講演会（ヒマラヤ周辺における水・土砂災害への取り組みについて―ネパールとブータンの最近の事例―）における資料

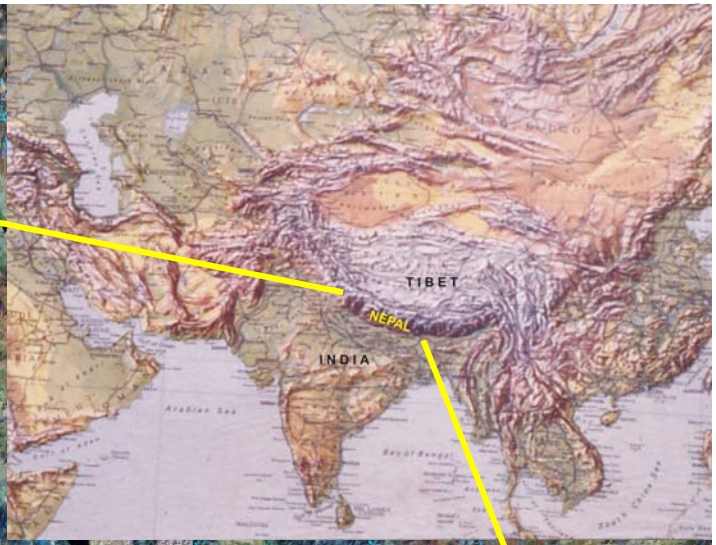
開催日時・平成 23 年 9 月 22 日（木）17 時～18 時 45 分
開催場所・（財）砂防フロンテイア整備推進機構会議室

ネパールにおける水・土砂災害対応の現状

Shanmukhesh Chandra Amatya 氏（ネパール政府　灌漑省治水砂防局　地すべり課長）

ブータンにおける氷河湖決壊洪水危険性調査と氷河湖排水工事の状況

Ugyen Wangda 氏（ブータン政府　通産省地質鉱山局　地質課長）



Water Induced Disaster Status in Nepal

Shanmukhesh C. AMATYA
DWIDP, Nepal, 2011

Content of Presentation

- Background
- Debris flow and Landslide
- Flood and Inundation
- GLOF

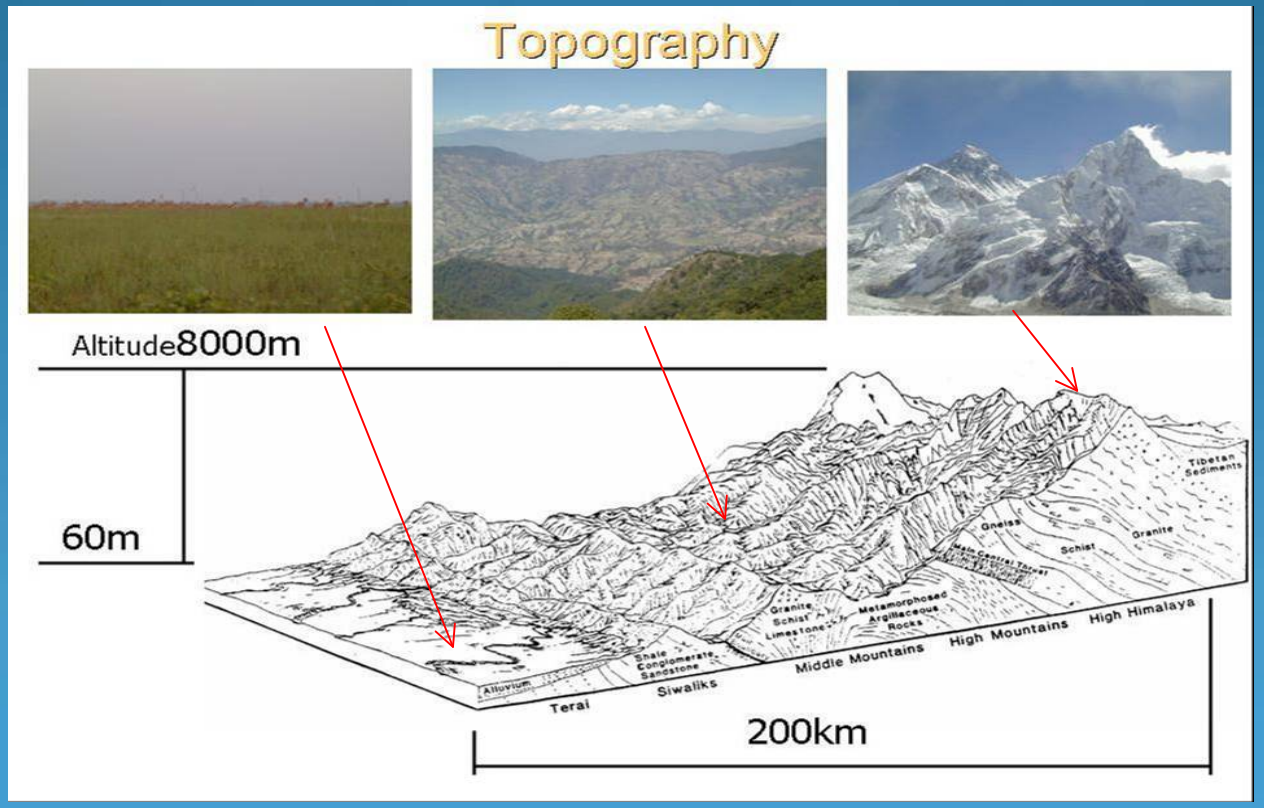
Background

Background cont...

- Lat: 26°22'-30°27' N
- Long: 80°04' – 88°12' E
- Total Area = 147,181 km2
- Total Population = 25 mill.
- Literacy = 54 % +

Area Coverage

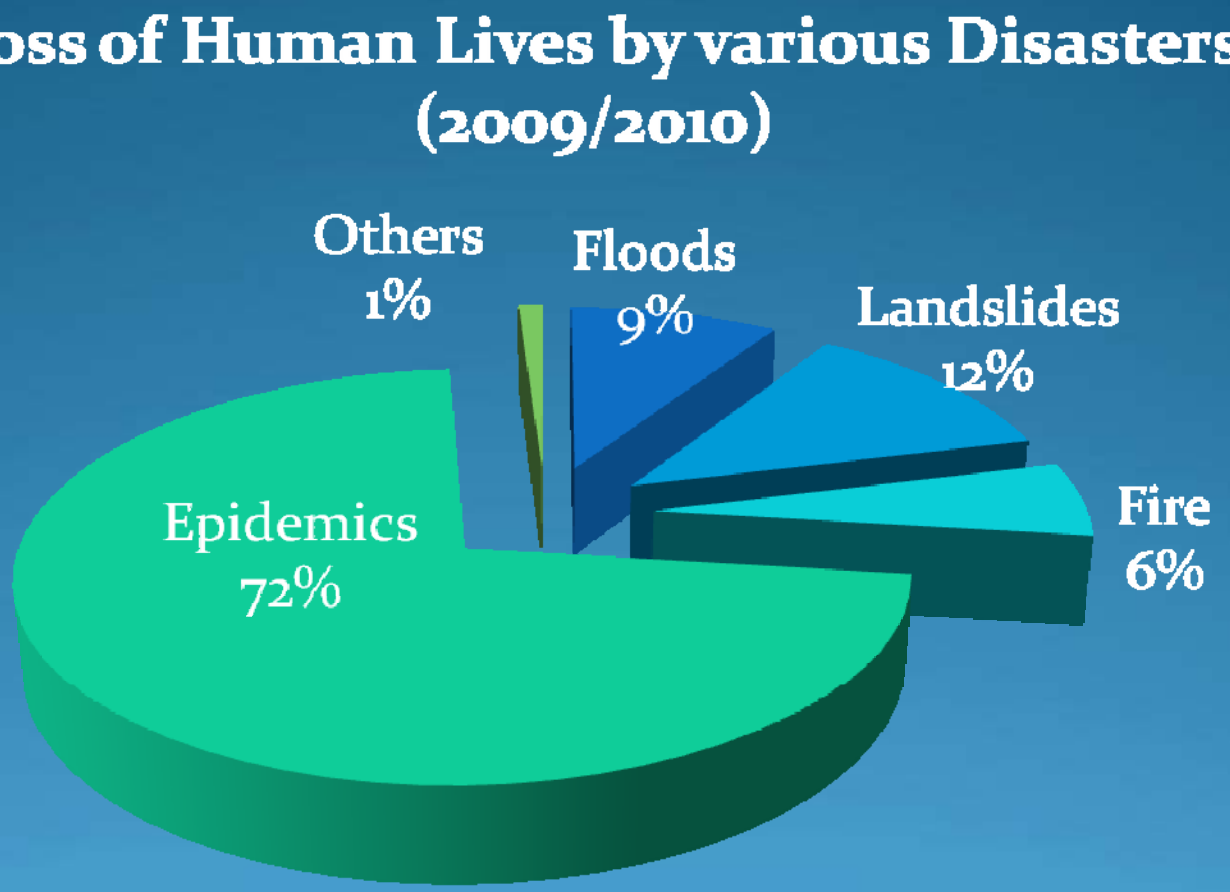
The Himalayas (4000 - 8848 m)	= ~ 15 %
The Hills/Mountains (330- 4000 m)	= 68 %
The Terai Plain (60- 330 m) ...	= 17 %



Background cont...

- Nepal often suffers from various types of Water induced disasters due to
  - High intensity of rainfall
  - Young and Fragile geology and steep morphology
  - Earth Quake
- Those disaster caused loss of lives and properties and environmental degradation each year.

Background cont...



Others: includes Earthquakes, Thunderbolt, windstorms etc
Total deaths : 641

Source: MoHA

Landslide and debris flow

Mugling Narayanghat (MuNa) Disaster Event

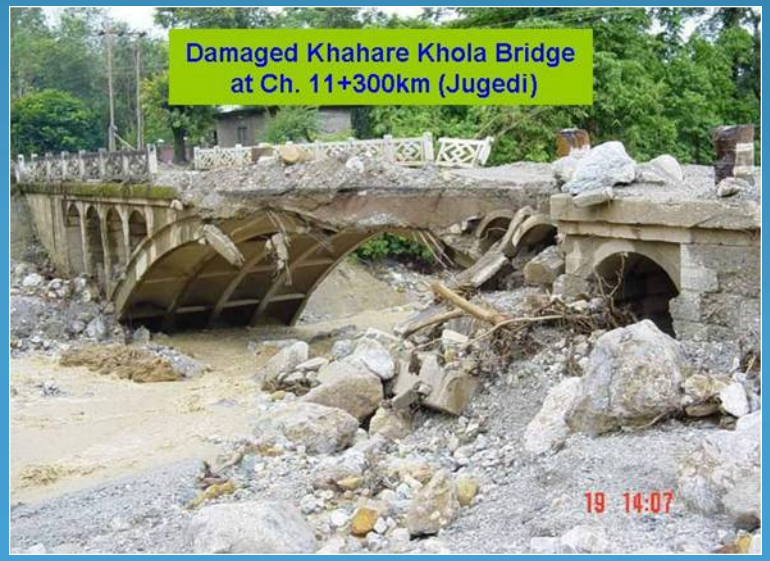
- Triggered by a torrential monsoon rainfall of 446mm in 24 hours was recorded in 30th July 2003 and caused a heavy damage to the main link road Highway from Terai to Kathmandu (Capital of Nepal), due to the major water induced Sediment Related Disasters (SRD).
- The disaster caused;

SN	Description of Damages	Unit	Quantity
1	Landslides/Debris flow	Nos	148
2	Embankment washed out	m	1480
3	Pavement damage	m	8675
4	Structural damages		
4.1	Retaining structures	m	494
4.2	Slab culverts	Nos	9
4.3	Bridges	Nos	2

  - Traffic flow disrupted thereafter
  - Acute shortage of food and fuel in the capital city affecting 2 million people
  - On the same day 11 people were died in Kabilash village.
- A project was conceptualized after field visit by a team of JICA Experts as well as the Nepalese Counterpart Experts to control and mitigate this disaster.
- Besides the project, a mutual effort of JICA and Nepal Government were introduced the Early Warning System in the disaster area Mugling-Narayanghat road section including the Kabilash Village, Chitwan District which is a most effective preventive measure and challenge to Landslide Risk Reduction.

