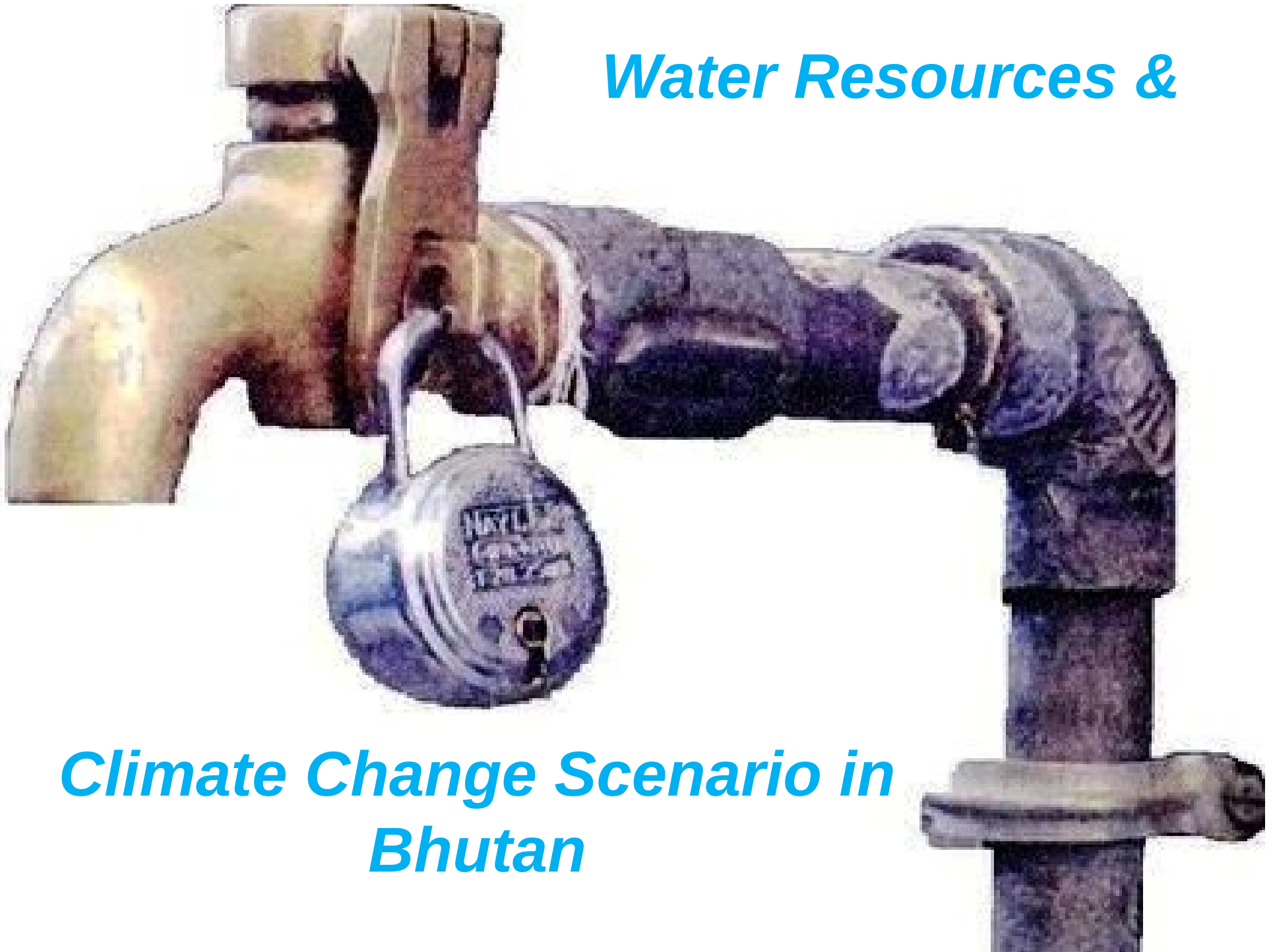


Water Resources &



***Climate Change Scenario in
Bhutan***

About Bhutan

Total area: 38,394 Sq. km

Population: 672,000

Elevation: 100-7000m

Forest Coverage: 72.5%

Protected Areas: 51.44%

Industry: Agriculture 69%, Hydropower (20% of GDP)



