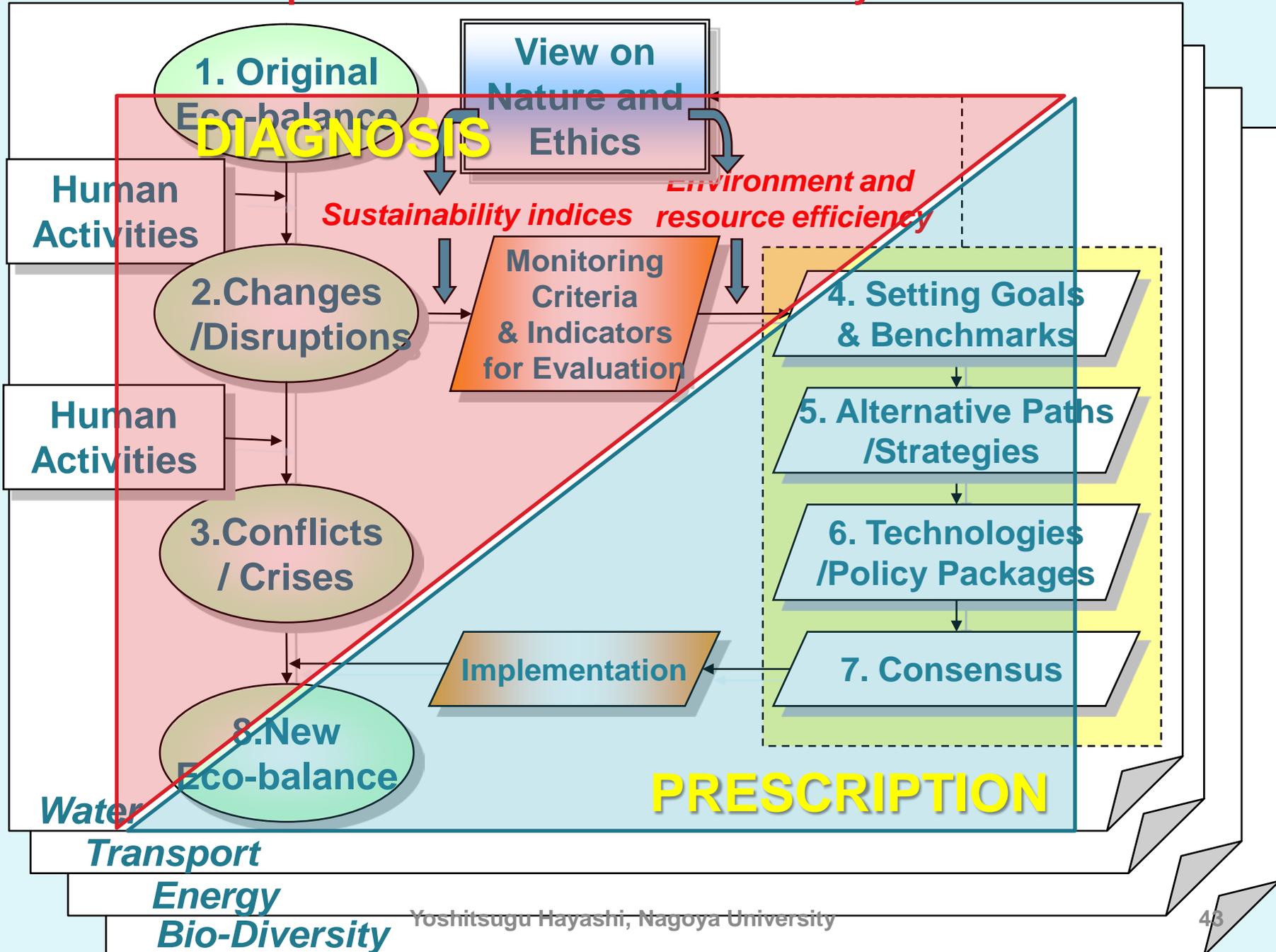
## Leap-frog (2): Innovative Technologies

- CO<sub>2</sub> reduction by passenger car  
high technology diffusion Scenarios (China) -



# Income Growth & Low Birth Rate/Aging

# Proposed Process for Sustainability Studies



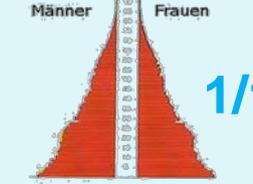
# Ageing (Growth → Maturity → Shrink)