Some pictures of the Mu-Na Highway disaster events

Photographs of Damaged Khahare Khola Bridge at Ch.11+300 Km due to Debris flow



Debris Flow at Ch. 31+950km

Broken retaining wall and road shoulder at Ch.33+000

Slope failure and broken road shoulder at Ch.31+000

Condition of Road Foundation Failure

Countermeasures

- In the **structural mitigation measures**, we use to apply engineering technology and bio-engineering technology.
- In case of **non-structural mitigation measure**, we are in practicing the awareness training program, education program to local community, school teachers and local leaders of the disaster area.
- Few examples of those countermeasures applied in Mu-Na Highway disaster area and Si-Ba Highway disaster area are presented as follows.

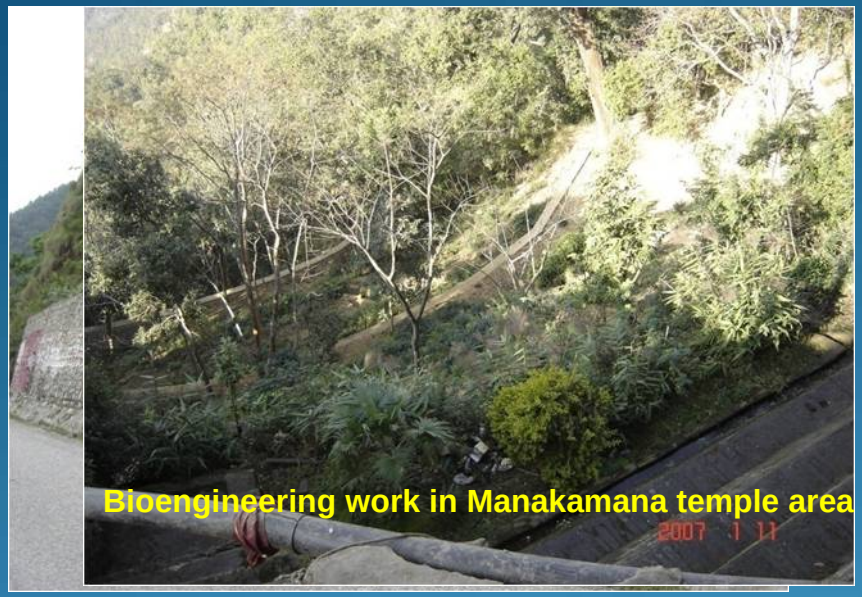
Mu-Na- Highway Disaster area

➢ The types of countermeasure works applied along the Mu-Na Highway are as follows,

- *Sabo dams/ Check dams*
- *Retaining walls*
- *Toe wall*
- *Horizontal pipe drains*
- *Surface and sub-surface drains*
- *Bio-engineering*
- *Spurs and revetments etc.*

Photographs of the countermeasure works applied in the Mu-Na Highway Disaster area

Masonry Retaining wall at 15+100 Km



Slit type Sabo dam in Das Khola

Gabion Check dam, Gaighat, Ch 18+460 Km

Masonry checkdam,Gaighat,Ch18+460 Km

Recent Photo monitoring of MuNa Highway Disaster area (March 2011)

Stable structures

Muna ch 25+200

Muna ch 27+100

Toe protection work at ch 21+900

Stable structures with debris flow

Structures needed to be maintained

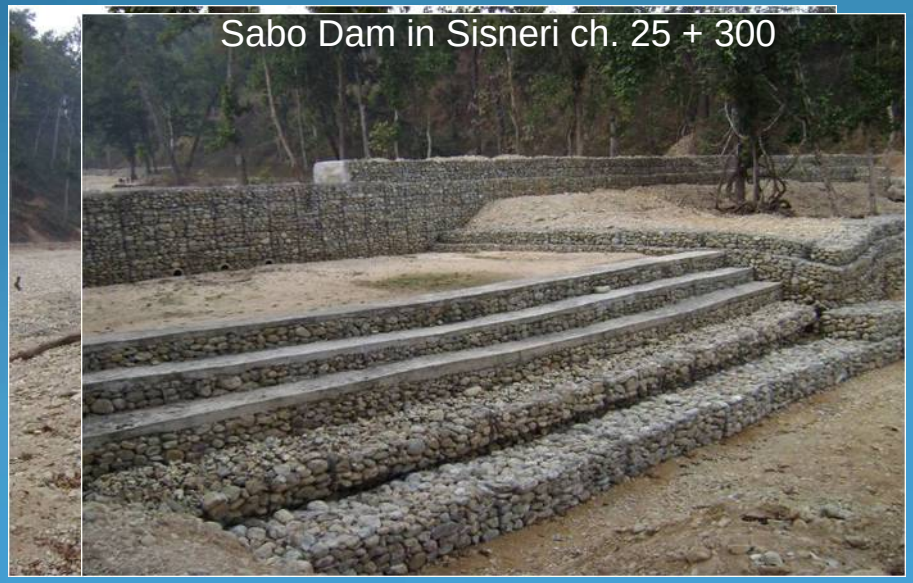
Constructions on newly formed debris flow

Countermeasure works applied in the Si-Ba Disaster area

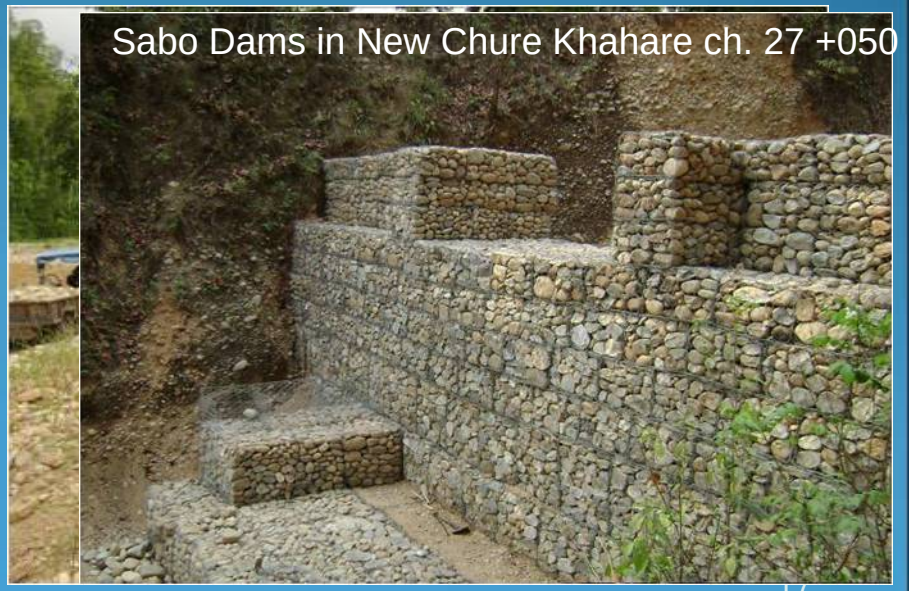
Sabo Dams in Thapa Kholsi near road ch. 25 + 746

