Risk Reduction in One Belt One Road Corridors

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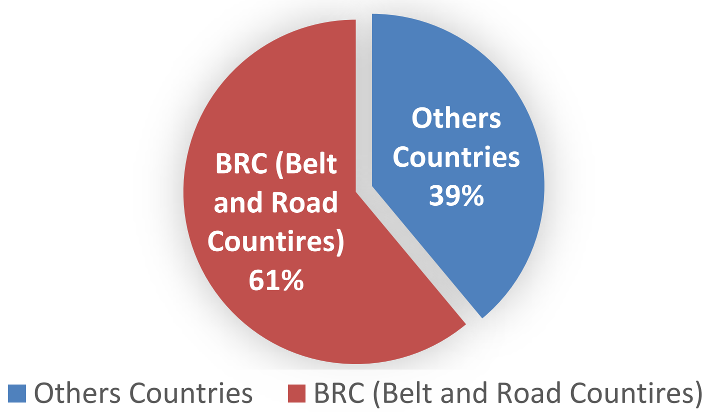
The Belt and Road Initiative was proposed at Bo'ao Forum in 2014

World Population



The **Belt and Road Initiative** involves **3** Continent, **8** Regions, **65** Countries and **4.4 Billion** people

- South-eastern Asia
- Southern Asia
- Central Asia
- Western Asia
- Central and Eastern Europe
- CIS
- Eastern Asia(China, Mongolia)
- Africa(Egypt,Kenya)

Contents

I Natural Hazard Risk

Background of Mountain Hazards in Mountain Region

- Active tectonic movement in young mountains: frequent mega earthquakes and severe erosion generate abundant solid mass for formation of mountain hazards;
- High intensity rainfall and quick snow melting provide plenty of water for the formation of mountain hazards;
- Steep slope and high relative altitude is conductive energy condition to development of mountain hazards

Natural hazards in the land and maritime silk road area

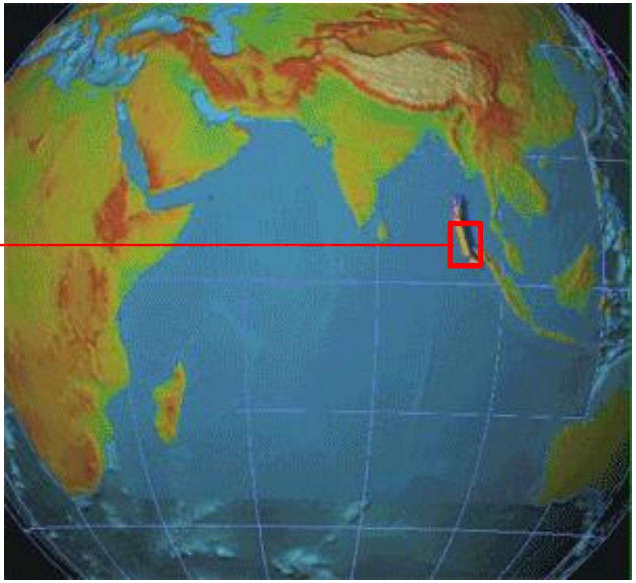
Geophysical	Hydrological	Meteorological	Climatological
Earthquake	Flood	Storm	Drought
Landslide	Debris Flow	Extreme temperature	Glacial lake outburst
Volcanic activity	Wave action	Fog	Wildfire

Mountain Hazards: landslide, debris flow, flash flood, GLOF, snow avalanche

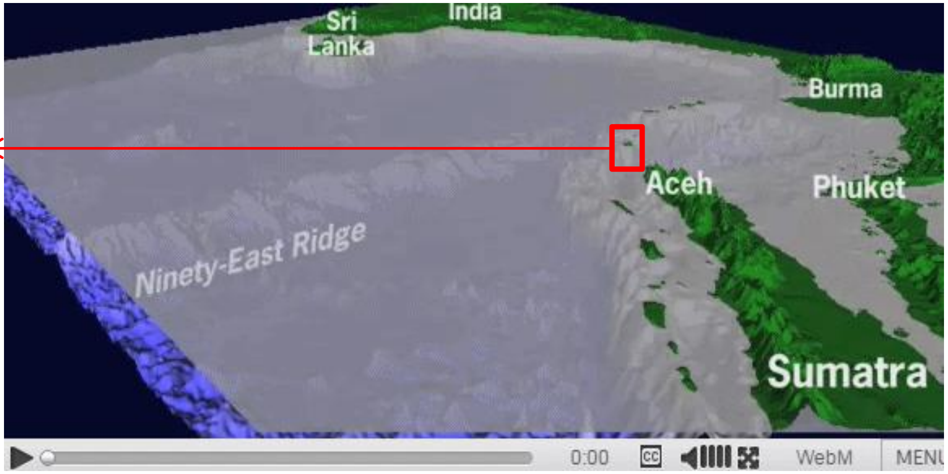
Earthquake, Tsunami, Flood, Landslide, Rock fall, Debris flow, Snow avalanche, Dammed lake, GLOF….

Earthquake and Tsunami – Indonesia

Dec 2004, Earthquake at Indian Ocean induced Tsunami, affecting 14 countries, 300,000 casualties



West coast of Sumatra Island, Indonesia



Debris flow- China

On August 8th, 2010, the giant debris flow killed over 2000 persons , caused 22,667 homeless, and induced enormous property losses.

Landslide- Afghanistan

May 2, 2014, Landslide at Afghanistan, 2700 casualties.

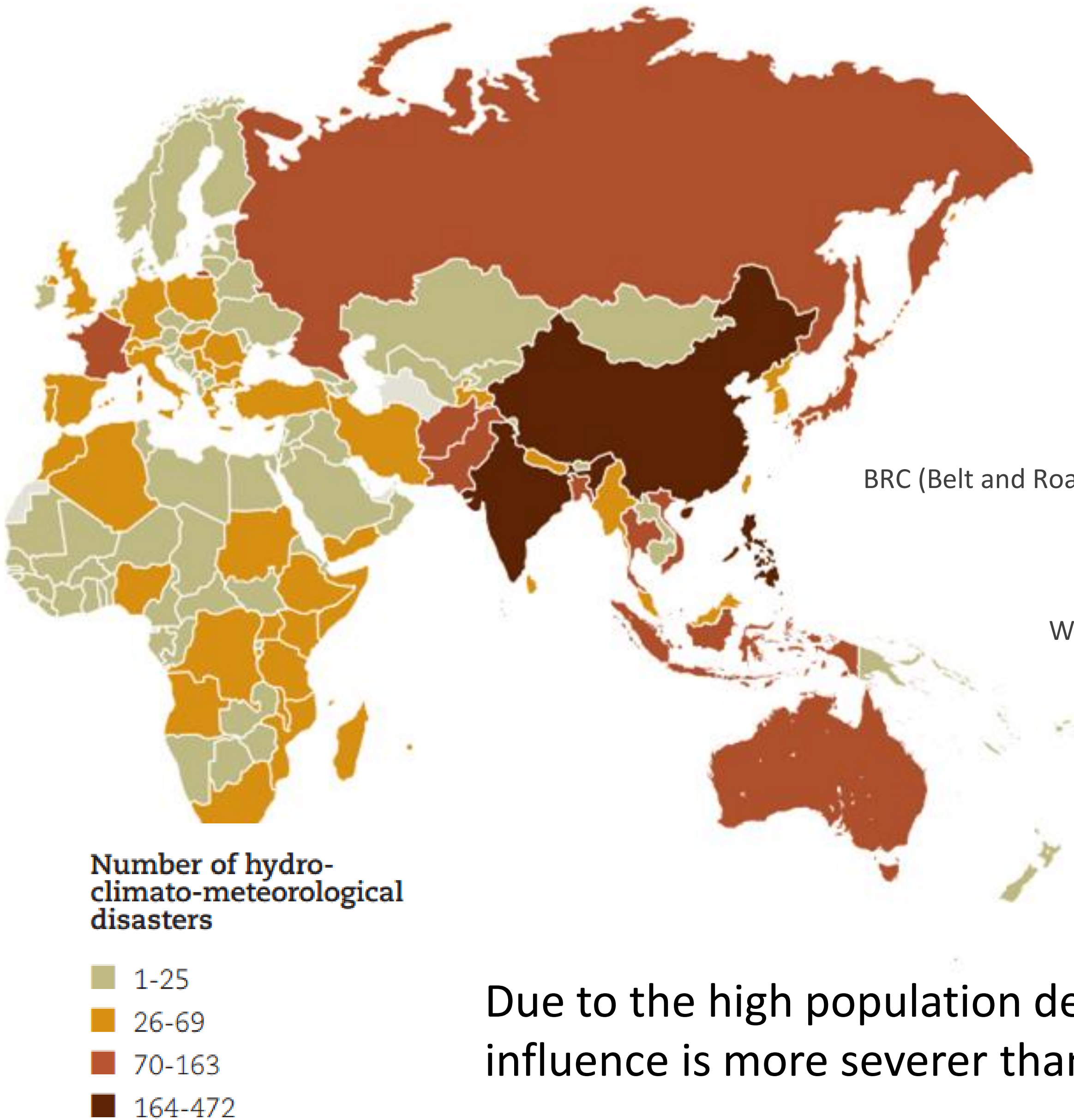
Flood- India

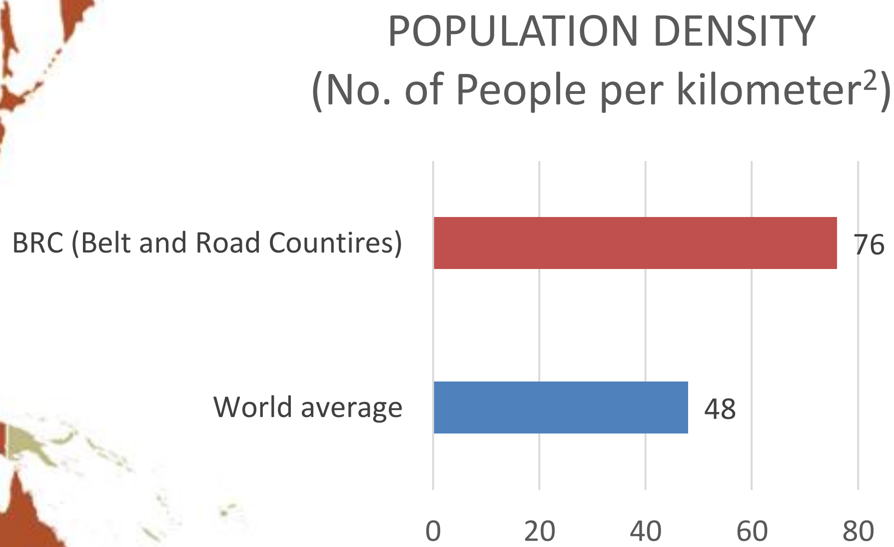
June 2013, North part of India suffered from flood and landslide, 6000 to 10000 casualties

Cities, towns and villages were ruined;

Highways, railways, bridges, pipelines dames, and other infrastructures as well as farmland were seriously destroyed.