**1900**

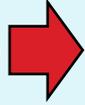
**1950**

**2000**

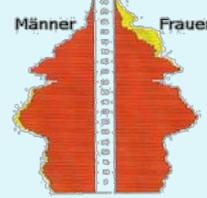
**2050**



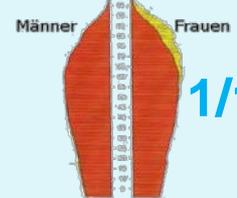
1/1.4



1/2.04



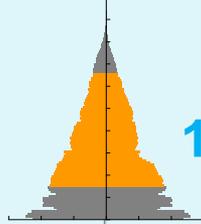
1/2.13



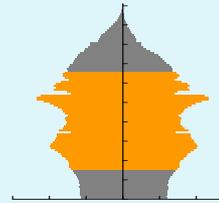
1/1.28

**Germany**

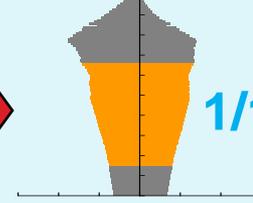
**Japan**



1/1.48

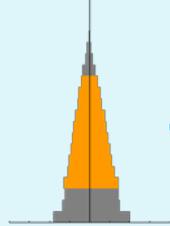


1/2.14

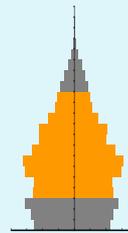


1/1.04

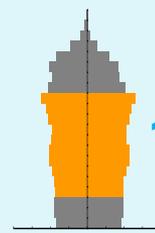
**China**



1/1.63

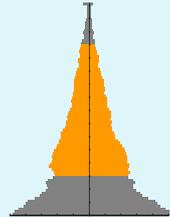


1/2.15

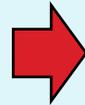


1/1.56

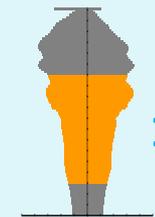
**Korea**



1/1.24



1/2.55

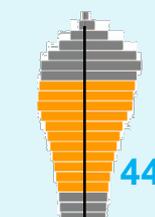


1/1.20

**Singapore**



1/2.97



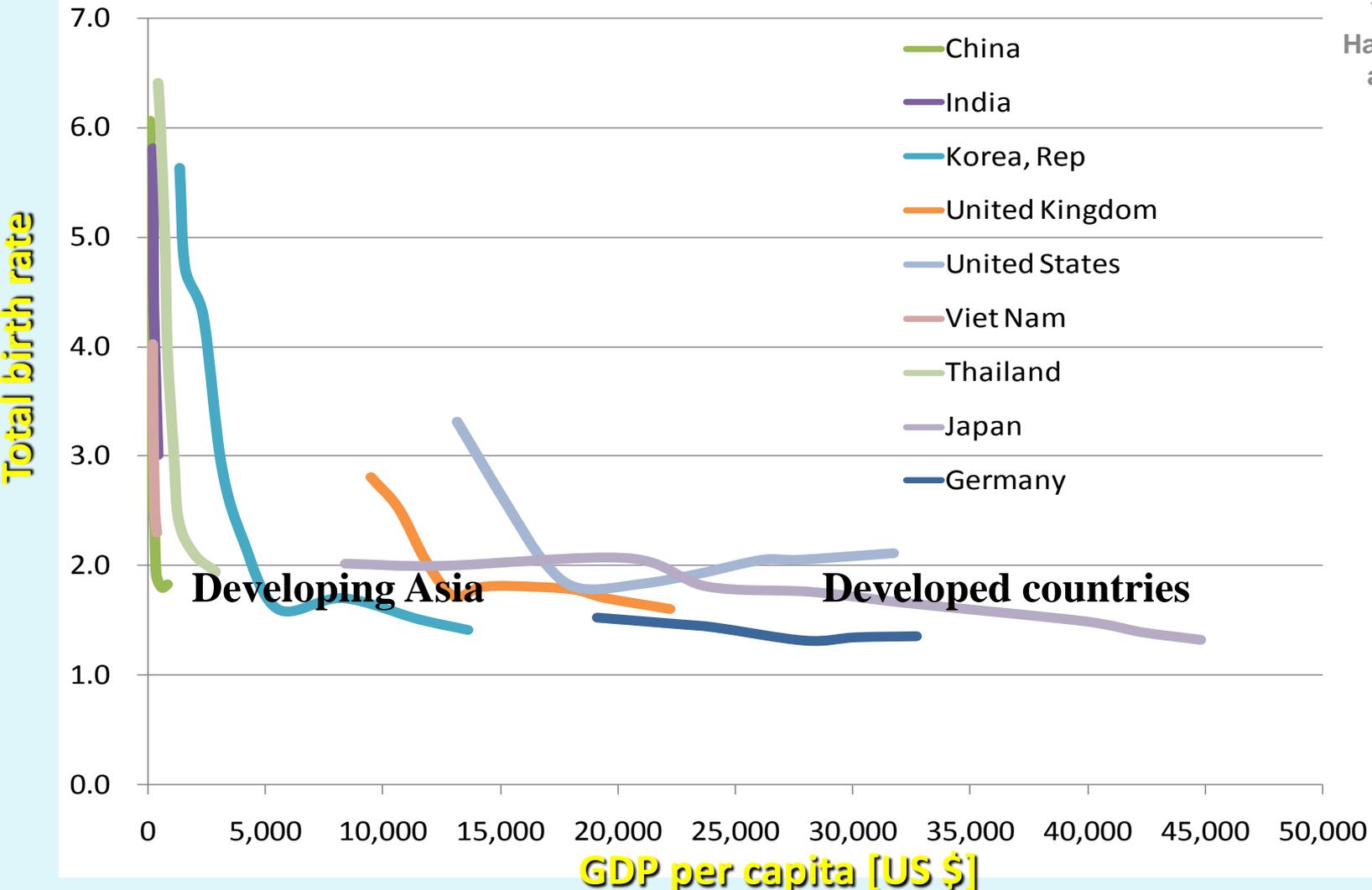
1/1.12

44

# Challenges for Low-carbon Transport Sector

## Drastic Drops in Birth Rate in Asia

Yoshitsugu Hayashi, Nagoya University



# Growing Small / Smart Shrink

# What do the Changes of Economic, Geographic and Demographic Factors Mean ?

- Rapid Growth in Asian (Current) Developing Countries
  - Rich people with poor infrastructure
- Westernization of Society in Asian Developing Countries
  - Aging, Recession & Unemployment, Nuclear Family
- Vulnerability of Society
  - Poverty
  - Aging → Less Potential Economic Power in Future