Environment

High-level political commitment

- ***Constitution - 60% forest cover for all times***

10 protected areas representative of different ecosystems = 51.44%

- ***42.71% protected area***
- ***8.61% biological corridors***
- ***0.12% conservation area***

Pristine Environment

- ***biodiversity hotspot***

Water Resources

Endowed with abundant water resources of good quality

Major rivers flow from north to south with source in the alpine zone

Large volumes of flow in monsoon and snowmelt at the end of dry season

Information on groundwater is scarce as exploration and development in infancy

Glacier, spring, inland lake, marsh land, monsoon rain as the major sources of water

Four major river basins

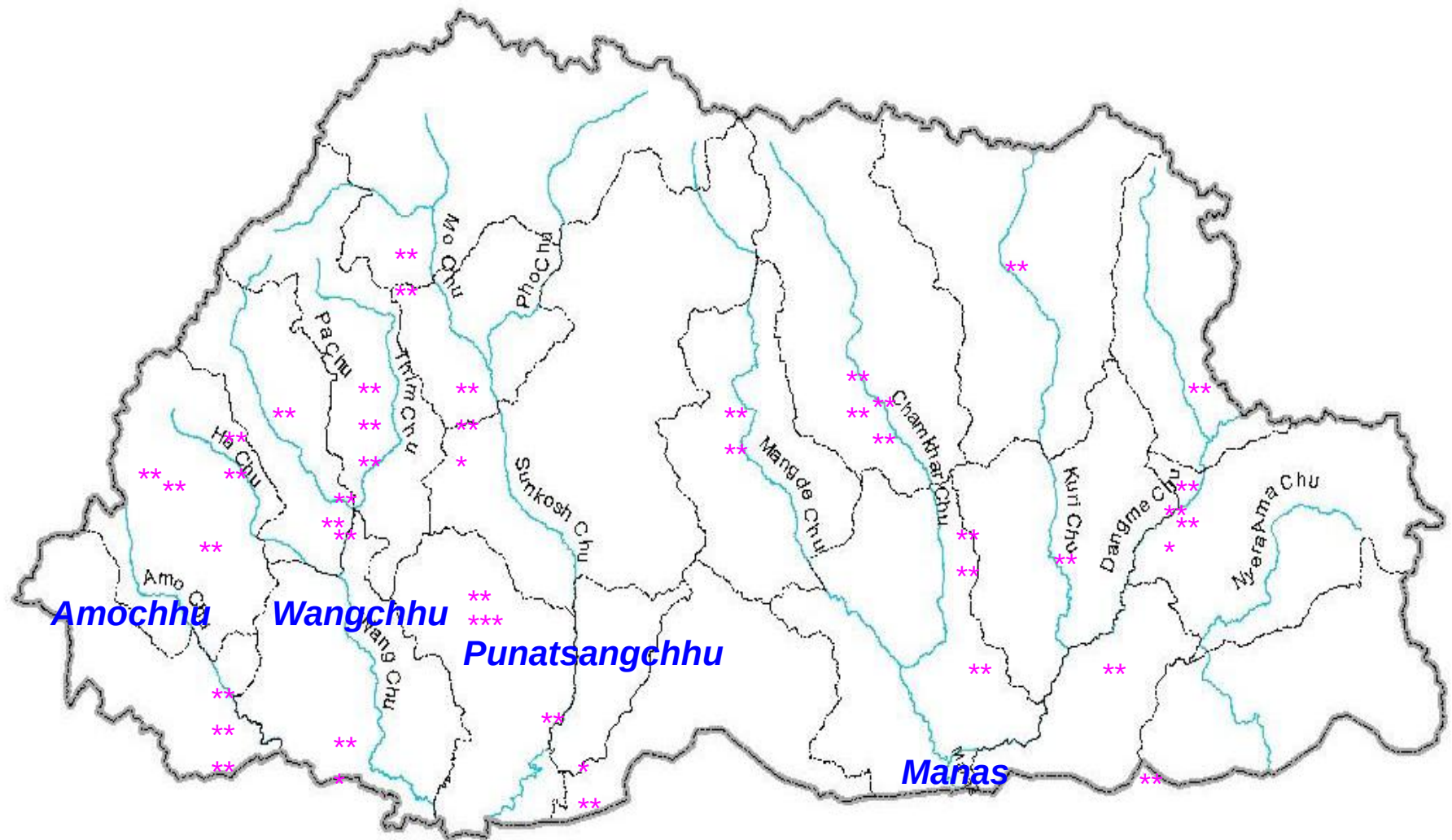
2,674 glacial lakes - (25 potentially dangerous)

