INTRODUCTION VULNERABILITY ANALYSIS

Session

Developed by:

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Short Bio

Dr. Dyah Rahmawati Hizbaron, M.T, M.Sc
UGM, Geography (Bachelor)
ITB-RuG, Civil Engineering, Planning & Spatial Science (Master)
UGM, Environmental Science (Doctor)

Main interest:
Urban, vulnerability, risk, disaster, coastal & watershed management.

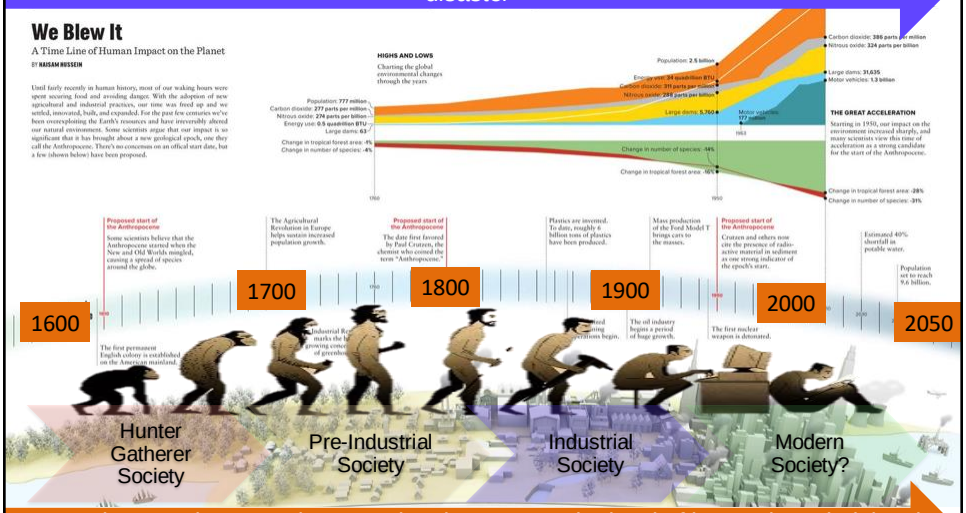
Publication:

https://scholar.google.co.id/citations?user=Bn-JvpsAAAAJ&hl=en

LEARNING OBJECTIVES

- Understand the basic concept and technique of vulnerability
- Develop critical thinking about different types of vulnerability indicator and the scales at which they are developed
- Understand the interrelations between humans and their natural environment
- Understand the linkages between global environmental problems and disasters
  - Understand that good land and ecosystem management will reduce disaster risks
  - Understand the importance of the Sustainable Development Goals for disaster risk reduction

Human occupied land, whereas, some of them are prone areas towards natural disaster



Human intervention to environment has been ages, the level of impact is varied, local to global

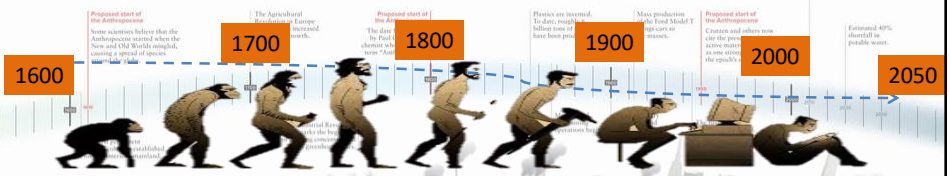
VULNERABILITY

HG Society + Natural Law = Vulnerable Society

PI Society + Spatial Inequality = Vulnerable Society

Id Society + Environmental Impact = Vulnerable Society

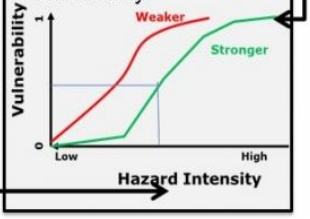
Md Society + Global Impact = Vulnerable Society



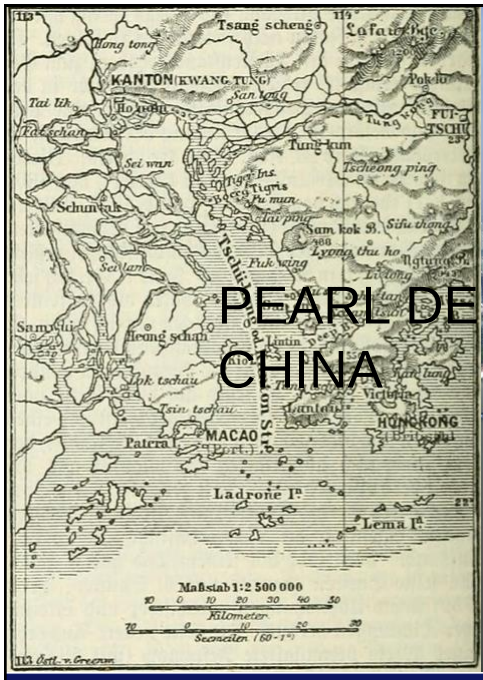
Vulnerability keynote: inability, adapt, cope, resilient, shock, stress

Risk = probability of losses =

Hazard	*	Vulnerability	*	Elements-at-risk
Temporal probability of hazard scenario, annual probability = 1/Return period	*	Degree of loss of a specific type of elements-at-risk given the intensity of a given hazard scenario	*	Quantification of exposed Elements-at-risk (e.g. nr. people/ buildings, monetary value)
• Hazard Type (e.g. debris flow, flash flood, river flood) • Other characteristics (Duration, onset time, hazard interaction etc.) • Hazard intensity: spatial distribution of damaging effects		• Focus is here on physical vulnerability.		• Type of elements-at-risk (e.g. people, building type, type of infrastructure). • Temporal variation of elements-at-risk (e.g. population scenarios) • Spatial location (e.g. points, lines, polygons)



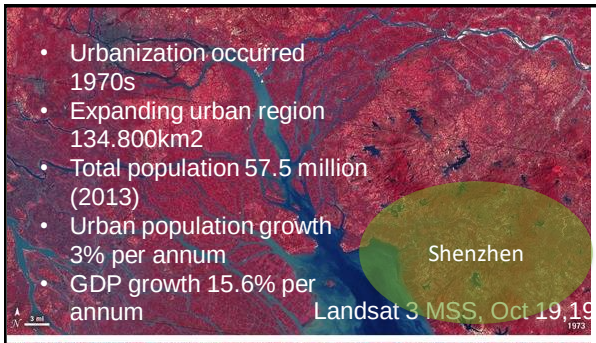
Exposure
Spatial overlay of hazard footprints and elements-at-risk locations



PEARL DELTA RIVER, CHINA

Golden Delta of Guangdong
9 megacities, 42 million populations

- Urbanization occurred 1970s
- Expanding urban region 134.800km2
- Total population 57.5 million (2013)
- Urban population growth 3% per annum
- GDP growth 15.6% per annum