Number of Natural Hazards Reported per Country/Income (1995-2015)

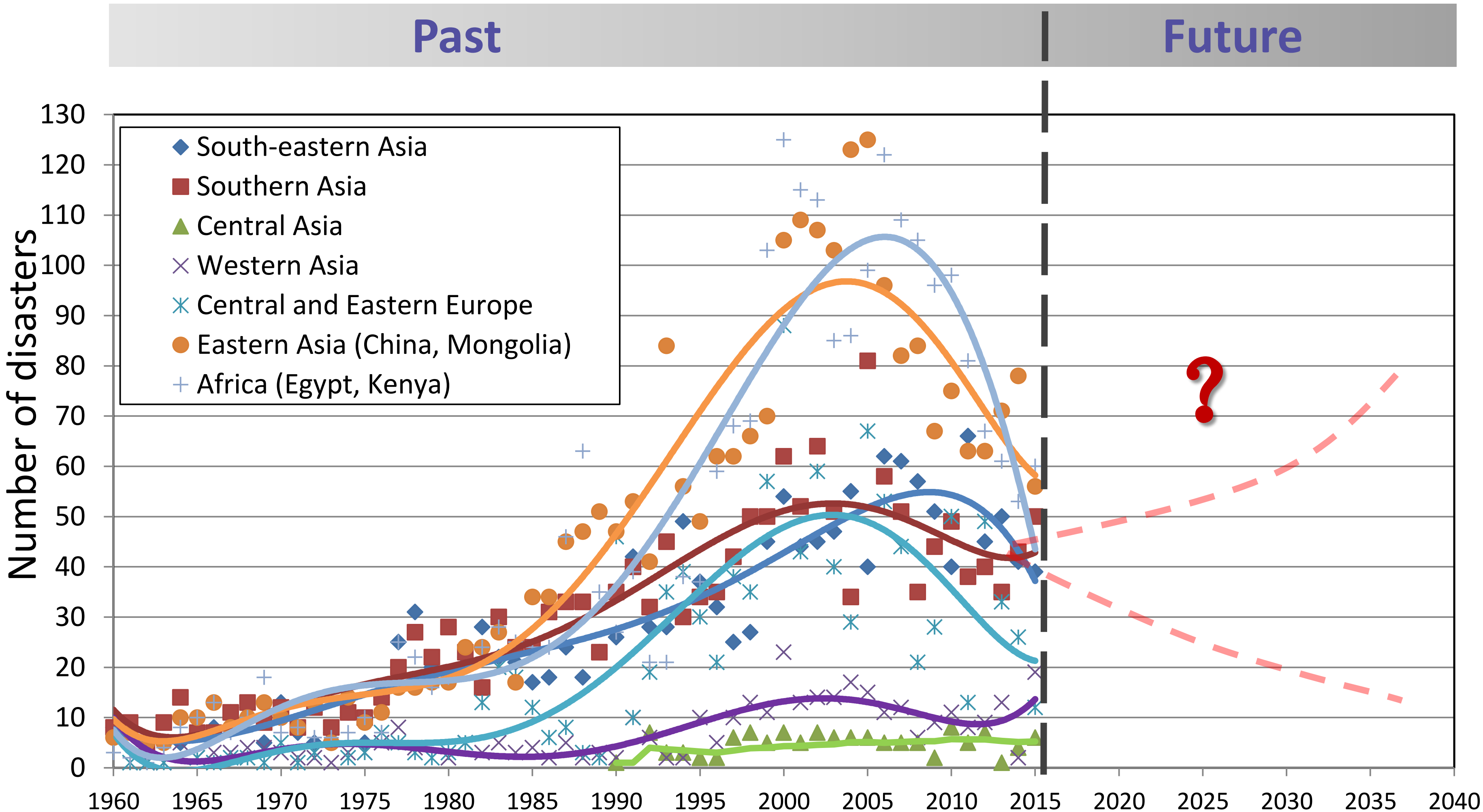




Due to the high population density at BRC, natural hazards' influence is more severer than it does to other countries.

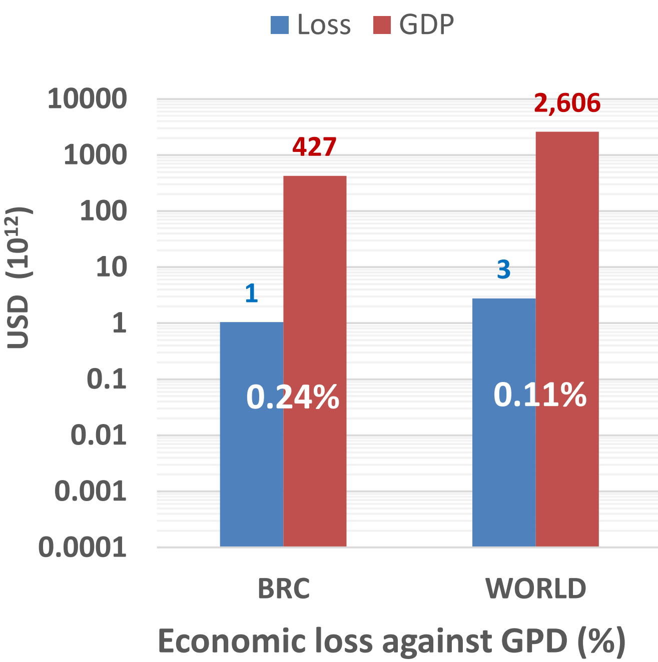
Data collected from "International Disaster Database" and "United Nations Office for Disaster Risk Reduction"

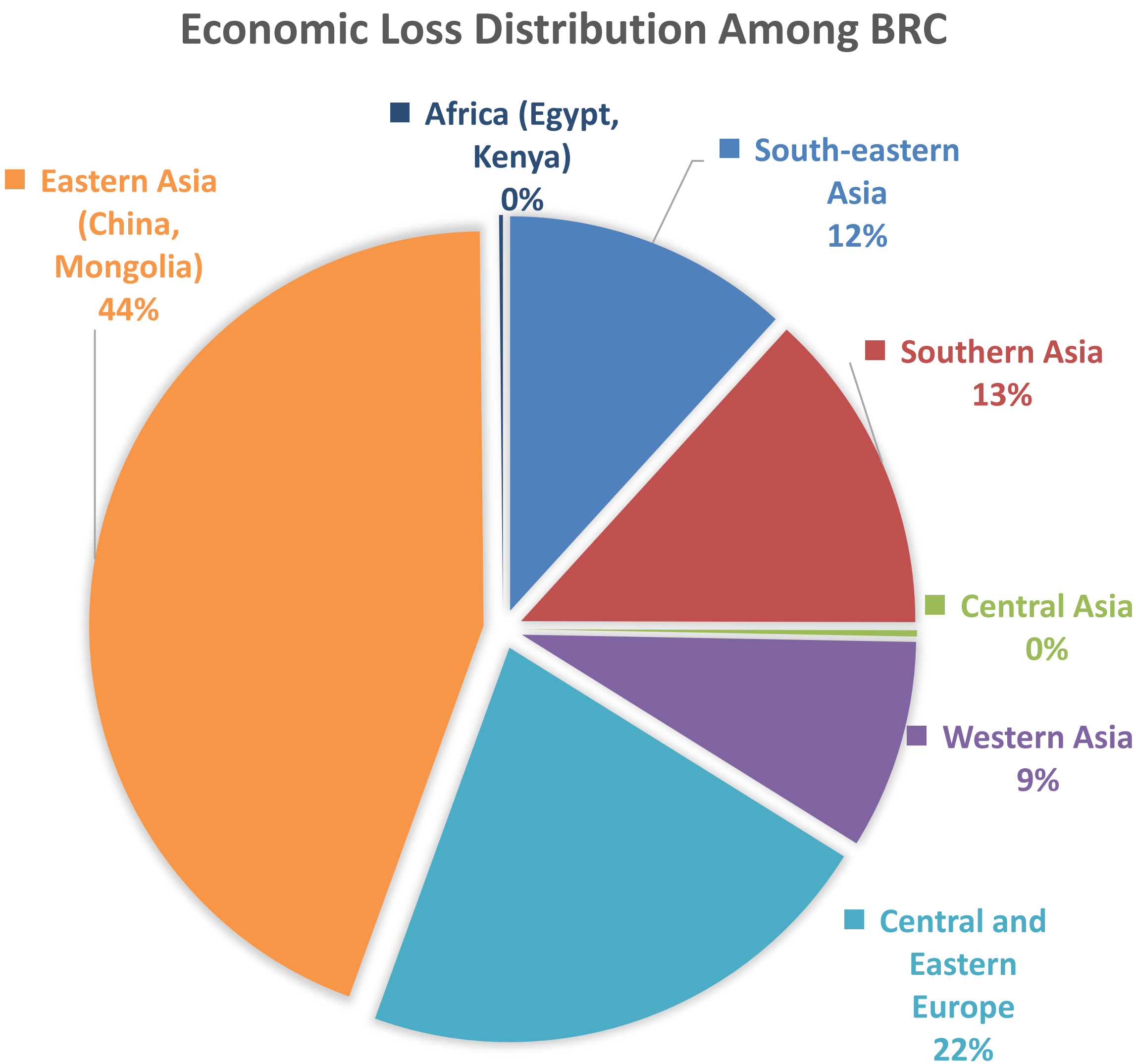
Trend of Disaster Occurrence (1960 to Future?)



Future trend is still an open question and threat have to be faced by all of us!

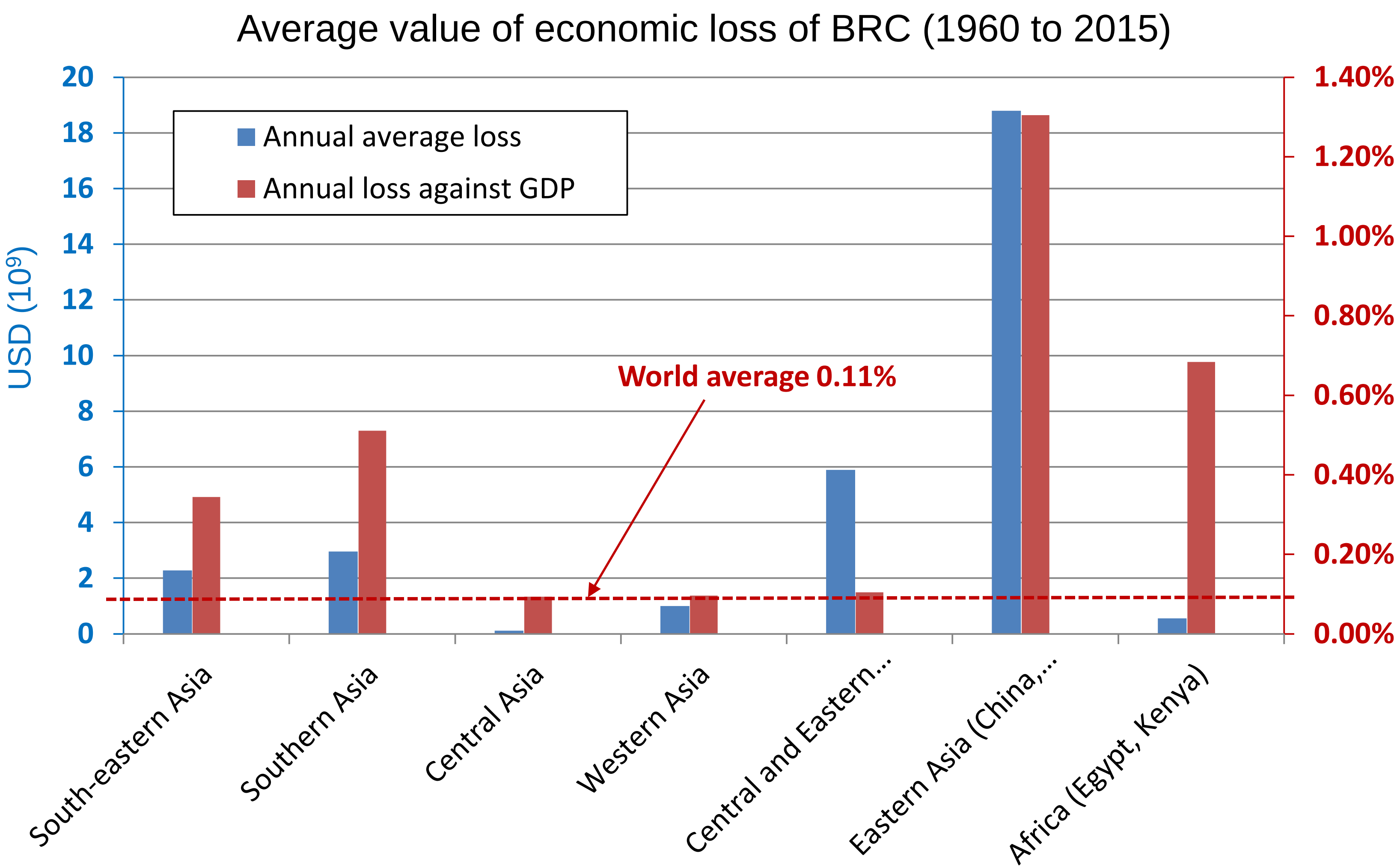
Economic Loss Due to Nature Hazards – World and BRC