Mean annual rainfall 500- 5,000 mm (*average of 150 days/yr*)

High summer flow and low winter flow

Per capita flow - 109,000m³/annum

Four major river basins



Water Quality

On a macro scale, the state of the country's water resources is good

The main rivers & tributaries are of pristine water quality with no tendency of heading towards eutrophication

River water quality characterized as highly oxygenated, slightly alkaline with low conductivities & low or no recorded salinities

Energy in Bhutan

Fuel wood is main source of primary fuel

Electricity is 99% hydropower

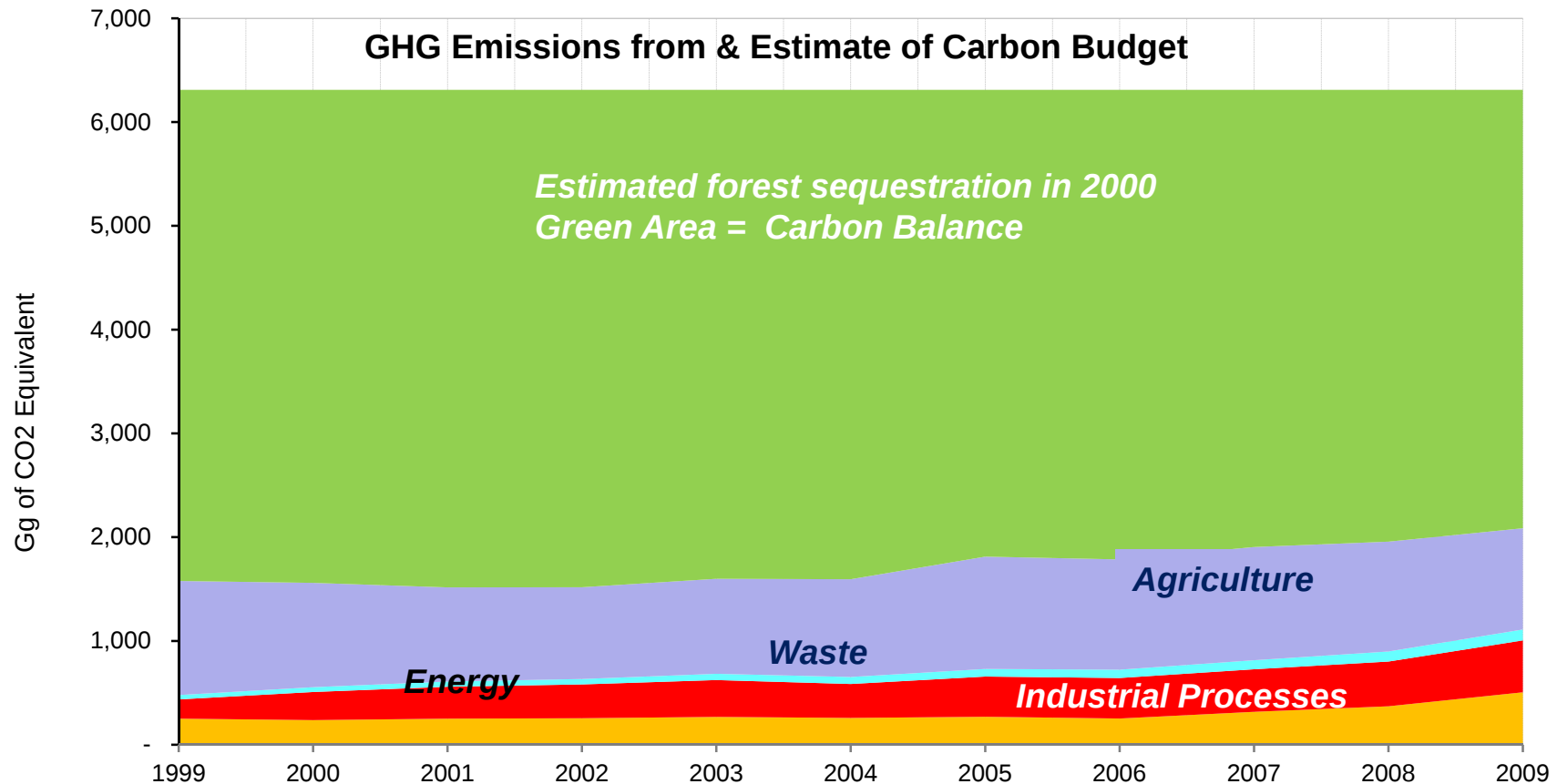
23,765 MW as techno-economically feasible Hydropower potential