# Bangkok

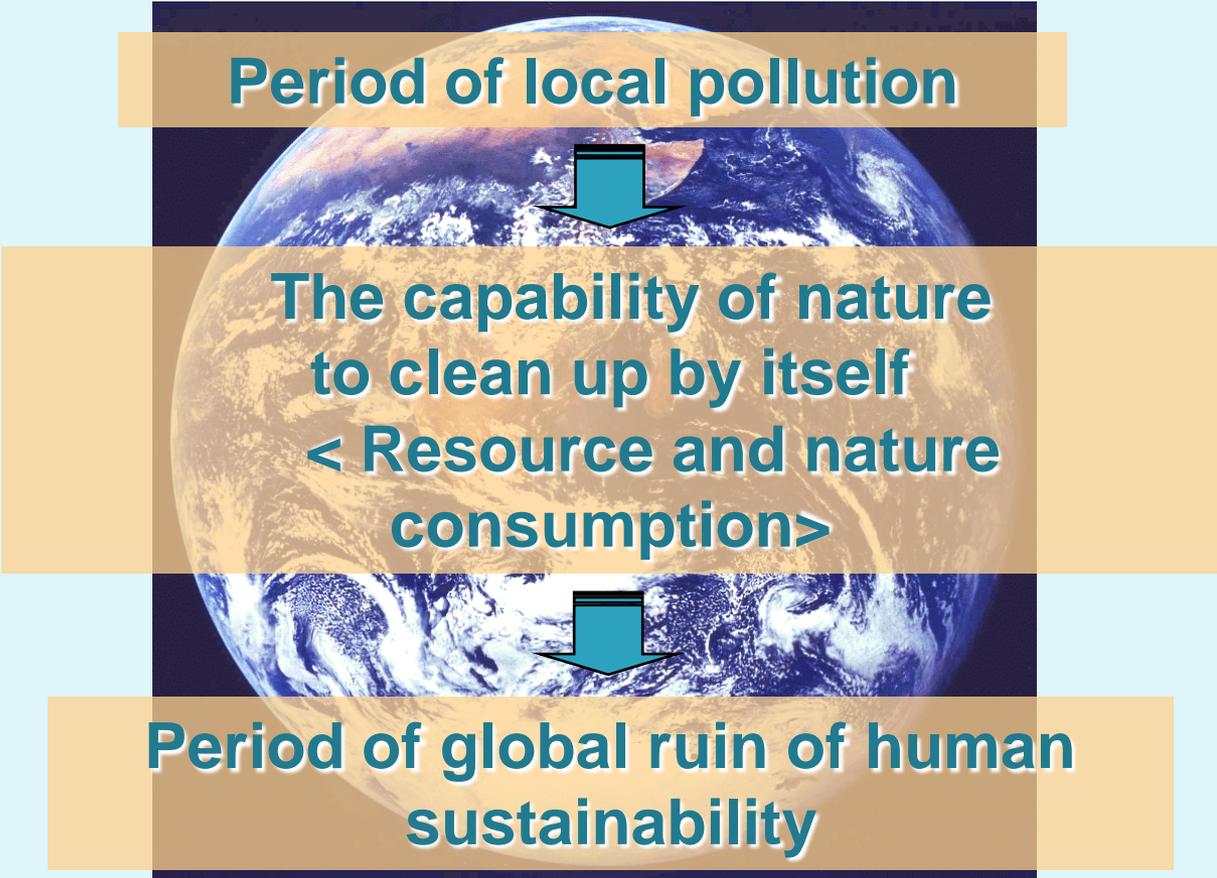


# Hanoi





# “Spaceship Earth”: Boulding, Kenneth E.(1966)



Period of local pollution

The diagram features a central image of the Earth from space. Three horizontal orange bars with white text are overlaid on the image. The top bar is labeled 'Period of local pollution'. A blue arrow points downwards from this bar to a central text block. The central text block contains the phrase 'The capability of nature to clean up by itself' followed by a mathematical inequality: '< Resource and nature consumption >'. A second blue arrow points downwards from this central text block to the bottom bar, which is labeled 'Period of global ruin of human sustainability'.

The capability of nature  
to clean up by itself  
< Resource and nature  
consumption >

Period of global ruin of human  
sustainability

# Rapid Growth in Asian Developing Countries

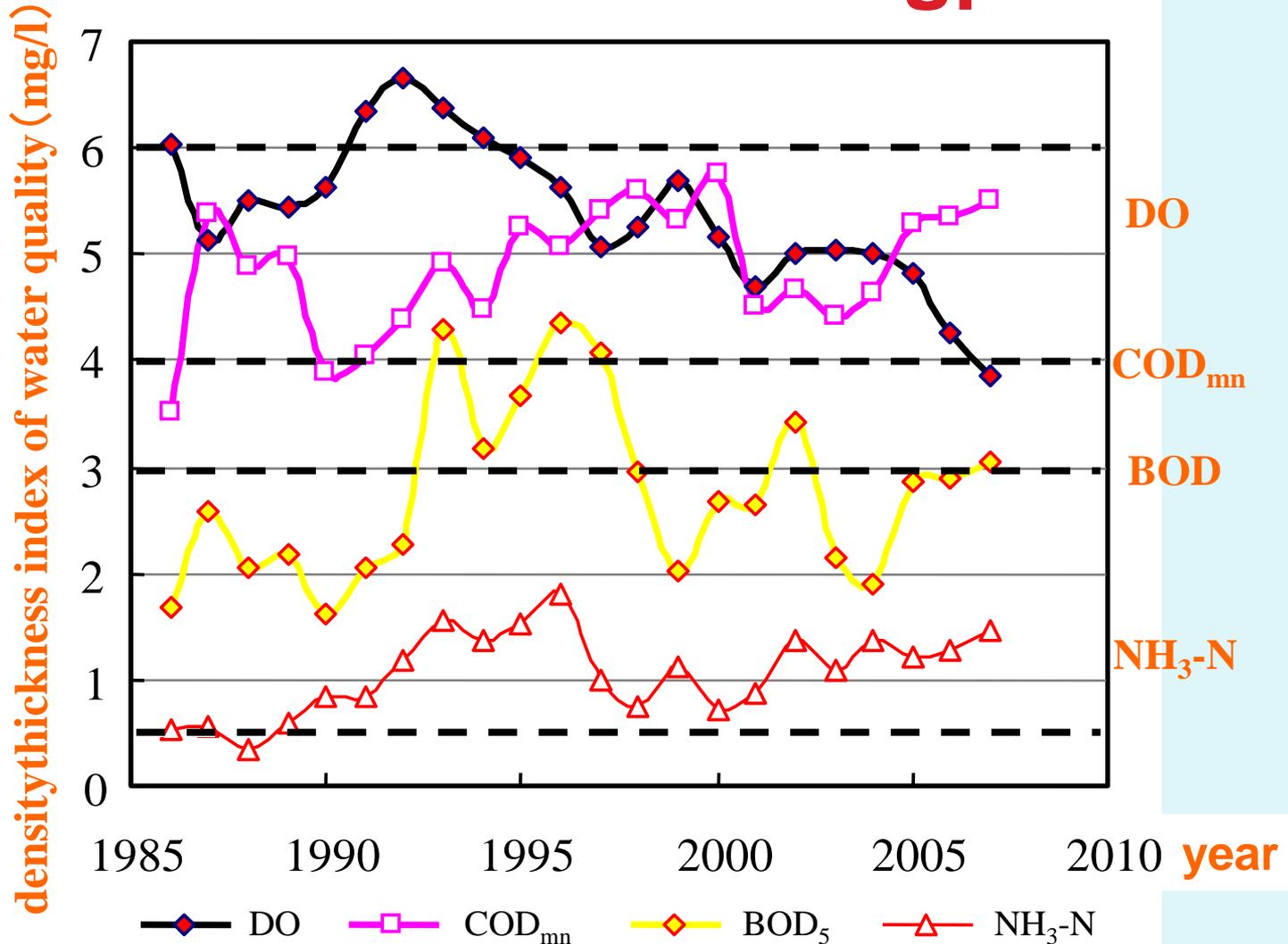
- Skyrocketing Increase in Car Ownership (20 times in 2050)
- Less Power to Self-finance Railways in Mega-cities
- Increasing Mega-cities (50 or more in 2050) without Railway Systems
  - Another many Catastrophic Congestion like Bangkok in 90's
- Unacceptable Increase in CO<sub>2</sub> from Urban Transport

# What do the Changes of Economic, Geographic and Demographic Factors Mean ?

- Rapid Growth in Asian (Current) Developing Countries
  - Rich people with poor infrastructure
- Westernization of Society in Asian Developing Countries
  - Aging, Recession & Unemployment, Nuclear Family
- Vulnerability of Society → Difficulty in Adaptation
  - Poverty
  - Aging → Less Potential Economic Power