Sabo Dam in Thulo Jholunge ch. 27 + 186

Embankment Protection work in Sisneri ch. 25 + 300

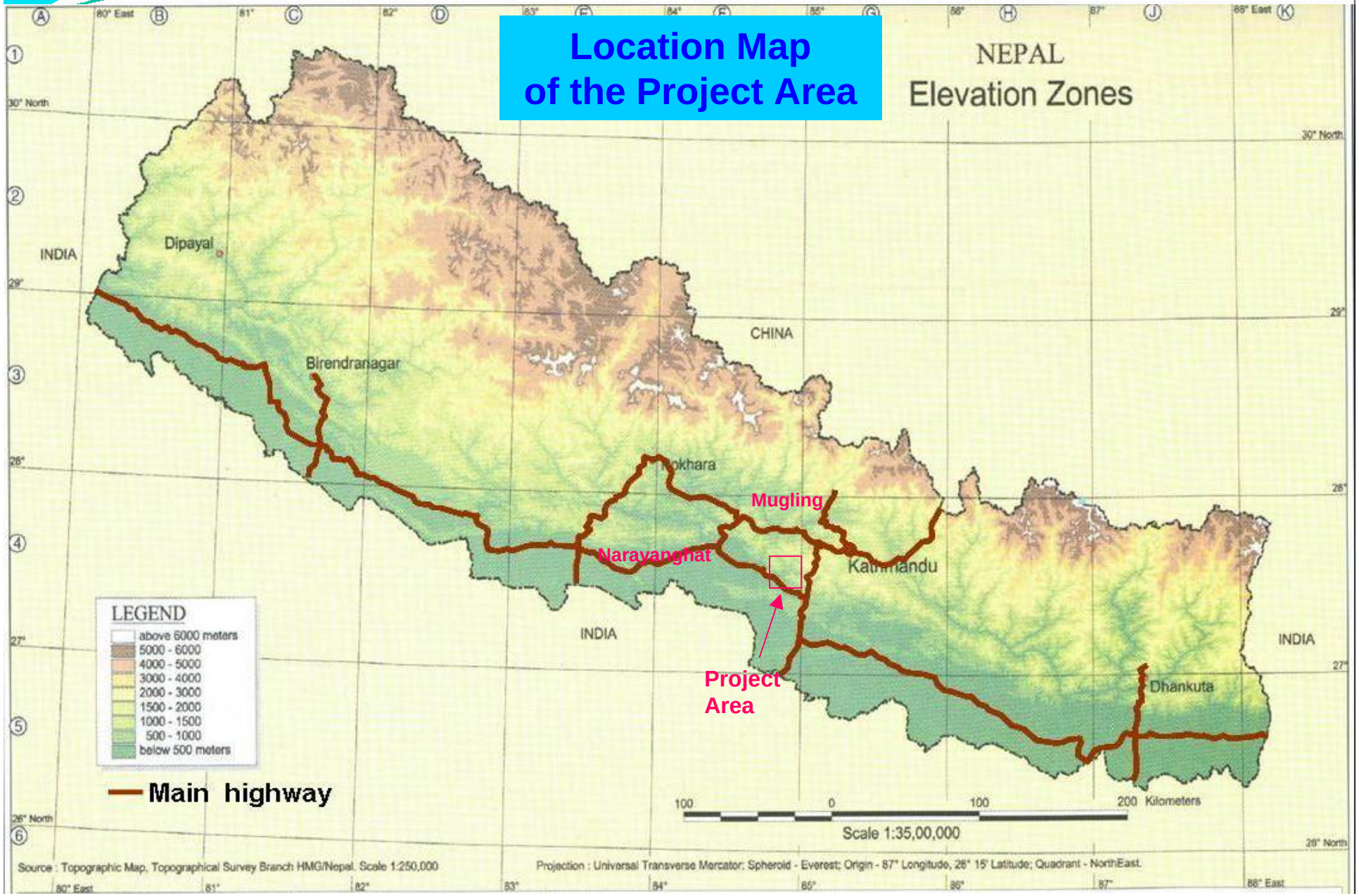


Bio-Engineering works in Balbasthan

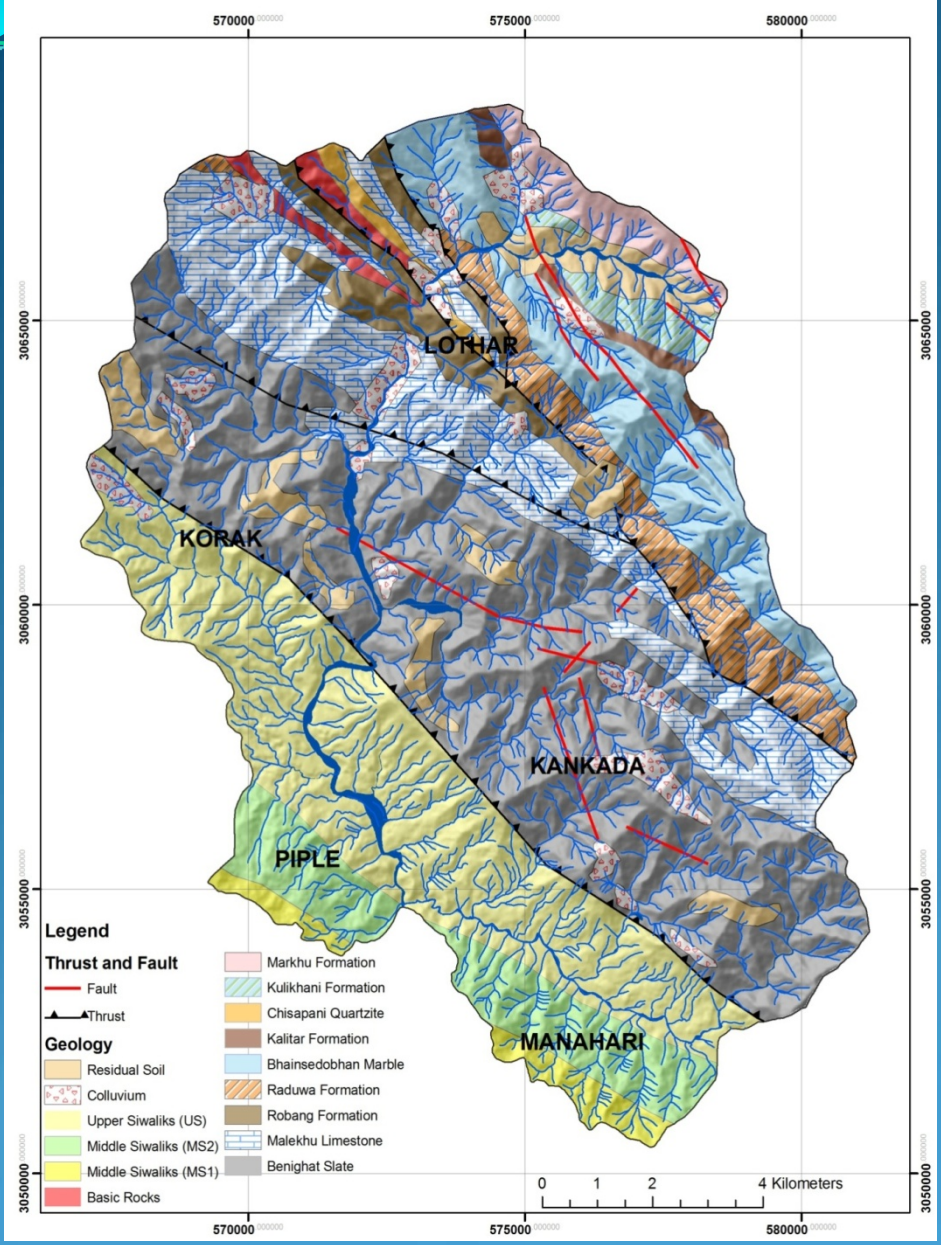


Debris flow in Lother Khola Watershed
(2010/2011)

- From FY 2010/2011 DWIDP lunched the Debris Flow and Slope failure mitigation works in Lothar Khola Watershed.
- Total area of the Watershed is about 165 sq.km
- Major problem in the WS is increasing of the bed level each year in down stream of the Lothar Khola near the East West Highway Bridge.
- Threatening the blockage and damage of Highway Bridge by overtopping of the debris.
- To control and mitigate the debris in the watershed following works were started from present FY 2010/11,
  - Construction of series of sabo dams, spurs and guide banks in the WS
  - Bioengineering works
  - Awareness trainings


Location Map
of the Project Area
NEPAL
Elevation Zones
INDIA
Dipayal
Birendranagar
CHINA
Pokhara
Mugling
Narayanghat
Kathmandu
INDIA
INDIA
Project
Area
Dhankuta
LEGEND
above 6000 meters
5000 - 6000
4000 - 5000
3000 - 4000
2000 - 3000
1500 - 2000
1000 - 1500
500 - 1000
below 500 meters
Main highway
100 0 100 200 Kilometers
Scale 1:35,00,000
Source : Topographic Map, Topographical Survey Branch HMG/Nepal. Scale 1:250,000
Projection : Universal Transverse Mercator; Spheroid - Everest; Origin - 87° Longitude, 26° 15' Latitude; Quadrant - NorthEast.

Status of Lothar Khola WS continued...



Geology and drainage Map of Lothar Khola Watershed

Recent photo monitoring of debris flow mitigation works in the Lother Khola Watershed

Lothar Hiway Bridge (June 19,2008)

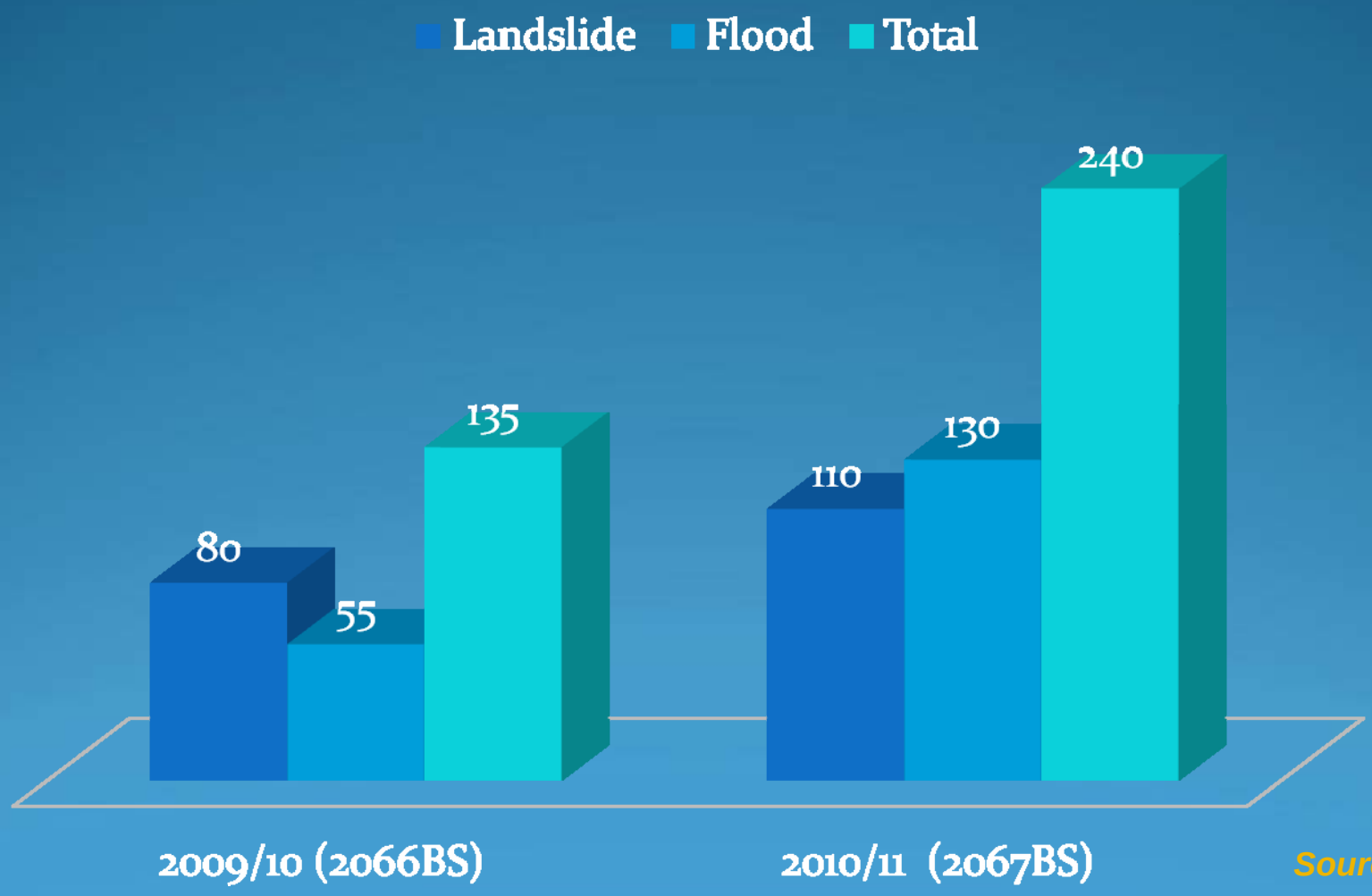
Lothar Highway Bridge (June 19,2008)

Lothar Hghiway Bridge (June 24,2011)

Ghatte Khola tributary of Lothar khola (June 25,2011)

Flood and Inundation

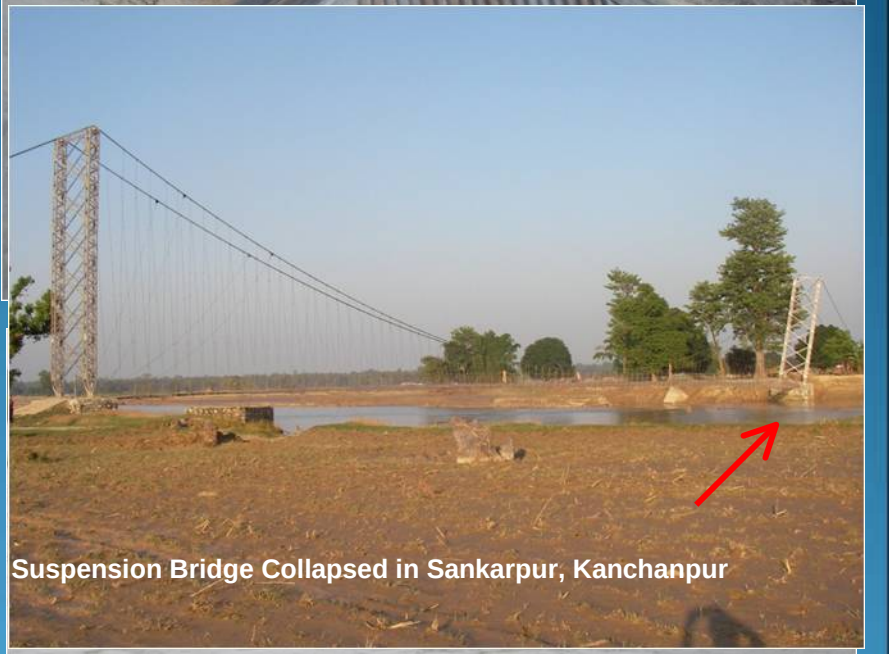
Loss of Lives by Landslide & Floods



Source: MoHA

Infrastructures Damaged by Flood

Highway Washed out due to Flood in Mohana River



Suspension Bridge Collapsed in Sankarpur, Kanchanpur

Flood and Inundation (continued…)

Status of embankment progress in rivers up to 2010

S.No.	River Name	Location	Work in Km
1.	Mechi	Jyamirgadh, Bhadrapur	5
2.	Biring	Ghailadubba	15
3.	Kankai	Mahabhara, Satidham	5
4.J	Ratuwa mawa	Madhumalla, Urlabari, sijuwa, rajghat	20
5.	Kamalbaniyani	Panch gachhi	2
6.	Bakraha	Embankment in both side are complete	76
7.	Sunsari	Enaruwa area	5
8.	Koshi	Embankment in both side are complete	70
9.	Triyuga	Sundarpur, jogidaha, Tapeswori, Hariya	4
10.	Balan	Maleniya, Bethi VDC	0.7
11.	Kamala	Right bank +Left bank	37.3
12.	Ratu	Kisanganj, Jaleswor	22
13.	Jhim	Salempur, Kisanpur, Laguwa	4.3
14.J	Lakhandehi	Haripur, Sakhuwa mauje, Sundarpur	18.2
15.	**Bagmati**	**Left Bank+Right bank**	**64**
16.	Lalbakaiya	Lelf Bank+Right bank	39
17.	East Rapti	Lothar Area	25
18.J	Narayani	Mangalpur, dibyanagar, salbas, rajahar	5
19.	Giribari	Both bank embankment is complete	45
20.J	Tinau-Danav	Buddhanagar, Khayarghari, Semalar, chhapiya	7
21.	Baan Ganga	Kajarawa, Simraha, Hardauna and Khuria	10
22.J	West Rapti	Holiya, Kachanapur, Gobardiya, Bijapur	30
23.J	Babai	Sanosri, Thapuwa, Gulariya, Padnaha	1
24.	Karnali	Okhariya, Chhediaghat, Rajapur	10
25.	Dodha	Kalika, Dekhatbhuli	1.70
26.	Mahakali	Chadani Dodhara, Bhimdutta	24.17
	Total		**546**

All GLOF data source: ICIMOD

Status of Glacial Lake Outburst Flood (GLOF) In Nepal 2011

www.icimod.org/publications and www.gfdrr.org
Glacial Lakes and Glacial Lake Outburst Flood in Nepal

Hindu Kush Himalaya Range

N

GLOF activities in Nepal

Definition: Melt-water lakes are potentially unstable; the sudden catastrophic release of water from such a lake is known as a glacial lake outburst flood (GLOF).