Current status 1,505 MW (about 5%)

10,000 MW by 2020



Emission in Bhutan



Emissions was 1.9 million tons of CO₂e (2008)

Carbon sink is 6.3 million tons of CO₂e (2000)



Climate Change in Bhutan



Northern side of Rinchen-zoe La

1984

Photo by Prof. Tsukihara

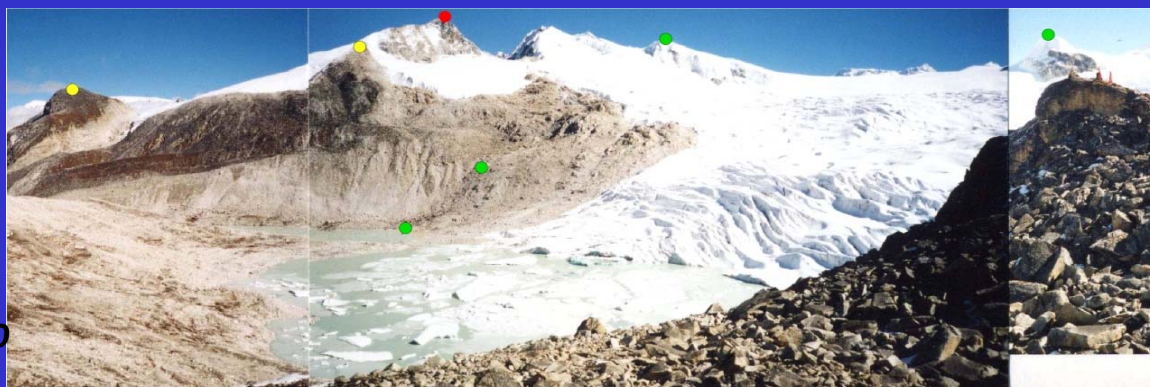
-In 1984, no water body

-After the formation of Lake, rapid retreat observed

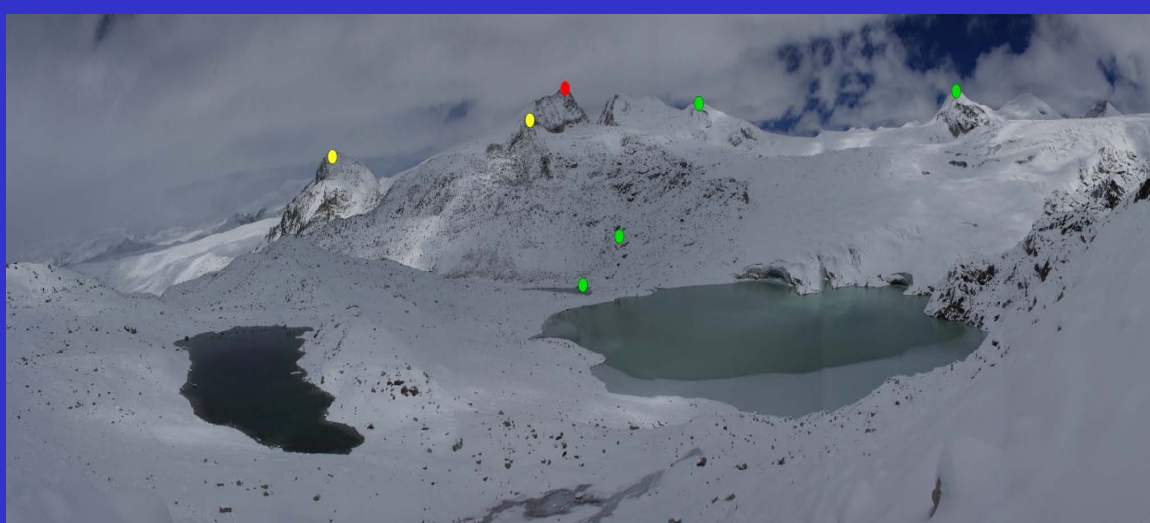


1999

Photo by Dr. Naito



2009



Roughly 500m retreat in 25 years

Repeat photography

1999



Jichu Dramo Glacier

2010



Potential Impacts of Climate Change

Agriculture:

80% of the Bhutanese practice subsistence farming. Climate Change can cause changes in temperature and precipitation patterns and increase the vulnerability of a large group of this population.