# Prescription

# Changing Quality of Water in source area of Huangpu River

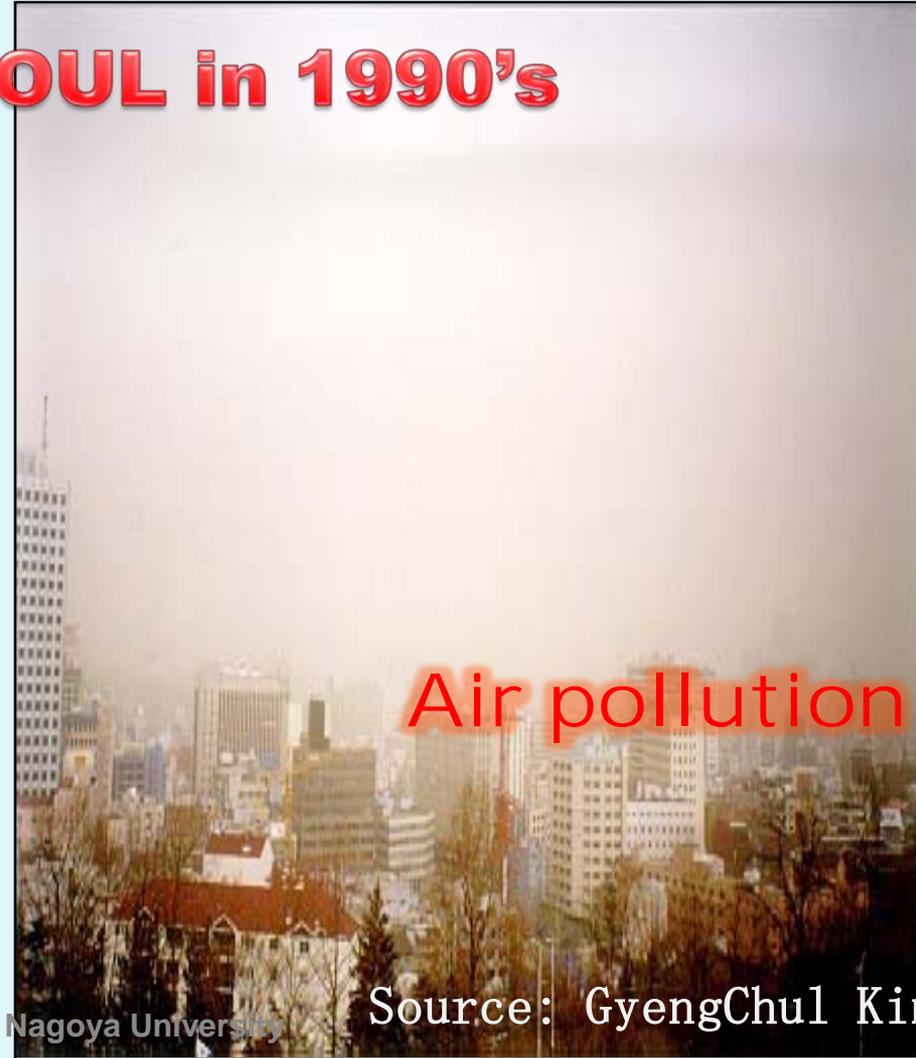
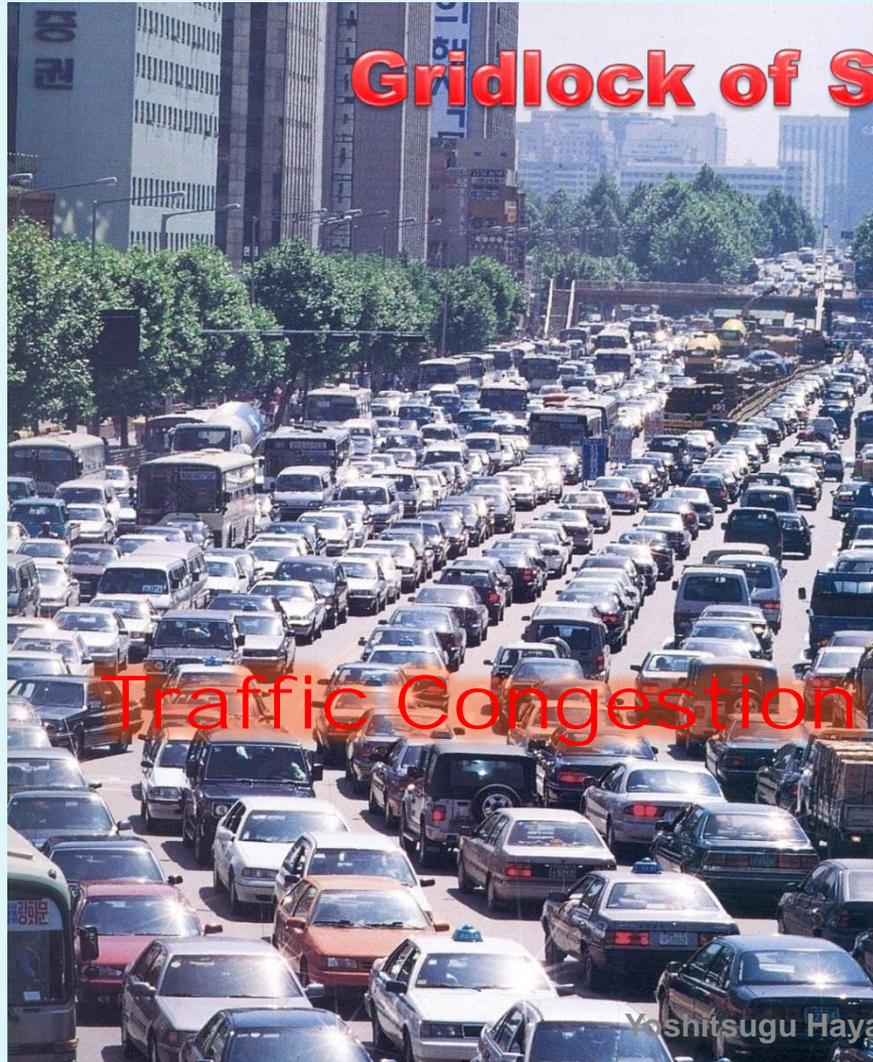


--- The environmental standard of groundwater in China GB 3838-2002 in second class standard