Initiative steps of GLOF Study in Nepal:

- **After the event, collapse of the end moraine dam of the Dig Tsho in 1985, the alarm bells for GLOF study.** *(the first detailed assessment of a GLOF event in Nepal 1986,1987)*

  The outbreak of Dig Tsho caused more than three million dollars worth of damage and disrupted the downstream community of Khumbu for several months.

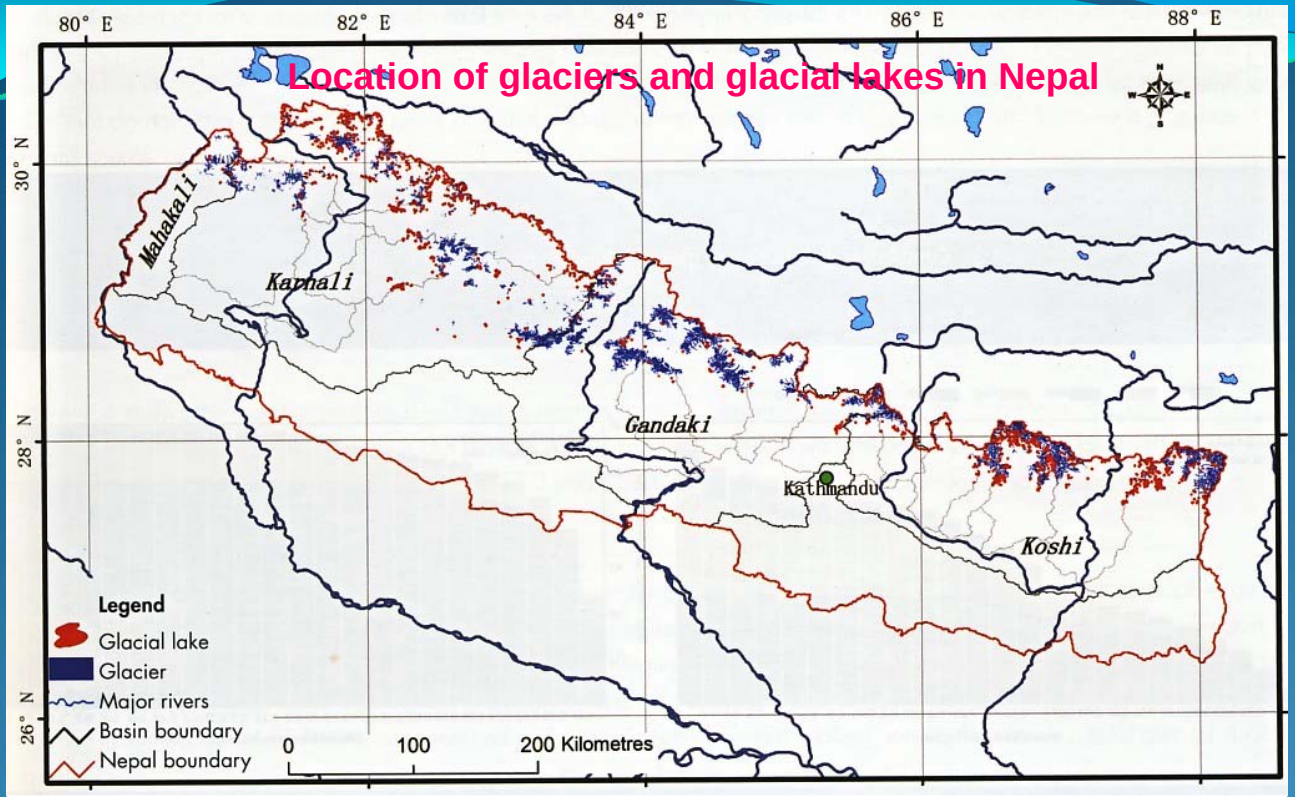
- **The scientific activity was a partial pause until the late 1990s.**

- **when it was noticed that Tsho Rolpa, a large glacial lake could be close to overtopping and destabilizing its end moraine, the mitigation efforts that included the construction works were done** *(Rana et al. 2000, Richardson and Reynolds 2000).*

- **After 2000, remote sensing technology were used to region-wide identification and mapping of the glaciers and glacial lakes** *(Mool et al. 2001a; 2001b), a preliminary inspection of Hindu Kush-Himalayan region (Mool and Bajracharya 2003; Bhagat et al. 2004; Sah et al. 2005; Roohi et al. 2005; Wu Lizong et al. 2005).*

- **Recently, a detailed multistep risk assessment methodology for glacial lakes were developed** *(With support of The World Bank Global Facility for Disaster Reduction and Recovery (GFDRR), and with additional support from the Swedish International Development Cooperation Agency (Sida) and the Norwegian Ministry of Foreign Affairs, Some preliminary results were provided in Ives et al. (2010).*

GLOF in Nepal (continued....)



S.No.	Name of River Basin	No. of Glacial lakes	Area in Sq.km
1.	Koshi River Basin	599	25.958
2.	Gandaki River Basin	116	9.538
3.	Karnali River Basin	742	29.147
4.	Mahakali River Basin	9	0.137
	Total	**1466**	**64.780**

Distribution of Glacial lakes and their area in the river basins and *sub-basins* of Nepal 2009BS

Present Status of GLOF Data in Nepal

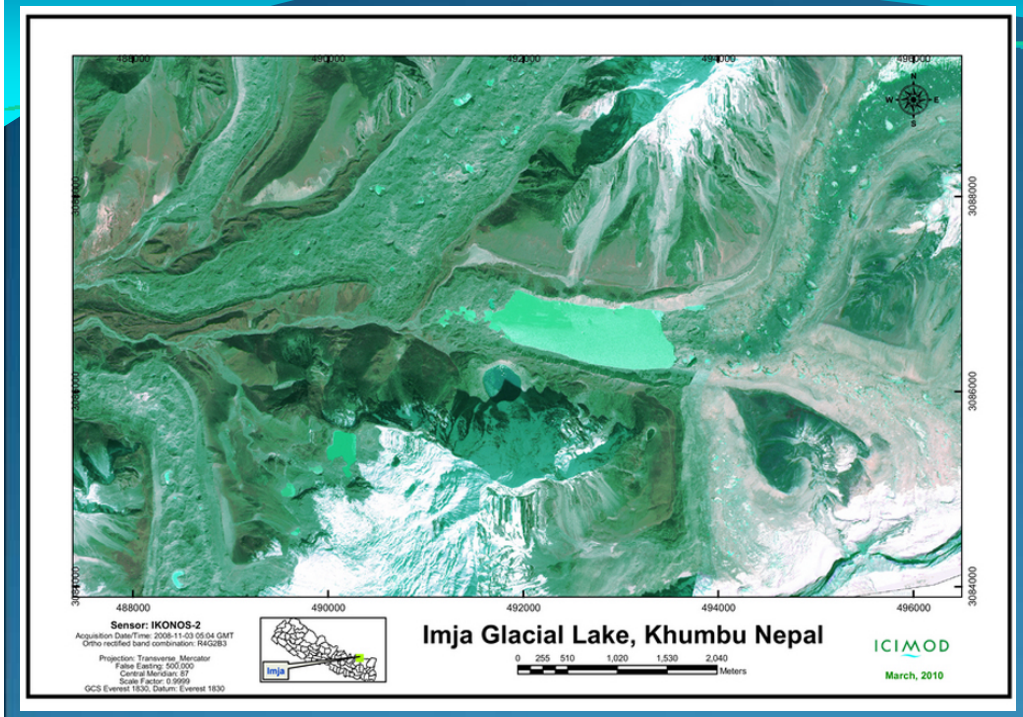
- Inventory of GLOF
- Mapping of Glaciers and Glacial lakes and their leveling
- Ranking of potentially dangerous lakes for further detail study, (Selected 21 Glacial lakes)
- Among them only 3 lakes are selected for investigation (i.e. Tshorolpa, Imja Tsho and Thulagi)
- Involvement Institution for the Investigation were DHM, DWIDP, MoHA, WECS, ICIMOD, Education Institutions, NGOs and INGOs.

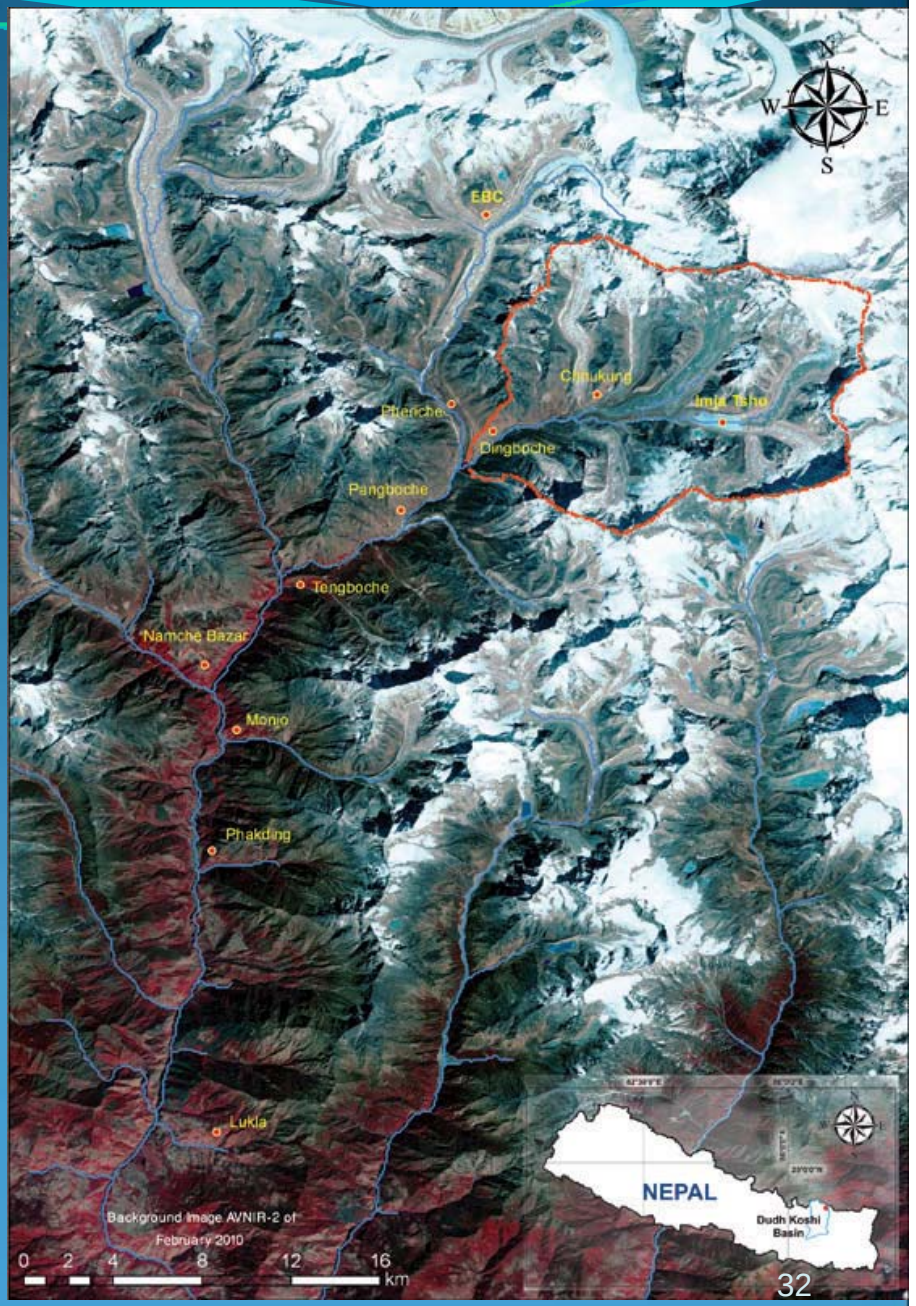
Besides,

- Establishment of Meteorological stations in some glaciers,
- Installation of Meteorological EWS (By DHM)
  - Gated structure channel in Tsho-rolpa Glacial lake
- Siphon system

