国際シンポジウム International Symposium

次の時代の交通と安全

～ 東日本大震災の教訓を踏まえて ～

Transportation and Safety for the Coming Age

Learning from the Lessons of the Great East Japan Earthquake

●非常時の交通と安全

Transportation and Safety during Emergencies

震災特別プロジェクト主催セッション
「非常時の交通と安全」

"Transportation and Safety during Emergencies"

Session by IATSS Special Research Project Team on Great East Japan Earthquake

2012年9月21日（金）13:30 ～ 17:00

Friday, 21 September 2012

資料集
Handouts

IATSS 公益財団法人 国際交通安全学会

International Association of Traffic and Safety Sciences

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研究報告　Research Report

林 良嗣　Yoshitsugu Hayashi


Beautiful Country
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Next to them...,
水沢
Mizusawa
江刺
Esashi
種山高原
Taneyama Heights
一関
Ichinoseki
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陸前高田
Rikuzentakata
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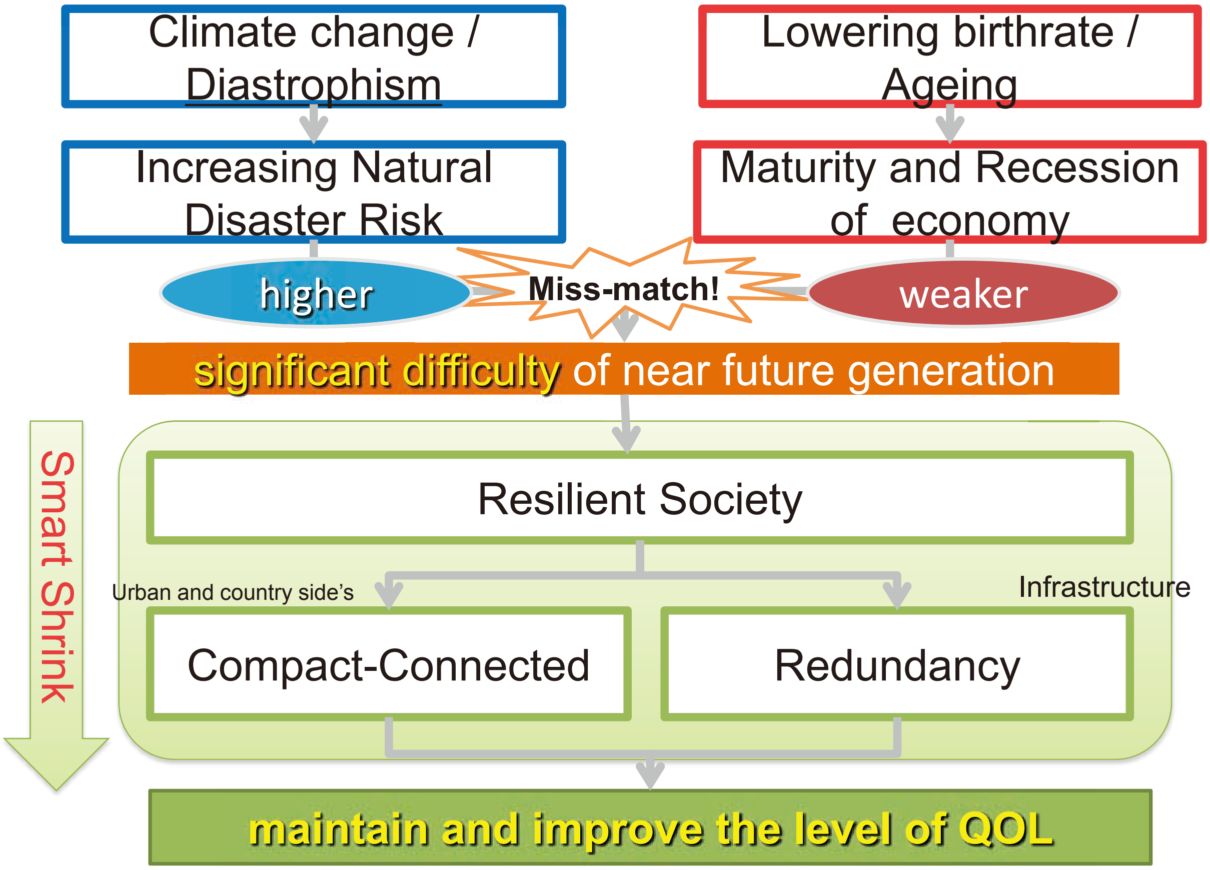
Natural disaster risk

How to recognize the Great East Japan Earthquake

Changes in Natural and Social acceptability



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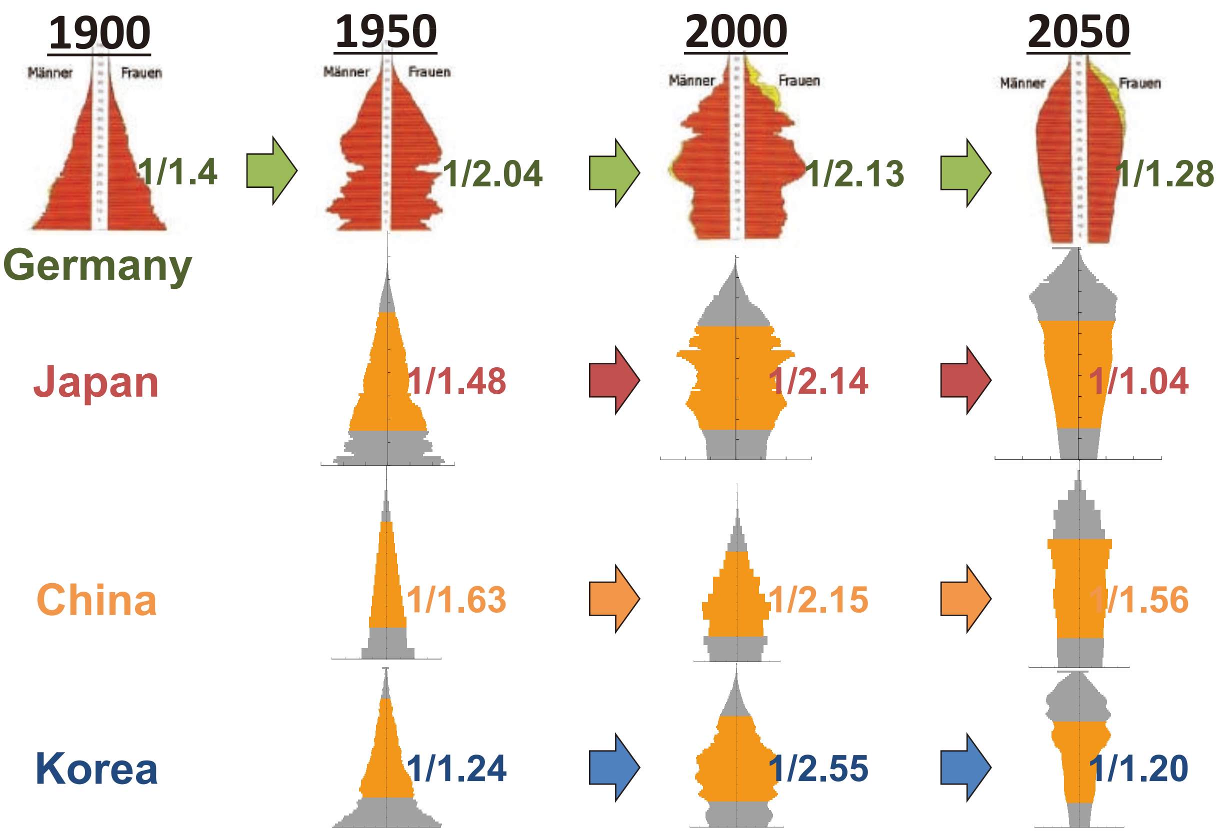
Ageing (Growth →Maturity →Shrink)



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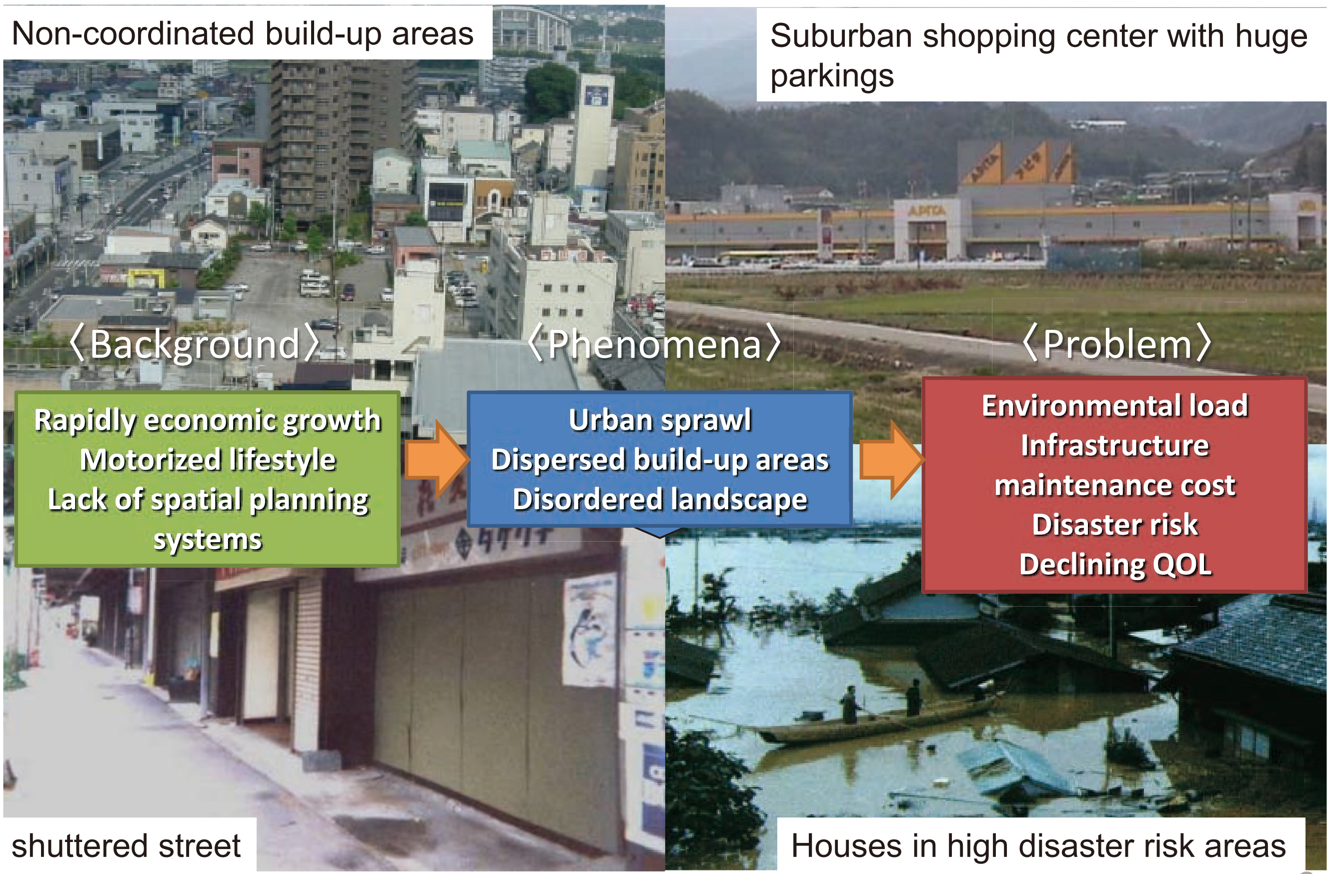
Japanese cities



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Requirement for Resilient Land and Society

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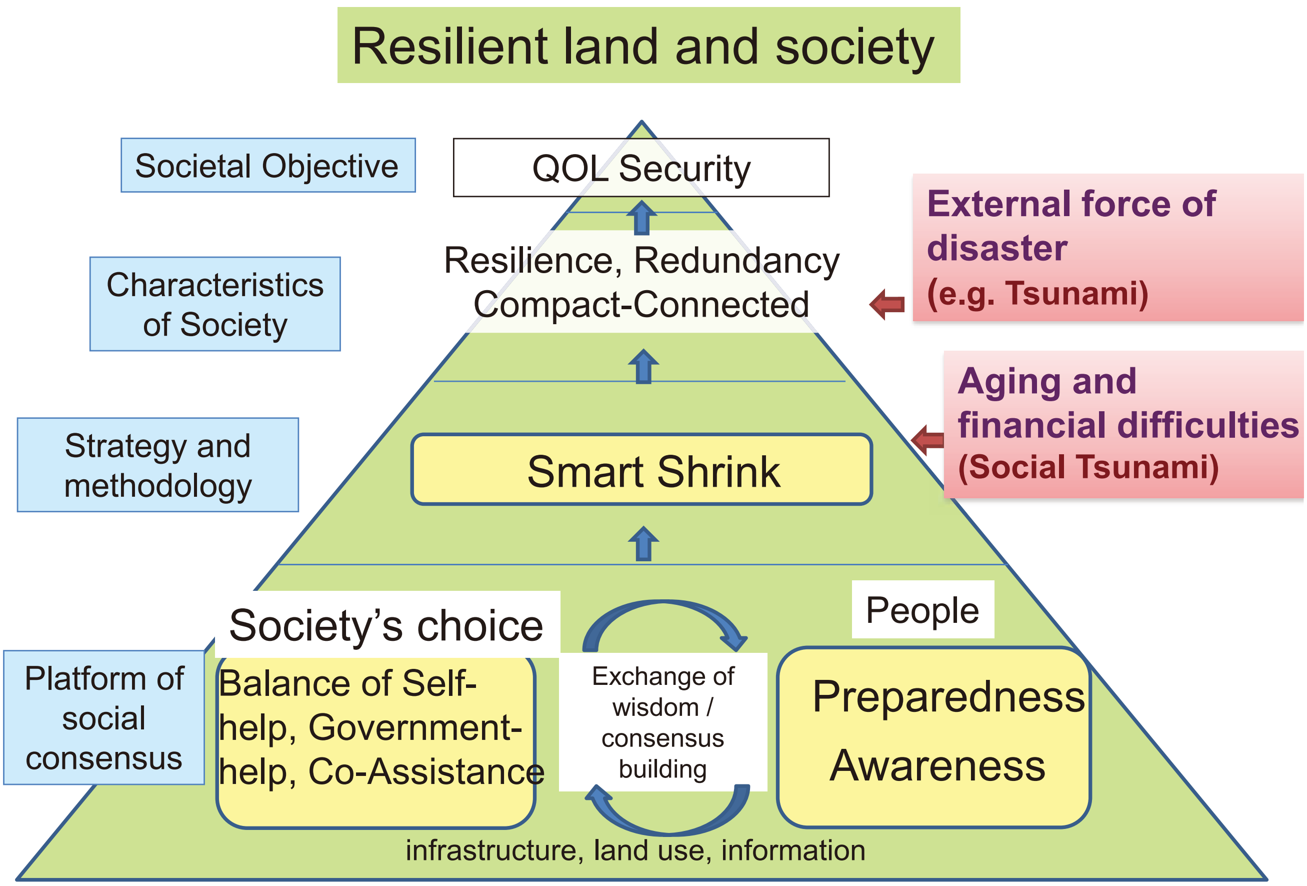
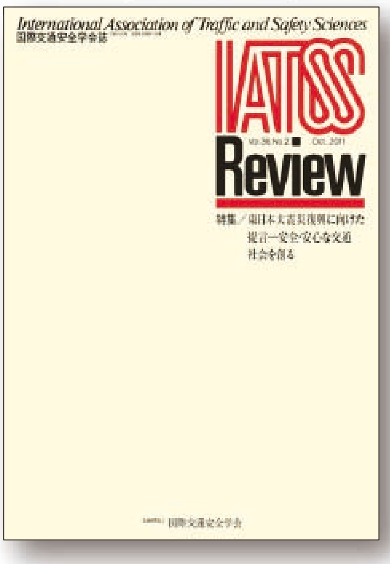