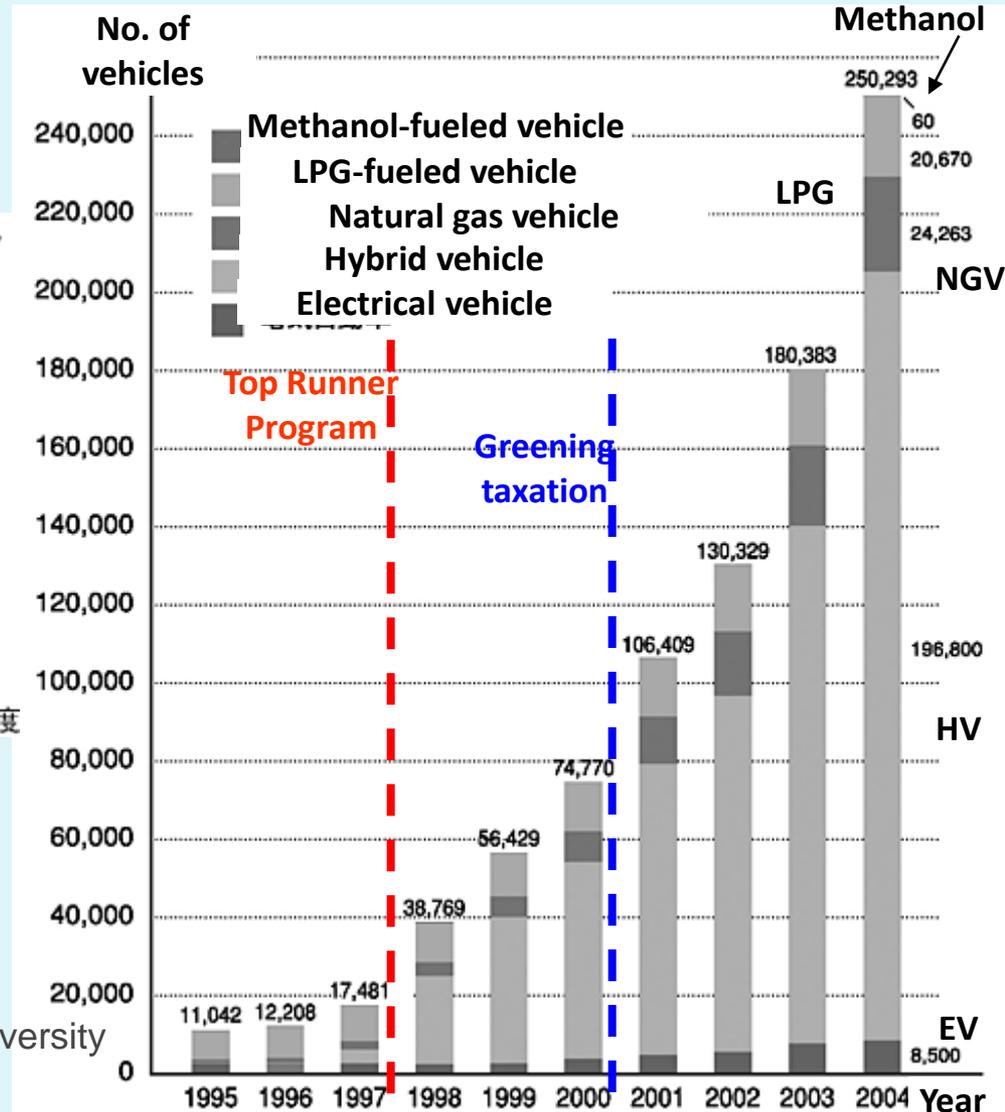
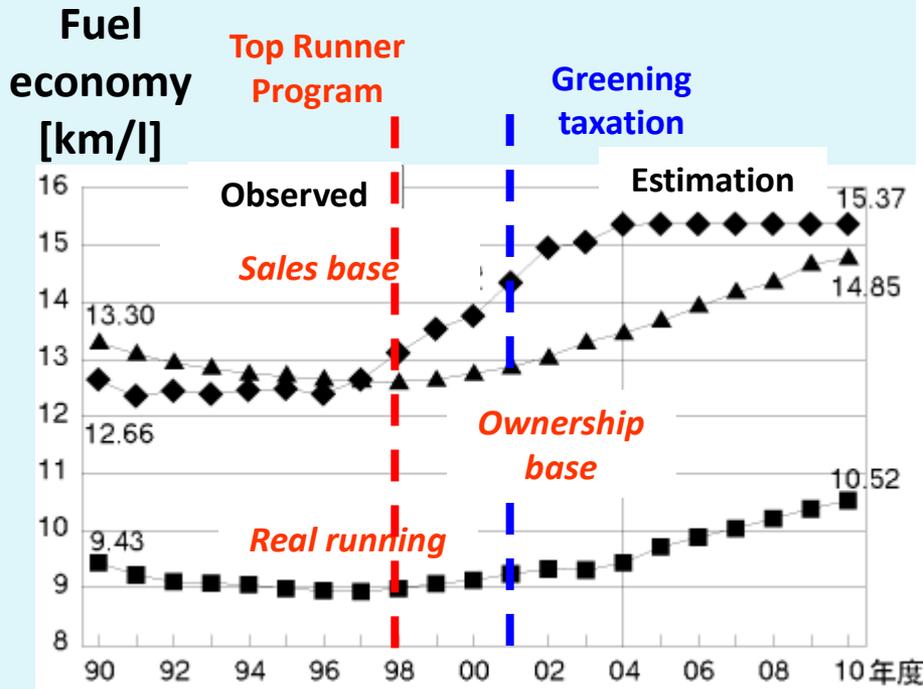
# Challenges for Low-carbon Transport Sector