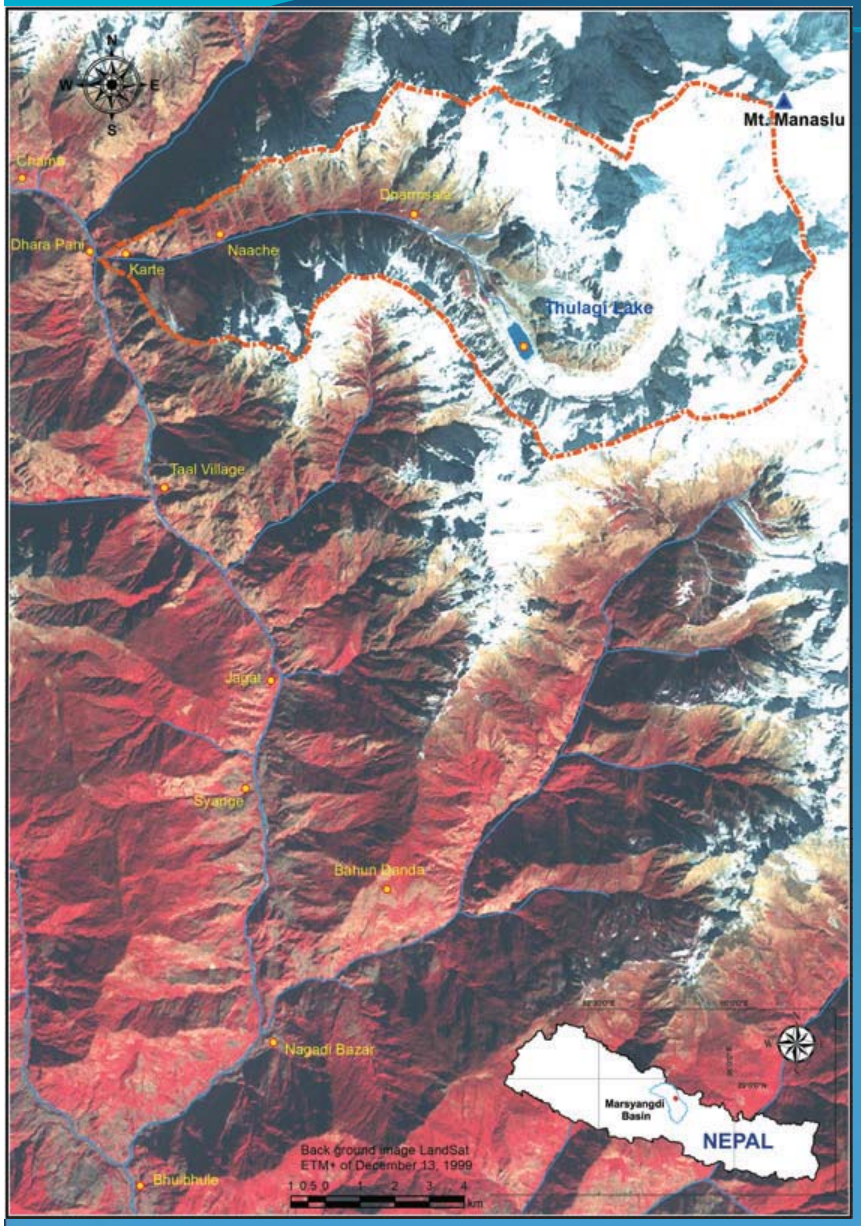
Field of study (in the selected Tshorolpa, Imja and Thulagi Glacial Lakes)

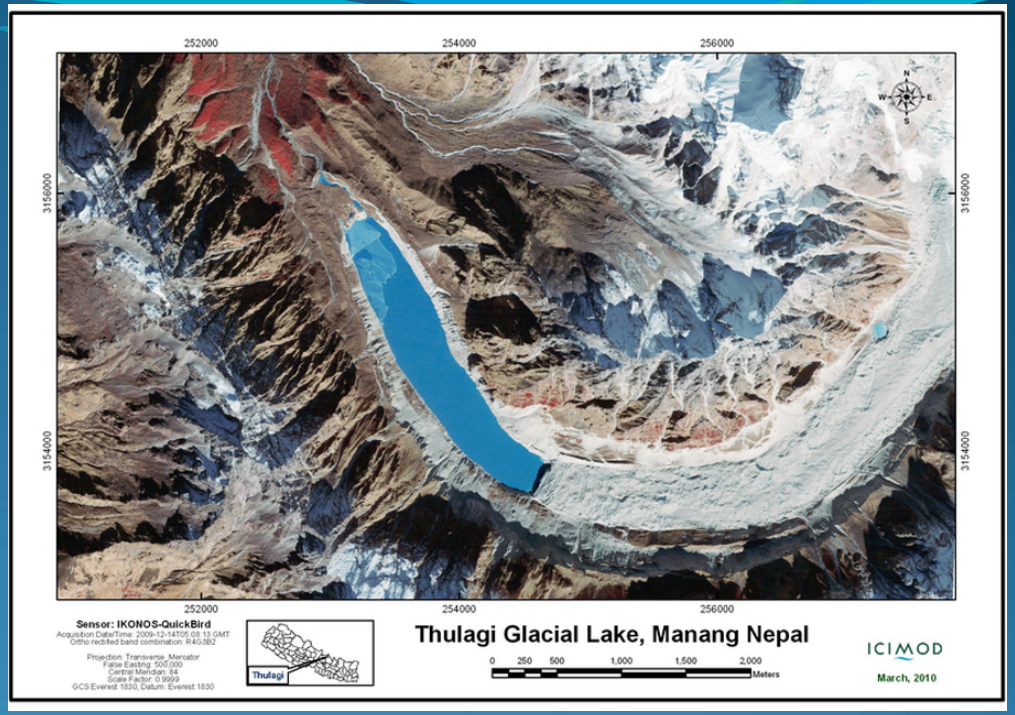
- Development of the Glacial Lake
- Topographical survey
- Bathymetric Investigation and mapping
- Hydro meteorological study
- Engineering Geology and geophysical Investigations
- Glacier Observation
- Modeling and Socio-economy analysis
- Vulnerability assessment of down stream





Location of Imja Glacial Lake





Location of Thullagi Glacial Lake

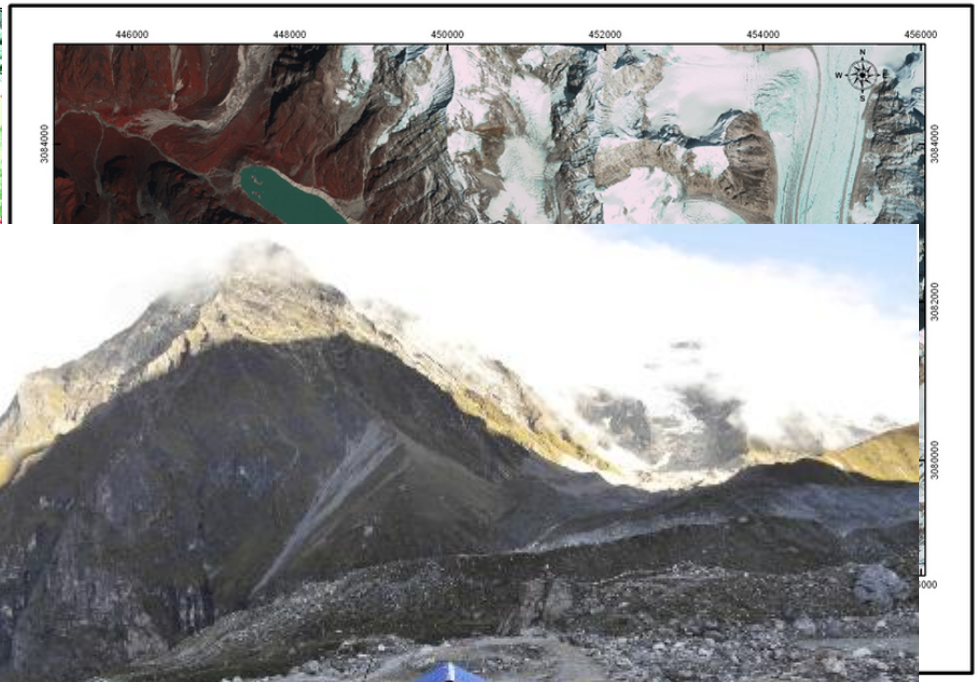


Photo: Sharad Joshi, 2009

Nepal is classified as the "Hot Spot" of Natural Disasters...

Ranked 6 th !!!
Climate Change Disaster

Adaptation Measures Possible

Ranked 11 th !!!
Earthquake Disaster

Beyond Human Control

Ranked 30 th !!!
Water Induced Disaster

Most Common in Nepal


Greetings from Nepal...
That's all
Thank you
Very Much
Mt. Everest, 8848m

Landslides and GLOFin Bhutan

By
Ugyen Wangda
Chief Geologist
Head, Geological Survey of Bhutan
Department of Geology and Mines
Ministry of Economic Affairs
Thimphu: Bhutan

Presentation structure

- Introduction
- Geographical Location
- Economy
- Climate
- Geology
- GLOF
- Landslides
- Conclusion and recommendation

- Bordered by the Tibetan Plateau and the Indian States
- Total land area = 36,000 Km^2
- The rugged terrain has elevation ranging from 150 m to 7500 m within a distance of <175 km
- Area above 4200m above sea level covers 20.5% of the total land

Introduction: Economy

Bhutan's economic growth was 7.7% in 2008.

- Hydropower projects (Tala, Kurichu, Basocho)

  The Power Master Plan estimated hydropower potential of 30,000 MW from the rivers in the country. Hydropower provides 25% of the governemnt revenue.

