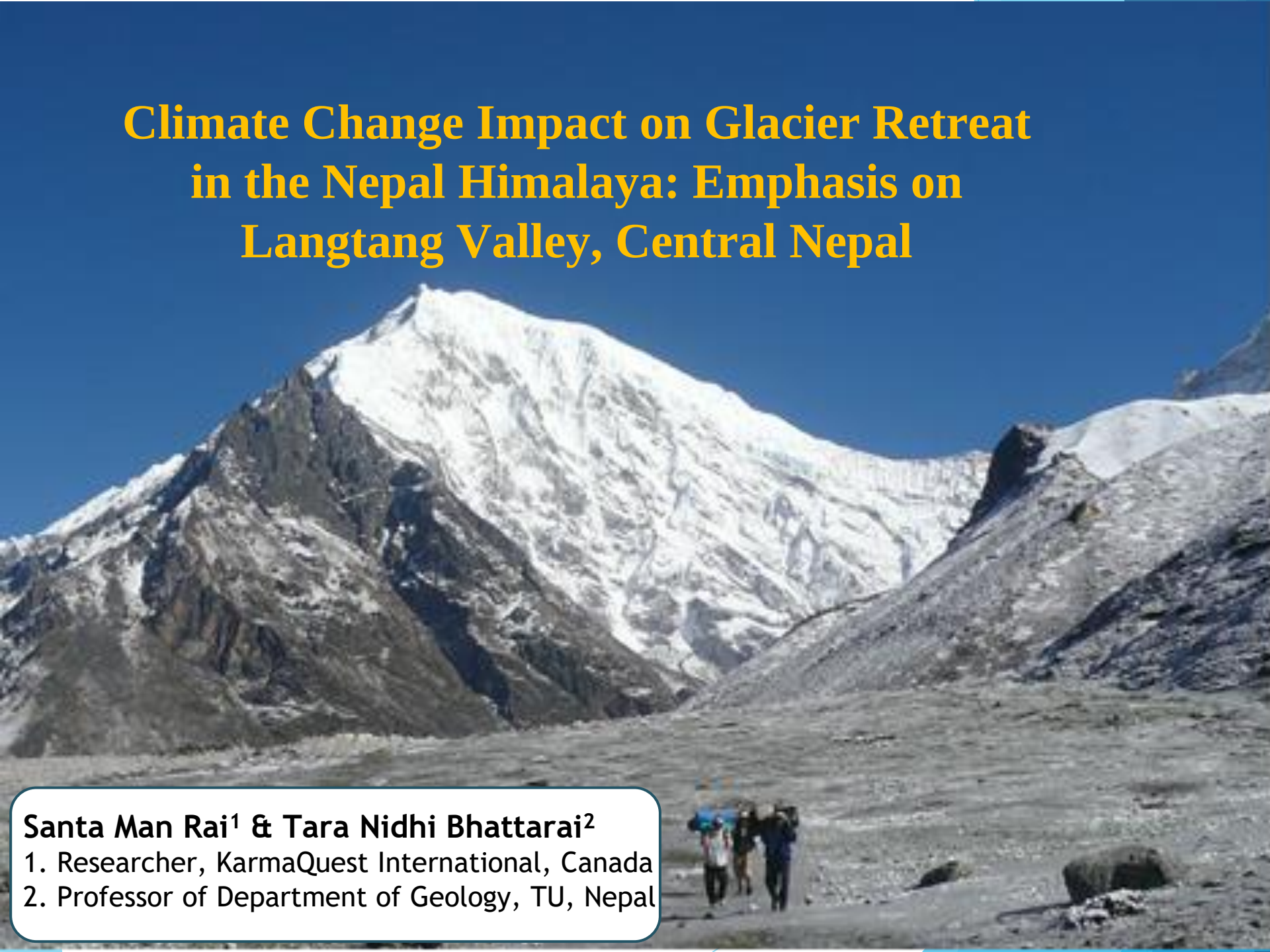
Climate Change Impact on Glacier Retreat in the Nepal Himalaya: Emphasis on Langtang Valley, Central Nepal