Water Resources:

Changes in the hydrological cycle such as lower winter flows in streams and intense monsoon rains may affect drinking water and supplies as well as hydropower generation



Forests & Biodiversity:

Increasing temperatures may cause species and ecosystems to shift and species at higher elevations and other species unable to migrate to become extinct.



Natural Disasters:

Rapidly retreating alpine glaciers is increasing the risk of 'glacial lake outburst floods' endangering life and property downstream. Increasing flash floods may also be caused by intensifying



Human Health:

Rising Temperatures may cause the spread of tropical diseases and heat stress into higher altitudes.



Most of the smaller glaciers may disappear as temperature continues rising

Glacier melt fed basins during dry season will become seasonal flow

Seasonal discharge will be more – surface runoff – flashfloods – more casualties

Lakes formed due to melting glaciers (glacial lakes) possess threats (GLOF)

Hydrological pattern changes, hydropower generation, floods, drinking water shortage..

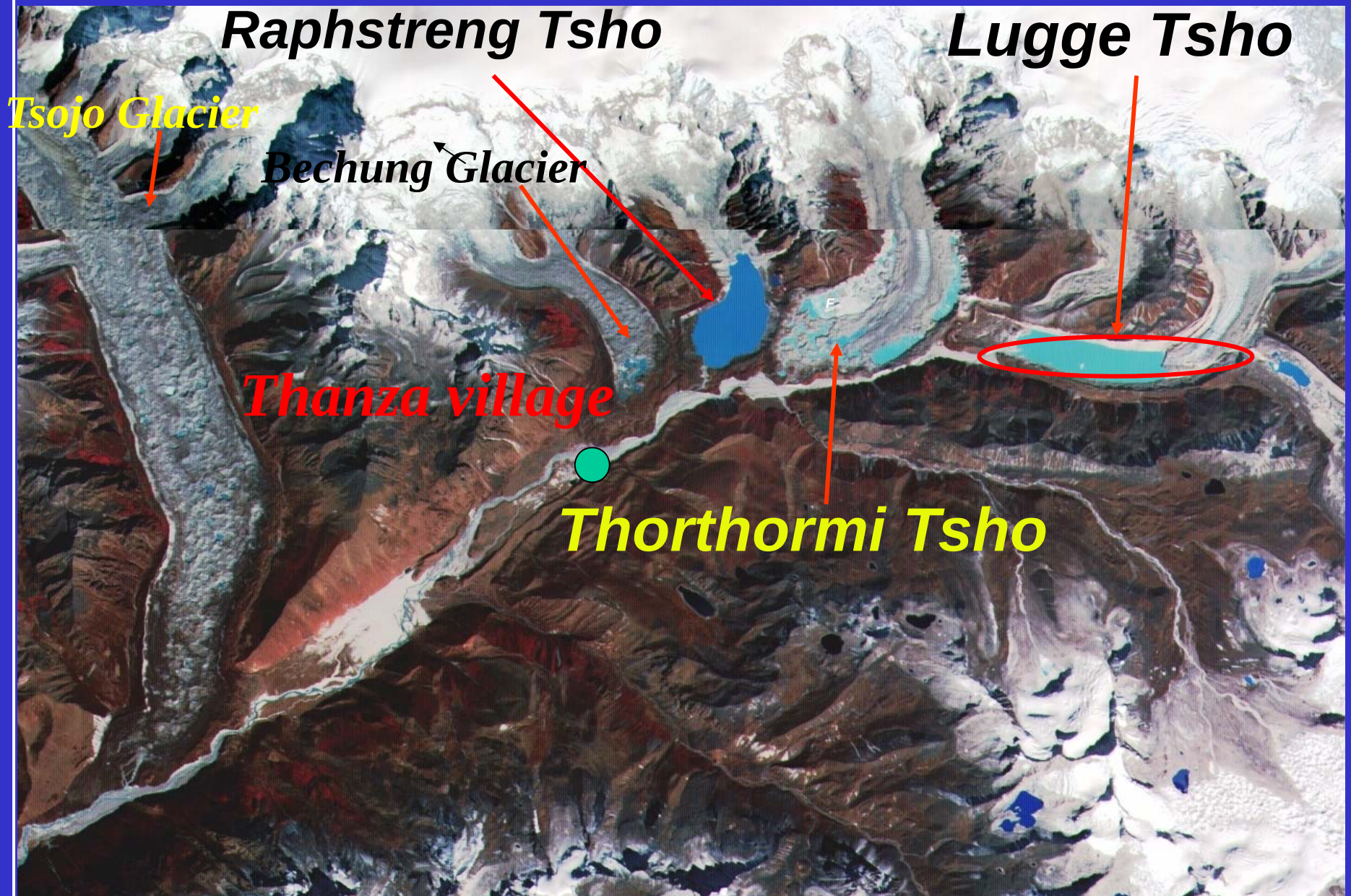
Climate Change & GLOF

Temperature increases due to apparent climate change have changed glacier behavior

There exist the possibility of excessive melt water bearing down on moraine dams causing GLOFs

Glacier lakes provide a hazard in many basins of Bhutan

1994 Glacial Lake Outburst Flood



1994 Glacier Lake Outburst Flood



GLOF hazards

Glacial lake outburst floods;