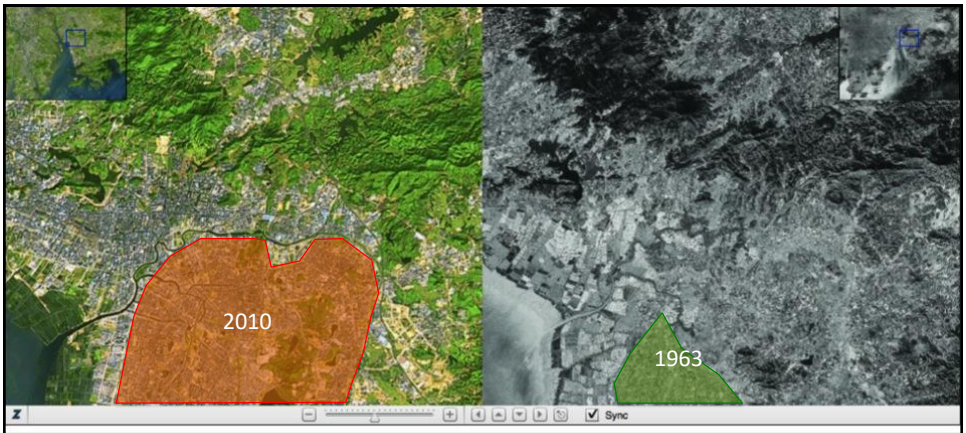


- Interpretation:
- Red: vegetation
- Grey: built up environment
- Blue: water body
- Centre for manufacture (Shenzhen & Zhuhai Special Ec Zone, 1980)

VULNERABLE SOCIETY

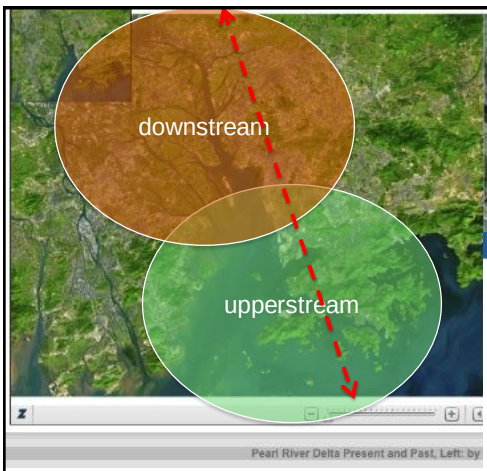
VULNERABLE AREA

VULNERABLE

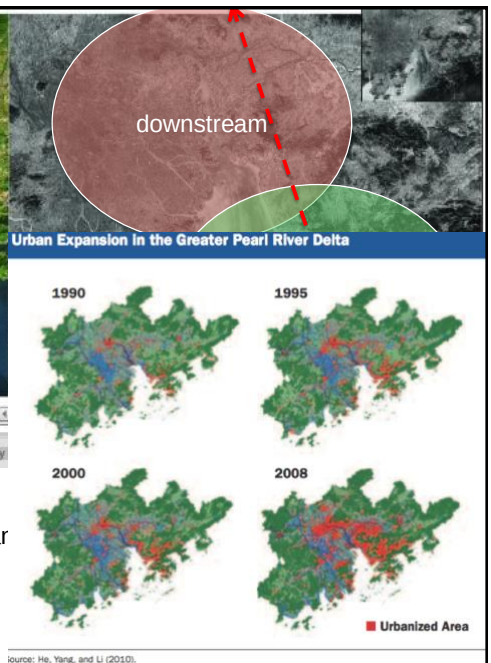


Pearl River Delta Present and Past, Left: by Landsat-7 in 2010; Right: By Corona in 1969

- Hong Kong was established 1842 during British colony
- '**Hong**' (香): 'fragrant', '**Kong**' (港): 'harbour'.
- A major hub of port and services
- Transcend into major urban port along South China Sea
- Worldwide investment accumulated in the area
- Now expanding to PDR for footloose industry
- Sending migrants across China Mainland



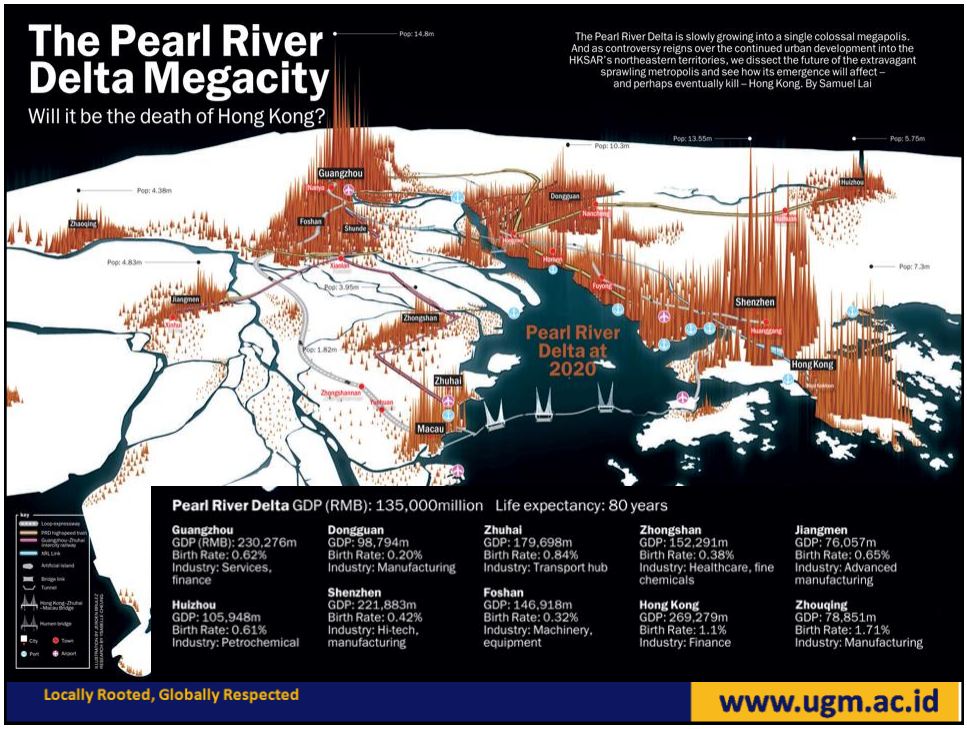
Pearl River Delta Present and Past, Left: by



Source: He, Yang, and Li (2010).

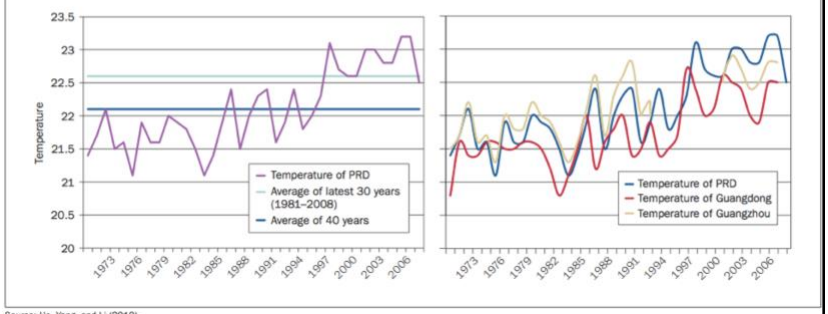
In the coastal-watershed management:

- Downstream likely more developed than upper-stream
- Not in the case of PDR (2010)
- It is the case of PDR (1968)



ENVIRONMENTALLY VULNERABLE?

Temperature Change in the Pearl River Delta, 1971–2008



Source: He, Yang, and Li (2010).

Urbanization – increase built up environment – less water retention – urban inundation

Urbanization – increase heat – less evapotranspiration – less precipitation – increase temperature – sea level rise – land subsidence – global warming, etc.