## Failure of Urban Transport System

### Gridlock of SEOUL in 1990's



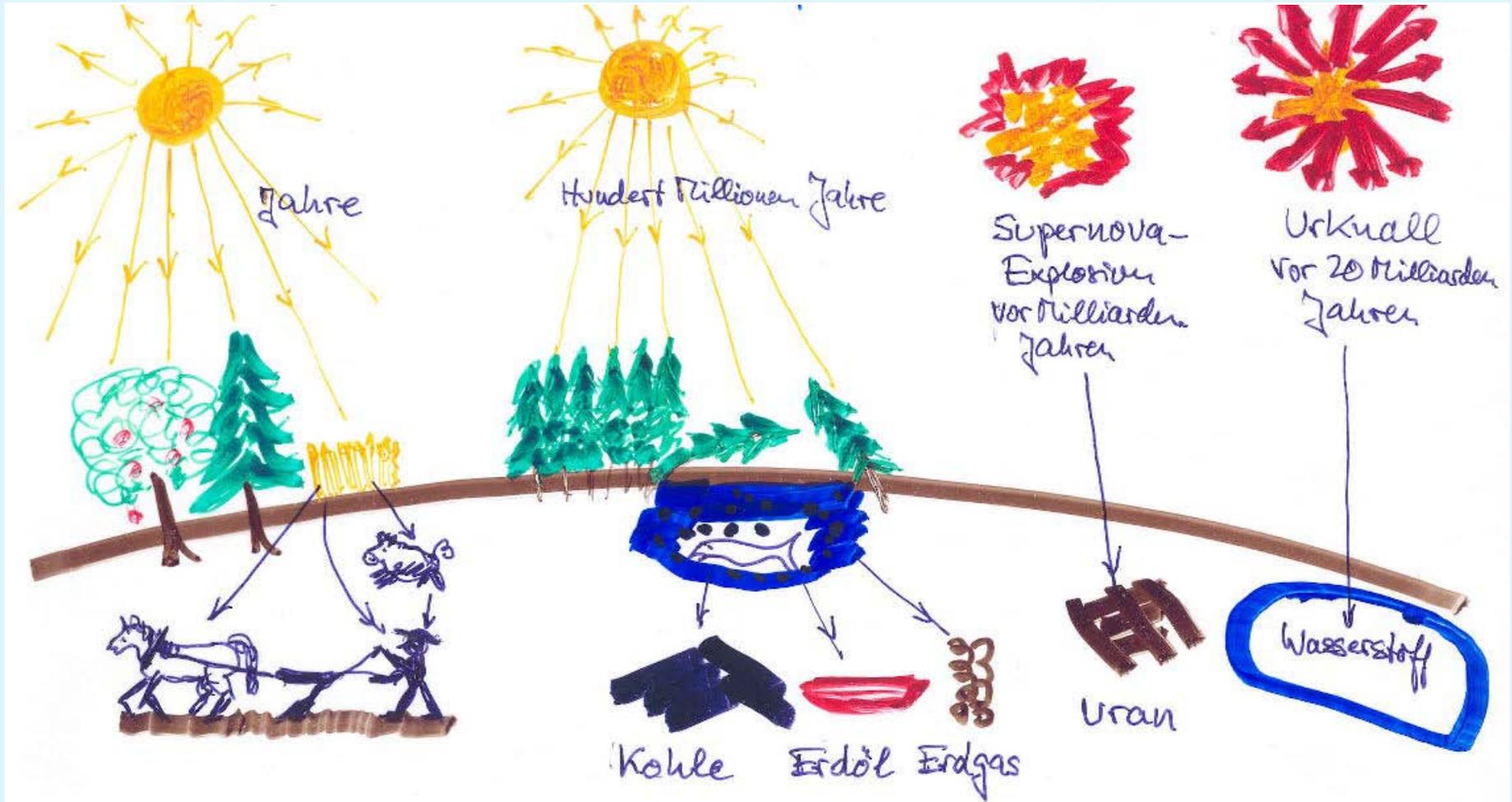
# Innovation of Transport System Effects of Tax and Subsidy Policies