参考文献
- ·武内和彦：自然と共生できる社会を目指して一震災復興と自然共生社会
- ·林良嗣：レジリエントな国土と社会に向けたスマートシュリンクのすすめ、IATSS Review, Vol.36,No.2, 2011

5）IATSS Review 特集号

■Vo.36,No.2 Oct.,2011



Three strategies for resilient land and society

- **Resilience**
  - **Opposing/Adaptive infrastructure** (Seewall in Taro, Iwate Pref.)
    ※New wall: collapsed, Old wall: survived
  - **Infrastructure Alignment** (Case of Sendai east motor way)
- **Redundancy**
  - **Failure of emergency mode** (Route 43 at the Great Hanshin-Awaji Earthquake)
  - **Lack of redundancy**(Eastern Sendai Motorway)
- **Compact-Connected**
  - **Removal to high land** (Case of Ofunato and Kamaishi)
  - **Regeneration of Social Connectivity** (Shanghai)

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Strategy for resilient land and society（1）

- **Resilience**
  - **Countermeasure/resilient infrastructure** (Seewall in Taro, Iwate Pref.)
    ※New wall: collapsed, Old wall: survived
  - **Infrastructure Alignment** (Case of Sendai east motor way)
- **Redundancy**
  - **Failure of emergency mode** (Route 43 at the Great Hanshin-Awaji earthquake)
  - **Failure of redundancy**(Express way network in Tohoku area)
- **Compact-Connected**
  - **Move to higher ground**(Case of Ofunato and Kamaishi)
  - **Regeneration of social bonds**(Shanghai)

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①Resilience
Was levee in Taro, Miyako resilient?
Old levee (avoid)
国道45号
防護区域 A=100.4ha
至宮古市
防潮堤（水産庁所管）
S48-53年に
至岩泉町
田代川水門および
河川堤防
S47～53年
New levee
(directly opposing)→broken
Tsunami
After
Before
出典：国土交通省
東北地方整備局
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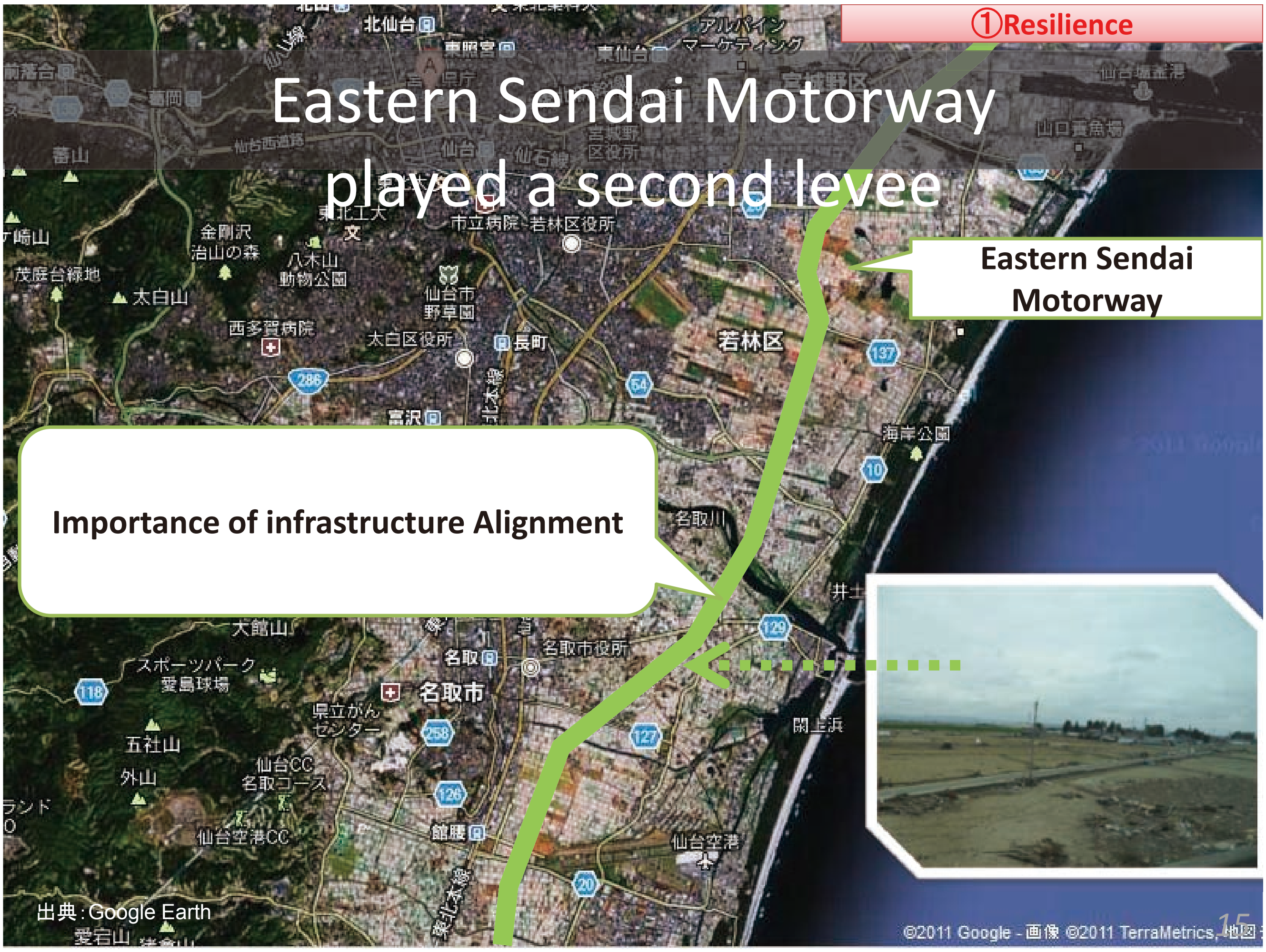
①Resilience
Eastern Sendai Motorway
played a second levee
Eastern Sendai
Motorway
Importance of infrastructure Alignment
若林区
名取市
仙台空港
出典：Google Earth
©2011 Google - 画像 ©2011 TerraMetrics, 地図

Strategy for resilient land and society(2)

- **Resilience**
  - **Countermeasure/resilient infrastructure** (coast levee in Taro, Miyako, Iwate)
    ※New levee: collapsed, Old levee: survive
  - **Importance of infrastructure arrangement planning**(Case of Sendai east motor way)
- **Redundancy**
  - **Failure of emergency mode** (Route 43 at the Great Hanshin-Awaji Earthquake)
  - **Lack of redundancy**(Eastern Sendai Motorway)
- **Compact-Connected**
  - **Move to higher ground**(Case of Ofunato and Kamaishi)
  - **Regeneration of social bonds**(Shanghai)

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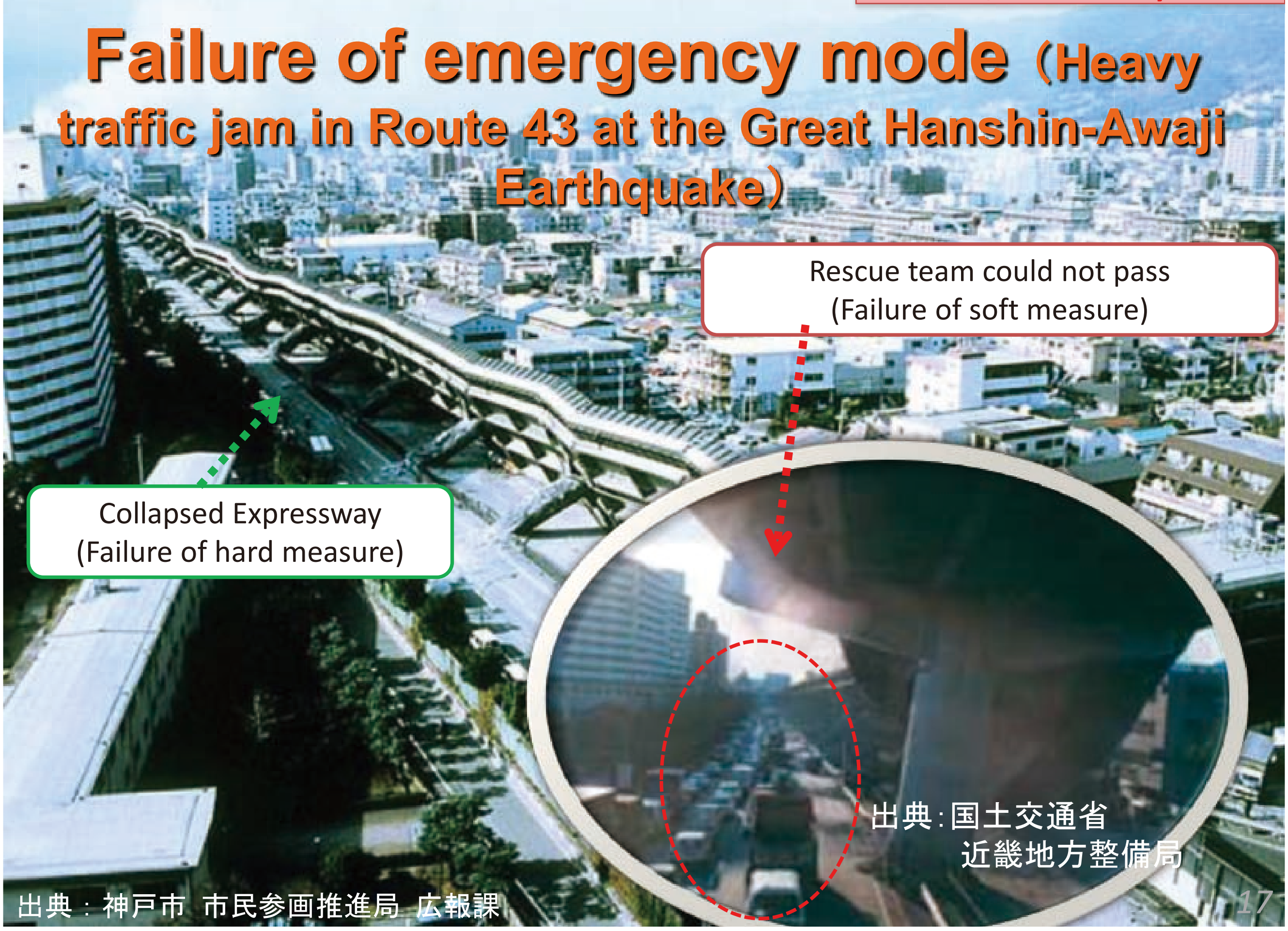
②Redundancy

Failure of emergency mode (Heavy traffic jam in Route 43 at the Great Hanshin-Awaji Earthquake)



②Redundancy

Failure of redundancy (Express way network in Tohoku area)

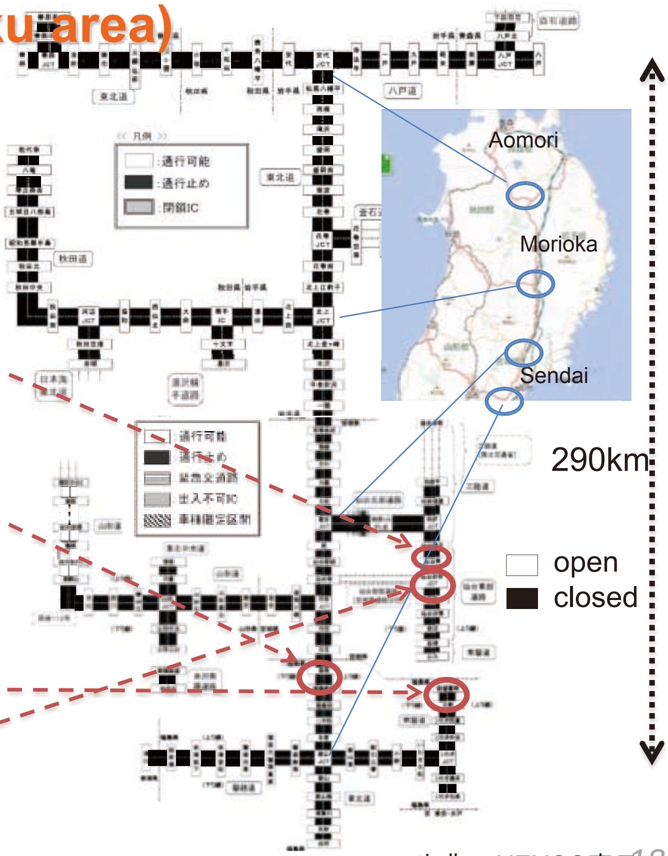
Closure just after the earthquake (15:50 11 March)

Crack

Bump

Subsidence

Debris



出典： NEXCO東日本 18

Strategy for resilient land and society(3)

- **Resilience**
  - **Countermeasure/resilient infrastructure** (coast levee in Taro, Miyako, Iwate)
    ※New levee: collapsed, Old levee: survive
  - **Importance of infrastructure arrangement planning**(Case of Sendai east motor way)
- **Redundancy**
  - **Failure of emergency mode** (Route 43 at the Great Hanshin-Awaji earthquake)
  - **Failure of redundancy**(Express way network in Tohoku area)

- **Compact-Connected**
  - **Removal to high land** (Case of Ofunato and Kamaishi)
  - **Regeneration of Social Connectivity** (Shanghai)