Locally Rooted, Globally Respected
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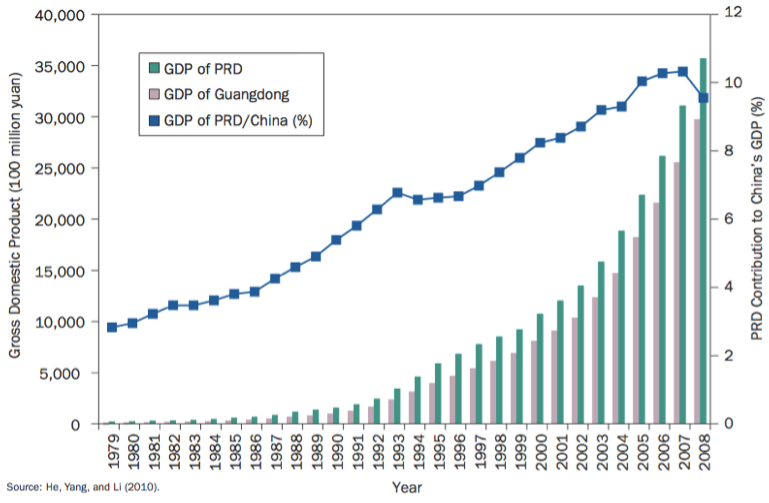
ECONOMICALLY VULNERABLE?



Abundant investment → "risk paradox"
The more asset, the more risk to bear

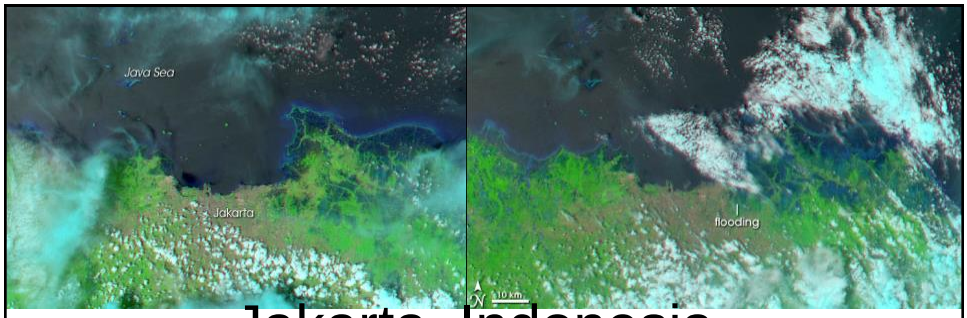
SOCIALLY VULNERABLE?

Climate Change Impacts on China's Coastal Provinces, 2008

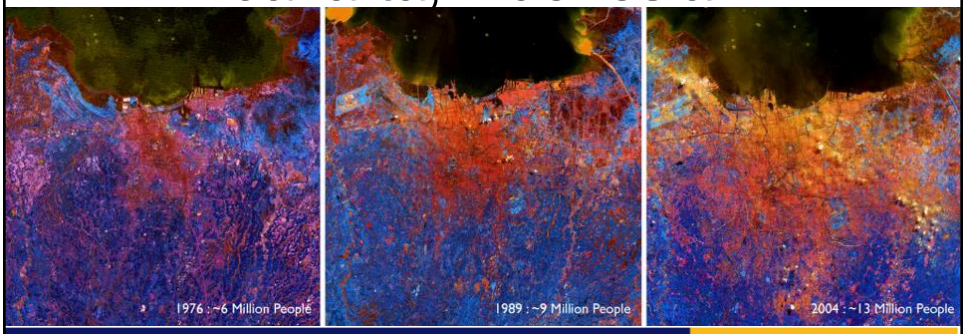
Province	Marine hazards			Sea level above the average of 1975–1993 (mm)	Estimated sea level rise, 2008–2038 (mm)
	Direct economic loss (100 million yuan)	Deaths	Erosion (km)		
Liaoning	0.24	27	142	50	78~120
Hebei	0.26		280	45	66~110
Tianjin			34	47	76~150
Shandong	12.89		1211	69	89~140
Jiangsu	0.38		225	76	77~130
Shanghai	0.02		75	47	98~150
Zhejiang	0.97		54	39	96~140
Fujian	17.52		90	54	68~110
Guangdong	**154.29**	**73**	**602**	**75**	**78~150**
Guangxi	15.82	2	168	60	70~110
Hainan	3.66	23	827	86	80~130
Total	206.05	152	3708		

Vulnerable groups

Sources: China Meteorological Administration (2009a; 2009b).



Jakarta, Indonesia



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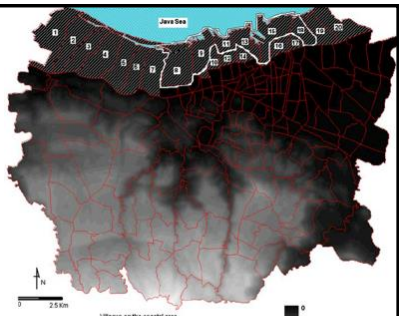
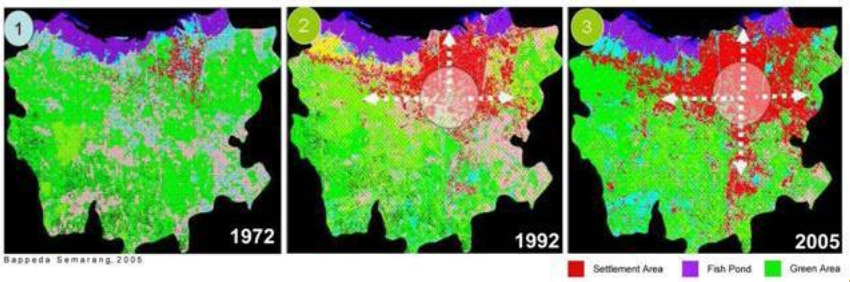