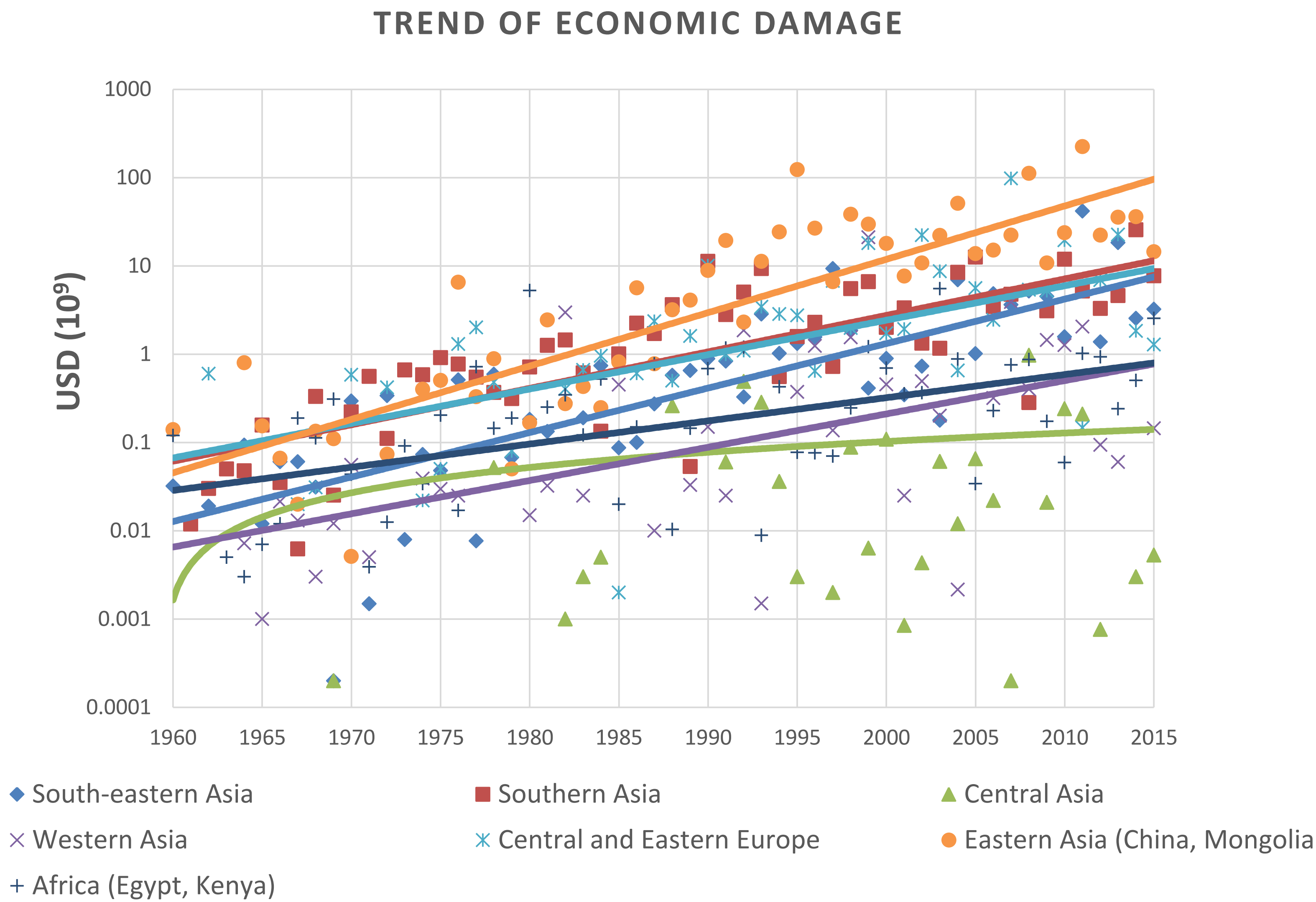


- The average economic loss against GDP in BRC is 2 times the world average
- Eastern Asian and Central and Eastern Europe suffered most, more than 64%

Economic Loss Due to Nature Hazards – Among BRC

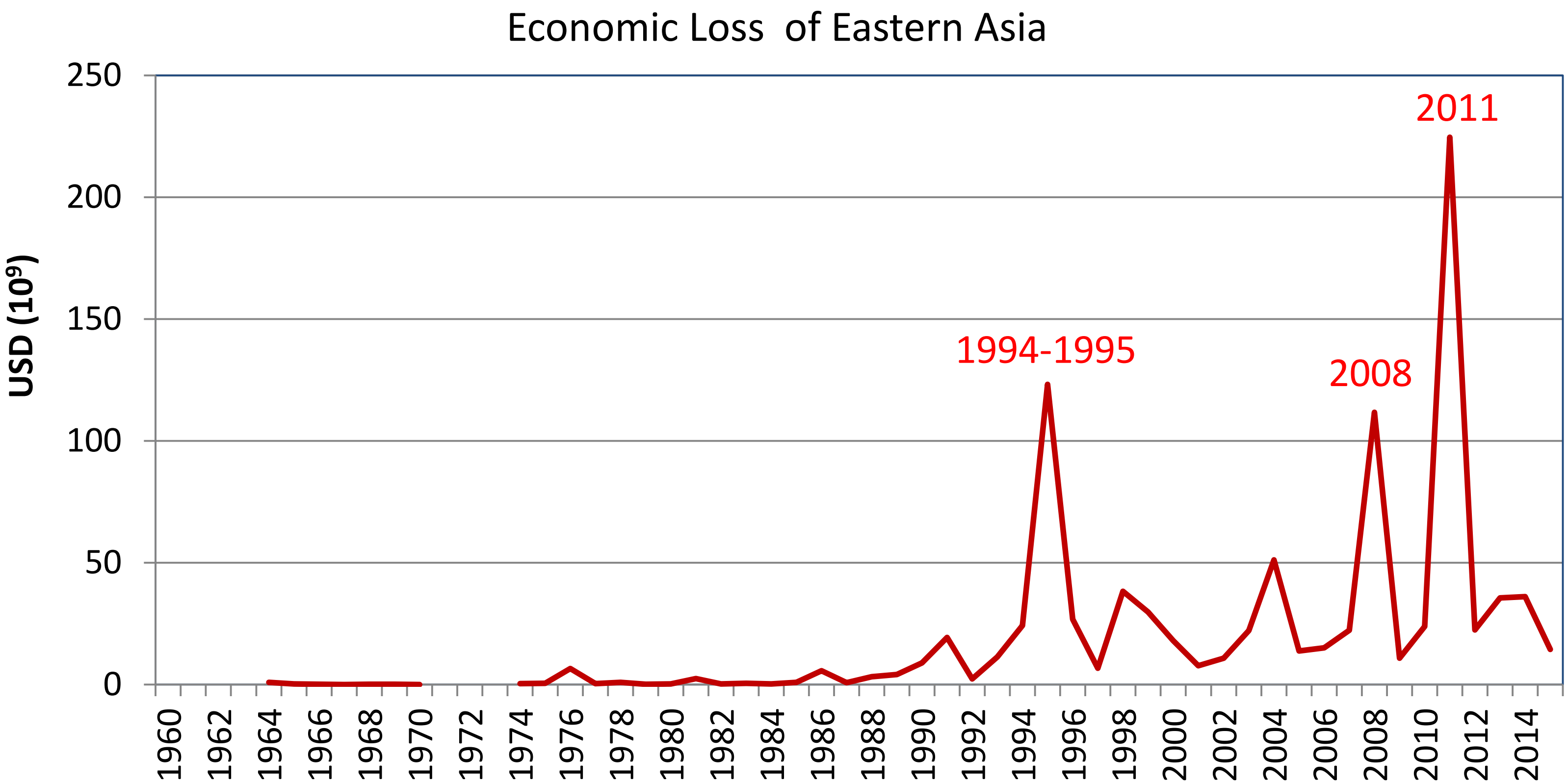


Trend of Economic Loss Due to Nature Hazards



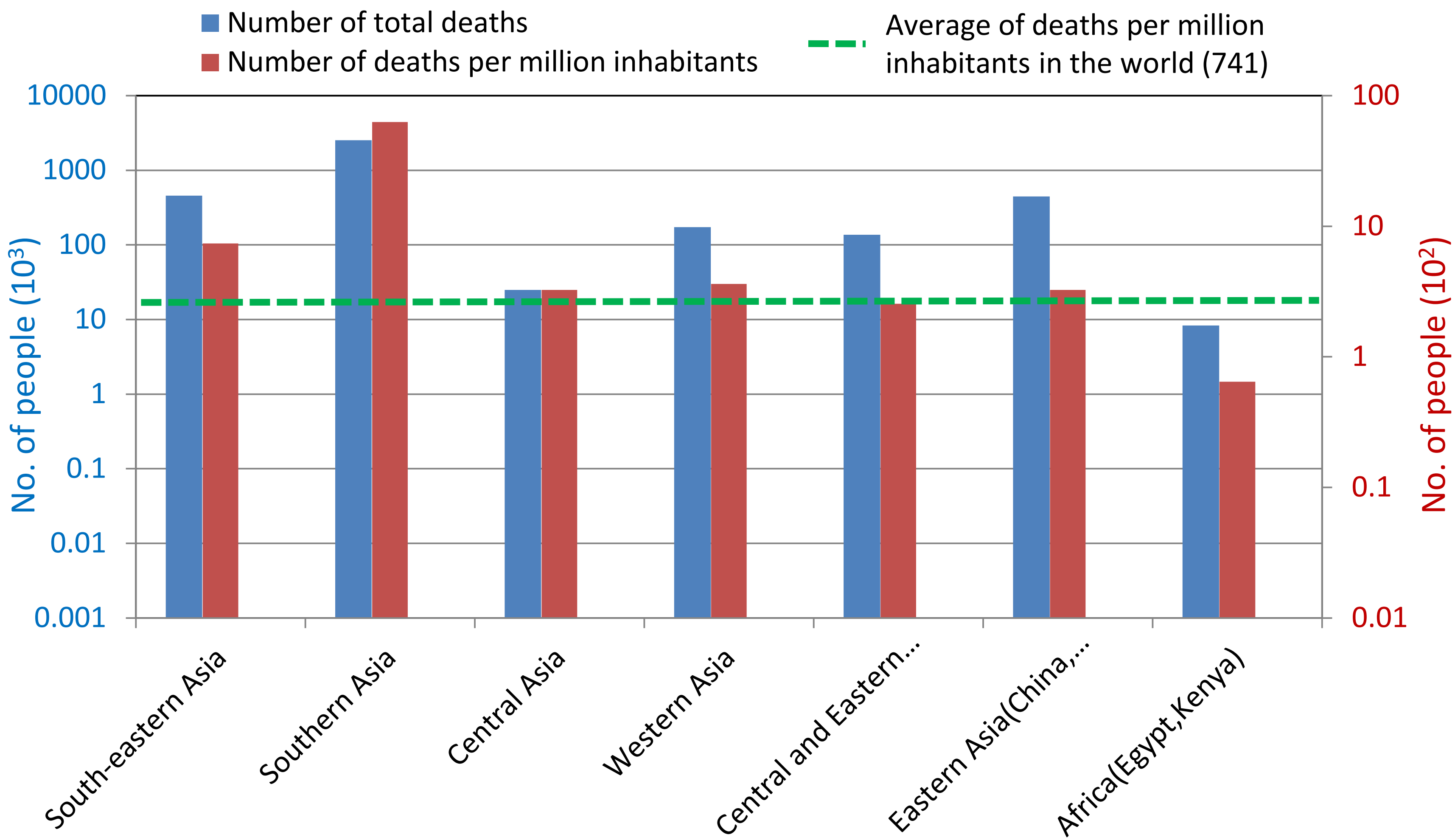
Economic loss from nature hazards increases exponentially from 1960 to 2015

Economic Loss Due to Nature Hazards – Eastern Asia



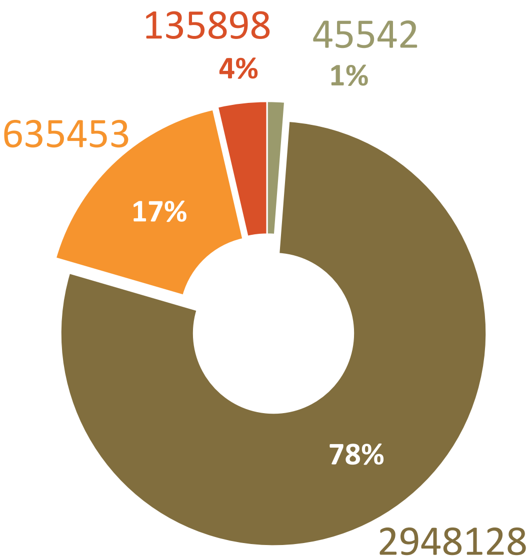
- 1994-1995 : Drought, Flood, Storm in China
- 2008: Wenchuan Earthquake in China
- 2011: Drought, Flood, Extreme Low Temperature in Southern China

Human Casualties Due to Nature Hazards –Among BRC

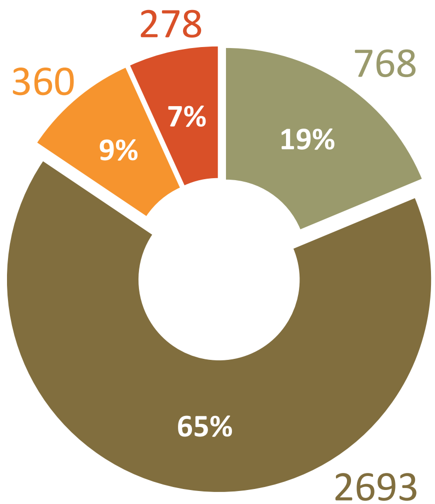


- The human casualties in BRC is above world average .
- For Southern and Eastern Asia, the average death per million people is 10 times more than the world average.