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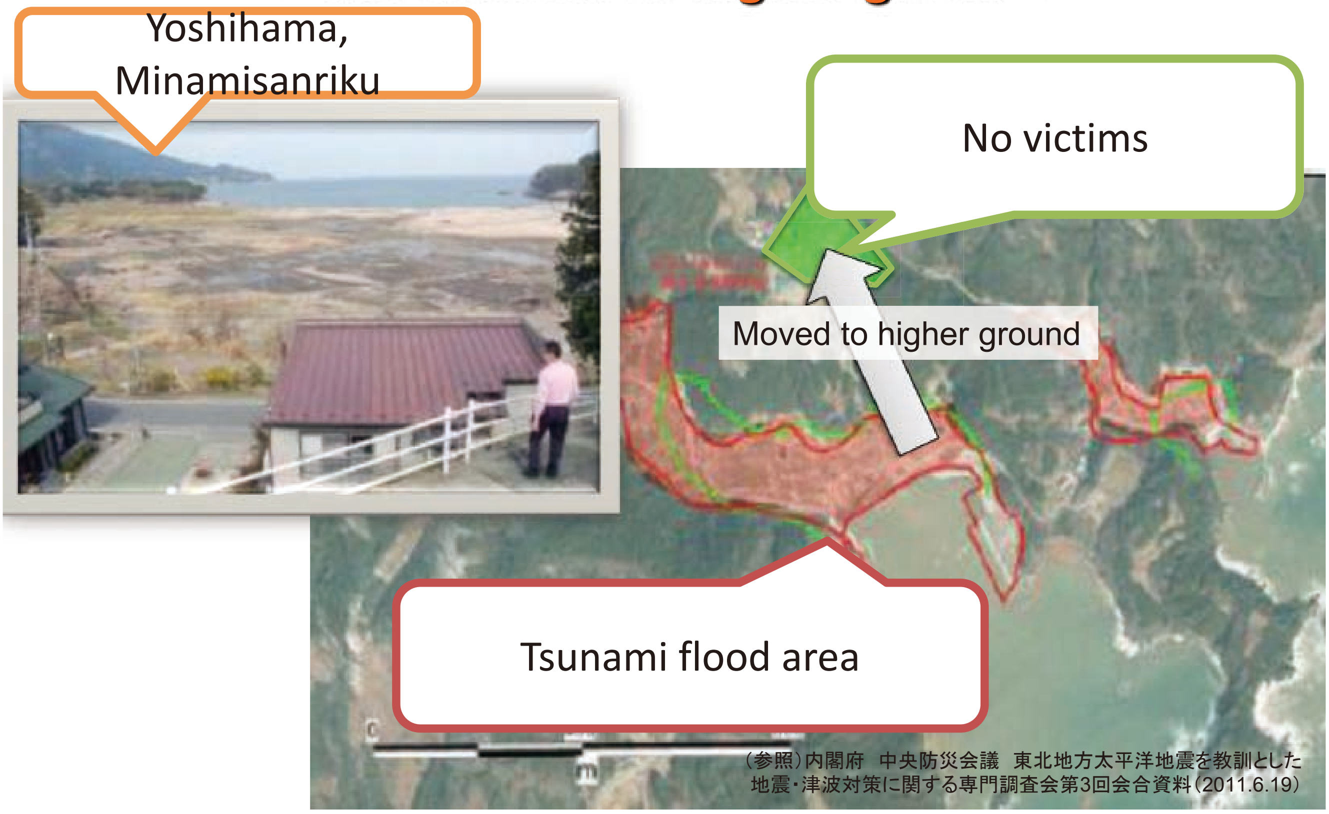
③Compact-Connected

Long term evacuation
(case of move to higher ground)

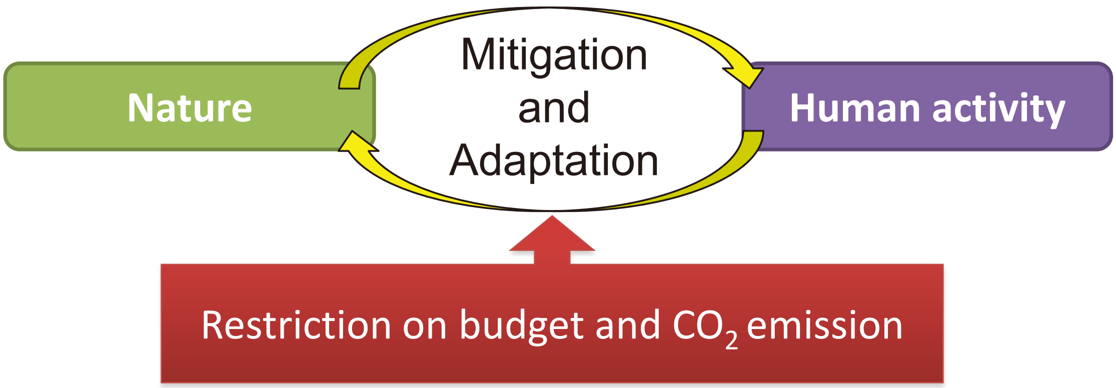


③Compact-Connected

Regeneration of social bonds(Shanghai)

Countermeasures for Resilient Land and Society

	Mitigation	Adaptation
Hard	<Long term> Defensive Infrastructure	<Long term> Shrinking
Soft	<Short to Long term> Education Information Service	<Short term> Evacuation Planning



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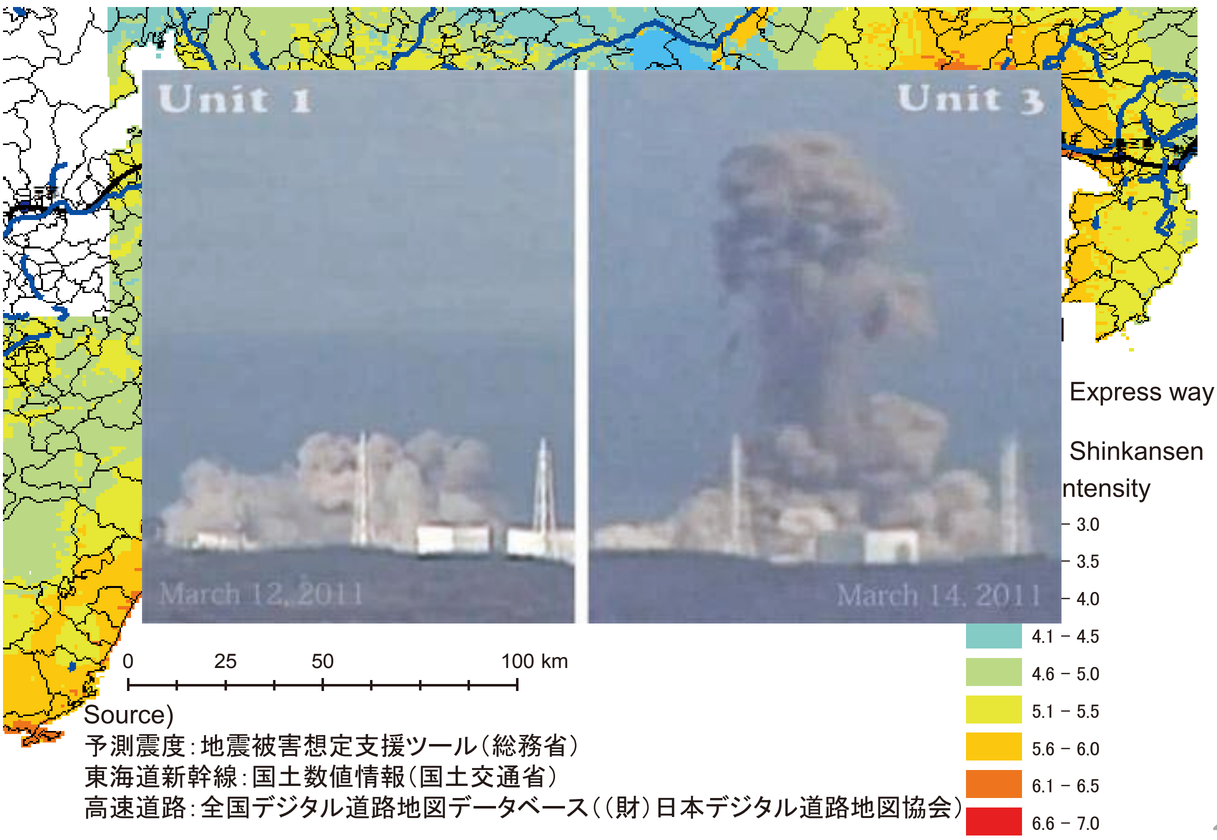
Predicted seismic intensity of Tokai earth quake and trunk lines



Source)
予測震度：地震被害想定支援ツール（総務省）
東海道新幹線：国土数値情報（国土交通省）
高速道路：全国デジタル道路地図データベース（（財）日本デジタル道路地図協会）

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基調講演　Keynote Address

五百旗頭 真　Makoto Iokibe

国際交通安全学会 国際シンポジウム
「非常時の交通と安全」基調講演

「東日本大震災の復興と教訓」

公立大学法人熊本県立大学理事長
五百旗頭真

はじめに ------ この列島の住民の伝統的な生き方

(1) 自然と共生し、豊かな自然の恵みの中で生きる

(2) 時に暴虐なる大自然に対し、首をすくめてやり過ごし、同じ家を再建

(3) 砂丘プラス貞山堀、加藤清正の治水など、治山治水の伝統

1 近現代の対処

(1) 明治三陸津波後の高台移転 ------ 不便という代償

(2) 戦後の防災

・1959年伊勢湾台風→1960年災害対策基本法

・以後、一災害毎に、後追いパッチワーク的防災強化(実感主義)

・阪神淡路(1995)後に数個の新法 ------ ほぼ完成か

(3) あとは「津波防災」(河田恵昭書、岩波新書)

2 東日本大震災 ------ 広域複合災害

⑴ 大地震（M:9.0)には強かった日本社会

⑵ 大津波に対し不十分な日本社会、ただこの地なればこそ(cfスマトラ)

⑶ 原発と閉鎖的専門集団

3 復興の特徴

⑴ 関東大震災後 ------ 後藤新平の復興院とその挫折

⑵ 阪神淡路大震災 ------ スピーディーな具体的提言と全政府態勢

⑶ 東日本大震災

①遅い復興の足取り

②提言書「悲惨のなかの希望」

③復旧に留まらない全般的復興(より安全なまち、生業・農業の再生、長寿社会、再生可能エネルギー等への対応)

④「減災」概念、「特区」手法、創造的復興

⑤復興税を伴う財源

おわりに ------ 今後の課題

⑴ まちづくりプランの合意決定

⑵ なぜガレキで鎮魂の森をつくらないのか

⑶ 貞観地震後 ------ 悪夢のシナリオ

⑷ 自衛隊を減らし続けてよいのか

⑸ 次なる大災害と関西広域連合・海兵隊

⑹ 南海・東南海・東海 ------ 津波防災地域づくりに関する法律

パネルディスカッション　Panel Discussion

Prof. Sutanto Soehodho / Indonesia

"URBAN PROBLEMS, DISASTER RISK AND ITS RESOLUTION : JAKARTA CASE "

JAKARTA CAPITAL CITY GOVERNMENT

SUTANTO SOEHODHO

DEPUTY GOVERNOR OF JAKARTA FOR TRADE, INDUSTRY AND TRANSPORTATION
AND
PROFESSOR OF TRANSPORTATION, UNIVERSITY OF INDONESIA

GREATER JAKARTA OVERVIEW

- Jakarta consists of 5 Municipalities, 1 Regency, 44 Districts and 267 Sub-districts
- Land Area ± 652 Km² (excluded Thousand Islands Area)
- In 2007, per capita GRDP of DKI Jakarta inhabitants at current price was Rp.62.49 million (US$ 6.7 billion), and at 2000 constant price was Rp.36.73 million (US$ 3,95 billion)
- Total Population of Jakarta: ± 9.6 million
- Day Time Population: ± 12 million
- Population density of Jakarta: 14,000 to 15,500 per km2, in certain area 20,000 to 30,000 per km2
- Total Population of Greater Jakarta : ± 28 million

JAKARTA TRANSPORTATION OVERVIEW

- Number of motorized vehicles in 2010 is more than 6,5 million consist of 98.2% private vehicles and 1.8% public transport. Trip annual growth is 9,5% in the last 5 years.
- New vehicles : 240 unit cars, 890 unit motorcycles per day
- Modal share of public transport in 2010 is 17.8%, motorcycle is 42.8% and private vehicle is 12.4%.
- Road length = 7.650 km with the road area = 40,1 km^2 (6,2% from total area of the city). Annual average growth of road length = ± 0,01%.
- Total demand for public transport in DKI Jakarta has reached 20 million trips/day


PORTRAIT OF TRANSPORTATION PROBLEMS IN JAKARTA


TRANSPORTATION PROBLEMS IN JAKARTA

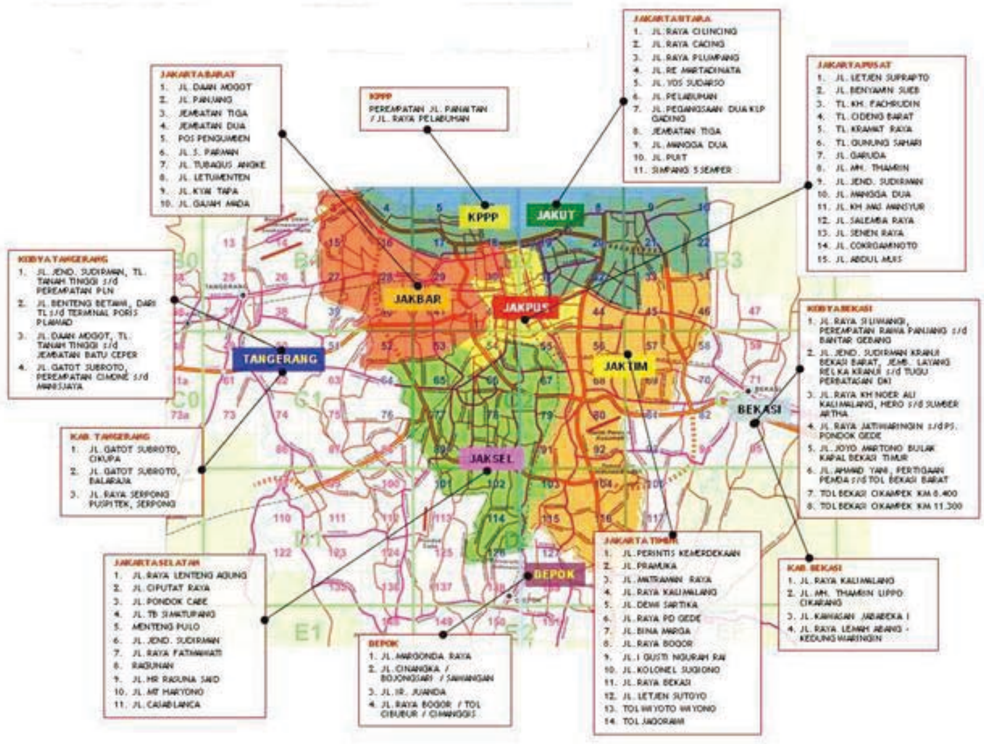
1. The number and variety of vehicles on the roads far exceeds the capacity of existing roadway infrastructure;
2. Poor of public transportation services;
3. Road conditions vary from good to dangerously poor;
4. Road safety awareness is very low, and many drivers, especially the motorcycle and moped drivers, disregard most traffic laws.