SEMARANG, INDON



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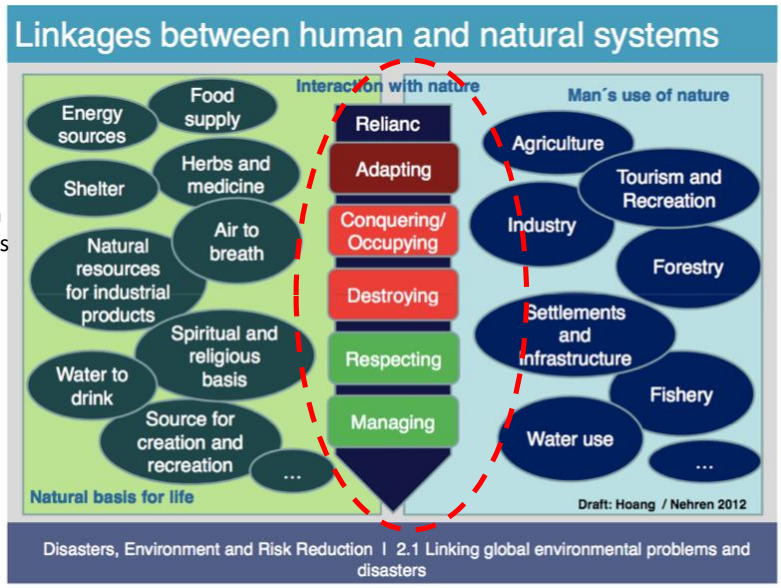
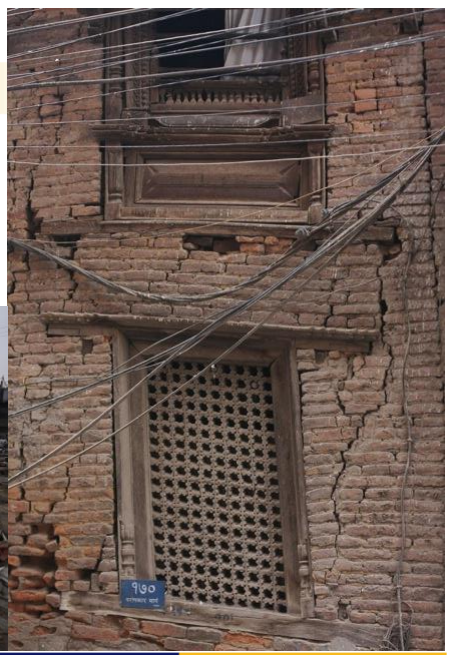
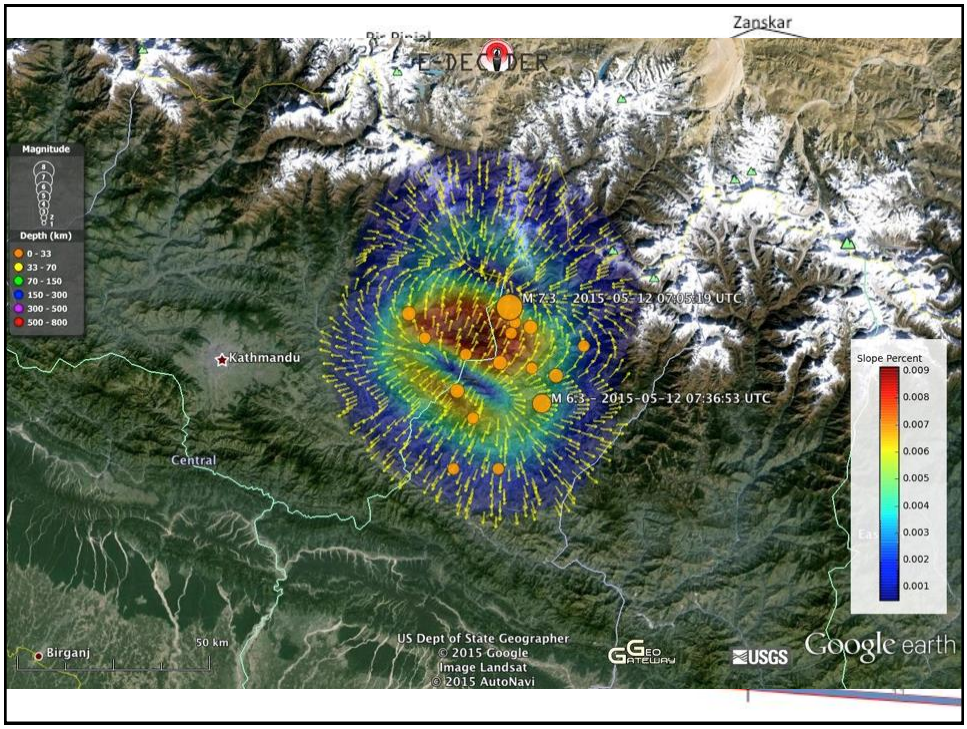
Additionally, this illustration depicts linkages between human and natural system in broader formats.