Human Casualties Due to Nature Hazards – 1960 to 2015



No. of absolute death



No. of death per million people

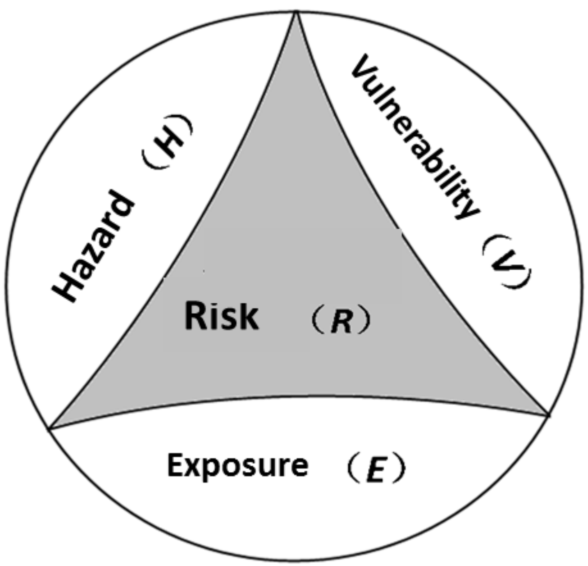
		All in USD
■	High-income	>12736
■	Upper-Middle-income	4125 to 12736
■	Lower-Middle-income	1045 to 4125
■	Low-income	<1045

- Low-income group:
  absolute deaths are low but deaths per million are high.
- Lower-middle-income group:
  Dominate group in terms of human casualties.
- Upper-middle-income group:
  absolute deaths are high but deaths per million are low.
- High-income group:
  deaths per million are high due to its population base.

Data collected from “International Disaster Database” and “United Nations Office for Disaster Risk Reduction”

II Risk Assessment and Risk Management

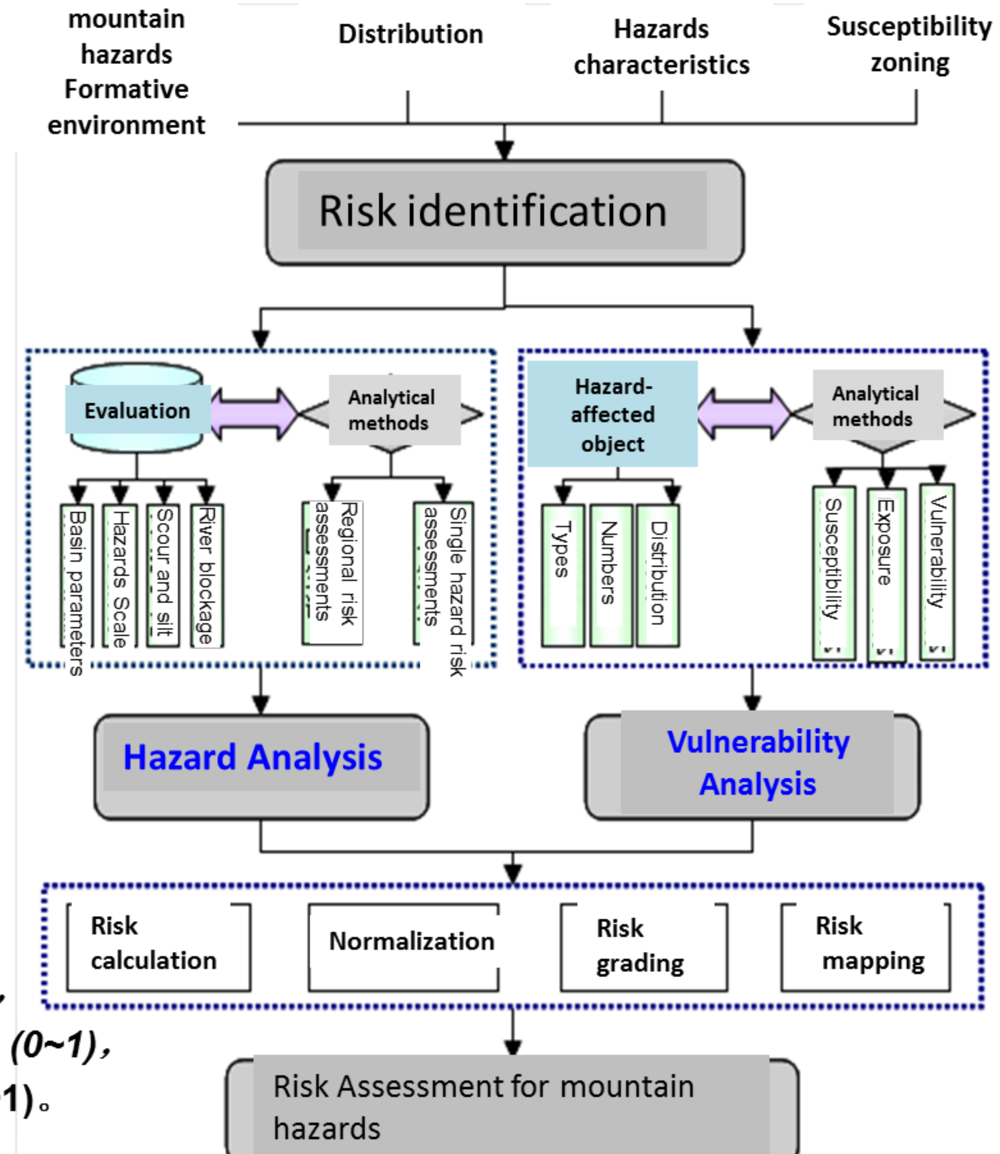
Regional Risk Assessment



$$R = f(H, V, E) = H \times V \times E$$

$$R = H \times V$$

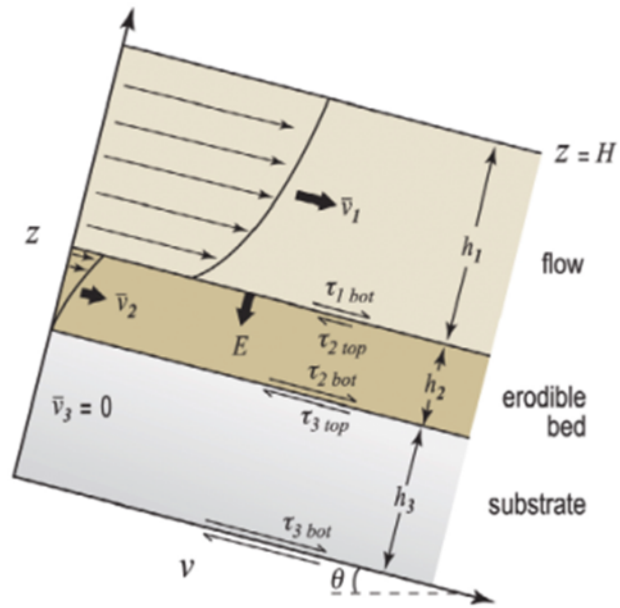
R-Risk degree(0~1),
H-Hazard degree(0~1),
V-Vulnerability degree (0~1),
E-Exposure degree(0~1)。



Risk Assessment Based on the Dynamic Process

◆ Channel bed erosion

$$E = -\frac{\partial z_b}{\partial t} = \frac{\tau_{1b} - \tau_{2s}}{\bar{\rho}\sqrt{\bar{u}^2 + \bar{v}^2}}$$



Iverson, 2012

Effective basal shear stress:

$$\tau_{1b} = C_f \rho_s (\bar{u}^2 + \bar{v}^2) \text{ or } (\rho_s - \rho_f) g_z h_1 \tan(\delta)$$

Shear strength of the erodible layer:

$$\tau_{2s} = c + \bar{\rho} g_z h (1 - \lambda_2) \tan(\phi_2)$$

Erosion rate:

$$E = \frac{\max[C_f \rho_s (\bar{u}^2 + \bar{v}^2),\ (\rho_s - \rho_f) g_z h_1 \tan(\delta)] - [c + \bar{\rho} g_z h (1 - \lambda_2) \tan(\phi_2)]}{\bar{\rho}\sqrt{\bar{u}^2 + \bar{v}^2}}$$

- **Consider different bed erosion due to different debris flows**
- **Modify the governing equation for the momentum exchange due to bed erosion**

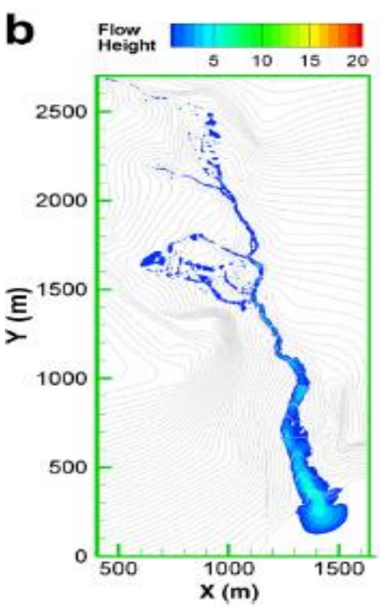
Kinetic equation of debris flow by considering the bed erosion and aggradation

$$\frac{\partial(\bar{\rho}h)}{\partial t}+\frac{\partial(\bar{\rho}h\bar{u}_1)}{\partial x}+\frac{\partial(\bar{\rho}h\bar{v}_1)}{\partial y}-\bar{\rho}E=0$$

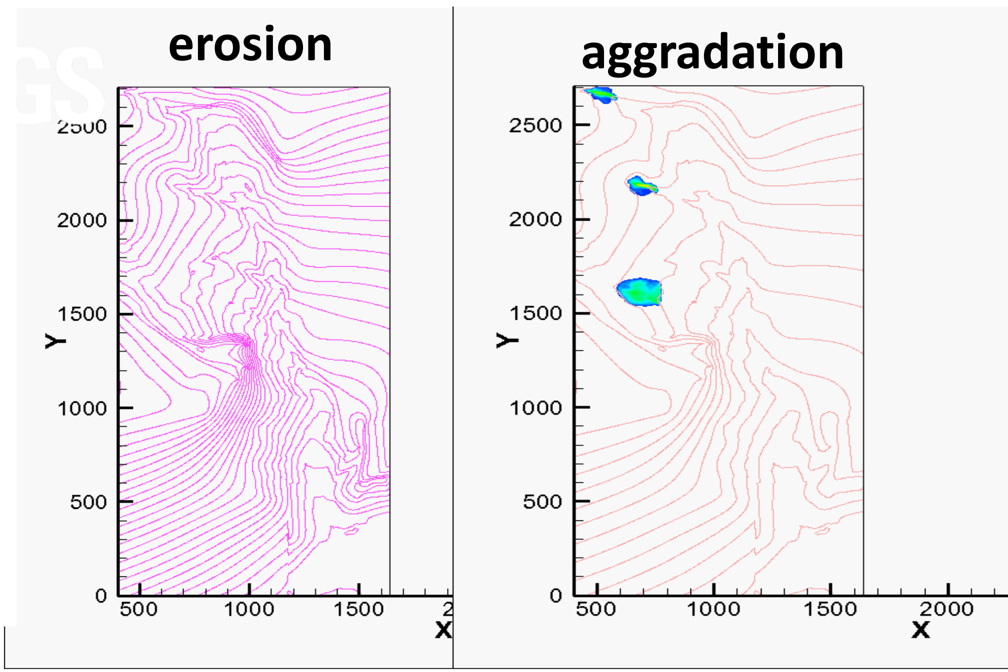
$$\frac{\partial(\bar{\rho}h\bar{u}_1)}{\partial t}+\frac{\partial(\beta_{uu}\bar{\rho}h\bar{u}_1^{\,2})}{\partial x}+\frac{\partial(\beta_{uv}\bar{\rho}h\bar{u}_1\bar{v}_1)}{\partial y}=\bar{\rho}g_x h-k\rho g_z h\frac{\partial(h+z_b)}{\partial x}-(\tau_{1zx})_b+\rho u_{1b}E$$

$$\frac{\partial(\bar{\rho}h\bar{u}_1)}{\partial t}+\frac{\partial(\beta_{uv}\bar{\rho}h\bar{u}_1\bar{v}_1)}{\partial x}+\frac{\partial(\beta_{vv}\bar{\rho}h\bar{v}_1^{\,2})}{\partial y}=-k\rho g_z h\frac{\partial(h+z_b)}{\partial x}-(\tau_{1zy})_b+\rho v_{1b}E$$

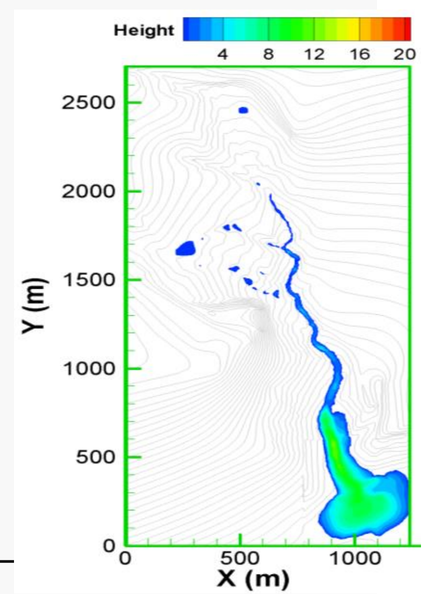
The calculation results are consistent with the actual debris accumulation both in shape and volume.