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Agenda

1. Nepalese Himalayan Glaciers

2. Climate Change Impacts in the Nepalese Himalaya Glaciers

- Causes of climate change
- Impacts of climate change
- Future challenges

3. Climate Change Impact in the Langtang Glaciers

- Methods of research
- Results : Hydro-meteorological data, glacier position
- Environmental and Socio-economic impacts
- Conclusions

4. Q & A

Terminologies

Climate
The long-term weather pattern in a region typically averaged over 30 years that have come to define Earth's local, regional and global climates

Weather
State of the air and atmosphere at a particular time and place as regards heat, dryness, sunshine, wind, rain, etc.

Climate change
A long-term shifts in temperatures and weather patterns

Glacier
A large, perennial accumulation of crystalline ice, snow, rock, sediment, and often liquid water that originates on land and moves down slope under the influence of its own weight and gravity.

Glacier melting
Due to increase of surface temperatures, the process of glacier melting occurs – a process where the ice changes from solid to liquid or water

Glacier retreat
The process of a glacier shrinking or receding in size over time due to a decrease in ice accumulation or an increase in ice melt.

Nepalese Himalayan Glaciers

Three Poles: The Arctic, the Antarctic and the Himalayas

THIRD POLE

- Unique geographic region centred around the Himalayas and Tibetan Plateau (Afghanistan, Bhutan, China, India, Nepal, Pakistan and Tajikistan)
- Ice field of largest reserve of fresh water outside the polar regions, snowmelt- or glacier-fed 10 major river system for 2.4 billion people

A tributary glacier of the Langtang glacier east of Lansishakharka

Ngozumpa glacier on the left side of Gokyo Lake, Everest region

Contd.

Nepalese Himalayan Glaciers

✓**Globe: increase of average T with 0.74 °C (1906-2005),**
0.13 °C (1956-2005) (IPCC, 2007)

✓**The rate of warming in globe since 1981 is 0.18° C per decade (climate.gov., 2023)**

✓**Hindu Kush Himalaya region: increase of T with 0.1 °C per decade during 1901–2014; about 0.2 °C per decade during 1951–2014 (Sabin et al., 2020)**

✓**Nepal: increase of annual T with an average of 0.06 °C/year (1971-1994) (Shrestha et al., 1999)**

✓**Increase rate of T is higher in higher altitudes: 0.08 °C/year than lower altitudes (Bajracharya et al., 2016; Rai et al., 2017)**

✓**54,000 glaciers in the Hindu Kush Himalayas (60,000 Sq. km);**
3,252 Nepalese glaciers above 3500 m altitude

Contd.