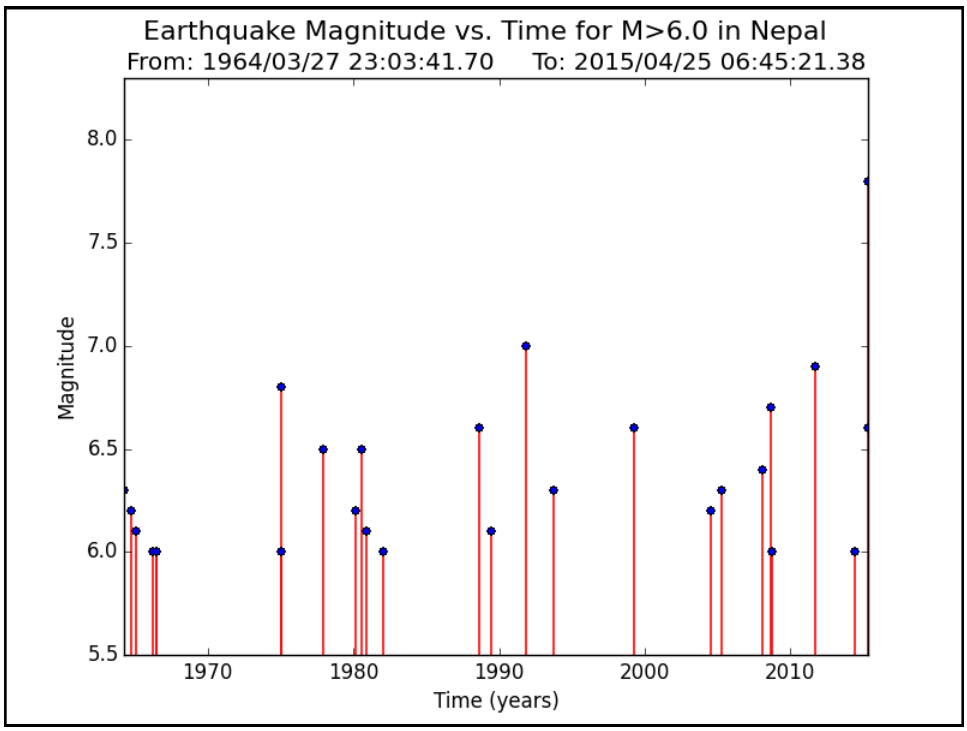


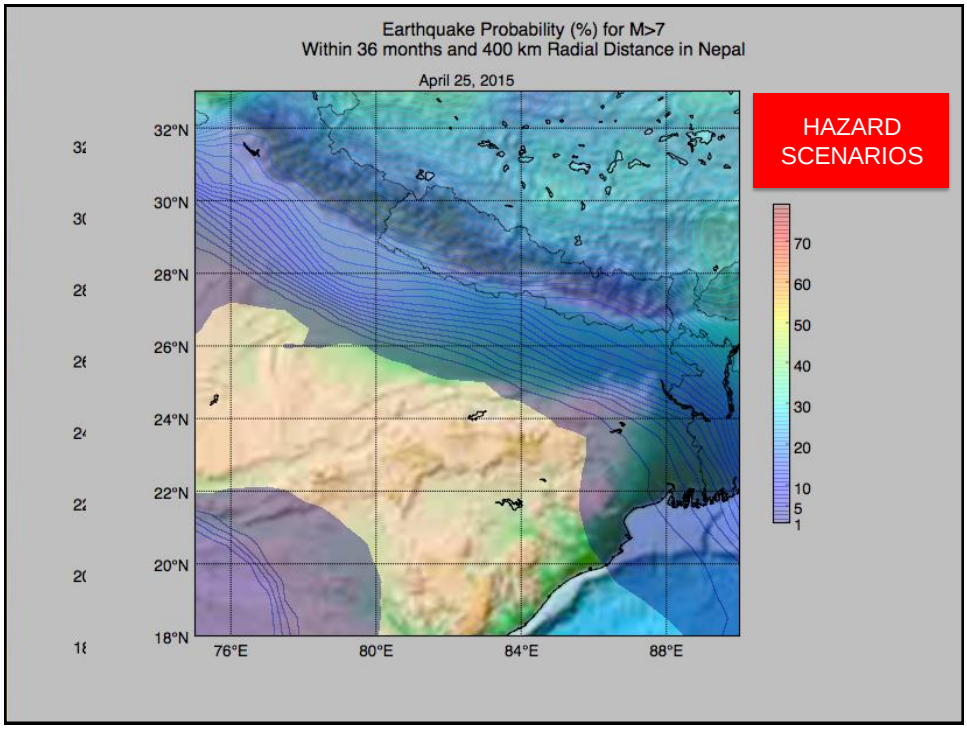
Source: Nehren & Sandholz, 2013

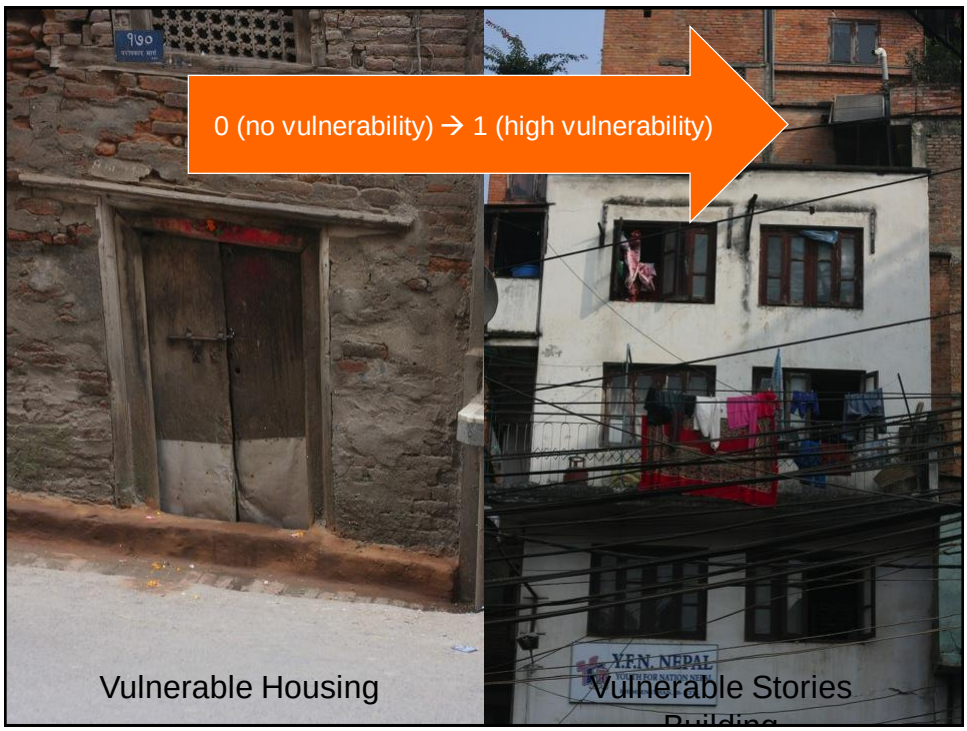
Kathmandu, Nepal




Zanskar
Magnitude
Depth (km)
0 - 33
33 - 70
70 - 150
150 - 300
300 - 500
500 - 800
M 7.3 - 2015-05-12 07:05:19 UTC
Kathmandu
M 6.3 - 2015-05-12 07:36:53 UTC
Central
Slope Percent
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
Birganj
50 km
US Dept of State Geographer
© 2015 Google
Image Landsat
© 2015 AutoNavi
USGS
Google earth

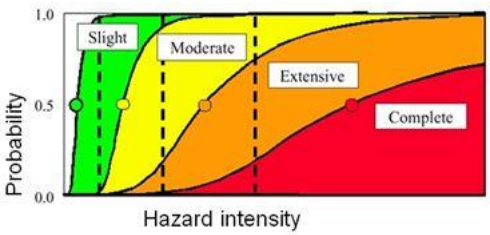

Earthquake Magnitude vs. Time for M>6.0 in Nepal
From: 1964/03/27 23:03:41.70 To: 2015/04/25 06:45:21.38
Magnitude
8.0
7.5
7.0
6.5
6.0
5.5
1970
1980
1990
2000
2010
Time (years)

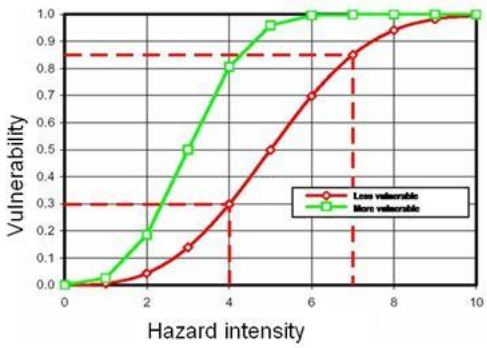

Earthquake Probability (%) for M>7
Within 36 months and 400 km Radial Distance in Nepal
April 25, 2015
32°N
30°N
28°N
26°N
24°N
22°N
20°N
18°N
76°E
80°E
84°E
88°E
70
60
50
40
30
20
10
5
1
HAZARD SCENARIOS


0 (no vulnerability) → 1 (high vulnerability)
Vulnerable Housing
Vulnerable Stories Building

Vulnerability = (Exposure) + (Resistance) + (Resilience)

With:
Exposure: at risk property and population;
Resistance: Measures taken to prevent, avoid or reduce loss;
Resilience: Ability to recover prior state or achieve desired post-disaster state.





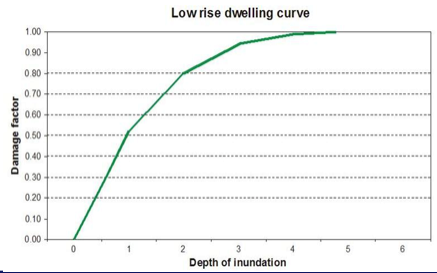
Landslide characteristics	Buildings at risk: S	L	M	H
T				
M				
S				
V				
R				

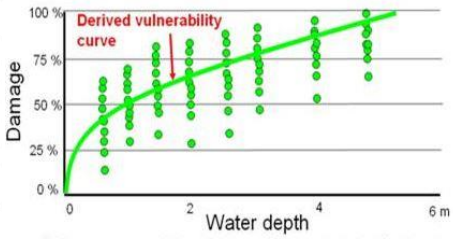
S – Squatter
L – Low-rise buildings
M – Multi-storey building
H – High-rise building

T – Type of failure
M – Mechanism of failure
S – Scale
V – Velocity
R – Runout distance

Location, nature and properties of low-rise buildings

Vulnerability	Distance to slide (m) <10	10-50	>50	Nature			…
Scale (m^3) $<10^2$	0.3	0.2	0.1				
10^2-10^3	0.4	0.3	0.2				
10^3-10^4	0.6	0.5	0.4				
$>10^4$	1.0	0.9	0.8				