TRAFFIC ACCIDENT IN JAKARTA

Year	Traffic Accidents (case)	Dead (person)	Seriously Injured (person)	Slight Injured (person)	Economic Losses (Rp million)
2011	7,817	984	2,706	6,093	17,722
2010	8,235	1,048	3,473	5,825	17,744
2009	7,329	1,071	3,388	5,155	12,393
2008	6,393	1,169	2,597	4,317	NA
2007	5,154	999	2,345	3,398	NA
2006	4,407	1,128	2,372	2,188	NA

Source : Jakarta Police Department (2012)

JAKARTA TRAFFIC ACCIDENT MAP



FIRE INCIDENT IN JAKARTA

- During 2006 – 2010 : 3.317 Fire Incidents, **90% occured in slum areas**;
- 36.478 households (or 1.046.161 people) are suffered from the fire incidents;
- Casualty : 82 dead and 238 injured;
- Fire Coverage : 1,339,489 square meter;
- Losses : Rp.669,3 billion (US$ 71,97 million);
- Causes: 54,6% due to short circuit and 10% stove explosion.

FIRE INCIDENT IN JAKARTA

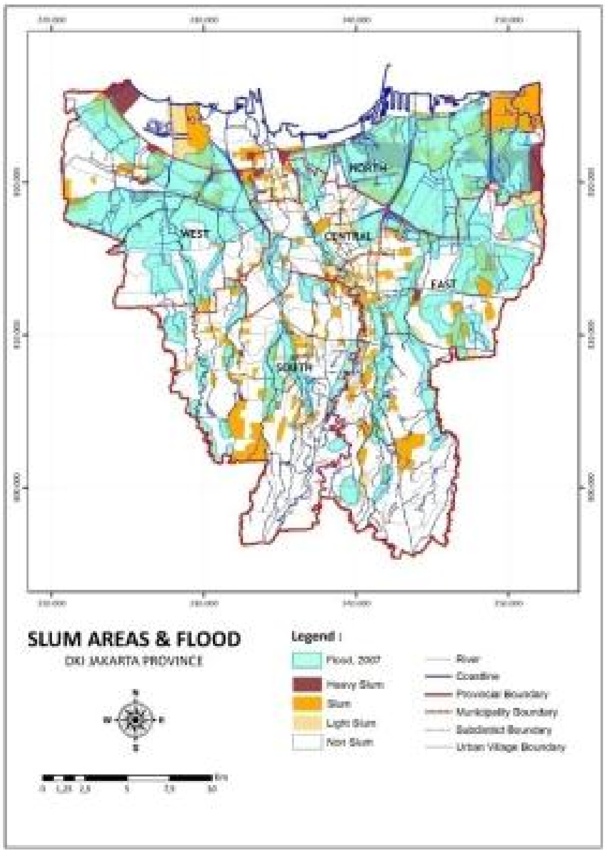
Year	Fire Incidents (case)	Dead (person)	Injured (person)	Economic Losses (Rp billion)
2011	963	13	67	180
2010	693	21	69	205
2009	769	NA	NA	253
2008	792	NA	NA	222

Source : Jakarta Provincial Disaster Risk Management Agency (2012)

JAKARTA FLOOD 2007

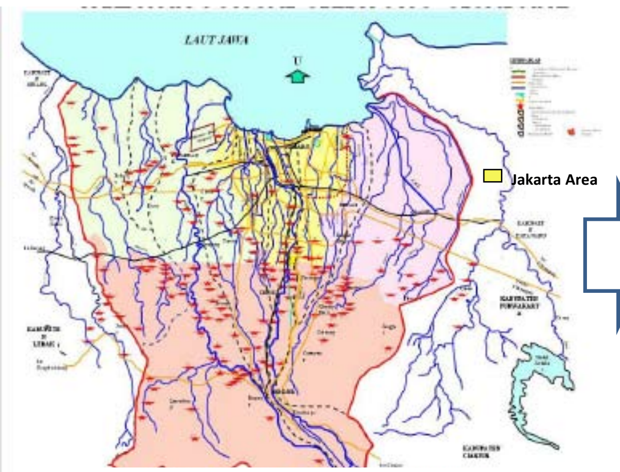
In February 2007, Jakarta was hit by one of the worst flood ever experience (return period 50 years), covering 70% of metropolitan area, with total Financial Loss of US $ 879,12 million, and Loss of Lives: 79, Refugees: 223,203.

JAKARTA FLOOD 2007

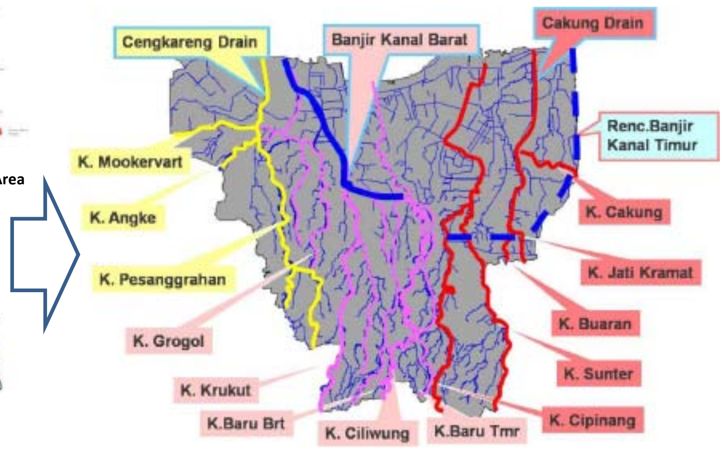


FLOOD RELATED FACTORS

- Jakarta is crossing by 13 River System from Greater Jakarta (Jabodetabek).
- 40% of Jakarta area, particularly at part of North Jakarta is a low-land, lies below Mean Sea Level.
- Land subsidence increased by 0.5 cm per year.
- High tide due to the increasing of Mean Sea Level by 0.5 cm per year as an impact of global warming
- Heavy rain fall due to the increasing of sea surface temperature to 0.5 - 1^{o} C



Jakarta is crossing by 13 River System from Greater Jakarta (Jabodetabek)

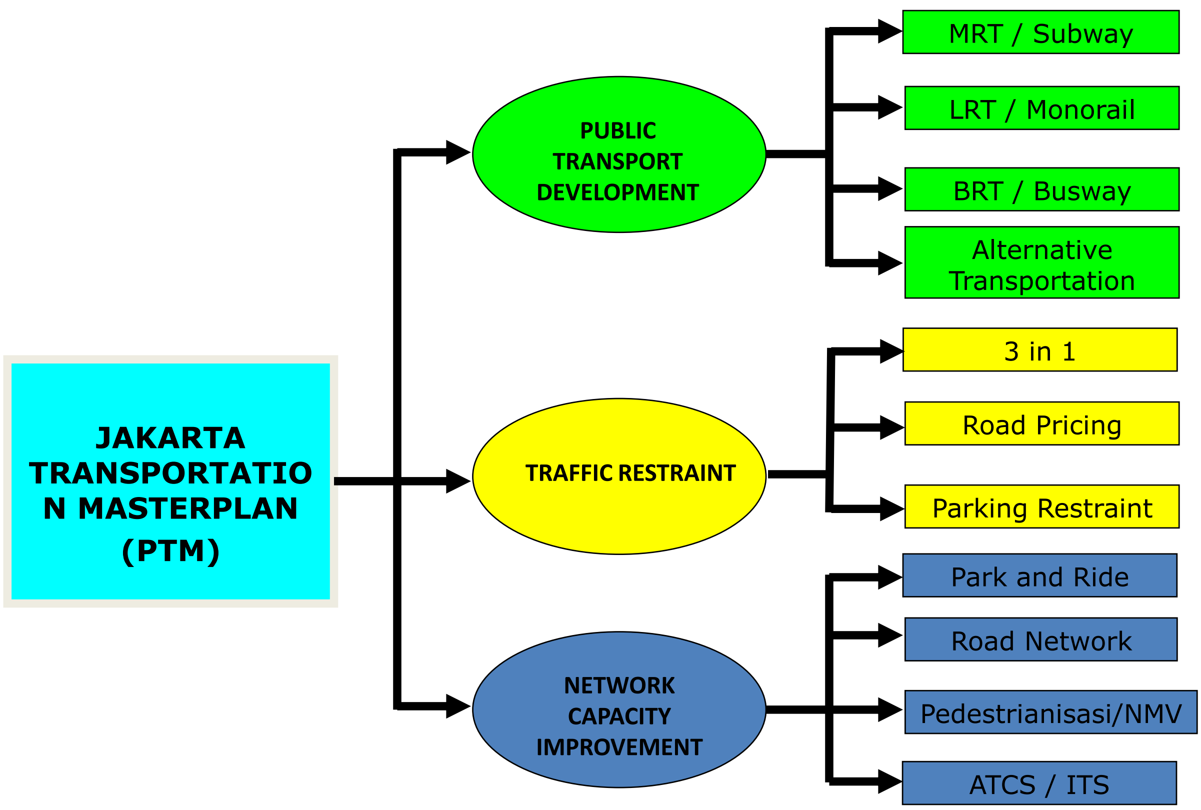


13 Rivers System Across Jakarta

MAIN CAUSES OF FLOODS IN JAKARTA

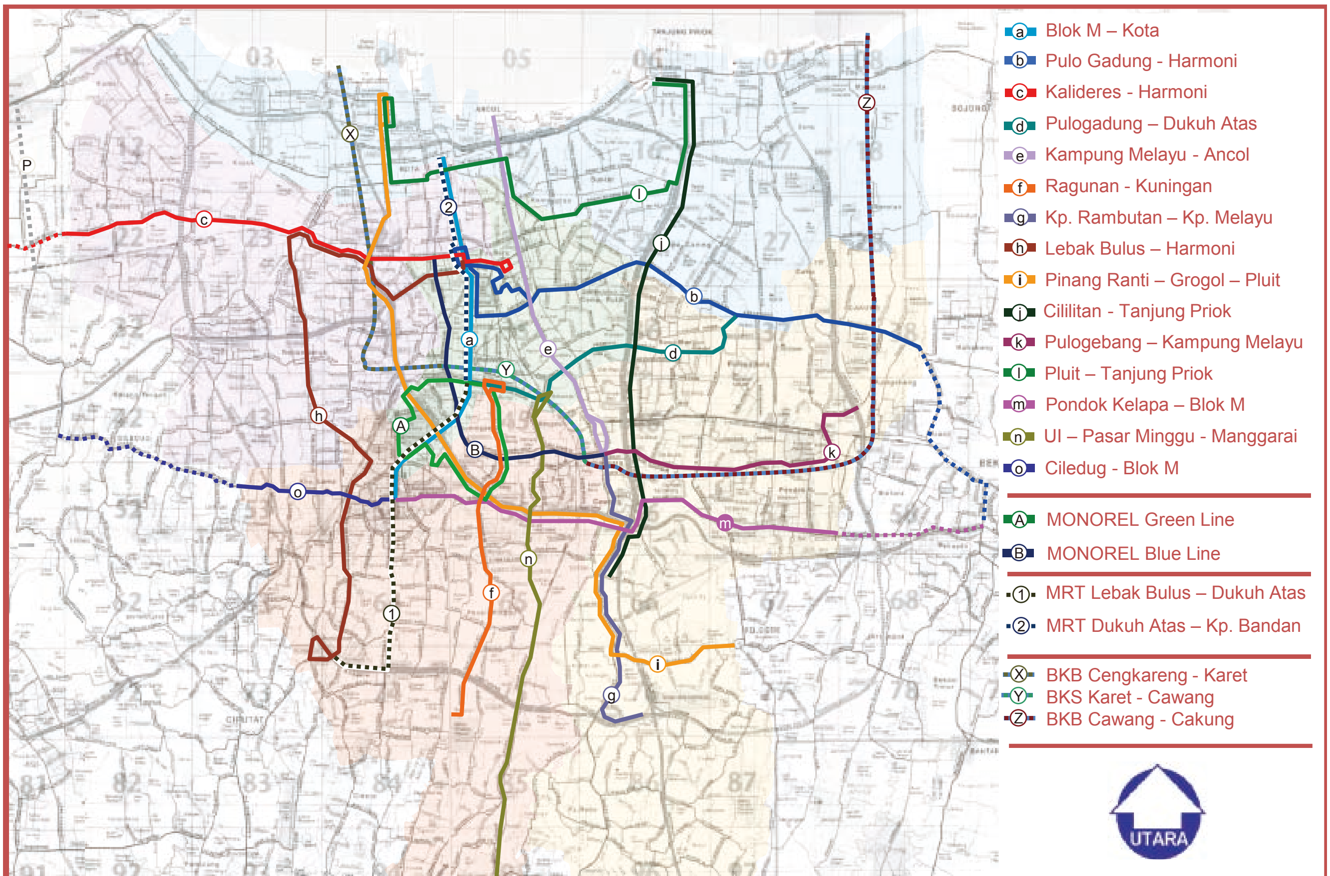
1. Encroachment of river corridors / drainage canals;
2. Reduced drainage capacity of rivers and canals due to sedimentation;
3. Land subsidence (North Jakarta) due to excessive ground water abstraction;
4. Indiscriminate solid waste disposal in rivers and canals;
5. Residential and commercial use of retention areas, open space and green areas particularly at upstream area outside Jakarta;
6. Insufficient retention and storage capacity upstreams (deforestation, real estate development, encroachment of natural lakes and reservoirs).