Melting glaciers and climate change

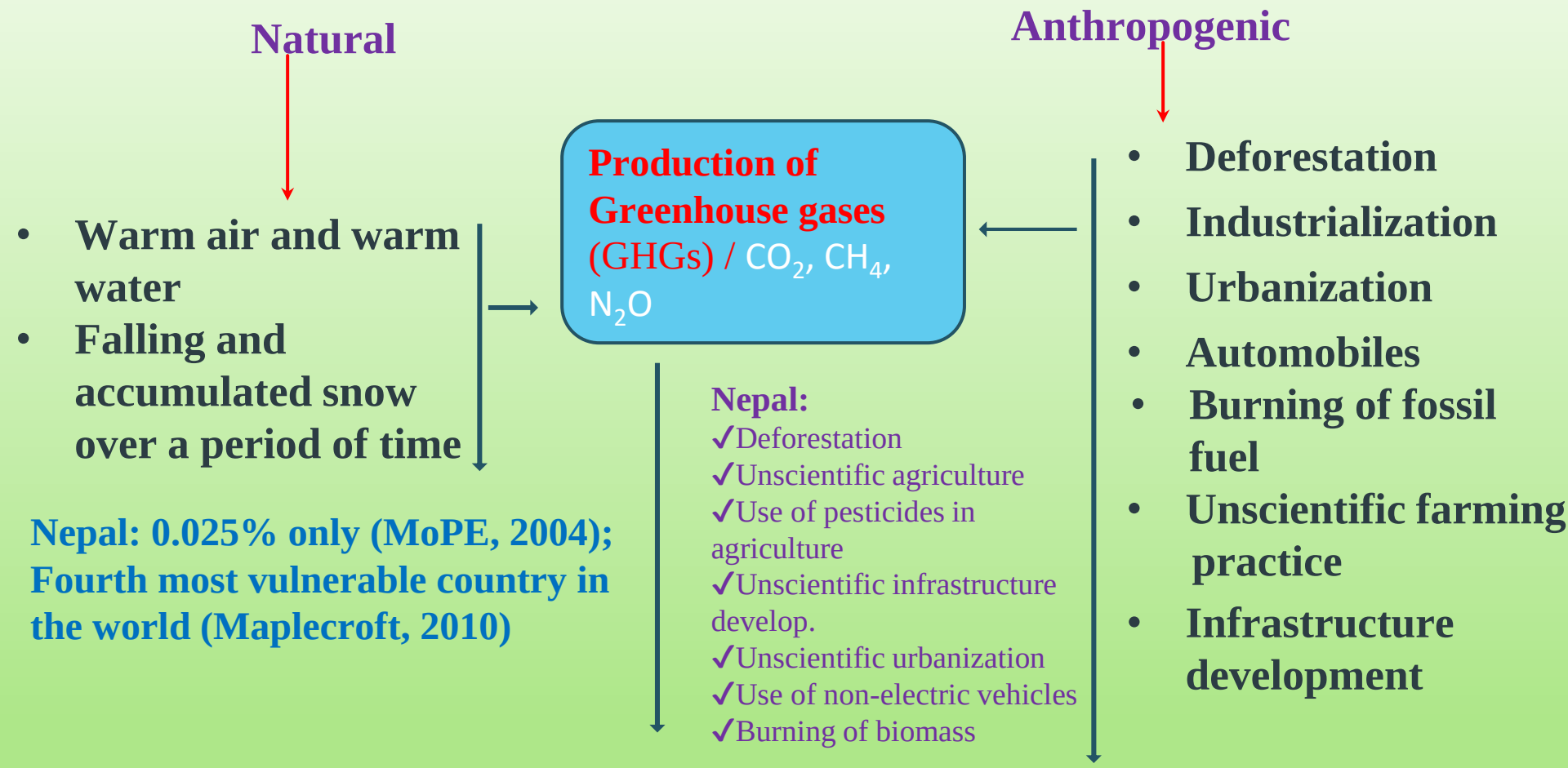
Retreat rate of Himalayan glaciers: 10 to 60 m/year, and retreat rates of 30 m/year are common. Temp. increases in Higher mountains: 0.08 **°C/year**

Intense impact of climate change on glaciers in the Himalaya results:
(a) retreating of the glacier (b) elimination of small glaciers
(c) formation of new glacial lakes and (d) enlarging the existing glacial lakes, breaching of some existing lakes resulting GLOF

Overall Result: : Impact on degradation of environment (biodiversity, ecosystem) and scarcity of drinking water and irrigation for agriculture

Nepal: Fourth most vulnerable nation in the world in the context of climate change, major impact of climate change in Nepal is glacier melting.

Causes of climate change in Nepalese Glaciers (IPCC, 2001)



A. Traps the heat by GHGs resulting the increase of temperature (Global warming)

B. Changing pattern of Monsoon (impact of climate change, increasing water vapour transport from the ocean into land increases because warmer air holds more water vapour)