# Review of Effects of Past Prescription

# Hans-Peter Duerr's Theory of Eco-balance and Sustainability

# Islands of high Syntropy on Earth



Plants-Animals-Human Beings

Fossile Fuels

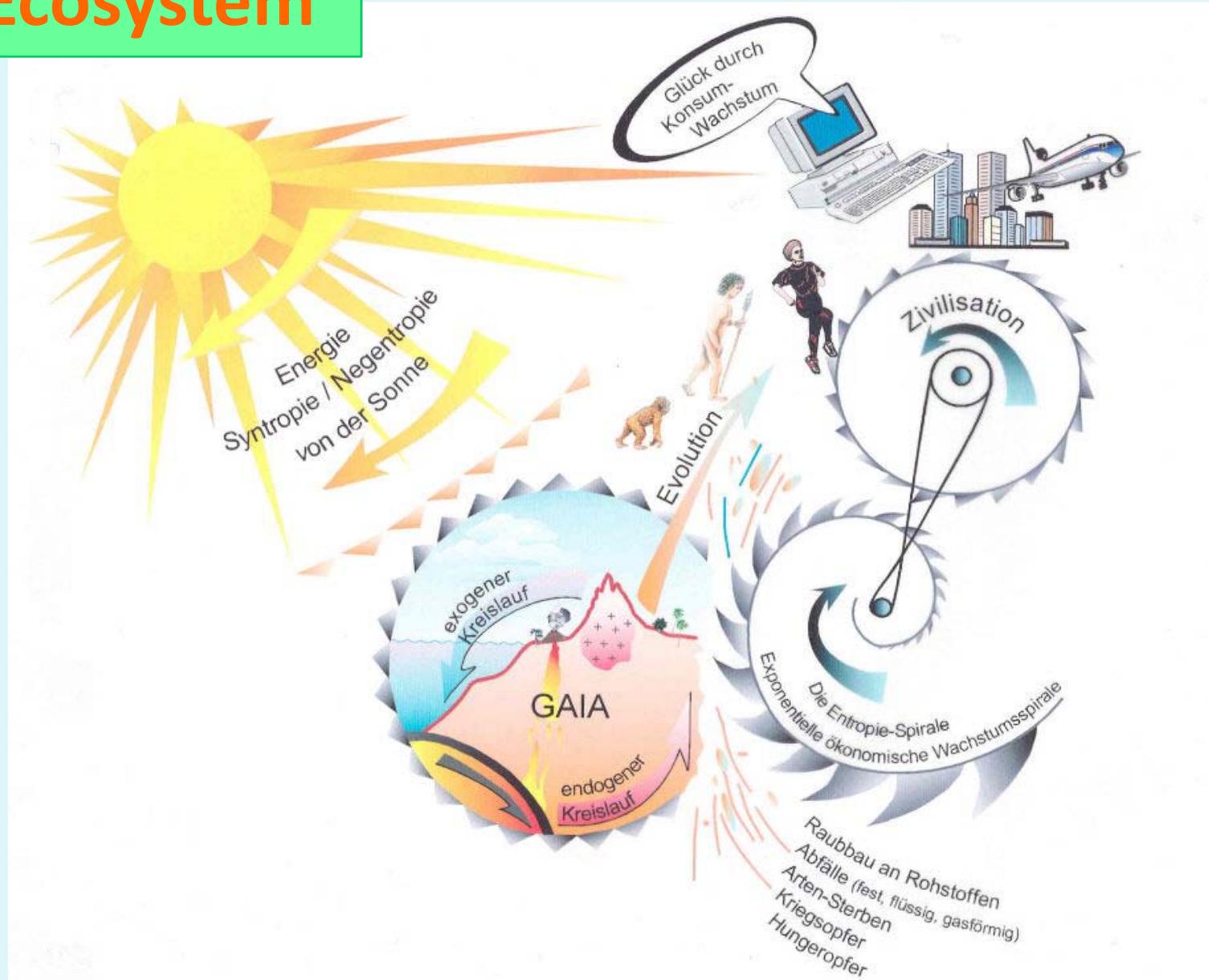
Nuclear Energy

Yoshitsugu Hayashi, Nagoya University

60

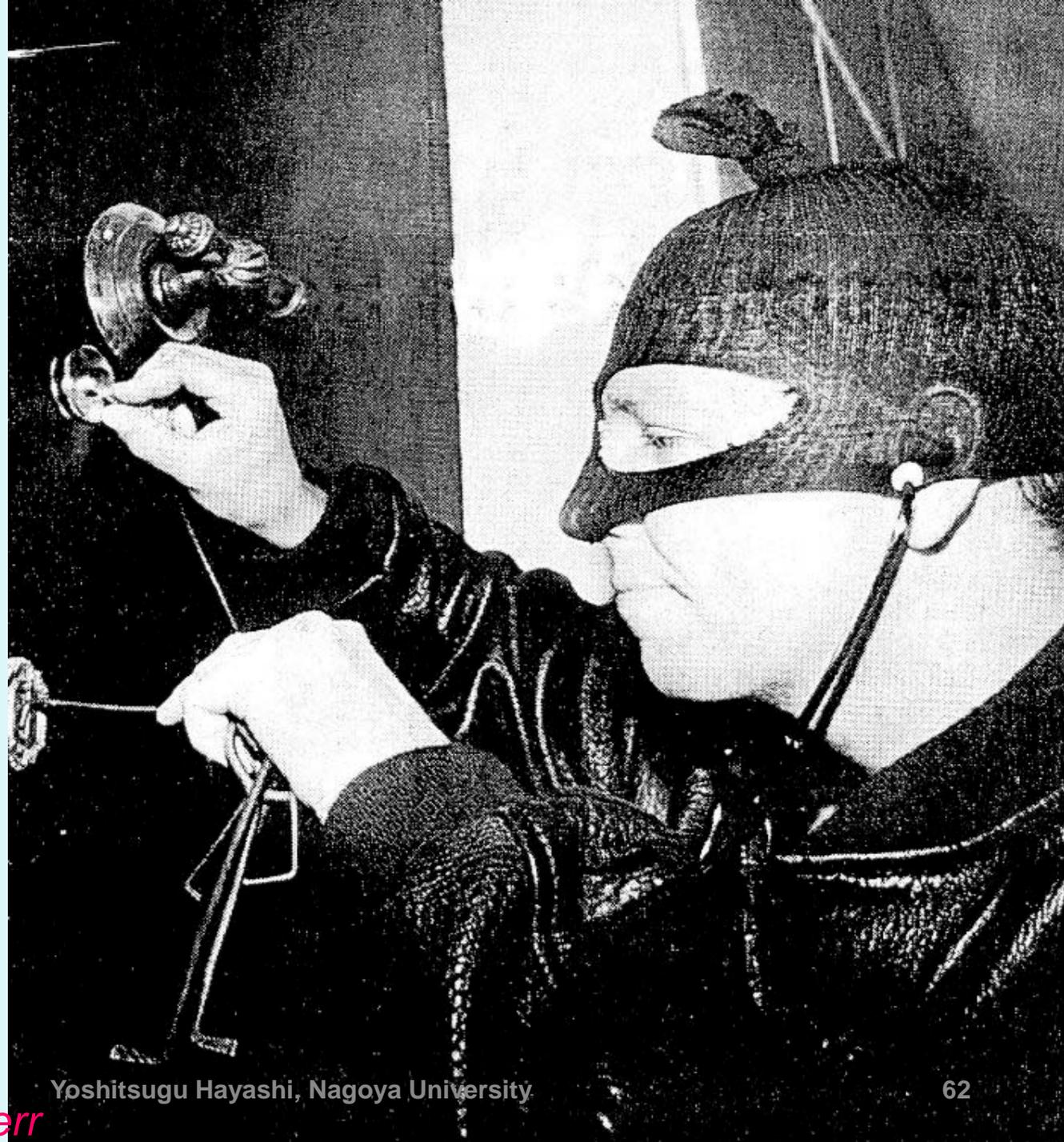
Source: Hans-Peter Duerr

# Geo-Ecosystem



# “Bankrobber“

„Investment  
in Welding  
Equipment to  
break open one  
Safe of Nature  
after the other“





## “Biosystem”

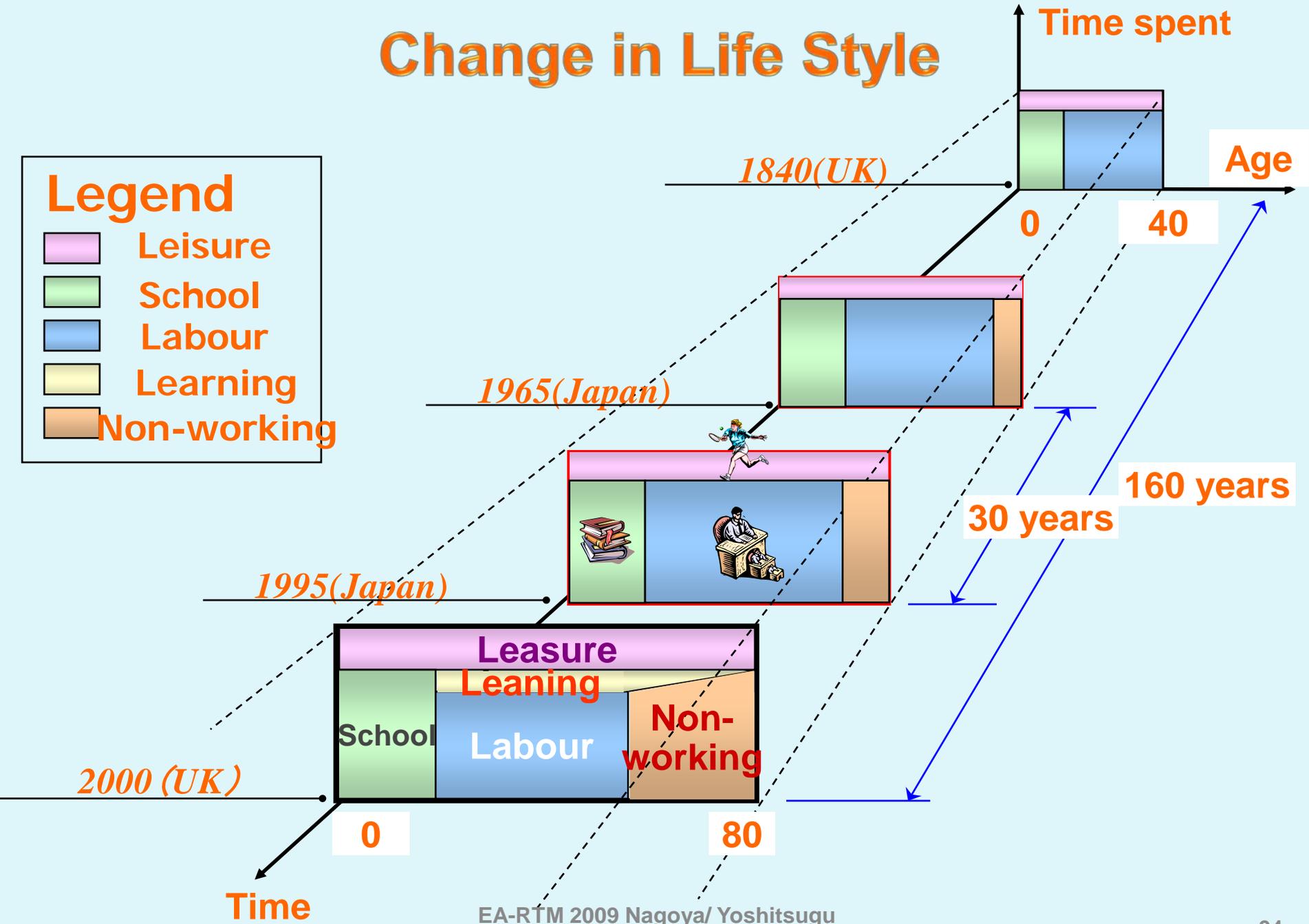
Many people think they are the crown of creation and jump around on top of the card house. They do not recognize that cards are collapsing and falling out, and that, hence, their own foundation is seriously endangered.