Not considering erosion



Numerical simulation

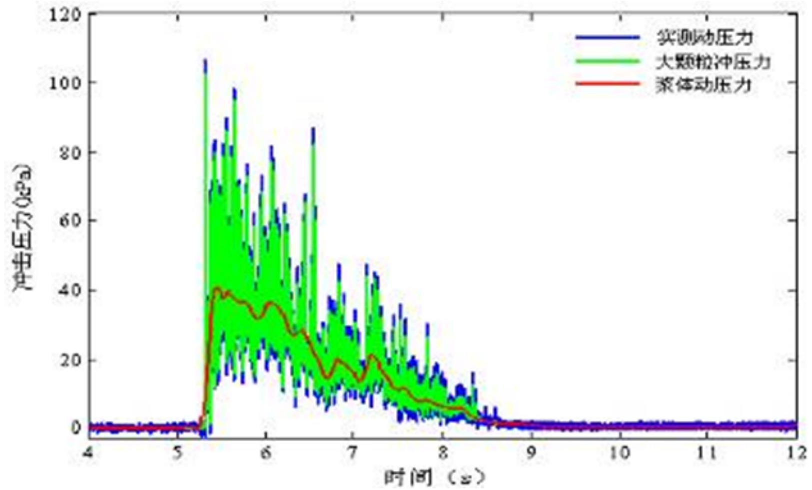


Actual deposit

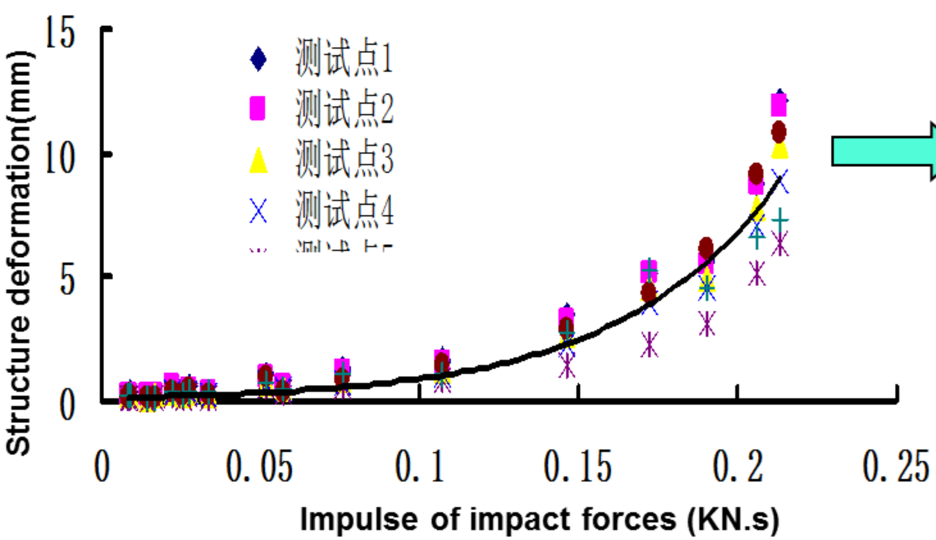
Impact forces due to fluid and solids

$$f(t) = \sum_{k=-\infty}^{+\infty} c_{j,k}\phi_{j,k}(t) + \sum_{j=-\infty}^{j} \sum_{k=-\infty}^{+\infty} d_{j,k}\psi_{j,k}(t)$$

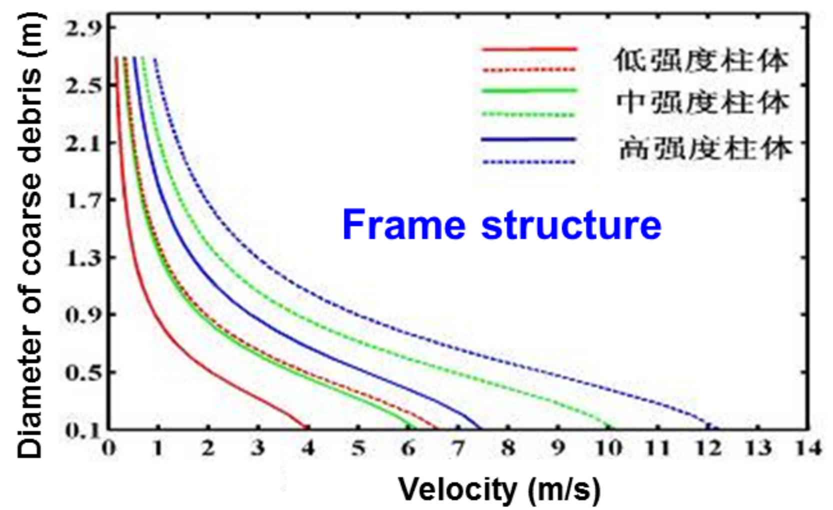
Fluid impact　　Solid impact



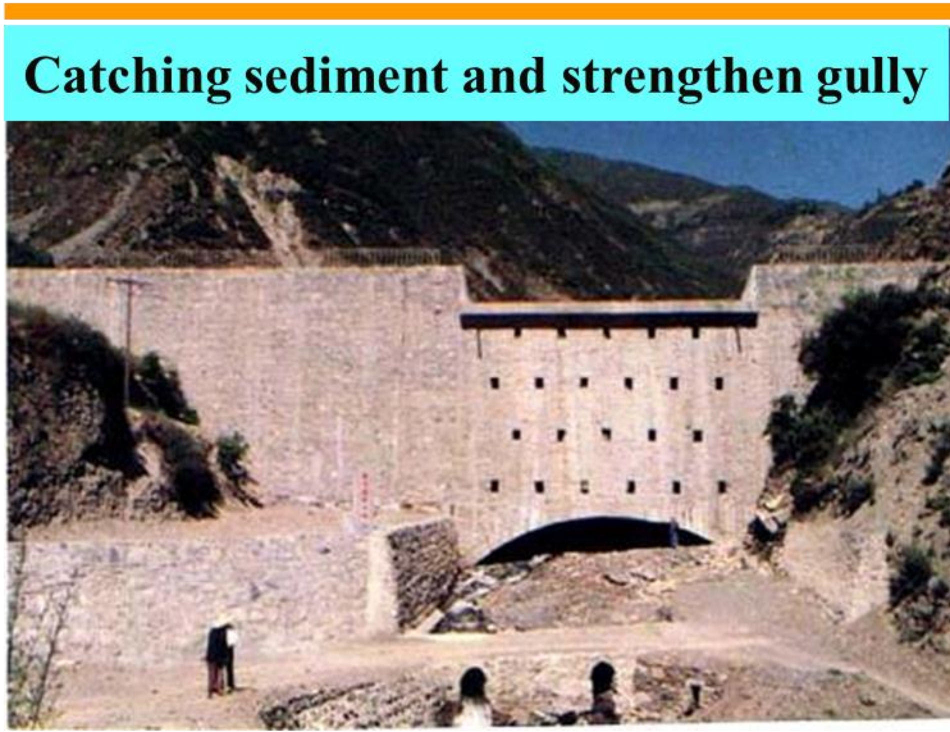
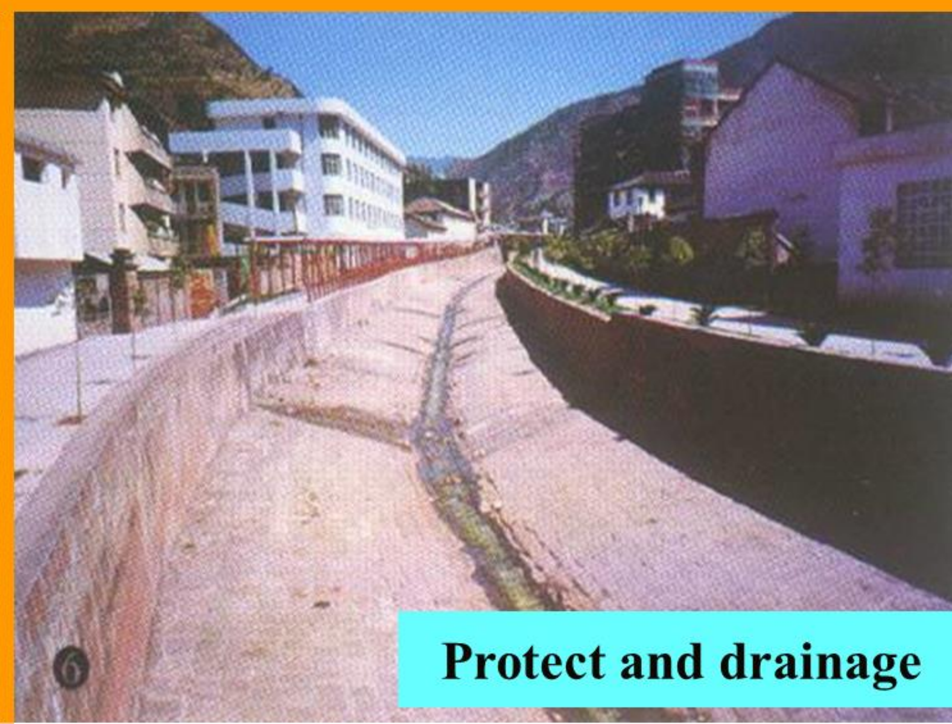
Dynamics response of structures to debris flows