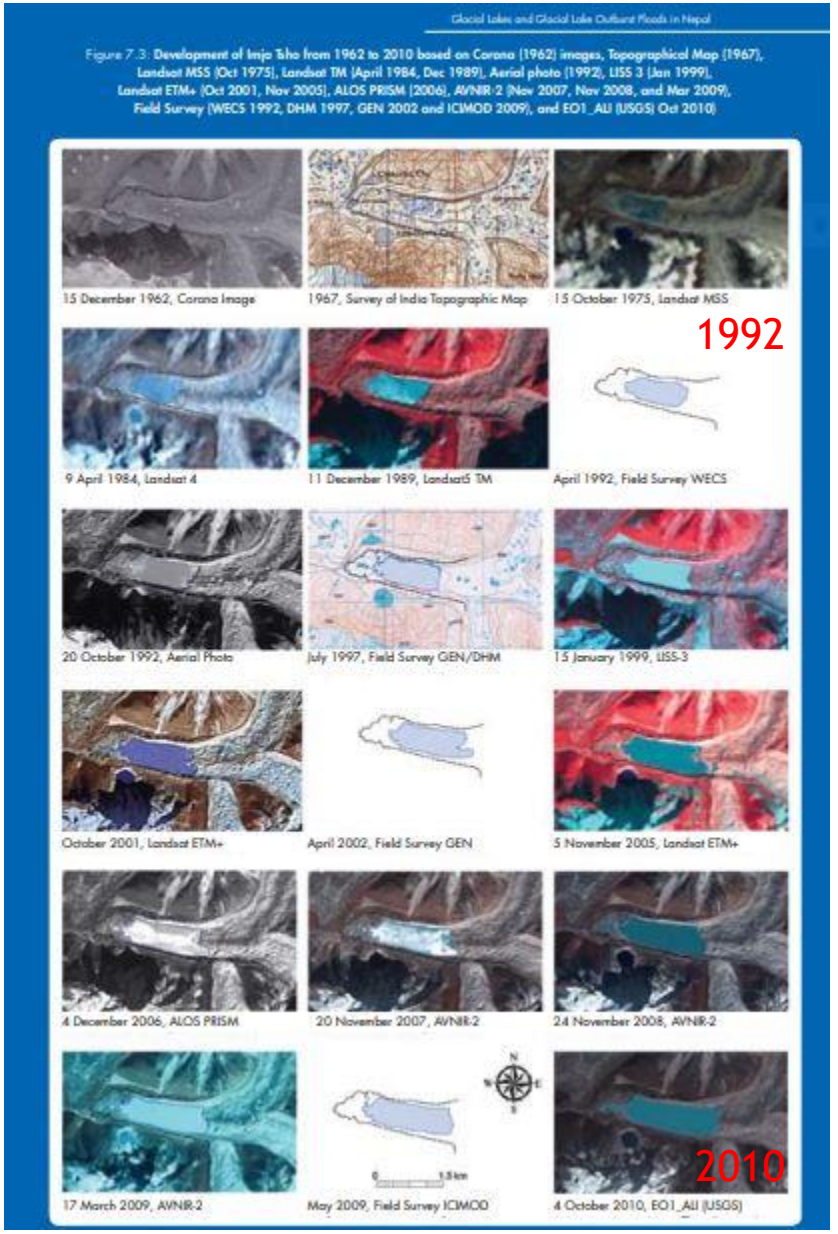
Impacts of climate change on glaciers

- ✓ Rapid glacial melting - retreating of the glacier, elimination of small glaciers, formation of new glacial lakes and enlarging the existing glacial lakes, breaching some lakes resulting GLOFs
- ✓ Increasing natural hazards – GLOFs, landslides
- ✓ Decline in agricultural yields
- ✓ Scarcity of drinking water during winter season
- ✓ Changing in monsoon pattern (rainfall rate decreases in summer, extreme rainfall for short duration)