TRANSPORTATION RESOLUTION : 3 STRATEGY IN JAKARTA TRANSPORTATION MASTERPLAN



FIRST STRATEGY : PUBLIC TRANSPORT DEVELOPMENT

1. **Mass Rapid Transit** (Subway)
2. **Light Rail Transit** (Monorail)
3. **Bus Rapid Transit** (Busway)
4. **Alternative Transportation** (Waterways)



PUBLIC TRANSPORT NETWORK 2020
JAKARTA TRANSPORTATION MASTERPLAN

SECOND STRATEGY : TRAFFIC RESTRAINT

1. **Traffic Restraint Zone (3 in 1)**
2. **Electronic Road Pricing (ERP)**
3. **Parking Control and Pricing**
4. **Park & Ride Development**

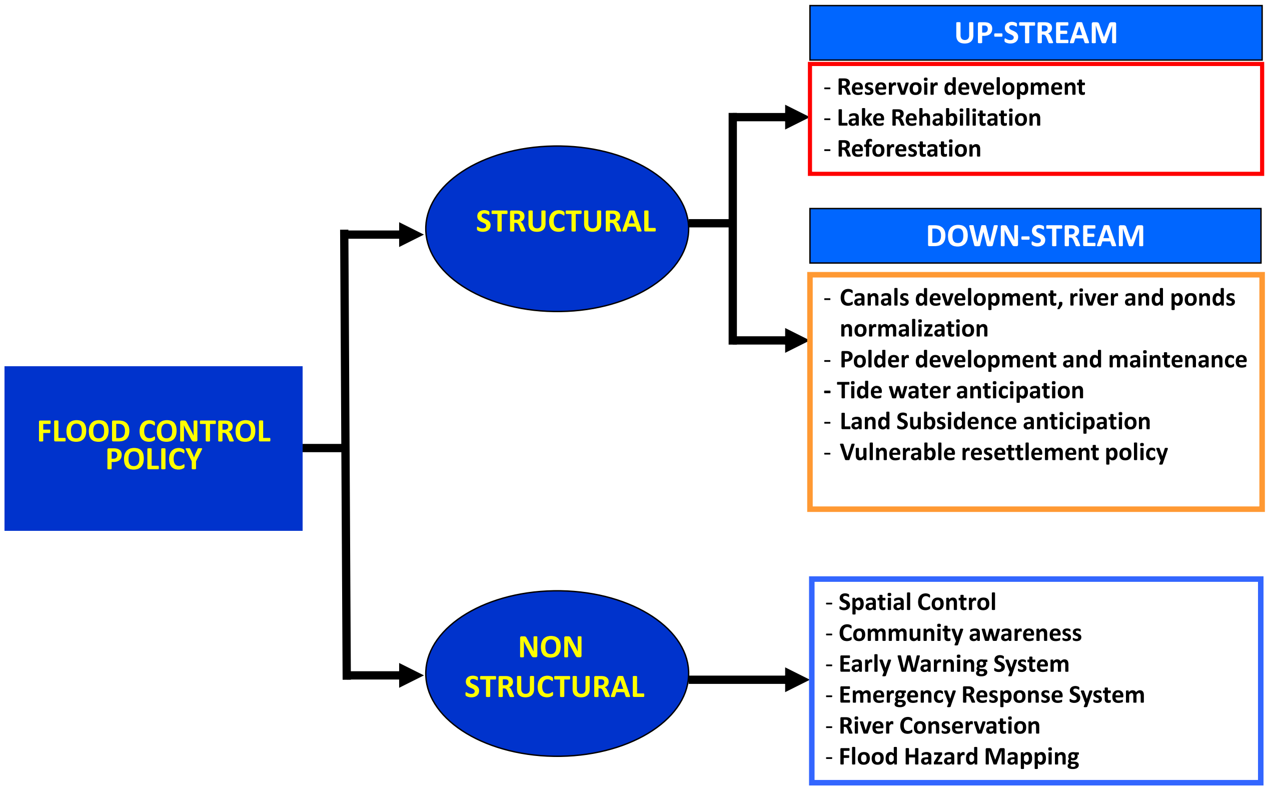
THIRD STRATEGY : NETWORK CAPACITY DEVELOPMENT

1. **Area Traffic Control System (ATCS) Development**
2. **Road Maintenance and Improvement**
3. **Flyover and Underpass Development**
4. **Toll Road Development**
5. **Pedestrian Facility Improvement**

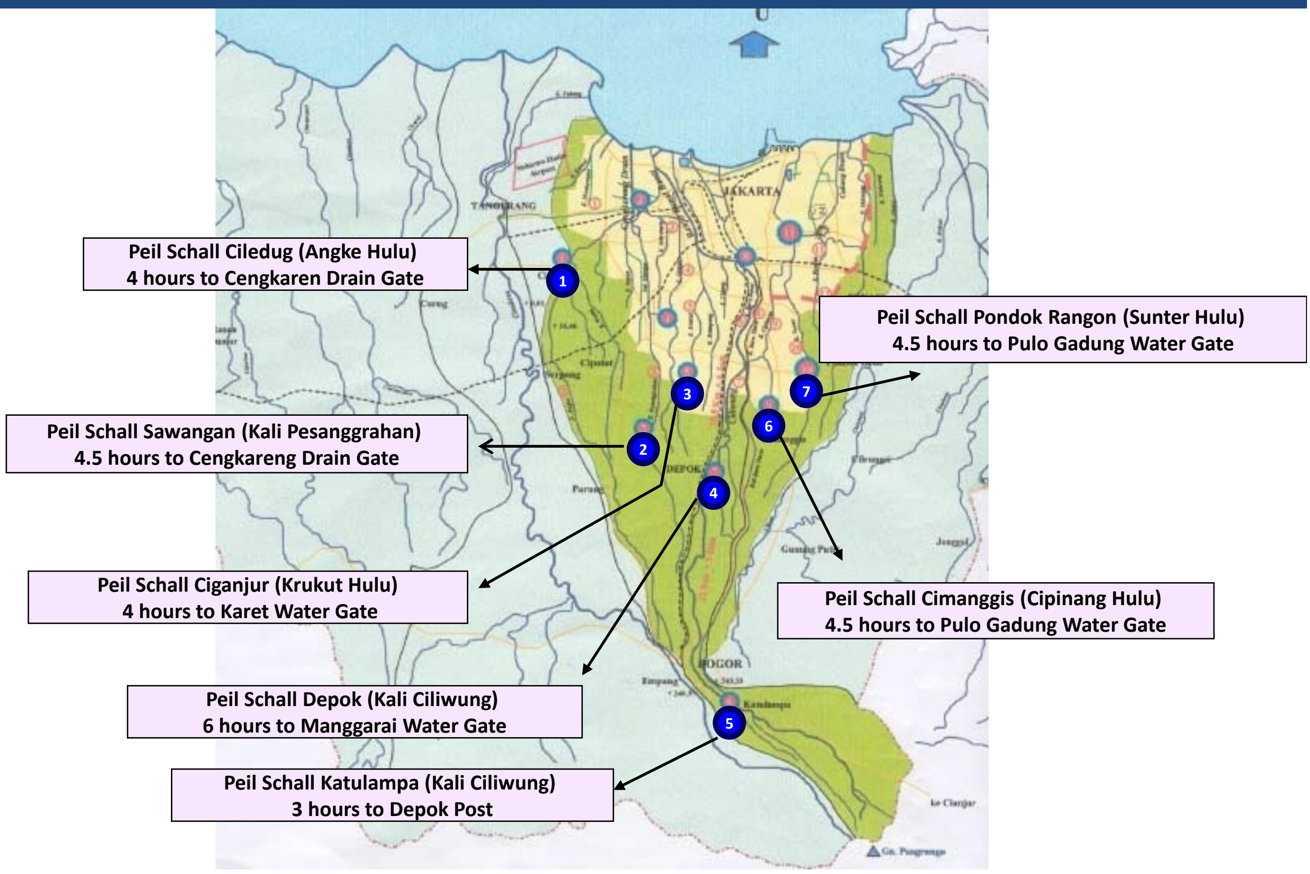
INTELLEGENT TRANSPORTATION SYSTEMS IMPLEMENTATION

1. **Area Traffic Control System (ATCS)**
2. **Electronic Road Pricing (ERP)**
3. **Traffic Management Center (TMC)**
4. **Bus Rapid Transit (BRT) Automation**

FLOOD RESOLUTION : FLOOD CONTROL POLICY



JAKARTA'S FLOOD EARLY WARNING SYSTEM



SPATIAL PLANNING STRATEGY FOR JAKARTA 2030

1. Developing Jakarta to the West, East and **North** and controlling development to the South
2. Expanding the development to the North while managing the Jakarta Bay through reclamation and building the **International Hub Port**
3. Optimizing and developing system of centre for service and trade, goods distribution, tourism and **creative economy**, both within national and international scale, supported with sufficient infrastructure and facilities
4. Developing Mass Rapid Transit system as a backbone of transportation network and implementing **Transit Oriented Development** for the area surrounding
5. Implementing **redevelopment, revitalizations**, and **renewing** areas in the city that is strategic and with high potency
6. Developing infrastructure and facilities for flood control by polder system development, returning and refunctioning dams and reservoir, river normalization and building **wall defense for sea and river**





SPATIAL PLANNING STRATEGY FOR JAKARTA 2030

7. **Integrating infrastructure system** of Jakarta with Bodetabek
8. Optimizing the utilization of land by **developing vertical housing** and selectively implementing the renewable and improvement of "kampung" area
9. Controlling ribbon development by consolidating **commercial activities into centers**
10. Preserving **heritage area** for tourism, cultural, historical and science interests
11. Protecting the conservation area, water resources and green open space for ecology balance
12. **Anticipating global warming** by implementing green building concept


ROLES OF GEO-SPATIAL, SATELLITE AND REMOTE SENSING

1. Provide synoptic overview of pre- and post-situation;
2. Substitute non-existing or outdated maps;
3. Provide tailored thematic information (damage);
4. Support the field mission planning (where is the most affected area, what type of damage can we expect, etc.);
5. Extrapolate field observations to statistically (more) reliable estimates of the total scale of the damage;
6. Unbiased information that is not distorted for political reasons or other forms of misinformation .

IMPORTANT STEPS TAKEN BY DKI JAKARTA GOVERNMENT

1. Establishing of the provincial disaster risk management agency (BPBD);
2. Jakarta Coastal Defense Project to build a 60 km long sea defense along coast to prevent damage both from tsunami risk, land subsidence and sea level rise;
3. Jakarta Urgent Flood Mitigation Project : conducted a study of dredging plan for river across Greater Jakarta Area;
4. The Jakarta Building Control and Monitoring Office is develo ping a risk map for Jakarta within micro zones of 150 square meters (for each zones), which analyzes buildings and soil condition within each. This program relates to earthquakes and building quality;

IMPORTANT STEPS TAKEN BY DKI JAKARTA GOVERNMENT

5. Empowering the civic police to undertake enforcement for traffic support, social issues, and disaster mitigations;
6. Implementing the PTM in the multi-years basis to rescue traffic problems in the short, medium and long term periods;
7. Establishing the crisis center managed by civic police and fire brigade to monitor incidents on day-to-day basis.

パネルディスカッション Panel Discussion

Dr. Srikantha Herath / Sri lanka

Managing Catastrophic Disasters

Srikantha Herath

Senior Academic Programme Officer

United Nations University, Institute for Sustainability and Peace

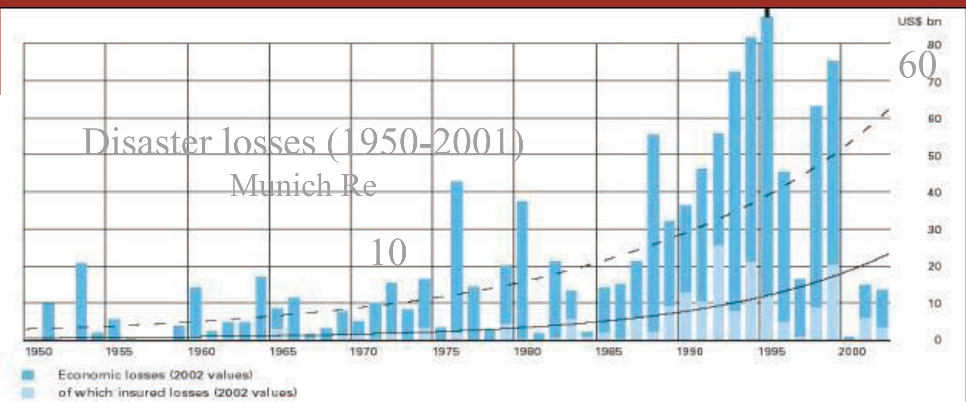
1

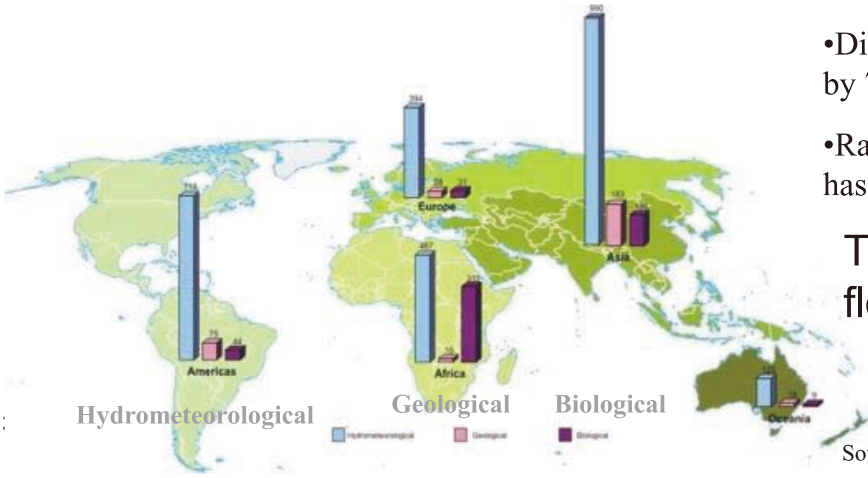
Outline

- Disaster trends
- Impact of 2004 Indian Ocean Tsunami in Sri Lanka and comparison with Tohoku experiences
- Disaster impacts in Frequency - Loss domain
- Recovery experiences from Sri Lanka
- Lessons for sustainable catastrophic risk management

UNITED NATIONS UNIVERSITY
UNU-ISP

Global Disaster Trends and Characteristics





•Disaster losses have increased by 7 times in last 40 years

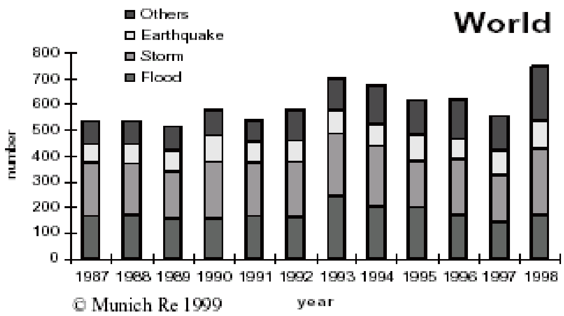
•Ratio to insured vs. non insured has expanded

This talk will focus on flood disasters mainly

Source: ISDR based on EMDAT

UNITED NATIONS UNIVERSITY UNU-ISP

Are floods increasing?