  Bhutan has a vision for 10,000MW by 2020

- Tourism

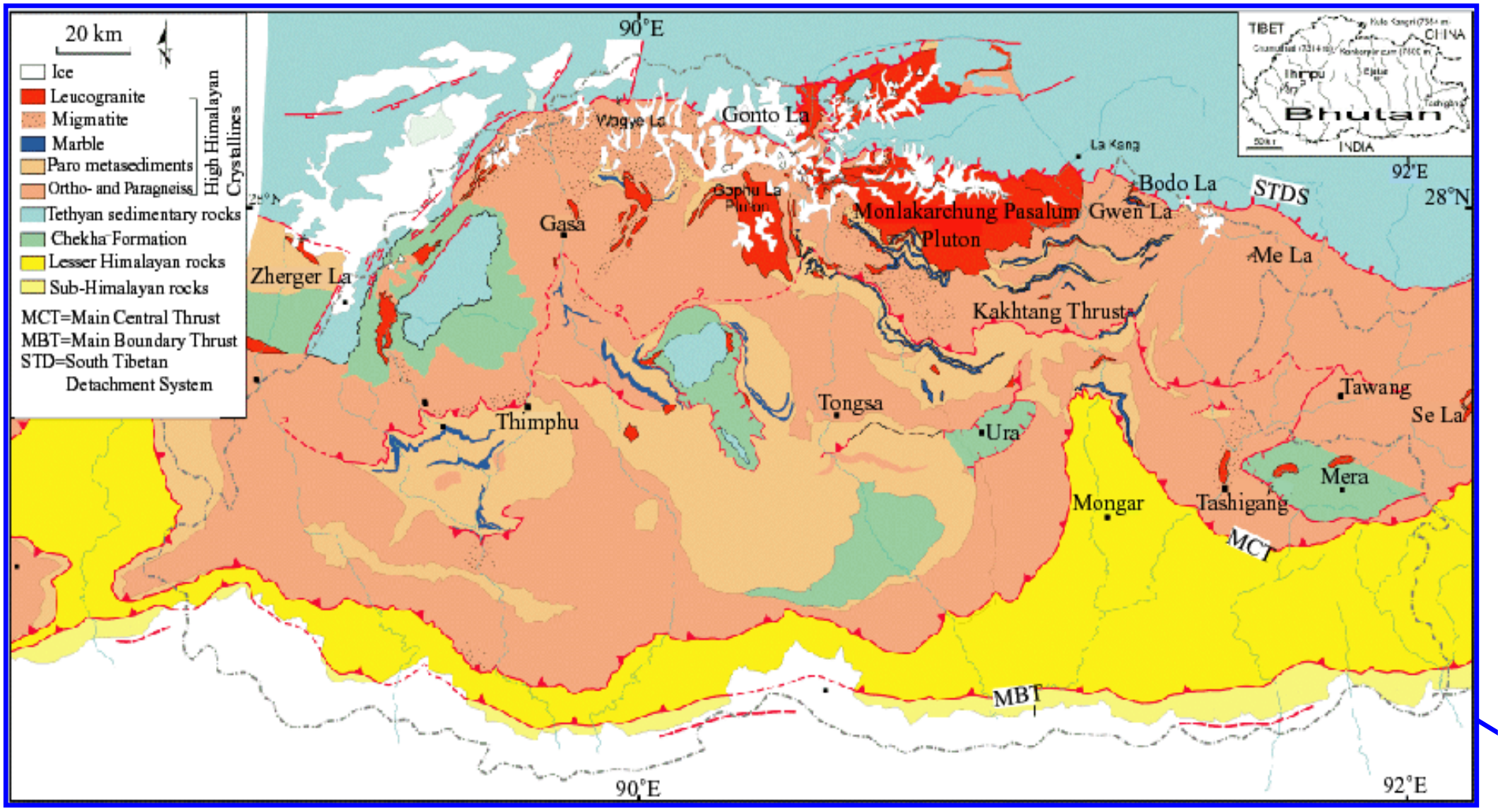
  In 2008, 76093 tourists visited the Kingdom contributing US$208.4 million to the economy.

- Agriculture

  Agriculture share to GDP was 36.4% in 2007.

Electric power export to India generate >40 % of foreign currency earnings since the last few years

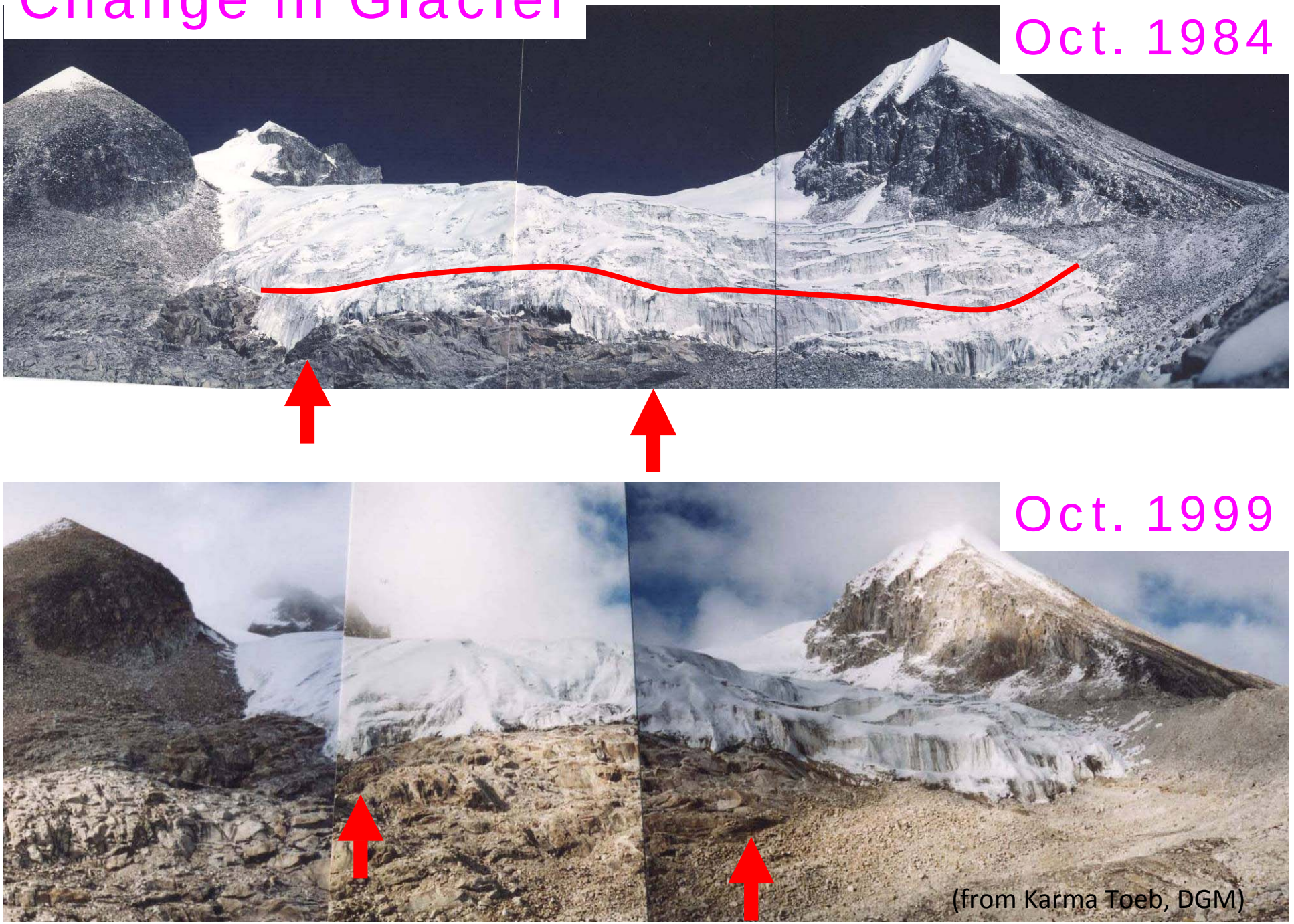
Geology of Bhutan



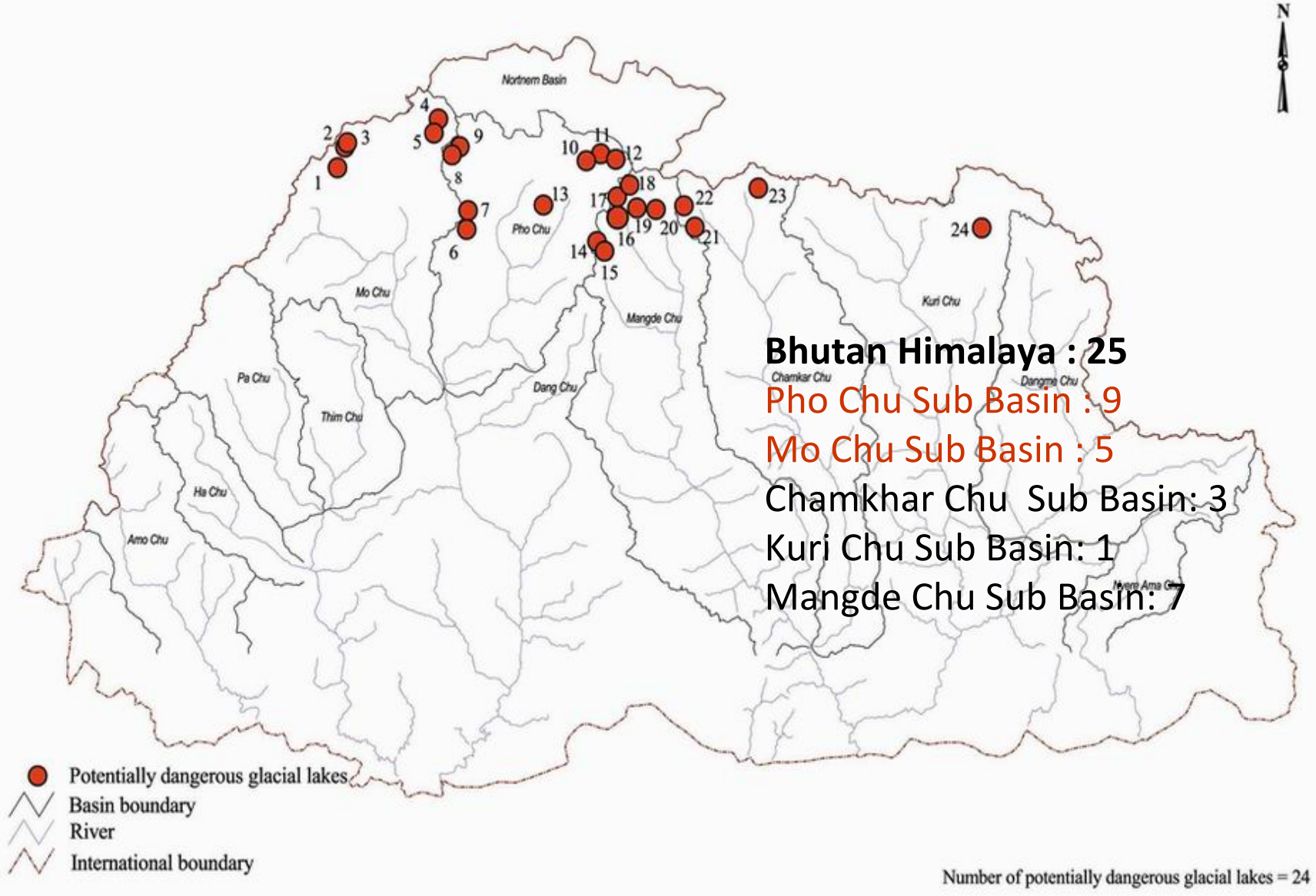
Glacial Lake Outburst Flood(GLOF)

- If the Southern, Central and the areas falling in Lesser Himalayan part of Bhutan are highly exposed to risk from Landslide and related hazard, then the northern Bhutan is exposed to risk from Glacial Lake Outburst Flood (GLOF).
- All the Major River system in Bhutan are flowing from North – South and they are all Glacial fed river.
- There are a total of 677 glaciers known to exist in the Bhutan Himalayas, which cover an area of 1,317 km^2 with approximately 127 km^3 of ice reserves and occur above the elevation of 4000 m Above Mean Sea Level(AMSL)
- These glaciers, feed water into 2,674 glacial lakes formed due to the retreating processes of the glaciers. Bhutan has been described as being prone to dangerous GLOFs (Watanabe and Rothacher, 1996).