An example of melting of glacier due to increase of temperature

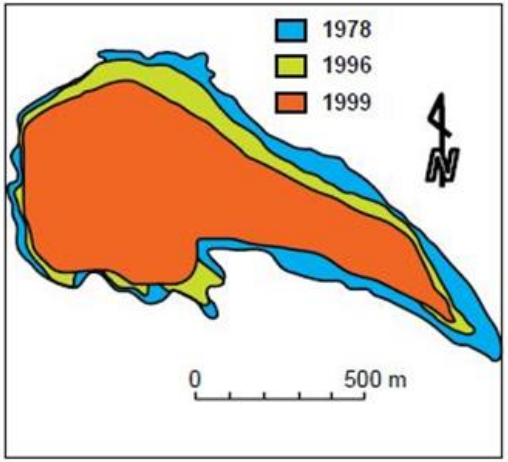
Melting of glacier

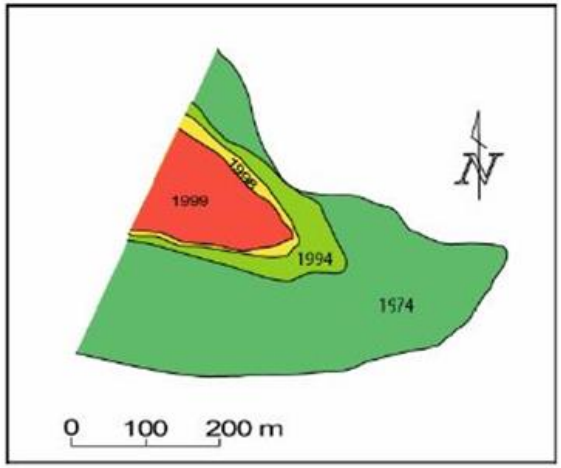
Evolution of Tsho Rolpa lake



Imja lake, ICIMOD, 2011

(a) Panorama view of Shorang Himal, Khumbu region, eastern Nepal.
(b) Panorama view of Dhulagiri Himal, western Nepal.





Shrinkage (melting) (8 m/yr) of the AX010 Glacier, Shorang Himal, Khumbu region, eastern Nepal (left) and terminus retreat (20 m/yr) of Rika Samba Glacier, Hidden valley, Dhaulagiri region, western Nepal (right) between 1978-1999 (Fujita et al., 2001)