Damage criterion of structures by debris flow




Monitoring and early warning

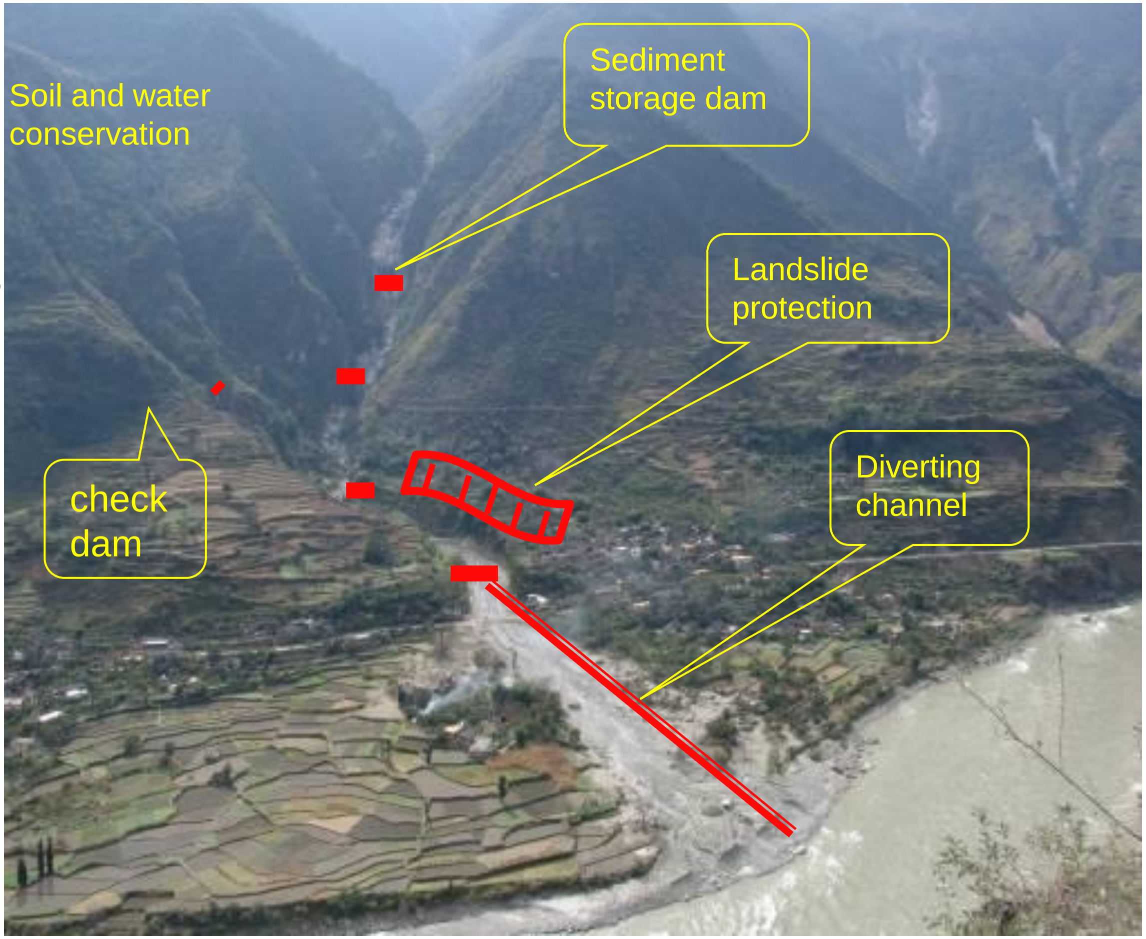
Water and soil conservation

Catching sediment and strengthen gully

Protect and drainage

Countermeasures

- on slopes
- in tributary areas
- in main channels
- in deposit zones

Integrated techniques

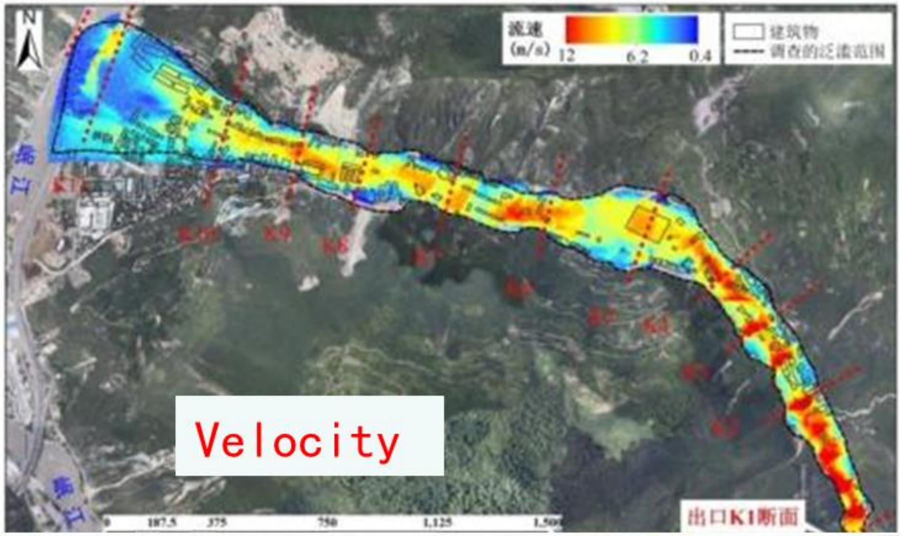
Integrated hazards mitigation techniques were proposed based on occurrence laws and movement characteristics



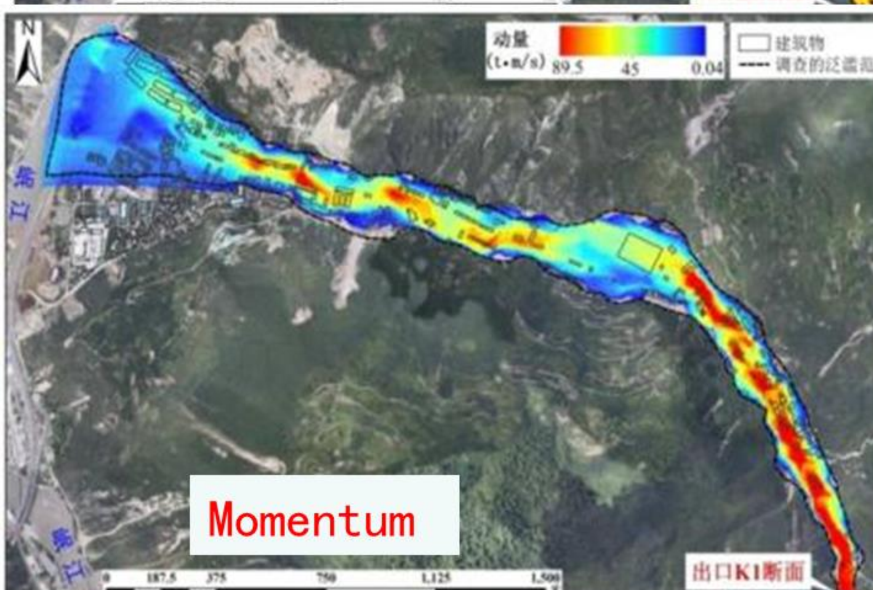
Case Study:

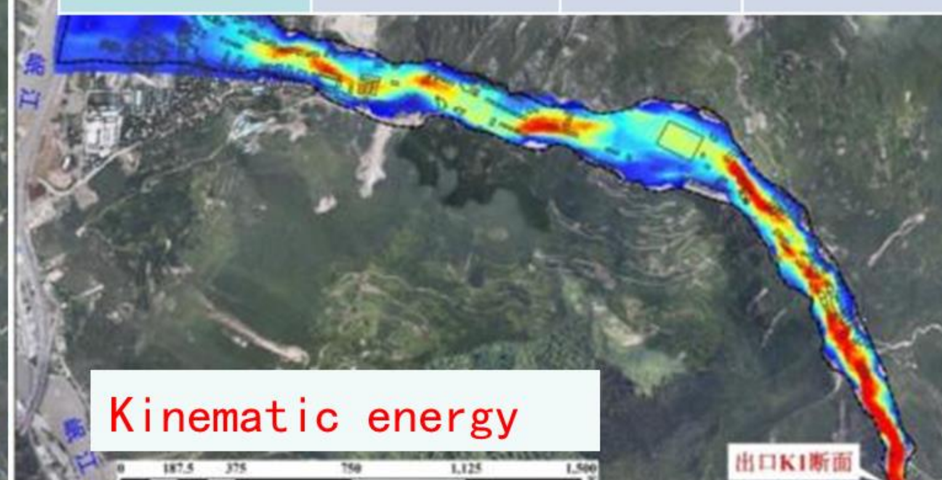
◆ Risk assessment for debris flow disaster in Wenchuan

◆ Hazard assessment

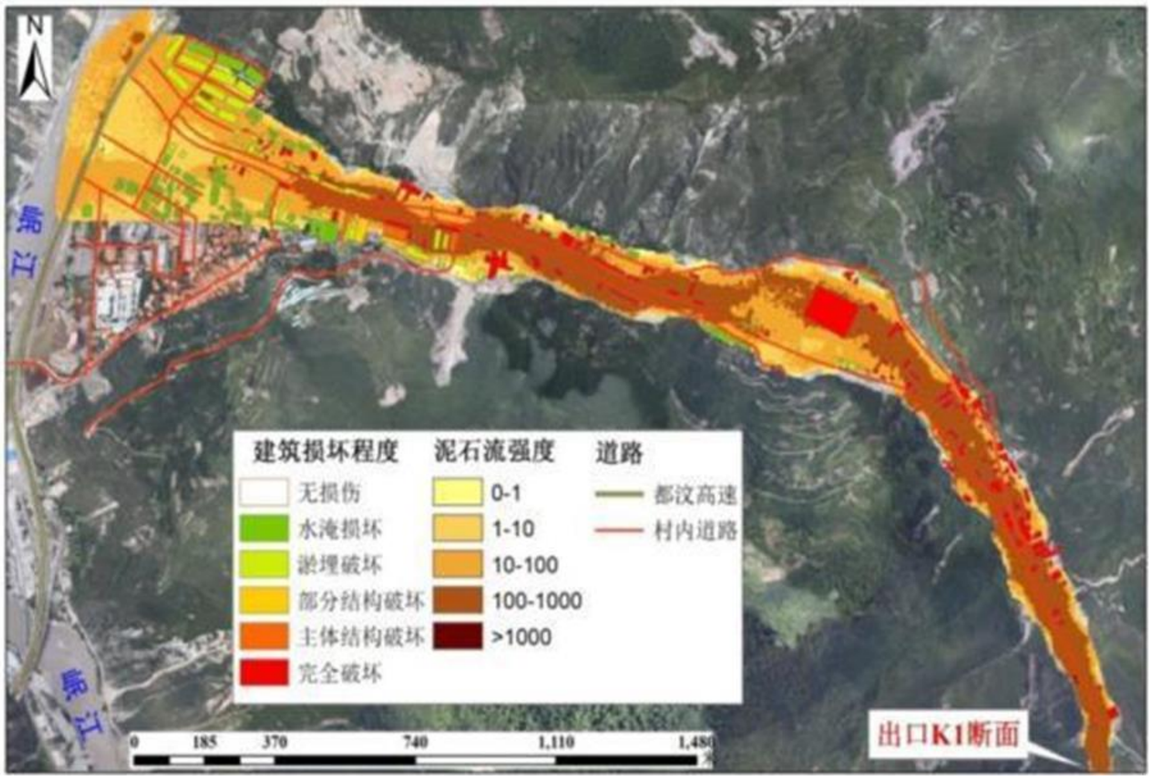


Zone No.	Velocity by field study	Averaged velocity	Averaged error
A：K1-K4	7.8-11.6m/s	8-12m/s	3%
B：K4-K6	6.2-7.8m/s	6.2-8m/s	1.5%
C：K6-K8	4.6-7.5 m/s	6-7.6m/s	12%
D：K8-K10	4.1-6.6 m/s	3-7m/s	8%
E：K10-K12	0-4.28 m/s	0-5m/s	16%





◆ Vulnerability calculation



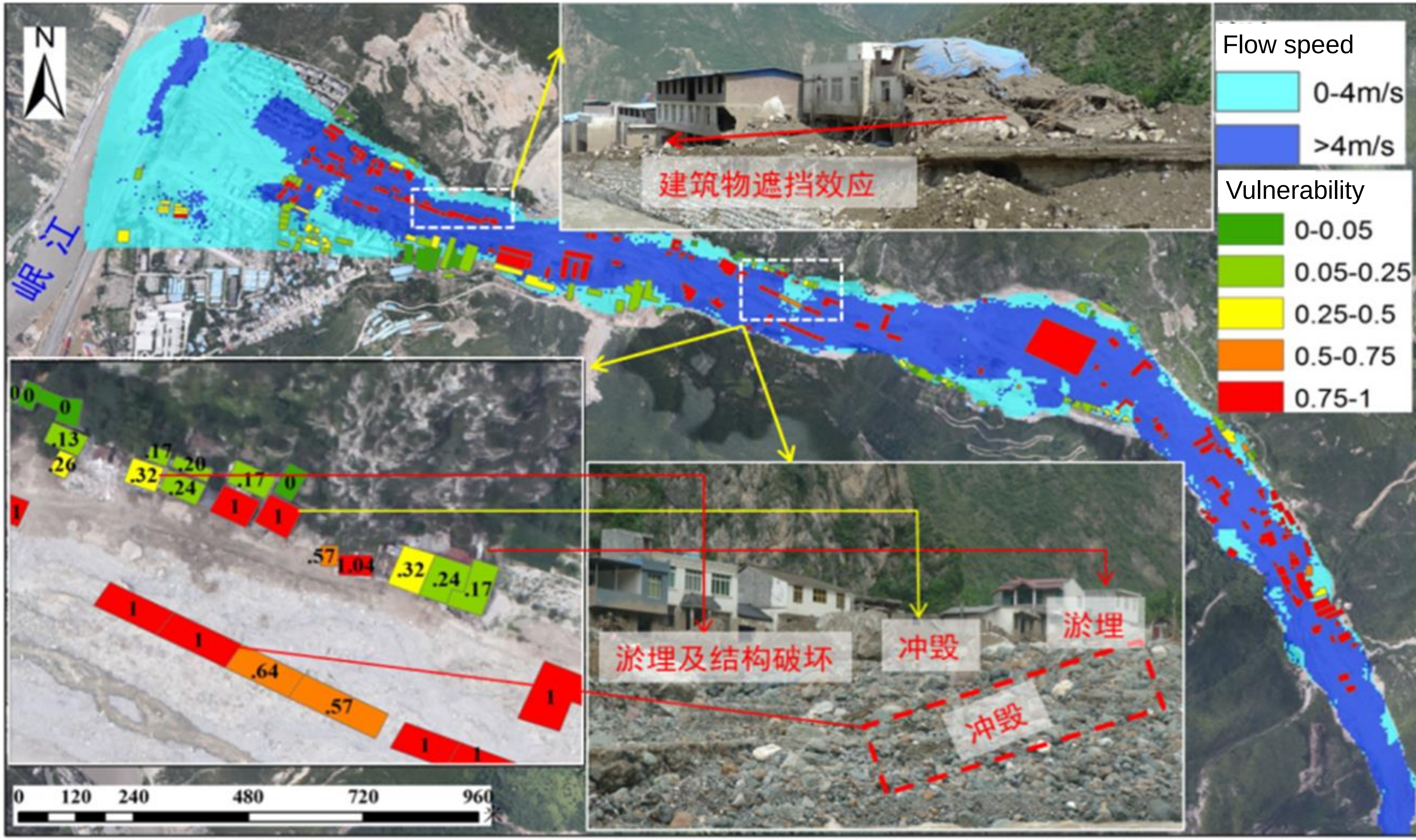
- Calculated amount of the destroyed buildings: 200m^2 per house
- Calculated economic loss for different structures