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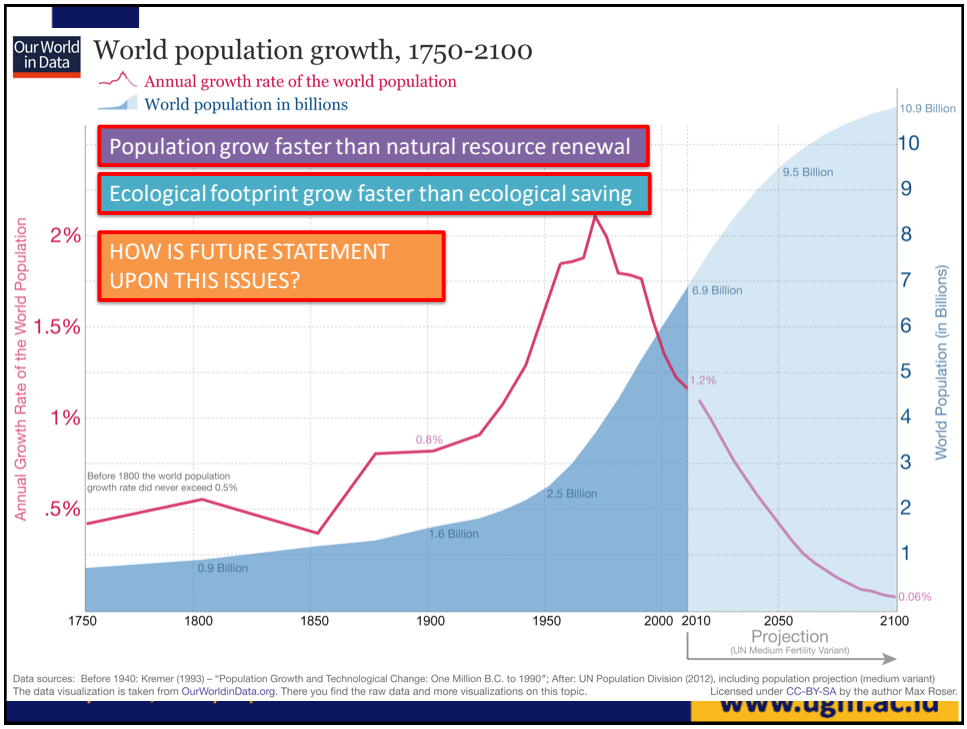


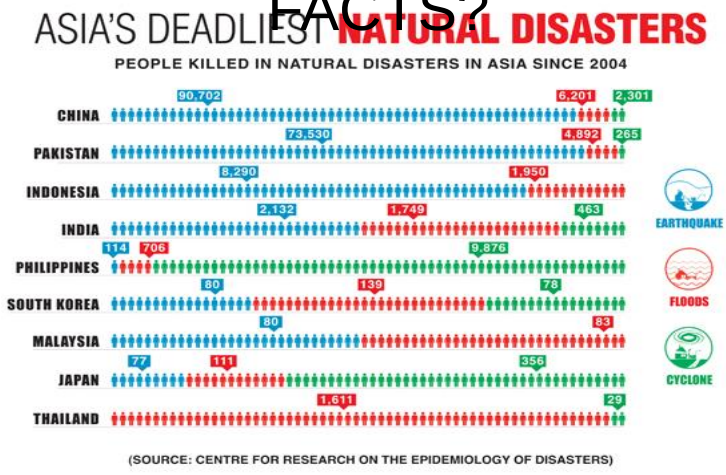
VULNERABLE TOWARDS?

Since prehistoric time, human occupied earth to continue living.
In order to do so: They need Energy/Natural Resources.

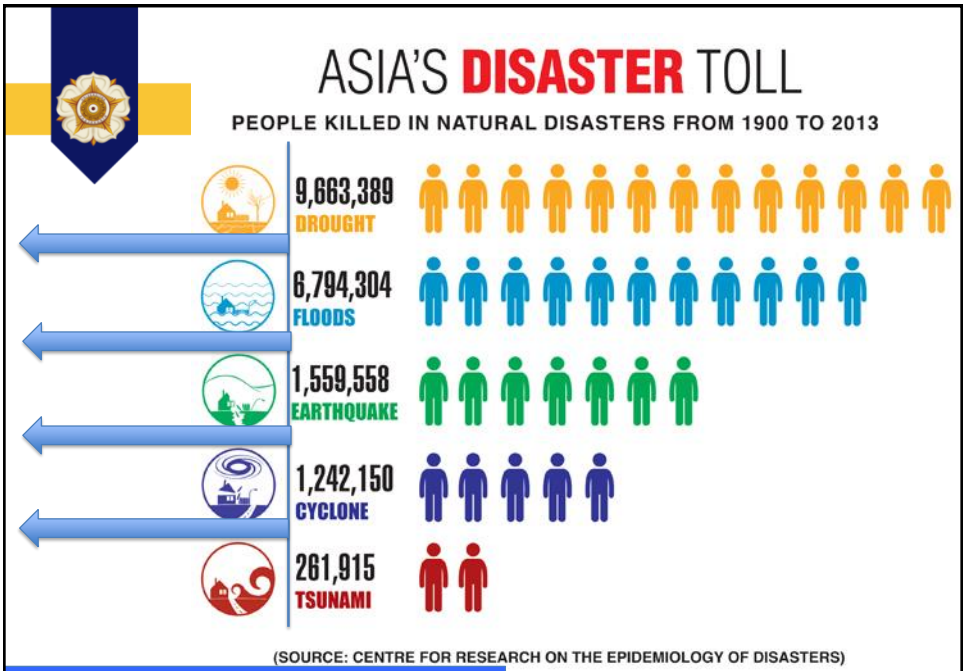
Recently, they have come up with various energy resource and natural resource exploration for their livelihood.

The most common impact was increasing demand and supply

WHAT ABOUT GLOBAL FACTS?



NON MATERIAL LOSSES PER COUNTRIES



NON MATERIAL LOSSES

DISASTER IMPACTS

127 active volcanoes

- **Disaster Impacts are varied:**
  - **Economic Impact**
  - **Social Impact**
  - **Environmental Impact**
- **These impacts are increasing rapidly. Indonesia for example, experience 1062 occurrence last 2016**

ECONOMIC IMPACT

0.3% on average of GDP each year

$1.5 on average over billion each year

Economic impact of 2004 Aceh tsunami estimated at **$4.5 billion** or **54% of provincial** and **1% of national GDP**

SOCIAL IMPACT

In the last 10 years disasters in Indonesia have killed over 200,000 people

ENVIRONMENTAL IMPACT

Sumber: AUSAID, 2015 UNOCHA, 2015

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COST OF NATURAL DISASTERS

ECONOMIC LOSS IN ASIA DUE TO NATURAL DISASTERS FROM 1900 TO 2013

359 Billion	314 Billion	223 Billion	167 Billion	34 Billion
FLOODS	EARTHQUAKE	TSUNAMI	CYCLONE	DROUGHT

(FIGURES ARE IN US DOLLARS)

(SOURCE: CENTRE FOR RESEARCH ON THE EPIDEMIOLOGY OF DISASTERS)

DAMPAK KERUGIAN MATERIAL PER BENCANA

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Damage and Loss Assessment

is the basis for Post Disaster Needs Assessment (PDNA)

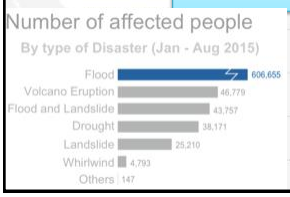
1,160 Disaster Occurrence in Indonesia

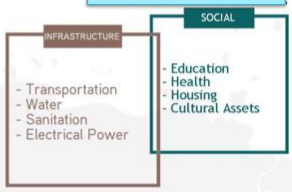
VULNERABILITY INCREASED DRAMATICALLY

$R = H \times V$

RISK POTENTIAL ARE NO LONGER IN STATIC FIGURE

NATURAL DISASTER INCREASED TREMENDOUSLY





- as well as negative effects on the ECONOMY.