- Munich Re study from a 25 year data base show that there is no significant change in the number of disasters from 1987 to 1998 (verified data). Comparison of total disasters to catastrophic disasters show a slight increase of total disasters due to the increased information flow.
- However, the economic loss has increased significantly over the past decades

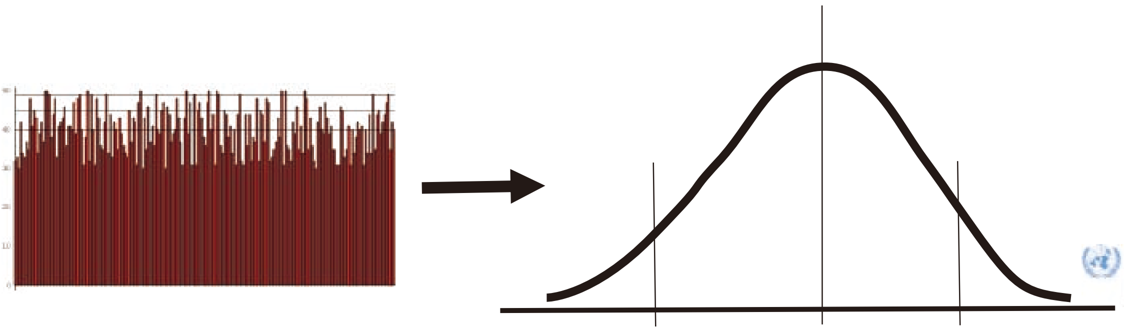
	Decade 1950-59	Decade 1960-69	Decade 1970-79	Decade 1980-89	last 10 1989-98	Factor last 10:50	Factor last 10:60
Number	7	7	9	20	34	4.9	4.9
Economic losses	27.9	20.2	19.2	25.5	199.6	7.2	9.9
Insured losses	---	0.2	0.4	1.4	7.4	---	37

Losses in bn US-$ - values 1998 © Munich Re 1999

Flood Trends and Global Change
Thomas Loster
Proceedings of the EuroConference on Global Change and Catastrophe Risk Management: Flood Risks in Europe
IIASA
Laxenburg, Austria

Extreme Events

- Extreme Events refer to events that are rare at a given place and time
  - Rainfall, temperature, wind, pressure
- How rare?
  - less than 10th percentile
  - greater than 90th percentile



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Why losses are increasing?

- Increased exposure
  - Population growth
  - Migration to vulnerable areas
    - Coastal areas
    - Flood plains
- Increase in the value of assets
- Increase in the vulnerability of structures (infrastructure, buildings due to aging)
- Changes in environmental conditions
  - Urbanization
  - Climate change.

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Catastrophic Disasters

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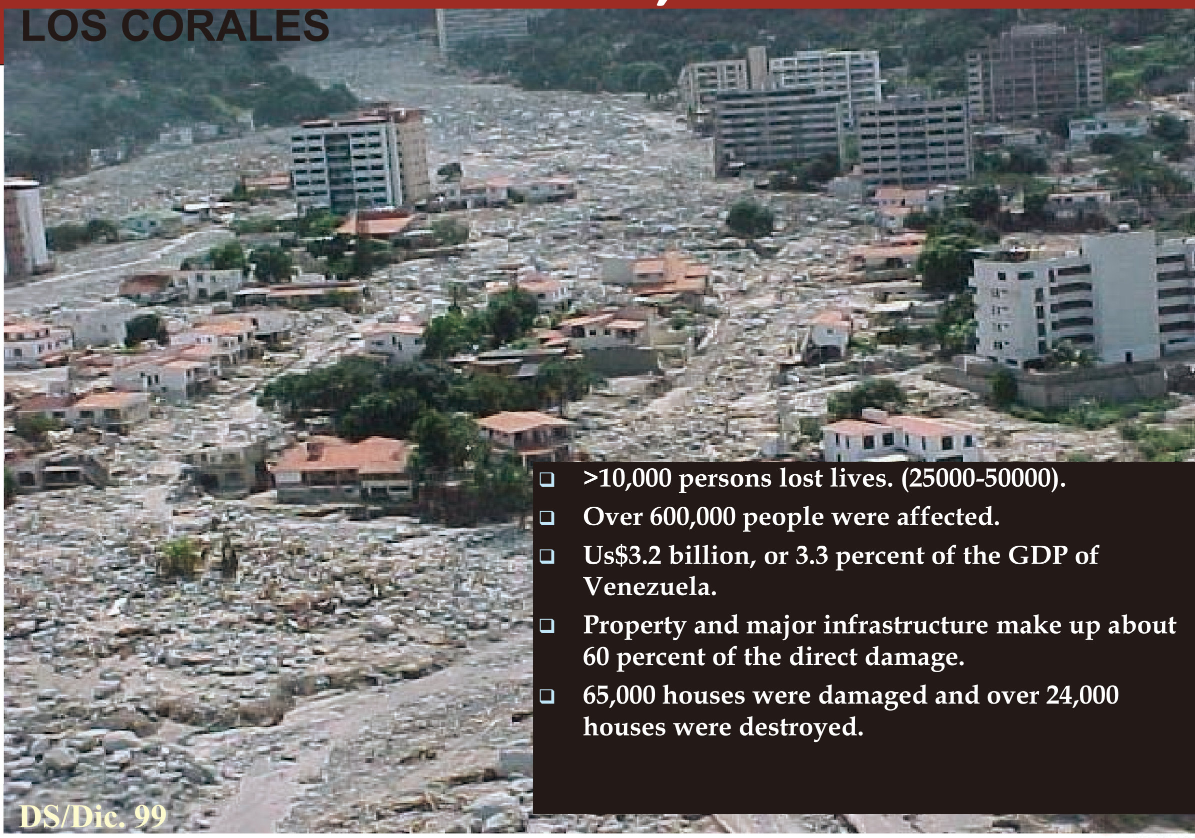
Venezuela, debris flow



- >10,000 persons lost lives. (25000-50000).
- Over 600,000 people were affected.
- Us$3.2 billion, or 3.3 percent of the GDP of Venezuela.
- Property and major infrastructure make up about 60 percent of the direct damage.
- 65,000 houses were damaged and over 24,000 houses were destroyed.

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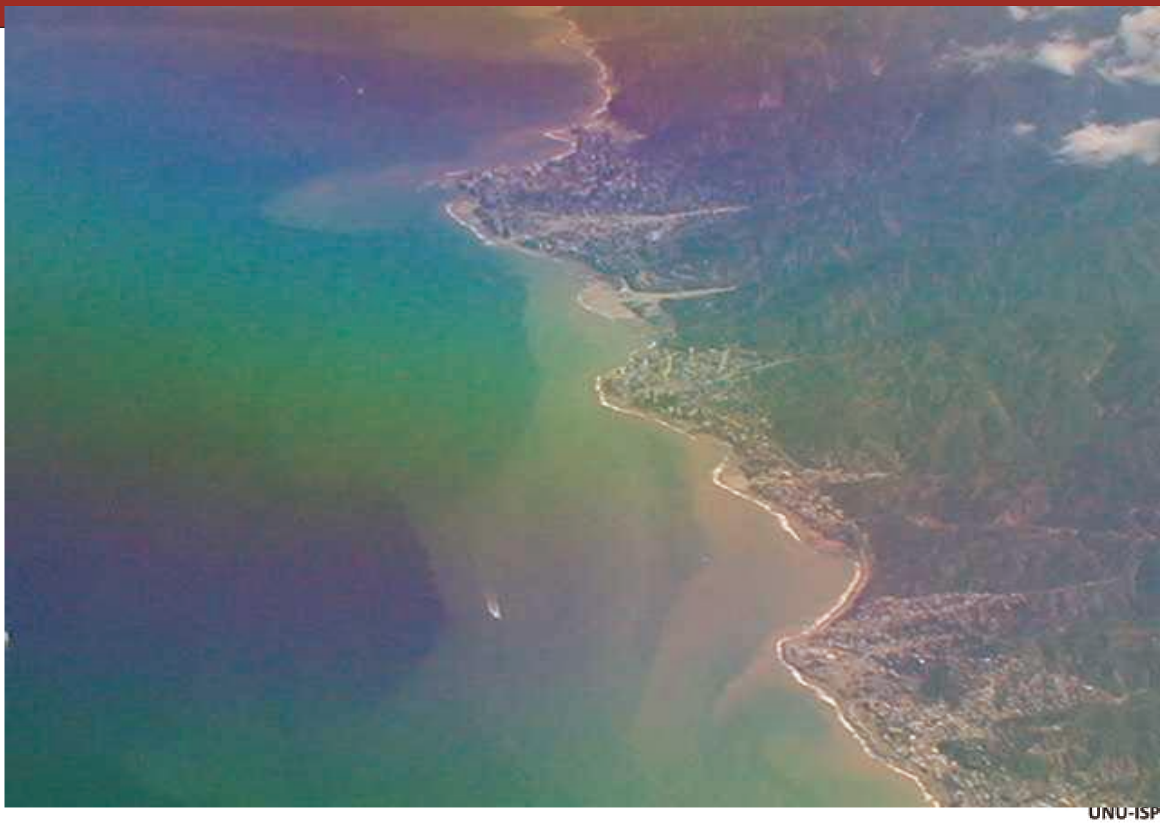
Development in vulnerable areas



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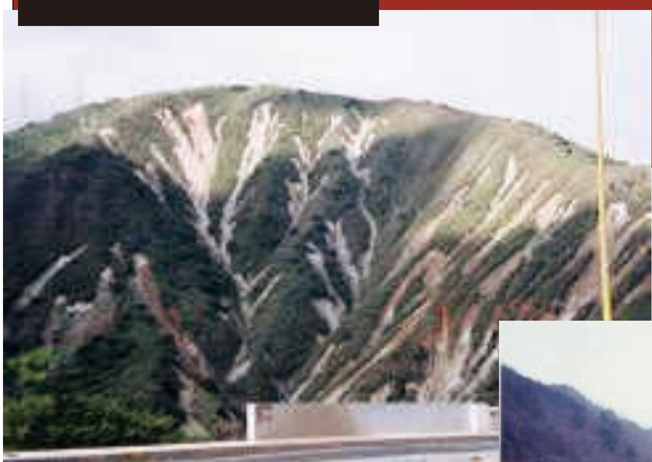

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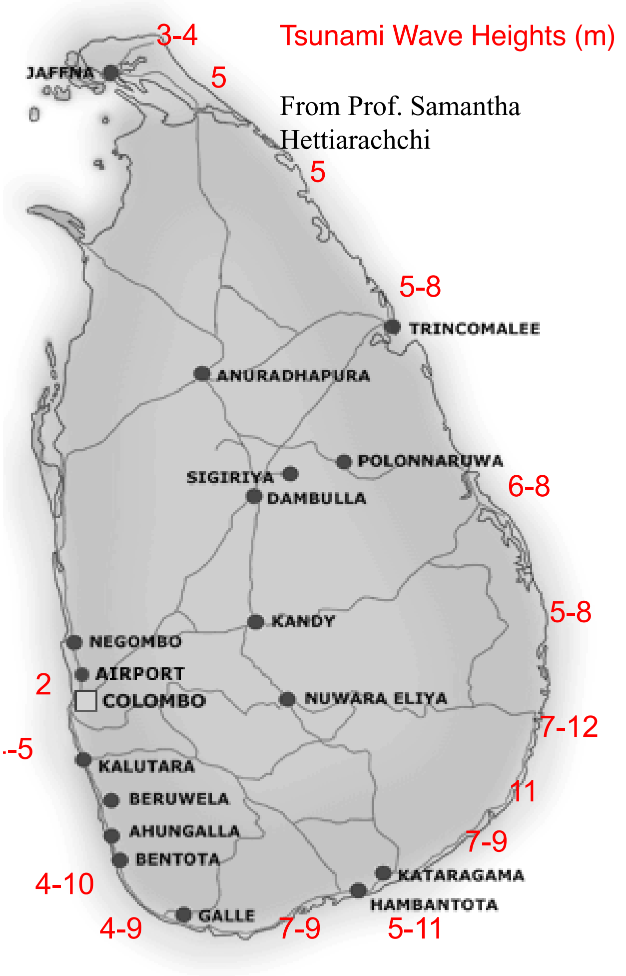
2004 Indian Ocean Tsunami

- In Sri Lanka estimates stood at more than **31,000** lives lost, **4,100** missing and 1 million affected. Almost half of the affected lost their livelihoods
- Sri Lanka: 1,809 persons killed per 1 million inhabitants; Next was Indonesia with 759 persons killed per million
- Economic losses at about 7% of GDP. Economic growth will drop by 1% (6 -> 5%)
- Damage to housing: 50,000(full) +38500 (partial) >>Build 100,000 new houses.