Brick-concrete structure: 800yuan/m^2

Concrete structure: 1200yuan/m^2

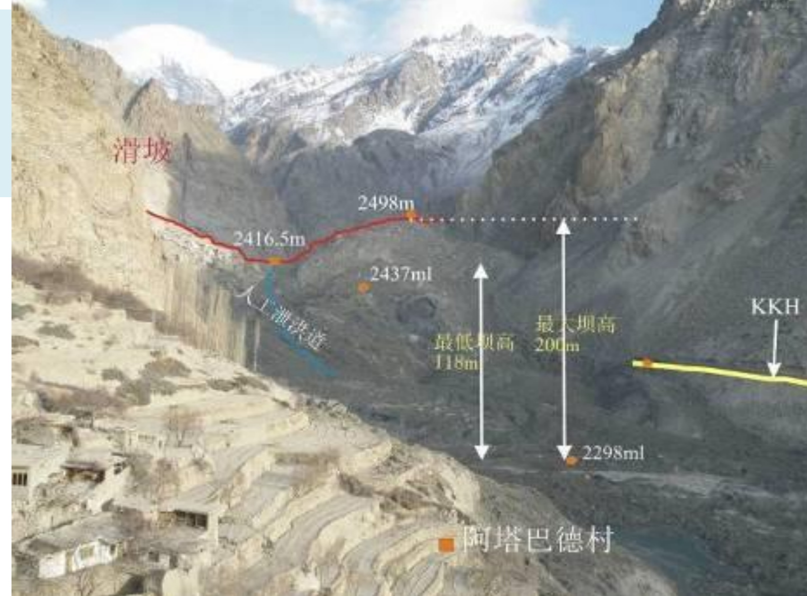
Strength	Inundation	Damaged by inundation	Partial structures	Main Structures	Completely damaged	Total Structures
<1	15	2	0	0	0	17
1-10	11	44	36	13	0	103
10-100	0	12	34	53	31	131
100-1000	0	0	1	24	58	83
>1000	0	0	0	0	0	0
Total	25	59	71	90	89	334

Verification of the Vulnerability Calculation



Calculated results based on the developed models are consistent to the field investigation

◆ China Academy of Sciences conducted Karakoram Highway hazards reduction



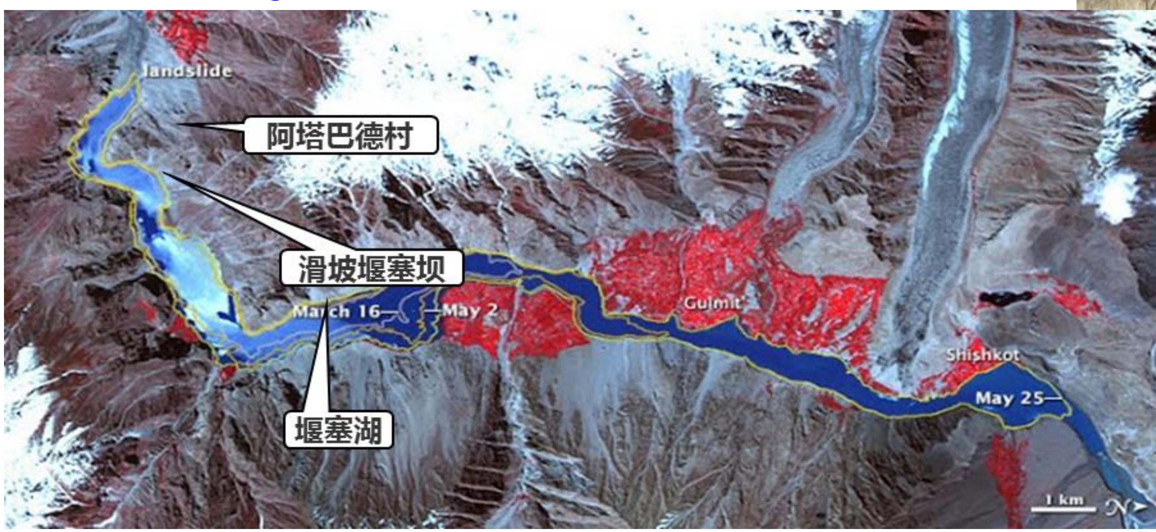
Attadbad dammed lake in Pakistan

Height : 116m

Reserved water : 0.5 billion m^3

Threaten 0.5 million people and the China-Pakistan Economic Corridor

◻ Risk analysis of the dammed lake



◻ Make the lake emergency disposal program, save the investment of $200 millionUS$ compared to the traditional scheme

2013 on May 23, Li Keqiang visited Pakistan released their joint statement pointed out "to accelerate the disposal of lake, promote the Karakoram Highway upgrading."

In September 2012, Pakistani Prime Minister Raja Pervez Ashraf attended Lake section of highway reconstruction ceremony

◆China-Nepal-India Koshi River Research Project

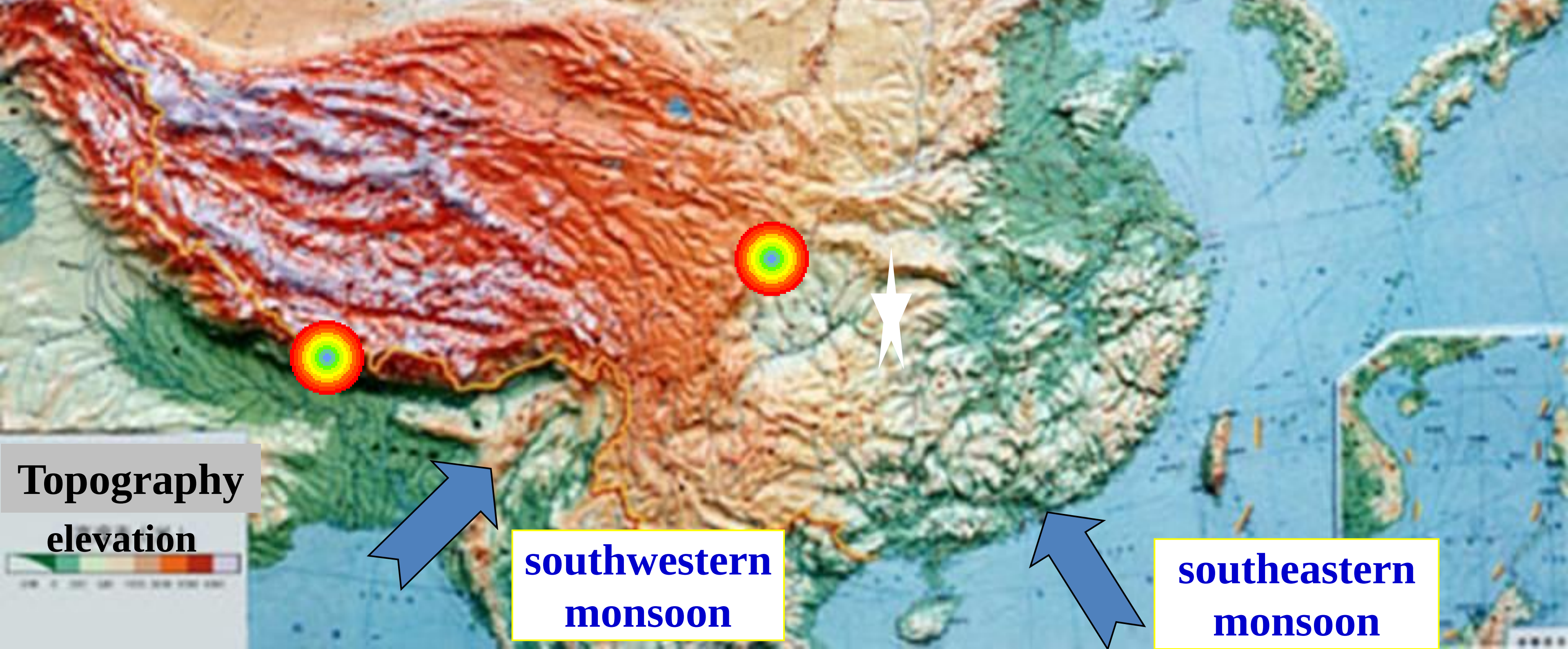
(financially supported by Australia)

In the village of Bhirkot (more than 1000 people), courses of hazards prevention and training were conducted

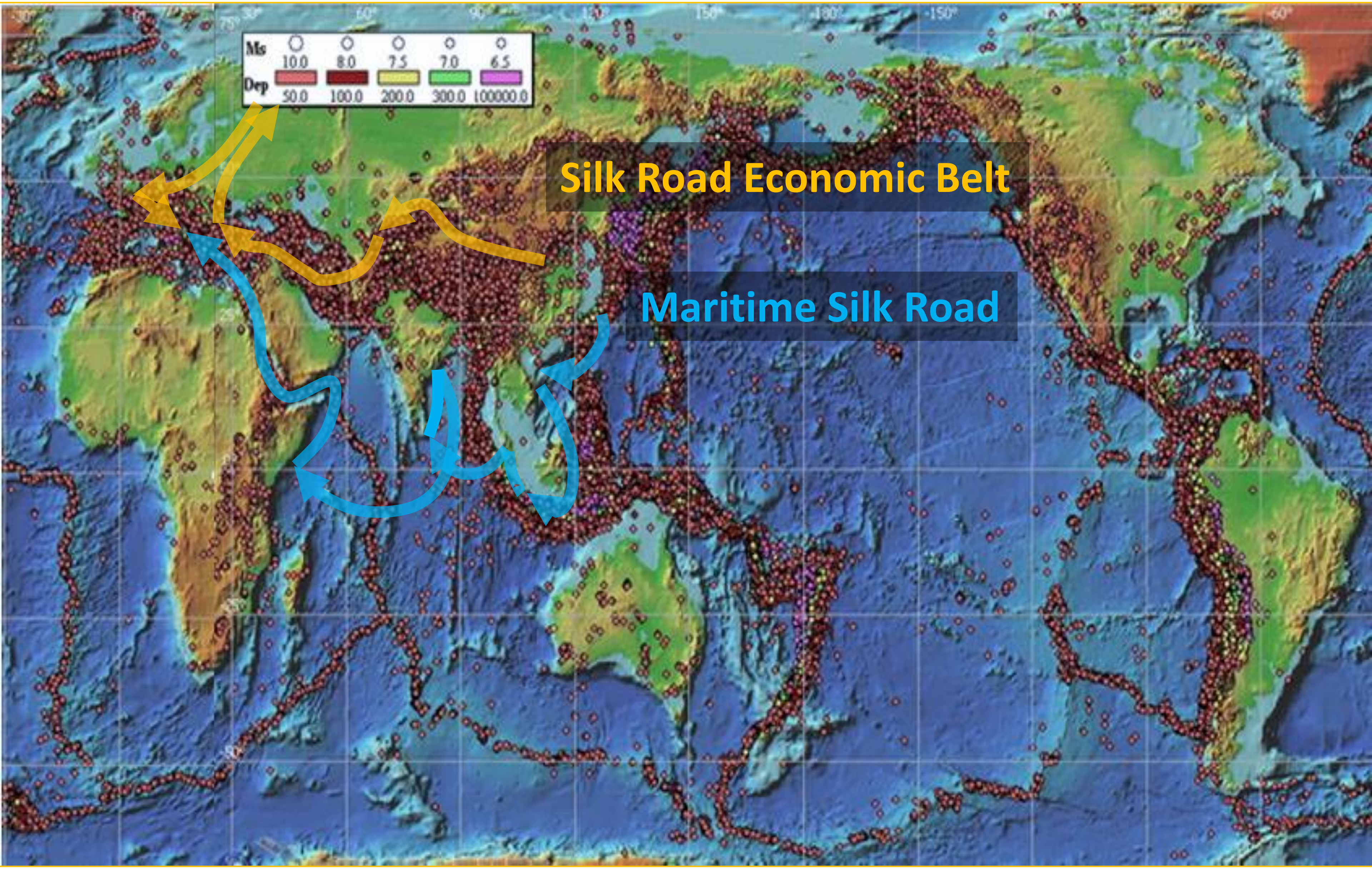
- **Built the China-Nepal geographic research center**
- **Chinese Scientists led and built 11 international cooperation teams; members from ICIMOD, Tribhuvan University of Nepal, etc.**
- **Published a book “Resources environment and development of Koshi River Basin under climate change ” ISBN978-75364-7921-0 ;**