Change in Glacier



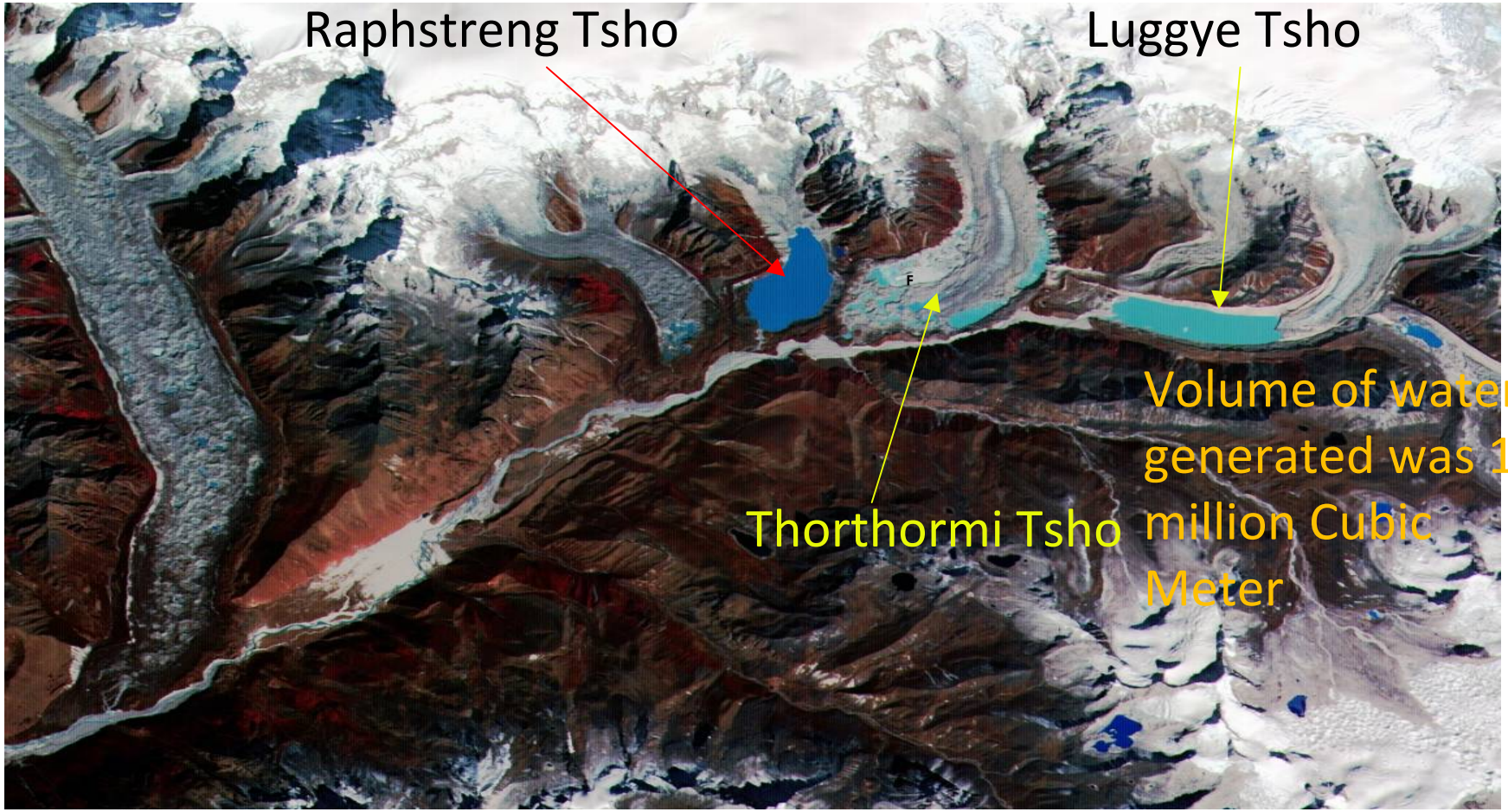
Map of Bhutan Showing the Location of Potentially Dangerous Glacial lakes



No. of Potentially Dangerous Glacial Lakes

- However these numbers may increase or decrease once the result of the detailed study being currently carried out by DGM/JST/JICA, through the funding of JST/JICA, are published.

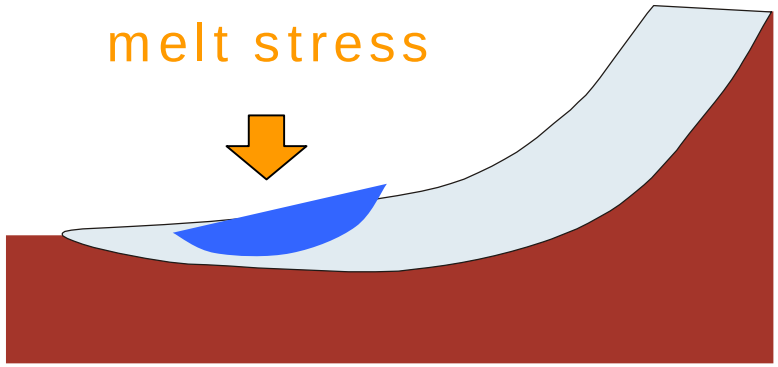
Location of Luggye Tsho, which burst in 1994

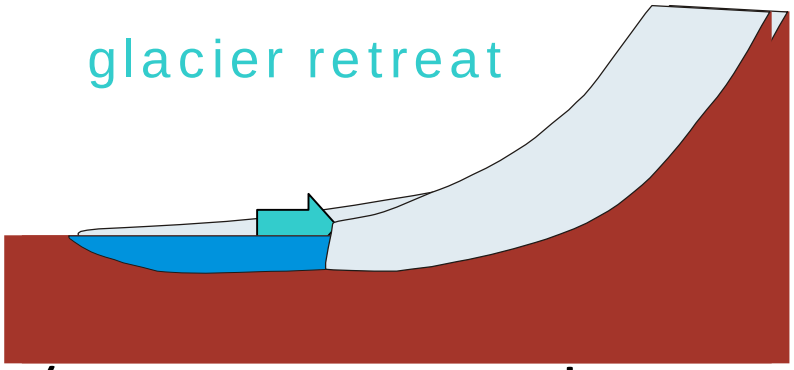


Glacier Lake Formation

Melting process
as vertical thinning of glacier

Glacier retreat
as horizontal expansion of lake





(From Karma Toeb, DGM)

GLOF -- causes

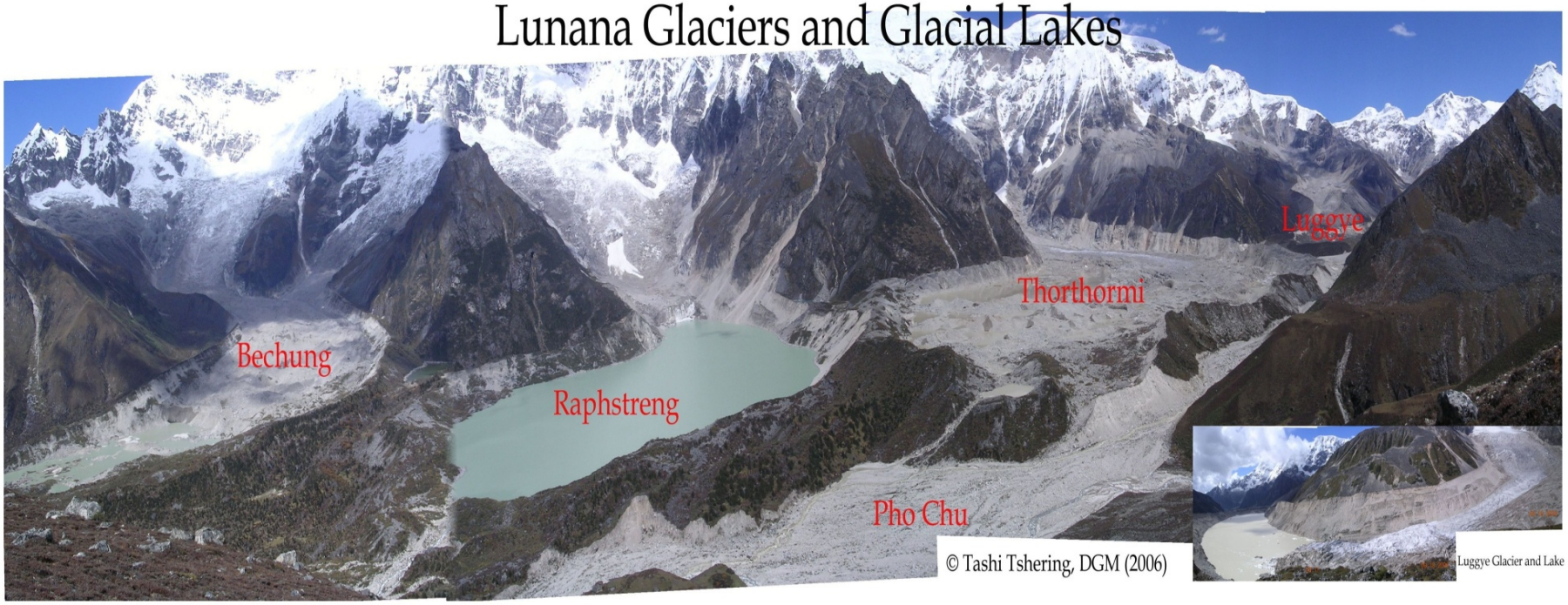
1. Increased melt rate (due to global warming?) → increase water volume → increased hydrostatic pressure on moraine dams
2. Weakening of moraine dams due to erosion and melting of ice (for ice-cored moraine dams).
3. This "fragile" system can be disturbed by external forces such as:
   - Earthquakes
   - Rock or ice avalanches
   - Outburst from adjacent glacial lakes
   - Landslide and debris flow

Downstream Punakha Dzong Affectd

Activities of Post Lugye Tsho GLOF

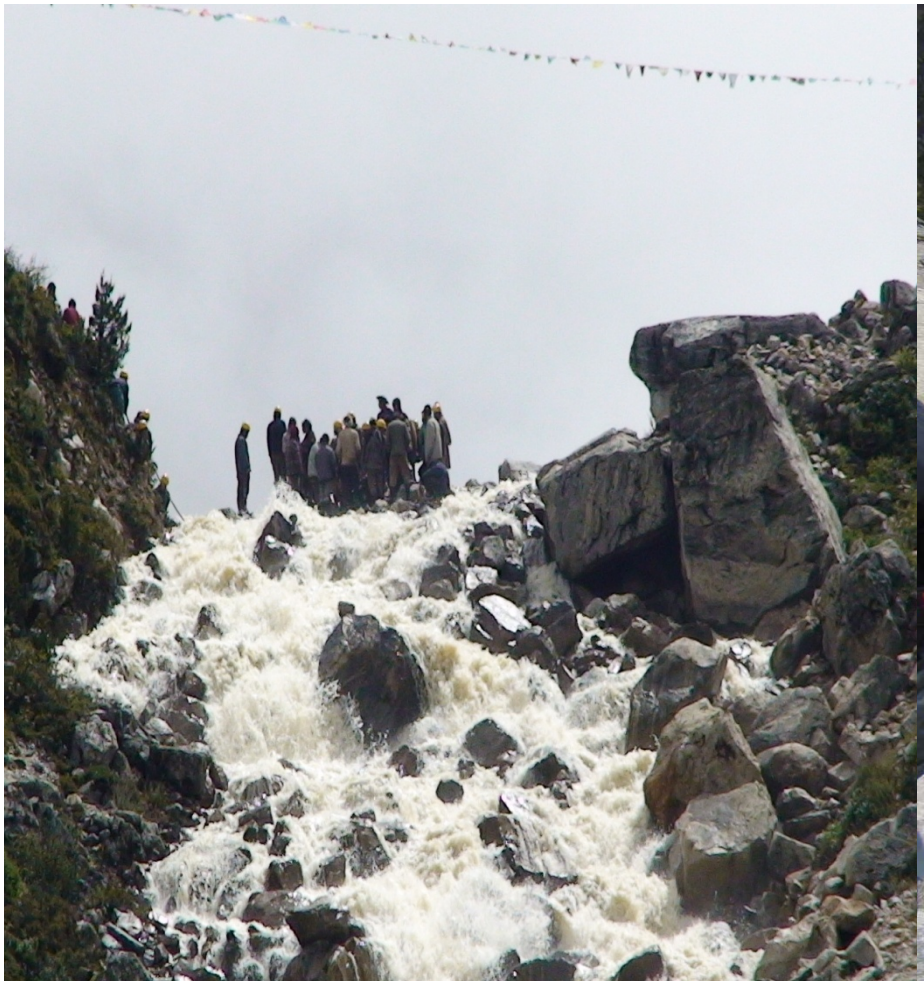
- 1998- Joint Bhutan – Japan Project for risk assessment of GLOF.
- 1999-2001- Joint Bhutan-Austria Project for risk assessment of glaciers and glacial lakes.
- 2002-2004 – Regular monitoring of glaciers and glacial lakes by DGM
- 2005-2007 - Detailed topographic survey by DGM.
- 2007-2008 – Monitoring of glacial lakes in Lunana
- 2009-2012 – Study of Glaciers and Glacial Lakes at the Head Waters of Mangdechu, by DGM/JST/JICA , through funding from JST and JICA.
- 2008 – 2012 – Artificial lowering of Thorthormi
  -- Installation of Early Warning System