WHAT NEXT? ?

ACCORDING TO DAMAGE AND LOSS ASSESSMENT IN INDONESIA

1. *There are increasing number of affected people, assets, as well as environmental losses*
2. *The disaster occurrence rapidly increased*
3. *Hereafter, risk potential are increased*

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WHAT ARE VULNERABLE?

Natural Vulnerability | Regionally increased vulnerability due to Climate Change | Land and Ecosystem Degradation

ECOSYSTEM UNIT

PEOPLE

BUILT UP ENVRIONMENT

Increase of natural disaster risk: landslides, erosion, floods, droughts, stronger impacts of Tsunamis, thunderstorms, etc.

Ecosystem Management for DRR

Draft: U. Nehren

Disasters, Environment and Risk Reduction I 2.1 Linking global environmental problems and disasters

Source: Nehren & Sandholz, 2013

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WHAT ECO-DRR?

Shifting Paradigm

REACTIVE

human-capital management within emergency situation

PROACTIVE

natural-capital management within whole disaster management cycle

The Sendai Framework 2015
The Sustainable Development Goals 2015
COP 21 Paris CC Agreement
The Lisbon Treaty

TECHNICAL ENGINEERING

TECHNICAL & SOCIAL ENGINEERING

A MULTILATERAL INITIATIVES

ECOSYSTEM BASED DISASTER RISK REDUCTION OR ECO-DRR

EXAMPLE OF ECO DRR

APPLYING STRUCTURAL MITIGATION

Dyke breaks: Flooding increases disaster vulnerability

LAND MANAGEMENT

Good practices in environmental management will go a long way in reducing our vulnerability to natural and human-induced disasters.

ECO DRR DROUGHT

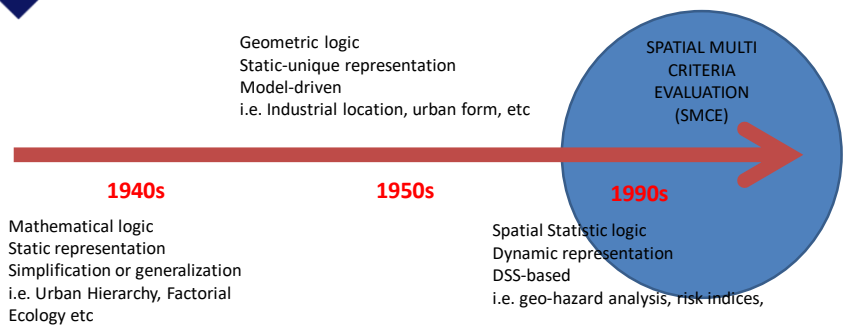
EMBUNG

EcoDRR is the sustainable management, conservation & restoration of ecosystems to reduce disaster risk EcoDRR aim to achieve sustainable & resilient development. Ecosystem management not only offers an opportunity to strengthen natural infrastructure & human resilience against hazard impacts, but also generates a range of other social, economic & environmental benefits for multiple stakeholders, which in turn feed back into reduced risk

FOR IRIGATION

FOR DOMESTIC USE

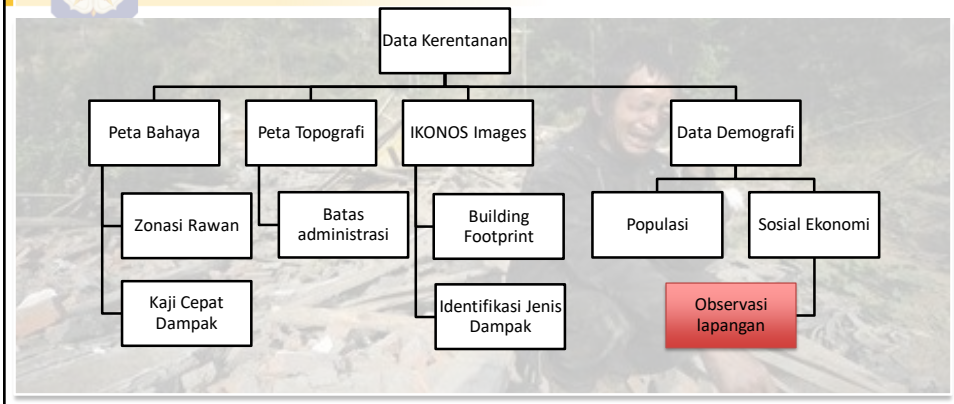
SPATIAL STATISTIC APPROACH



Source: (Murayama & Thapa, 2011; O'Sullivan & Unwin, 2003; Trochim & Donnelly, 2006)

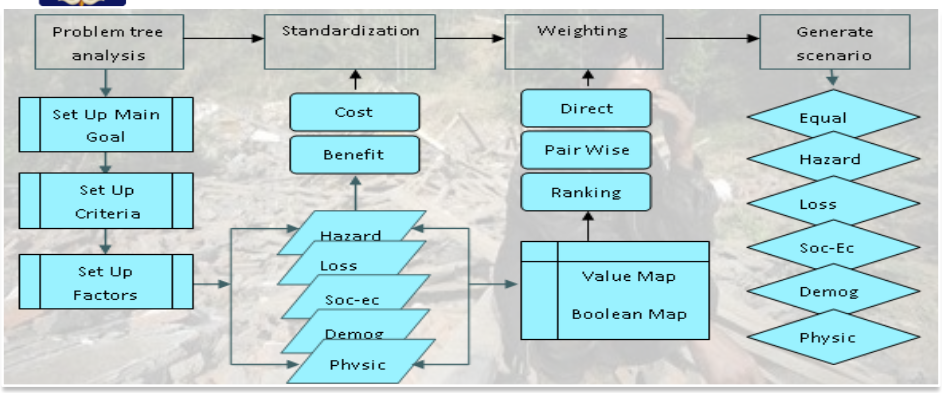
- Spatial Modelling for Vulnerability Assessment

SPATIAL MULTI CRITERIA EVALUATION (SMCE)