- **The consulting report (With friendly water resources development and water hazards management and control as the breakthrough point to promote the sustainable development of economy and society in the region of Himalaya River) has been accepted by China and Napal governments.**

III Demand and Significance of Risk Reduction



Earthquake Risk along Silk Road Economic Belt and Maritime Silk Road




Landslides destroyed subgrade

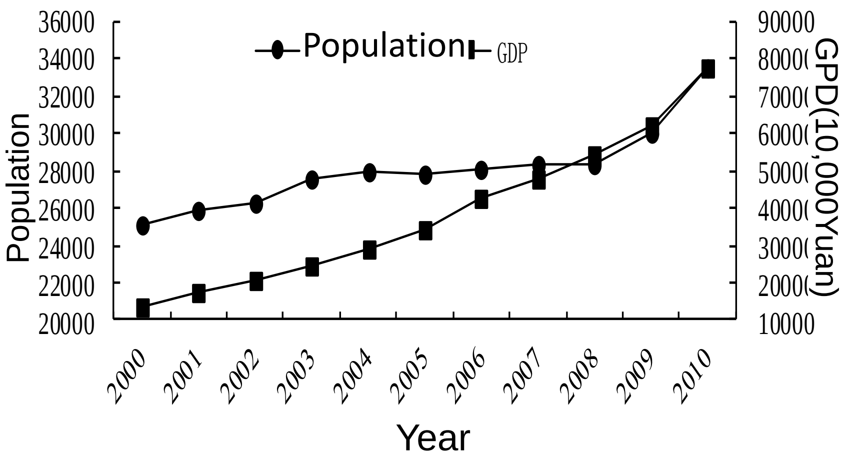
Landslides buryed subgrade

Landslides buryed subgrade

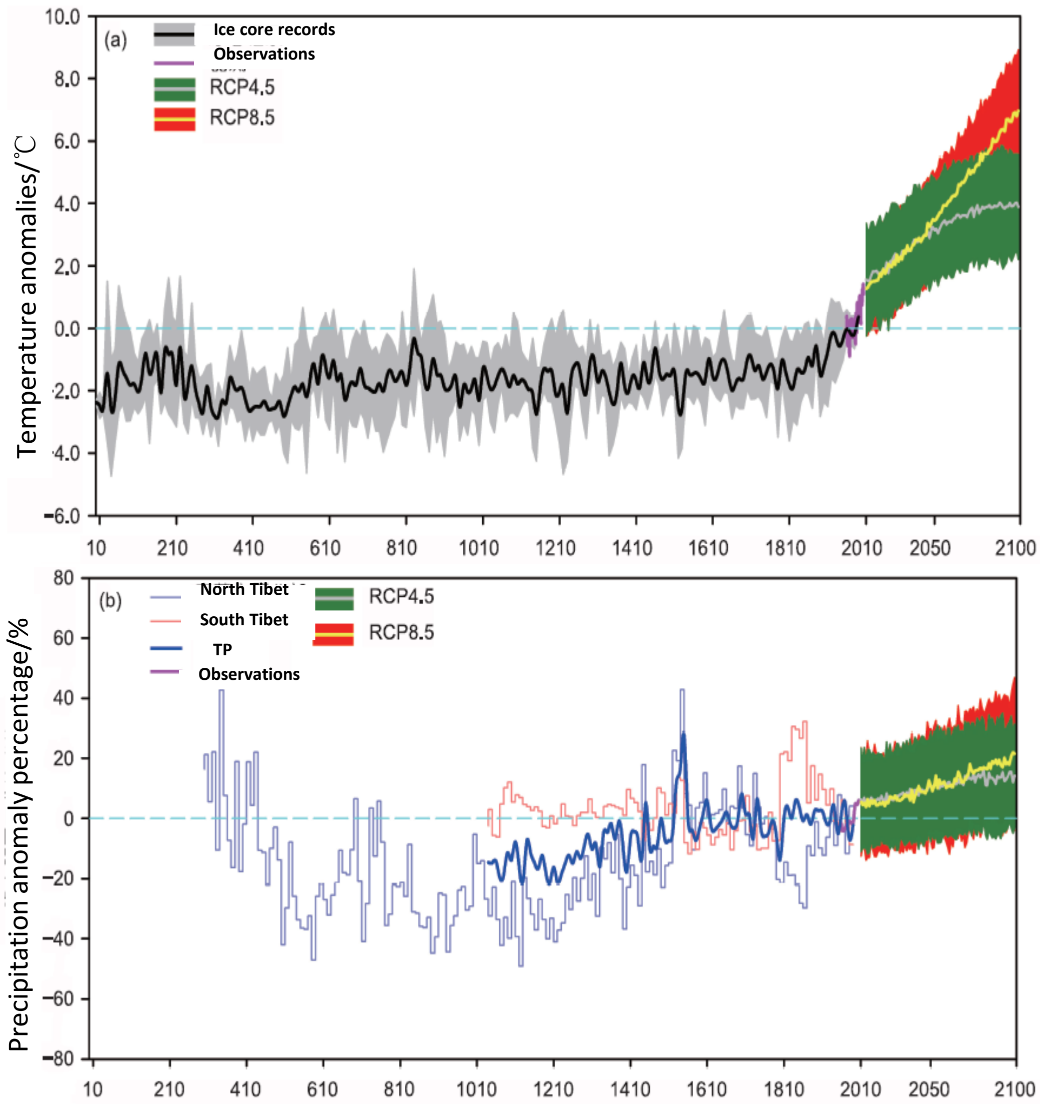
Barrier lake inundated road

The risk of hazards will increase as the rising hazard and vulnerability level at this region in the future

- The risk will significantly increase since the frequent occurrence of large scale hazards due to global warming.
- The valley with increasing density of population and economy overlap with the high risk areas of mountain hazards, which make the hazardous situation worse.



Variation of population and GDP of Bomi county



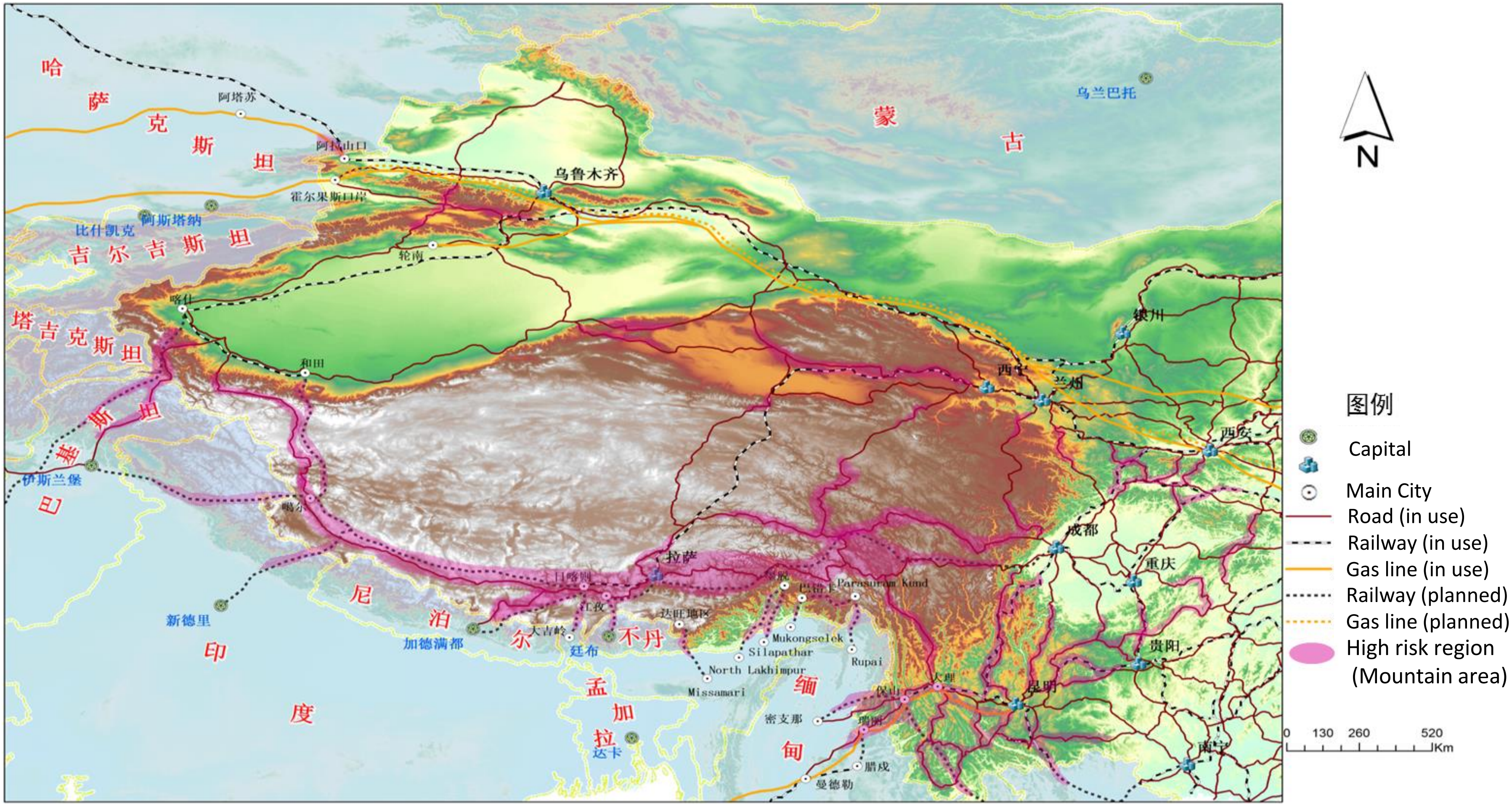
The current change of temperature and precipitation in the Tibetan Plateau and the future trends under different climate models (Chen et al, 2015)

Demand and significance of risk reduction

1. Lack of background data on natural hazards, detail survey are required to establish hazard database along “The Belt and Road”
2. Major infrastructure going to face new challenge since earthquake activity and climate change have altered the behavior of natural hazards
3. The characteristics of hazards in different countries have a significant difference; the un-unified practice and design standards need to be integrated and new effective mitigation technologies should be developed
4. The B&R area is vast, and hazards are scattered; it is urgent to develop the Space and Ground 3-dimensional real-time monitoring and early warning technology.
5. Most existing major projects and the planned economic corridors have not carried out a comprehensive hazard risk assessment.
6. Risk management and relief are closely related to different societal backgrounds, economic, cultural and religion; protocol needs to established for multi-nation relief coordination and information sharing

It is extremely important to carry out a comprehensive study on the risk of natural. The risk reduction can improve the resilience in developing counties, ensure the implementation of “The Belt and Road Initiative” and maintain the safety of the economic and cultural corridor.

IV International Research Program



Risk Analysis and Disaster Mitigation in the Belt and Road Economic Region: International Program for Risk Reduction

Research objectives

- Background survey technology and hazards database construction
- Evolution of natural hazards and their future trend
- Risk assessment at different spatial and temporal scales
- Monitoring and early warning technology (Space-ground integration)
- Key technologies of prevention and control for mega natural hazards
- Active mitigation policy and effective multi-national coordination protocol
- Enhancement of risk resilience in developing countries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不畏艰险 百折不挠
万众一心 众志成城

V What Can IRDR Do?

- Co-design an international project for risk reduction
- Organize international conferences for science and technology exchange
- Approach for data sharing mechanism
- Improve interaction between scientists and policy-makers to forward the effective multinational coordination protocol
- Develop community disaster management model
- Carry out training courses to enhance risk resilience in developing countries
- Set up some demonstrative projects for integrated risk management in poverty-stricken area
- Other actions?

Thank you for your attention!

NOTE: Data used in this presentation is from "International Disaster Database" and "United Nations Office for Disaster Risk Reduction"