Damaged infrastructure

Villages washed away

Loss of human lives

Loss of livestock

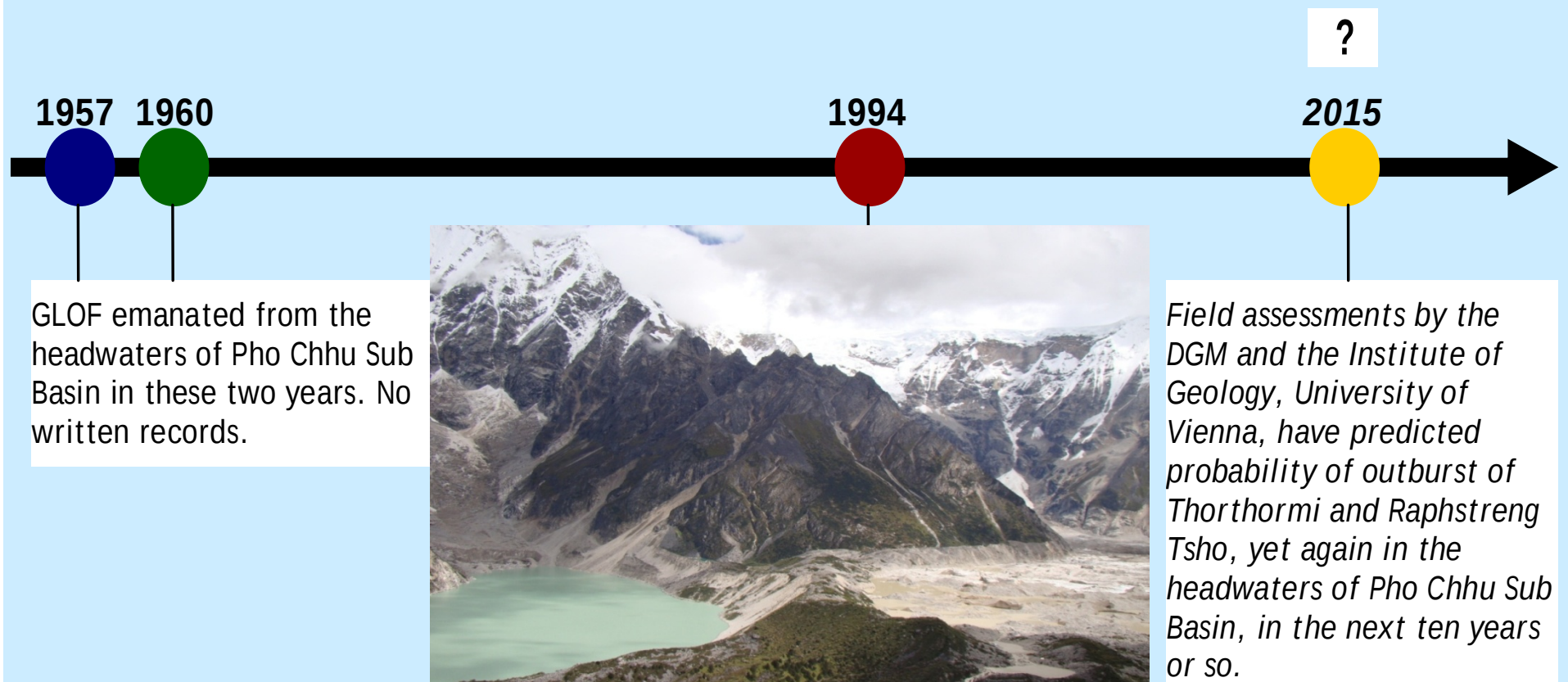
Damage to agricultural land

Damage to cultural heritage sites

Loss of natural vegetation

Time line for past and probable GLOFs

The Combined GLOF will be 53 million m³



Source: Inventory of Glaciers, Glacial Lakes and Glacial Lake Outburst Floods in Bhutan, ICIMOD/UNEP, 2001