52 million Cubic Meters of Water calculated if Thorthormi and Raphstreng Tsho breach

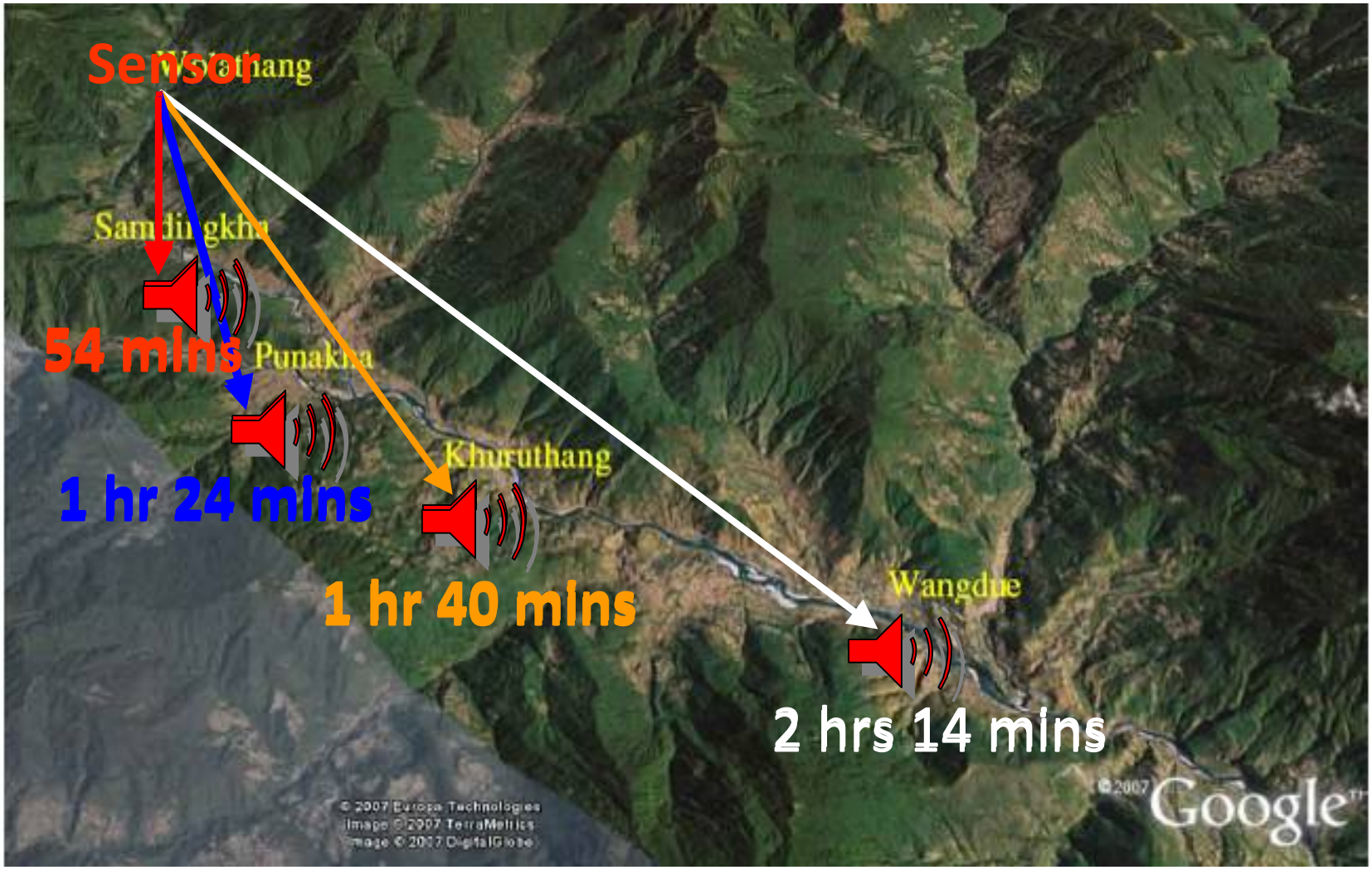


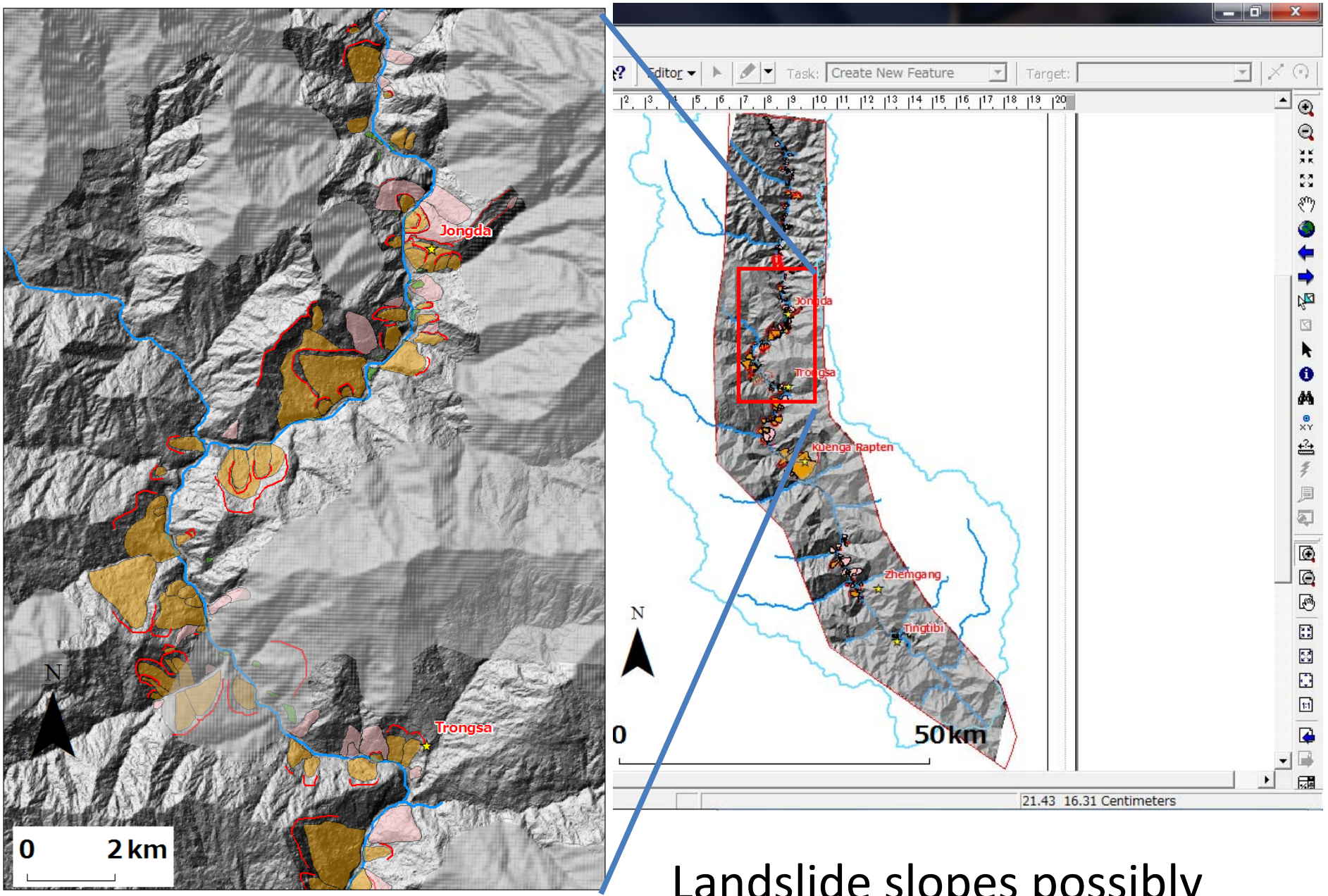
Thorthormi mitigation

Mitigation of Thorthormi Lake through Global Environmental Facility (GEF)



Early Warning





Landslide slopes possibly destabilized by a GLOF

Landslides

Causes:

- Steep Topography
- Fragile Geological Conditions
- Heavy Precipitation Rate

Landslide damming lake

One of the common threat in Bhutan is damming of the river system by the landslide and create havoc downstream (a typical example Tsateychu in Eastern

Southern Bhutan: Landslides (A Case Studies)

- This landslide is older than 15 years
- Construction of check dams (gabions) in 1999
- Effect of the 2000 monsoon
- Destruction of the road and checkpost
- New road under costruction

Jumjha Slides (Rock Slide)

Close up view of Jumjha

Bird’s Eye View of Jumjha Slide

Western Crown of Jhumjha Slide

Conclusion and Recommendation(GLOF)

- Proper research work on the Glaciers and Glacial Lake at the head waters of all the Glacial fed river in Bhutan , as is being done by DGM/JST/JICA on the head water of Mangdechu, should be carried out.
- Artificial lowering of lake water level like the one being carried out in Thorthormi lakes under GEF, where necessary should be carried out.
- Hazard zonation for GLOF in downstream area should be carried out
- Installation of reliable Technical Early Warning System (EWS), should emplaced.
- Since GLOF cannot be totally prevented or predicted, the threat from GLOF should be taken seriously.
- The mitigation measures for the glacial lakes are very challenging and expensive.
- Strict control of excavation has be done so that workers are not exposed to risk.
- Engineering designs have to be modified to suit the terrain while the excavation is in progress.

Conclusion and Recommendation (Landslide)

- For effective land risk management, the potential landslide prone areas should be identified. In this light, the first thing that has to be done is to delineate susceptible areas and different types of landslides hazards at a scale useful for planning and decision making. At present the hazard prone areas are mapped on 1:50,000 scale, which is not really useful for micro-scale infrastructure development. Hazard Zonation mapping along the main drainage system in Bhutan should be carried out in order to minimize the water induced hazard
- Further guidance and training ought to be provided regarding landslides not only to the geologists and engineers but also the decision-makers. The loss assessment from the landslide related hazards of the country and the economic impacts should be conducted to highlight the importance of such study. Public awareness and education with regard to the landslides is also of utmost importance.
- Improper land use, for example quarrying for construction material without considering the conditions of the terrain, agriculture practices on steep slopes, irrigation on steep and vulnerable slopes, etc. should be avoided.
- The short term mitigation measures including careful scaling of the rock mass, wire mesh on the slope to retain the unstable rock masses from loosening and falling down to the road should be carried out. Flexible wire mesh fences should be constructed on the slope to capture the moving rock blocks.
- Controlling drainage and reducing the slope angle reduces landslide potential. Concrete interceptor drains should be constructed to contain runoff and prevent infiltration. Where possible Steep slopes should be graded into gentler slopes. A series of "stair-steps" should be created on very steep slopes.
- Engineering methods can be used to help prevent slope failure. Retaining walls, rock bolts, and "shotcrete" (coating of concrete-rock mixture on slope surface and crevices to prevent water entry) should be used to inhibit slope failure. Wire cables and wire fences minimize the danger of rock fall.