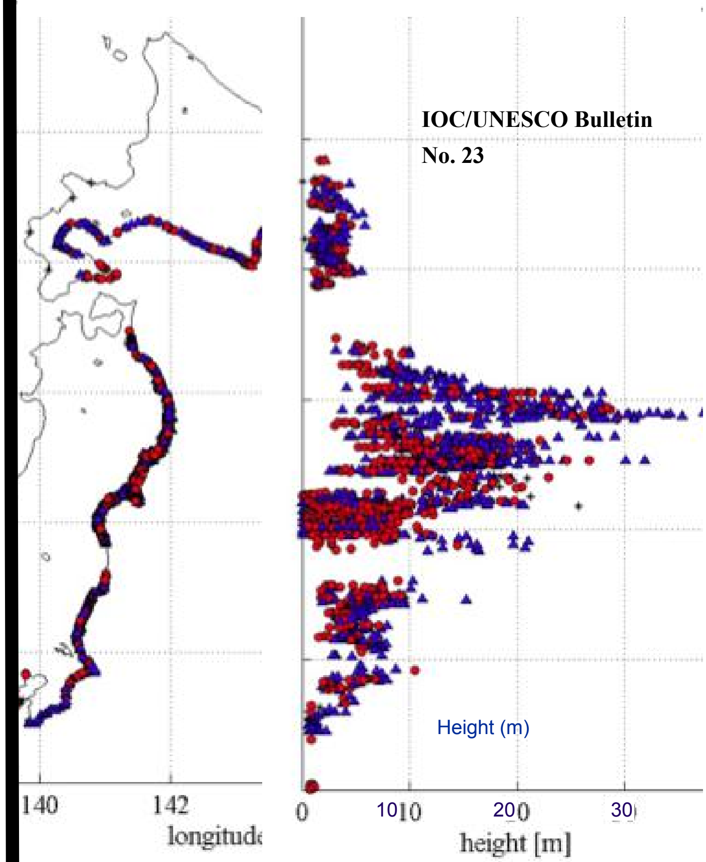
Tsunami Wave Heights (m)

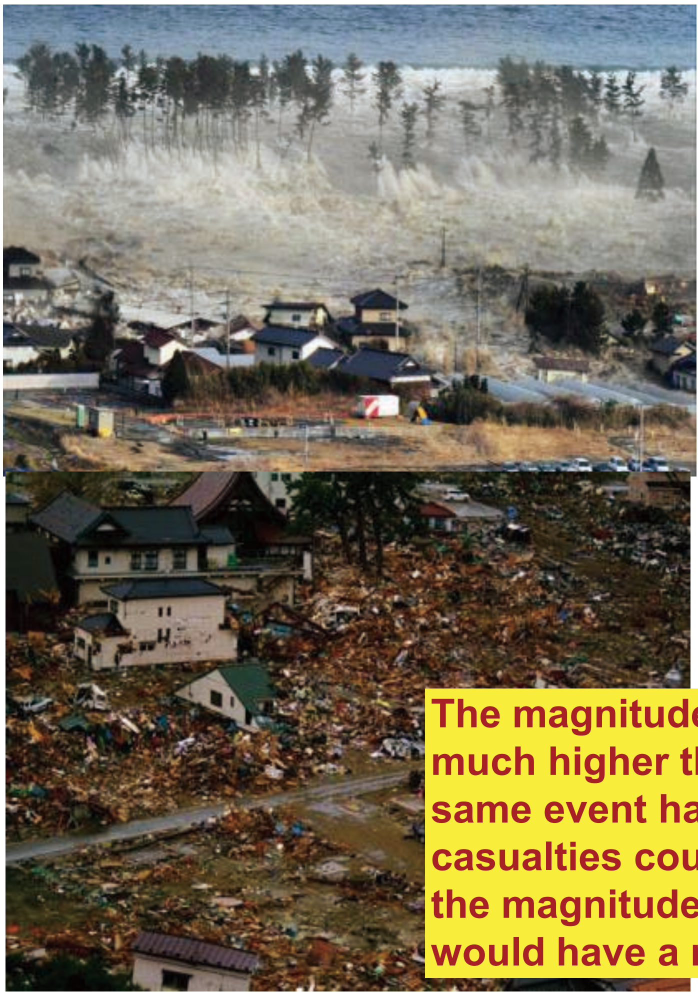
From Prof. Samantha Hettiarachchi



TOHOKU EARTHQUAKE TSUNAMI HEIGHTS

IOC/UNESCO Bulletin No. 23 As of 2 May 2011



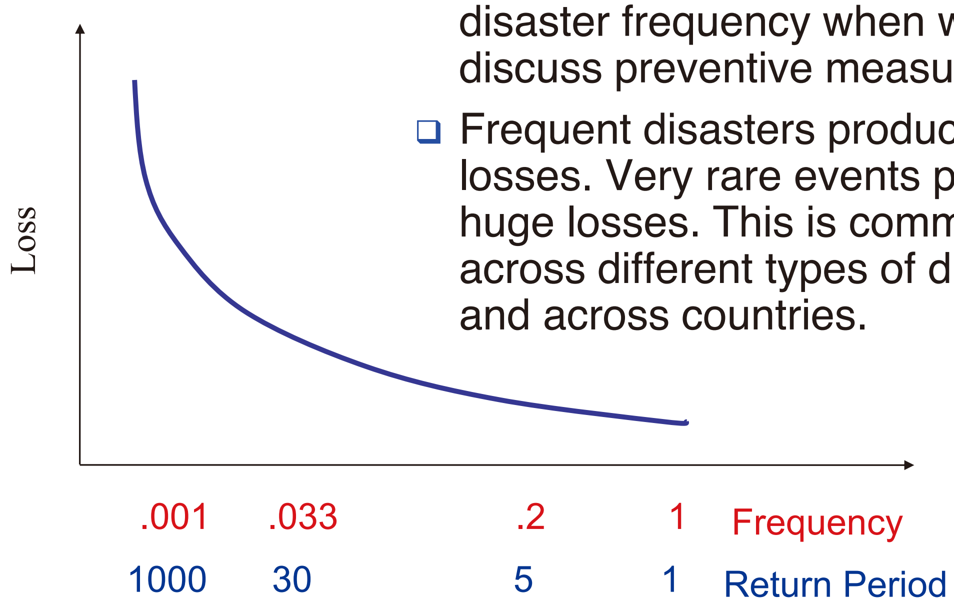


- Japan Losses are estimated 15,093 deaths, and 9,121 people missing .
- 195 persons per 1 million of population lost their lives.
- The Japanese Government estimates total economic losses from the Tohoku disaster to be between US$198 to 309 billion, approximately 3.6 percent to 5.7 percent of 2010 GDP.
- Over 125,000 buildings damaged o destroyed, about 1/4 of new constructions per year.

The magnitude of the Tsunami in Japan is much higher than that of Sri Lanka. If the same event happened in Sri Lanka the casualties could be extremely high where as the magnitude of 2004 Indian ocean tsunami would have a much lower impact in Japan.

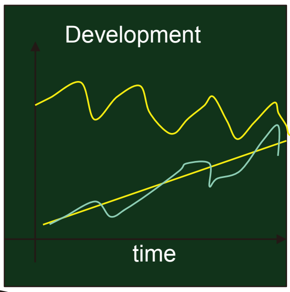
Frequency Loss Relation and Risk Reduction Strategies

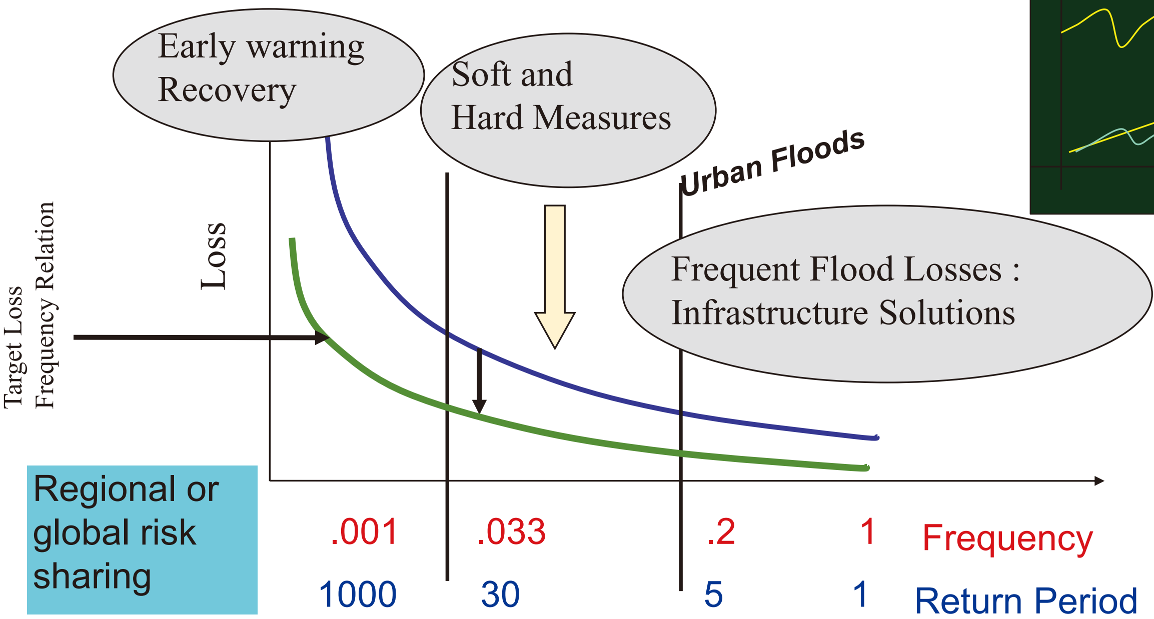
- It is better to compare losses with disaster frequency when we discuss preventive measures.
- Frequent disasters produce small losses. Very rare events produce huge losses. This is common across different types of disasters and across countries.



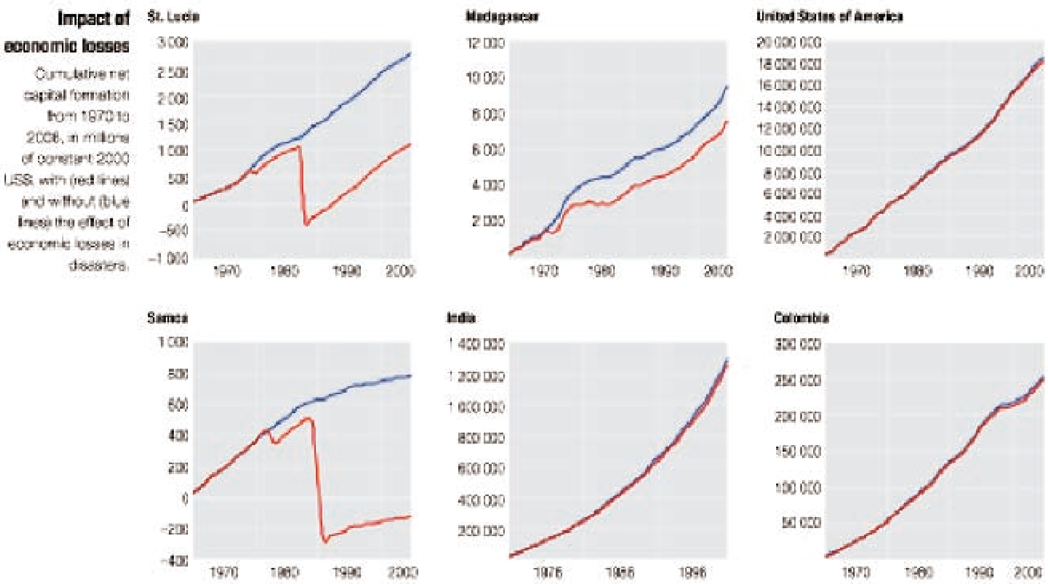
Frequency Loss Relation and Risk Reduction Strategies

- In disaster management our objective is to move the loss line as low as possible. This would need different approaches for different frequencies.
- Now, the challenge is to manage risks in the left most column, catastrophic events that are rare but have very high impacts.





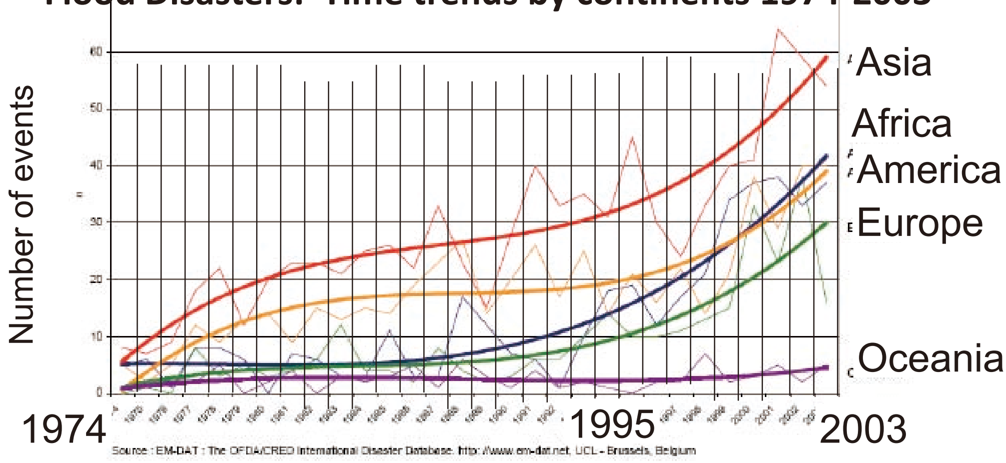
Development and disaster risk reduction



Global Assessment Report: ISDR, 2009

Climate Change impacts

Flood Disasters: Time trends by continents 1974-2003

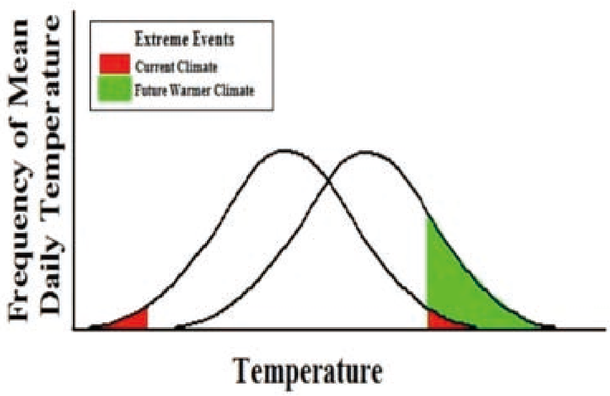


Nature Journal Feb, 2011

- **Human contribution to more-intense precipitation extremes**
- **Anthropogenic greenhouse gas contribution to flood risk in England and Wales in autumn 2000**

CC and change of extremes

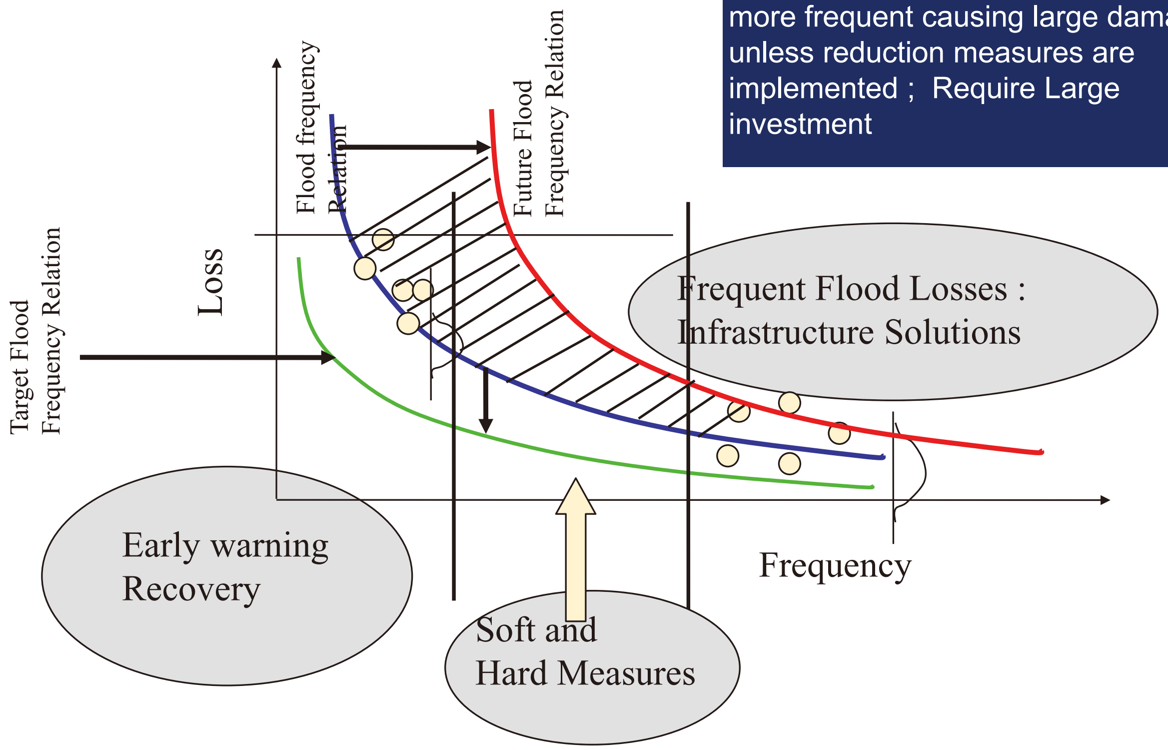
- Changes to extremes are more important than the changes to mean
- Past extreme magnitudes become more frequent
- Return period for a given magnitude will become shorter



- Extremes can increase from increasing mean as well as increasing variability

Flood Frequency Loss Relation Changes due to climate change

Rare extreme events will become more frequent causing large damages unless reduction measures are implemented ; Require Large investment



How do we mitigate such losses in the future?