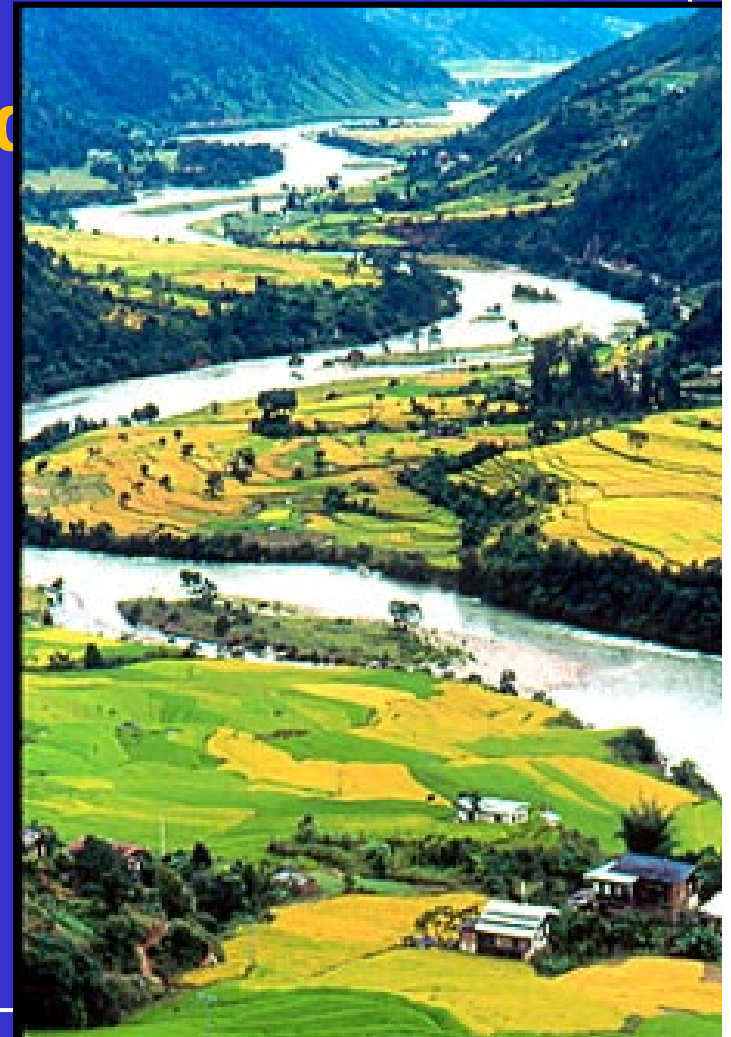
Impacts of CC: Agriculture sector need urgent attention

Being an agriculture based
country (80%) following need
attention:

Ensuring agricultural water
security

Agricultural land security

Prevention of crop damage
due to unpredictable rain, &
drought



Impacts of CC: forest & biodiversity

- *Species and ecosystems shift to higher elevation*



- *JDNP*
- *4200m*

Impact on Human health:

- *Spread of tropical diseases and heat stress into higher altitudes*

Impacts of CC: Water resources

Most of the smaller glaciers may disappear as temperature continues rising

Glacier melt fed basins during dry season will become seasonal flow

Seasonal discharge will be more – surface runoff – flashfloods – more casualties

Lakes formed due to melting glaciers (glacial lakes) possess threats (GLOF)



Impacts of CC: Water resources

Changes in hydrological cycle

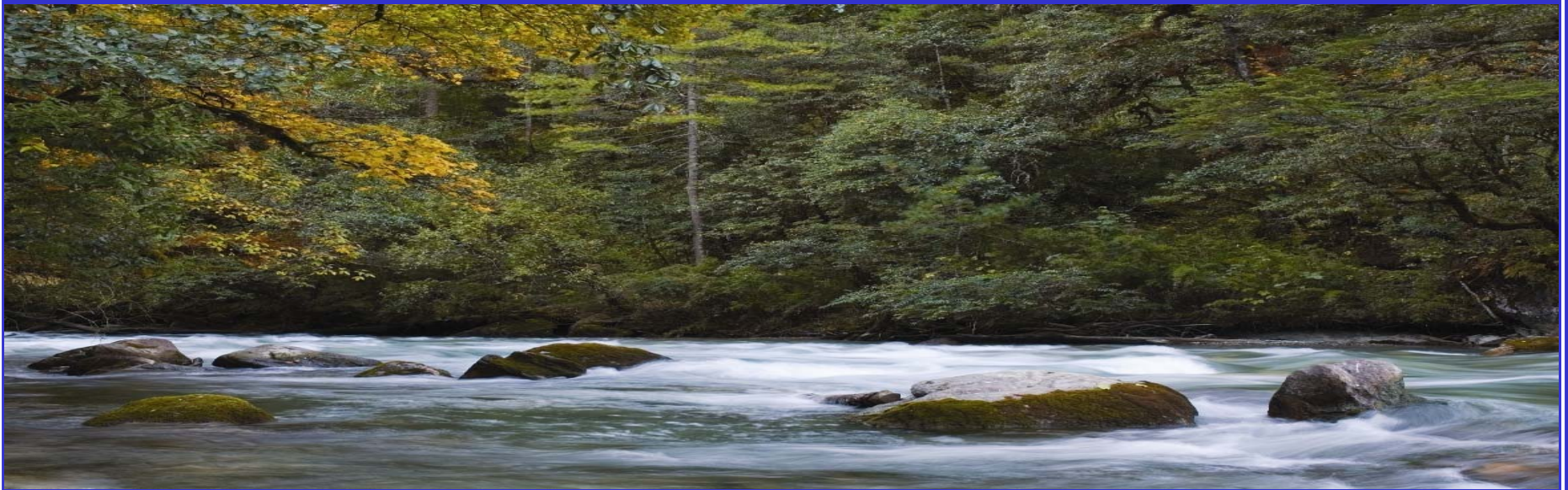
Intense monsoon – drinking water quality

9FYP (2008) - 1,488 MW

10FYP (2013) - 3,150 MW

10,000MW envisaged by 2020

30,000 MW potential ?



Impacts of CC: Hydropower

**Hydropower generations – less in dry seasons
(low winter flows)**

*e.g. Power generation in Bhutan in winter drops to 1/6th
of that of peak season (summer)*



Bhutan Adaptation and Mitigation Measures

Declared to be a Carbon Neutral Economy

60% forest coverage for all times to come

Green Economic policies – High Value Low Volume Tourism, Value addition on minerals, Service Industries and Enhance Hydropower development

NAPA1 & 2; Lowering of Thorthomi Glacier Lake with Early Warning Systems



Challenges in Bhutan on Water Resources

- No long term data and dependency on models
- Analytical skills are limited
- Lack of studies on snow, glaciers and groundwater
- Urbanization and development
- Climate Change
- Technology knowhow and finance!

10 5 2007

Conclusion

Currently the CO₂ concentration in the atmosphere has reached an all time high of 390ppm

South Asia, including Bhutan and developing countries are least responsible

Poor and mountainous regions are most vulnerable

Water Resources in Bhutan and other areas will be impacted due to Climate Change. Cascading effects to all other sectors and the whole economy and Livelihoods

TASHI DELEK