*Fotomontage* Spiegel *Magazin*

# Change in Life Style

**Legend**

- Leisure
- School
- Labour
- Learning
- Non-working



**【Goal】**

**Higher QOL**

**【Endogenous Condition】**

< Domestic >  
Low birth rate  
Aging  
IT

< Int'l >  
Growth of Asia  
Globalization  
IT

**Economy**

**Ecology**

**A. Economic Opportunity**

**B. Living & Cultural Opportunity**

**C. Amenity**

**D. Safety & Security**

**E. Burden on Environment**

- Opportunity for Income
- Accessibility to Agglomeration of Industries/Population

- Service
- Education/Culture
- Health/Medical Care
- Shopping/Service
- Amusement/Travel

- Housing
- District Landscape
- Nature of Region
- Identity of Region
- Comfortability / Punctuality of travel
- Time for leisure/cultural life

- Risk of Natural disaster
- Risk of Building / Facility disaster
- Risk of Chemical Pollution
- Risk of Traffic Accident
- Resource Preservation
- Criminal Rate

- Burden from Industry
- Burden from Domestic
- Burden from Transport
- Heat Island
- Noise

# Residence in Shanghai



EA-RTM 2009 Nagoya/ Yoshitsugu  
Hayashi, Nagoya University

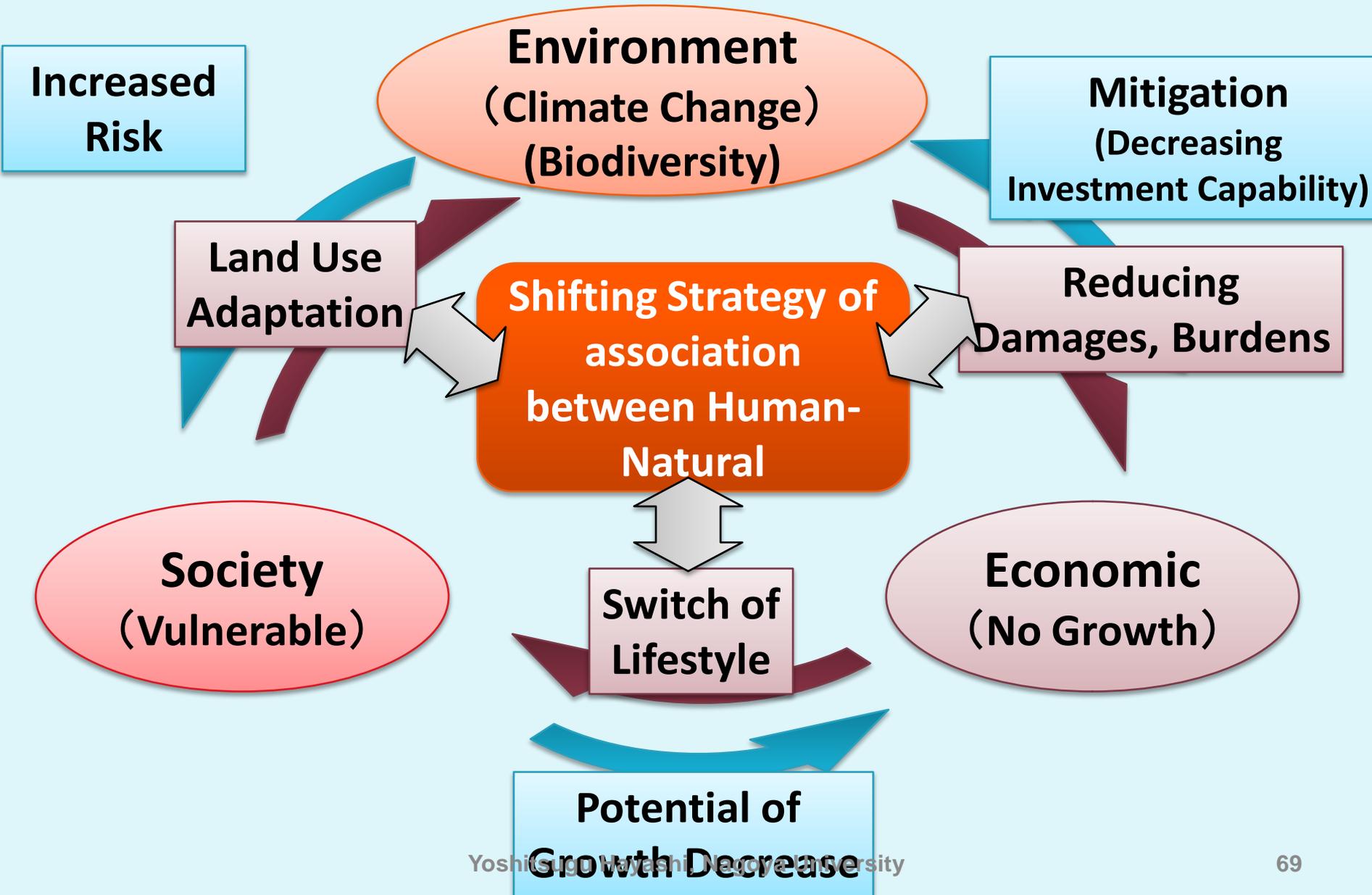
# Shanghai Shoes-repair only ?



# Shanghai 3 generations together



# Mechanism for Sustainable Development



# Where China will go ?

- Scale:
  - Population: China=Japanx10
- Speed:
  - Motorway Construction
    - China (8,000km/2years)=Japan (8,000km/46years )x20
  - GDP
    - China ?> Japan 9%/year ( latter half of 20<sup>th</sup> Century) x75in50years
  - Aging (non-working/working generation)
    - 2.16/1.56=1.4 in 50 years
- Factor 200 ???