- Rare events: Limited experiences--> need to share and disseminate
- Improve existing disaster mitigation strategies by considering catastrophic risks in a sustainable framework.
- Risks of catastrophic ‘rare’ events should not be isolated from daily livelihood needs.
- Solutions should be holistic -- integrated

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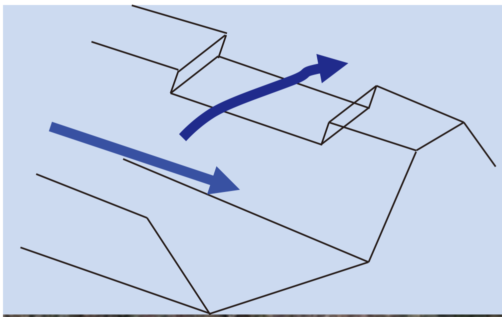
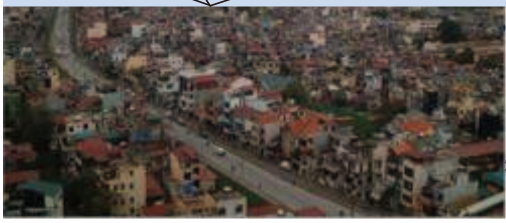
Coping with Extremes: UNU Experiences

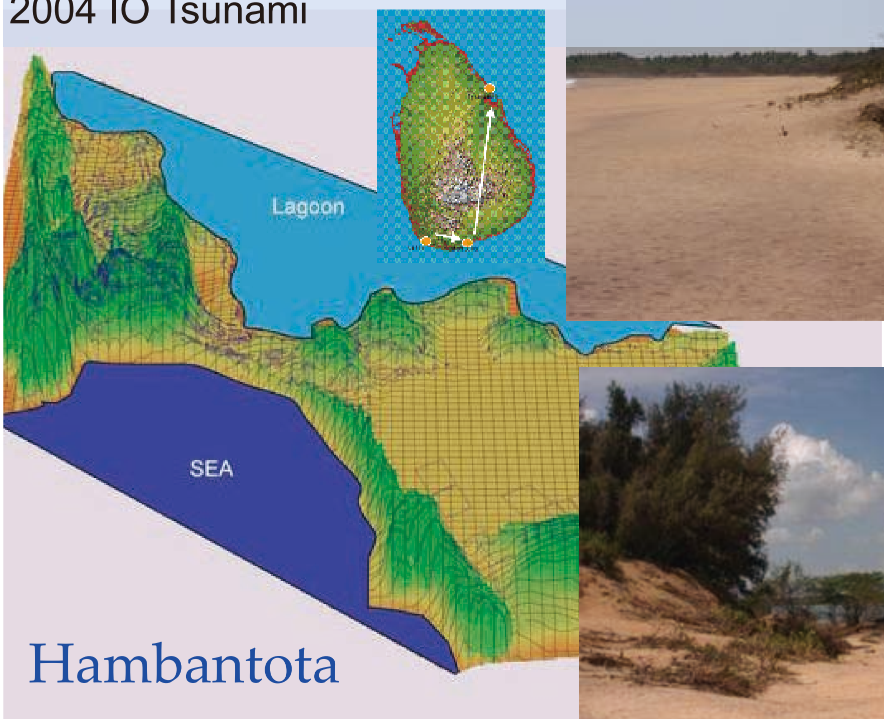
- Challenge: Accept complete safety is not possible
- Make infrastructure that would fail in a safe way when they exceed design standards, rather than trying to make protective structures that would not fail.: Provide a safety valve - ‘safefail’ instead of ‘failsafe’
- Share risks >> globally



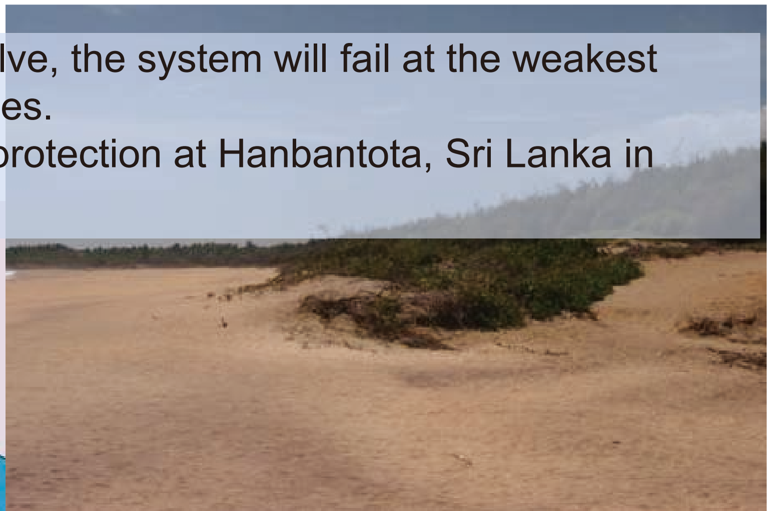


- Examples:
  - Make spillways along river dyke upstream. Excess water would spill off at designated locations along river preventing catastrophic losses
  - Ring dykes protecting vital assets and leaving space for floods

If we do not provide a safety valve, the system will fail at the weakest point, causing catastrophic losses.
Collapse of natural sand dune protection at Hanbantota, Sri Lanka in 2004 IO Tsunami



Breach of Sand Dunes



RBA Salinization: Experiences form Sri Lanka

- Salinization has made more than 15,000 wells unusable for drinking water supplies.
- Over-pumping to clean out often encouraged salt-intrusion and negative results
- Despite significant efforts, salinity improvements were driven mostly or exclusively by natural remediation from rainfall infiltration (IWMI)
- Rains helped to wash down the salt from soil, but increased the ground water contamination

Informing global community of the Japanese experience, the good practices, lessons, resilient systems

The process of recovery planning should be made available to other countries.

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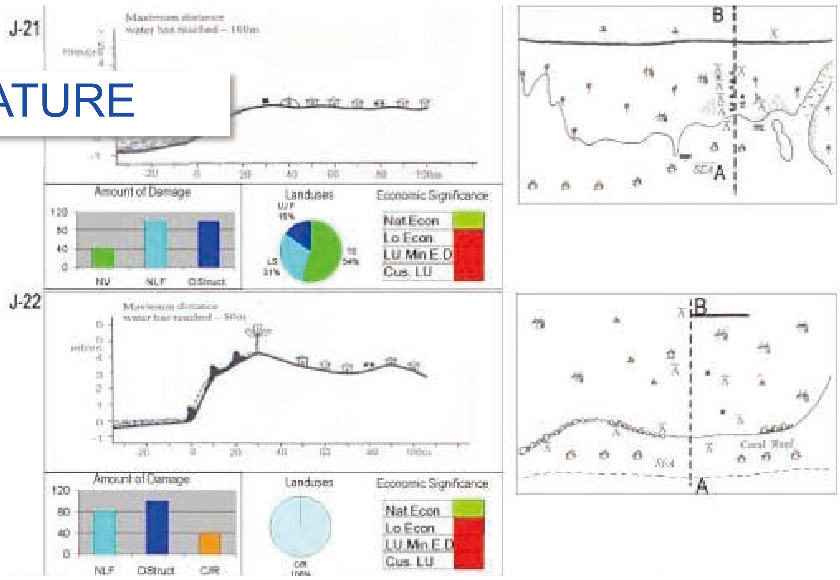
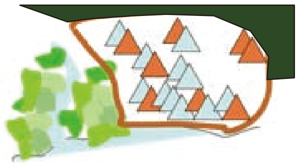
LEARNING FROM NATURE



An ecological survey with the support from UNEP had been carried out in Sri Lanka after the Tsunami. Surveys at 1 km interval went inland and took 6 transects each 500m to either side.

Inference: Limited impairment of ecosystem structure and functioning, (rare exceptions e.g., Bentota sand spit)

- Future cities may combine resilience of ecosystems to provide the 'safety valve' and protect people and important assets.



Galle Fort, Sri Lanka

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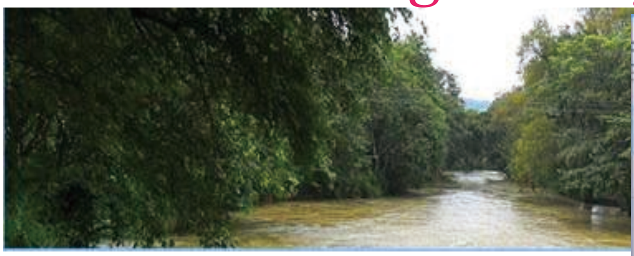
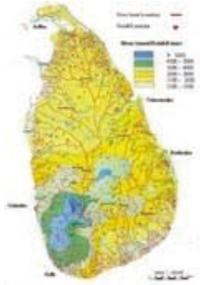
Ancient Irrigation Systems - Sri Lanka



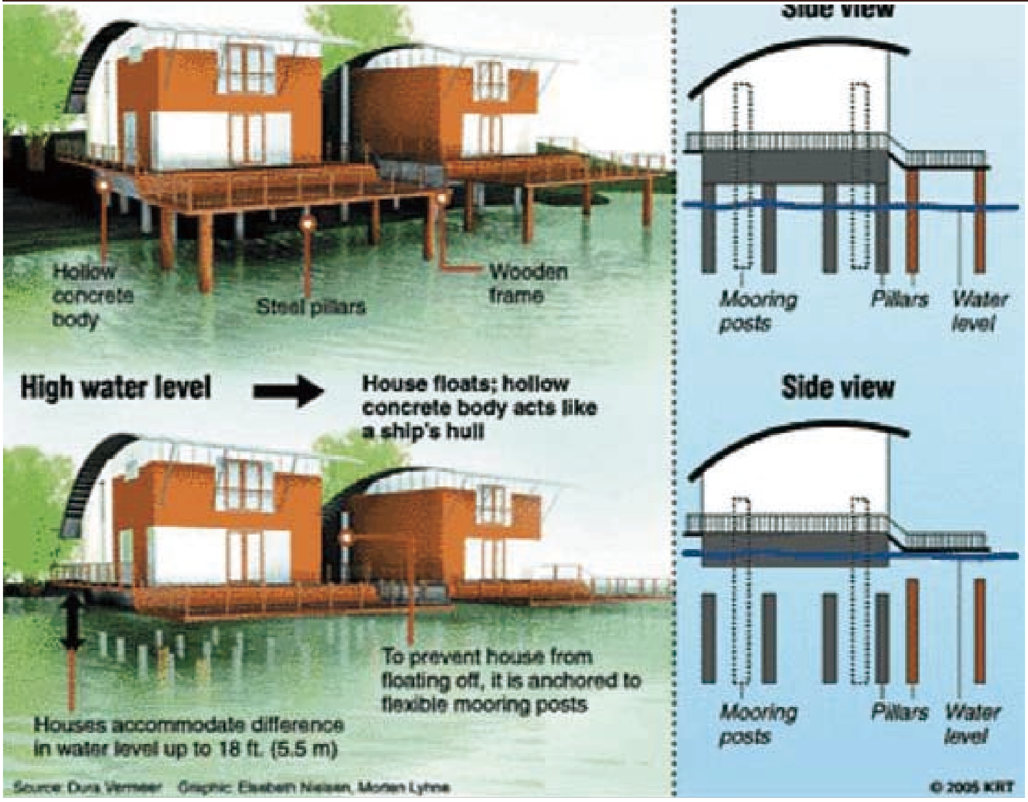


- They have been built from 5th century BC to 12th century AD → for 17 centuries
- Number of ancient small reservoirs (definition: have a command area < 80 ha) amount to about 20,000 (15,000 operating now)
- Micro-Macro Integration
- Resilience from Distributed Systems
- Multiple Benefits
- Community Based Management, integral part of daily life

Village tank also serves as the community center

Images of Parakrama Samuthraya

Floating Houses - Netherlands



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Low Impact Development (LID) New York City Plan

New York City has decided to invest US$5.3 billion in green infrastructure on roofs, streets and sidewalks to reduce flooding instead of US$6.8 billion in traditional pipe and tank improvements. This promises multiple benefits. The new green spaces will absorb more rainwater and reduce the burden on the city's sewage system, air quality is likely to improve, and water and energy costs may fall.

1. Build cost-effective grey infrastructure
2. Optimize the existing wastewater system
3. Control runoff from 10% of impervious surfaces through green infrastructure and other source controls
4. Institutionalize adaptive management, model impacts, measure CSOs, and monitor water quality
5. Sustain stakeholder engagement

Remarks

- Traditional disaster management does not handle creeping and catastrophic disasters well.
- We need to take ‘people cantered approaches to reduce impacts of such disasters.
- Concepts of environmental security provides a broad frame work to incorporate such activities.
- We also need to consider the global context to mitigate cases of climate related disasters and mechanisms to support mitigation and recovery measures.

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Thank you for your attention

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