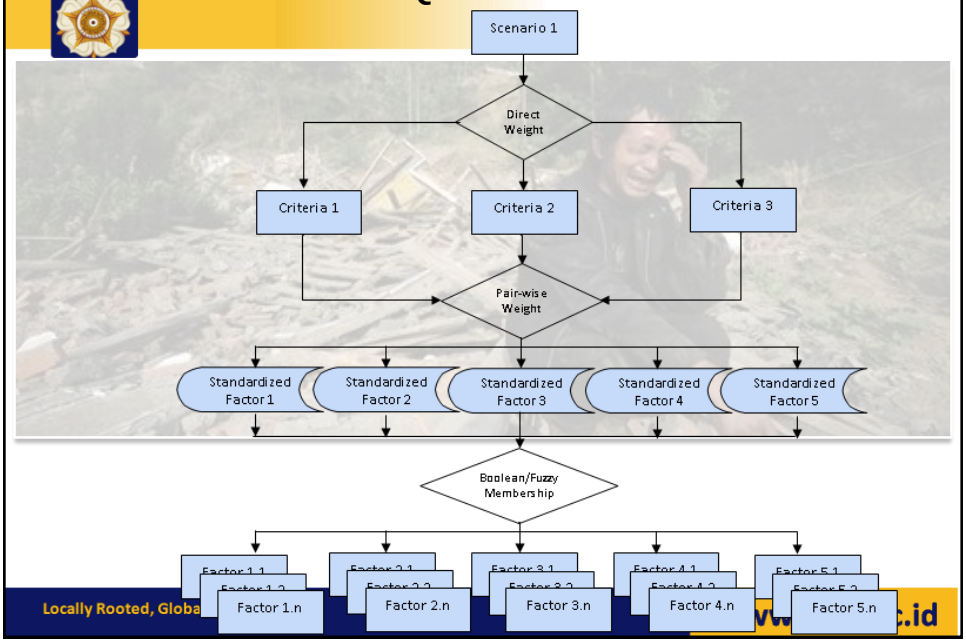


Some would argue that vulnerability assessment is a combination between qualitative and quantitative method. Is it true?

PROBLEM TREE ANALYSIS



TECHNIQUE ANALYSIS



TECHNIQUE ANALYSIS

	No	Criteria	Factor	Description	Methods to Obtain Data	Source
1	1	Physical	Land use, Faults, Road network, Stream network, Slope	built up areas (+) distance to fault lines (+) distance to road network (+) distance to river (+) mountainous area (+)	Secondary Data (Bappeda, 2009)	(Hewitt, 1981)
2	2	Demographic	Population density, Population by education, by age, by income, by occupation	High density (+) Low education (+) Elderly (+),children (+)	Secondary Data (BPS, 2009) Primary Data	(Hewitt, 1981); (Cutter *et al.*, 2003), (Schmidtlein, *et al.*, 2010)
2	3	Socio-economic	Asset, access, economic background, etc.	Low economic assets (+) Low wages (+)	Secondary Data (BPS, 2009) Primary Data	(Cutter *et al.*, 2003), (Schmidtlein, *et al.*, 2010)
1	4	Losses	Material loss ratio, immaterial loss ratio	High ratio (+)	Primary Data (Bappeda, 2009)	(Lantada, *et al.*, 2010)
1	5	Hazard	Distribution, Magnitude, Frequency, Intensity	High frequency, high magnitude, high intensity, wider distribution (+)	Secondary Data (Geological Agency, 2009)	(Marulanda, *et al.*, 2009)

TECHNIQUE ANALYSIS

Scenarios	Physical Factors	Demographic Factors	Socio economic Factors	Affected Loss Factors	Hazard Factors
Physical	0.40	0.15	0.15	0.15	0.15
Demographic	0.15	0.40	0.15	0.15	0.15
Socio-economic	0.15	0.15	0.40	0.15	0.15
Losses	0.15	0.15	0.15	0.40	0.15
Hazard	0.15	0.15	0.15	0.15	0.40
Equal	0.20	0.20	0.20	0.20	0.20

Upper Bo...	Class Name	Code
0	Not Vulnerable	NV
0.25	Marginaly Vulnerable	MV
0.5	Moderately Vulnerable	ModV
0.75	Highly Vulnerable	HV
1	Very High Vulnerable	VV

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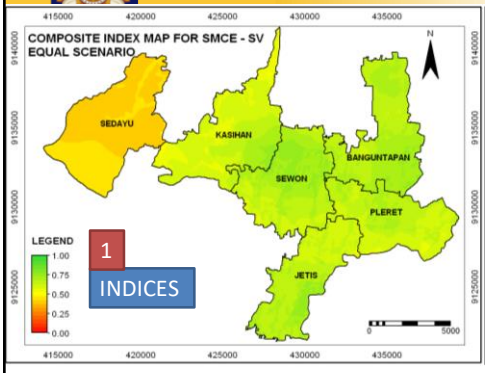
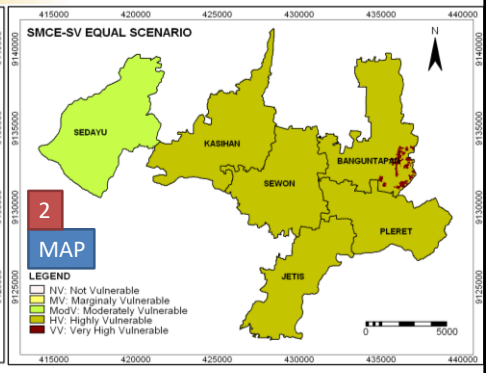
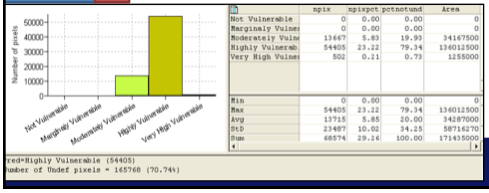
GENERATE SCENARIOS





GRAPH 3



The equal scenario pertains with this if scenario: if the research area likely to experience seismic activity originates from Opak fault or nearby active fault structure, magnitude > 5 S.R, attenuation < 0.15 g, recurrence period of 2009 - 2059 and experiences equal perturbation of the physical, demographic, social economic and expects to have steady element at risk, thus the likelihood of the social vulnerability seen in the picture

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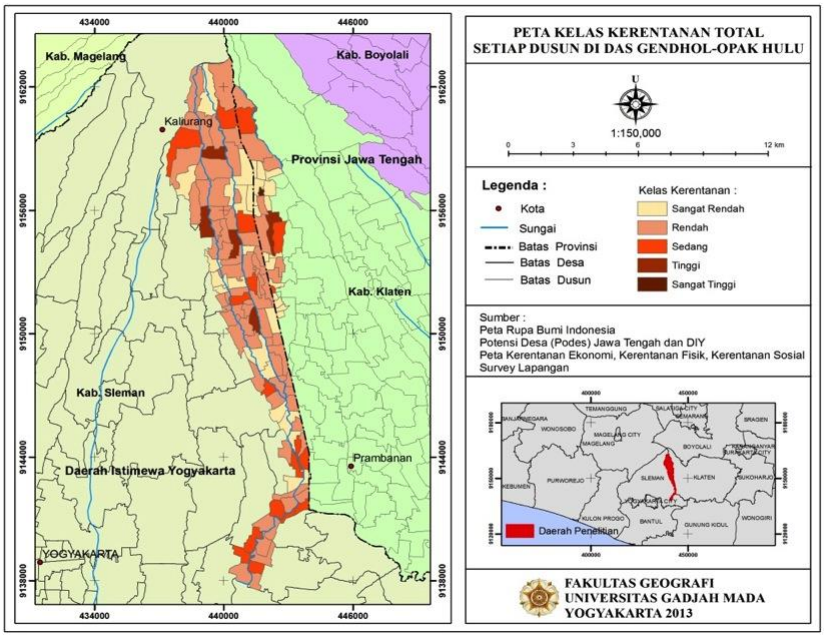

WHAT IS NEXT?

- How Eco-DRR would contribute in the vulnerability analysis?

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