Melting of glaciers, Formation of lakes & their expansions

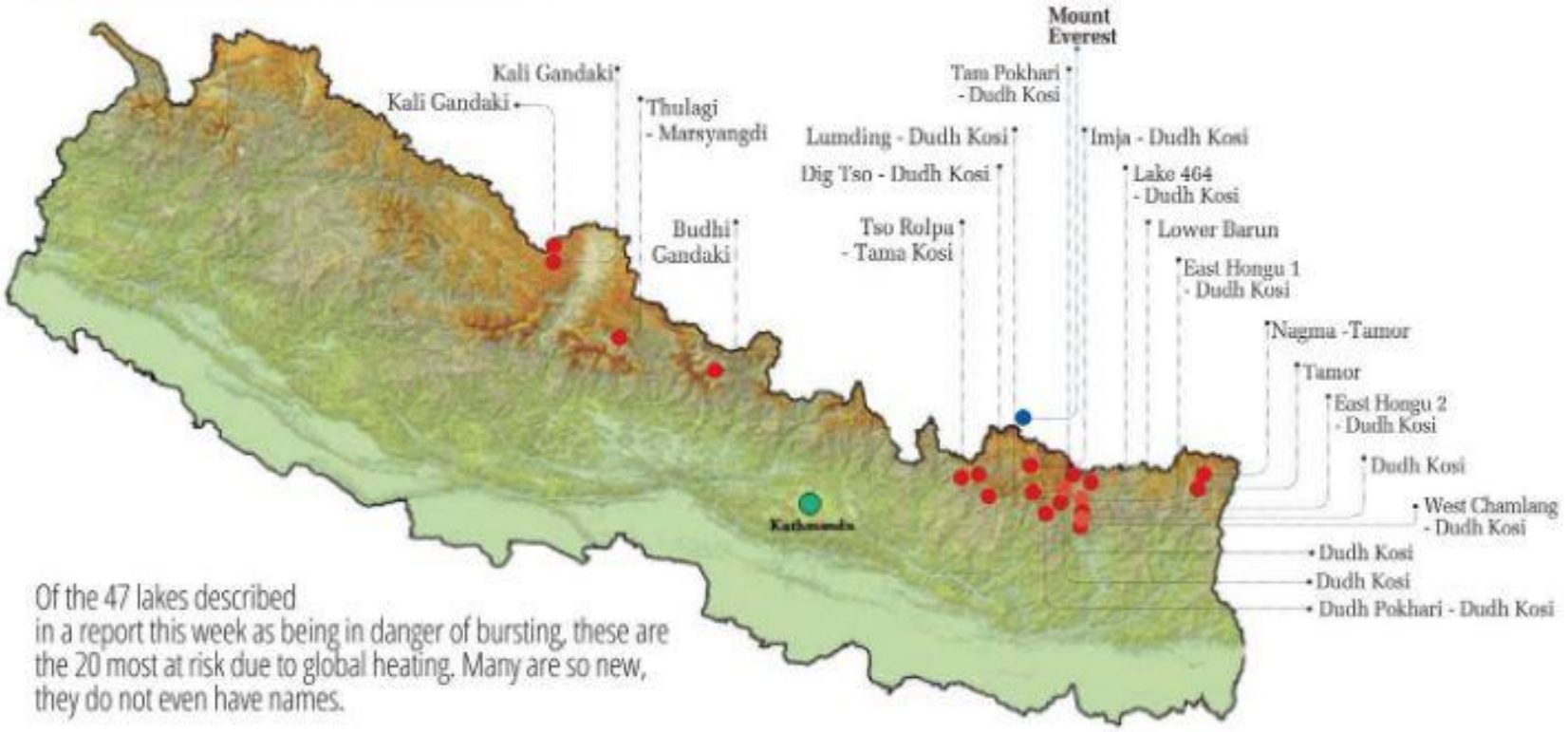
(a) Nare Himal,1977

(b) 2068 lakes, 16 out of 21, ready for GLOF (ICIMOD, 2015)

(c) Mass movement, ICIMOD

(d) Drain out water from Cho Rolpa Lake

The Top 20



Of the 47 lakes described in a report this week as being in danger of bursting, these are the 20 most at risk due to global heating. Many are so new, they do not even have names.

Challenges

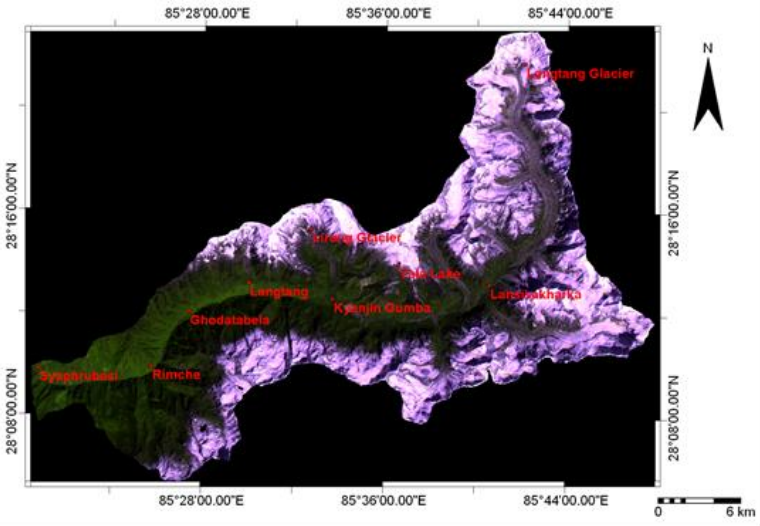
1. Himalayan region is consistently warming more than Global average
2. Glaciers and permanent snows are melting rapidly in the recent years
3. Shrinkage and melting of glaciers /Formation and expansion of glacial lakes
4. Increased risks and hazard: Glacial lake outburst flood (GLOF) is a serious problem.

If GHGs emission continue/average global T rise by more than 4 °C by 2100, 2/3 glaciers will be disappeared in the Himalayan region (ICIMOD, 2019)

Temperature control less than 1.5 °C by 2050 (IPCC, 2018); 40% of area of Himalayan glacier already lost until today. Is it possible to control global T less than 1.5 °C by 2050 ??? Serious challenge?

Climate Change impact on the Langtang Glaciers Retreat

Source: Langtang/besthike.com



Location map of Langtang Valley

Objectives of study

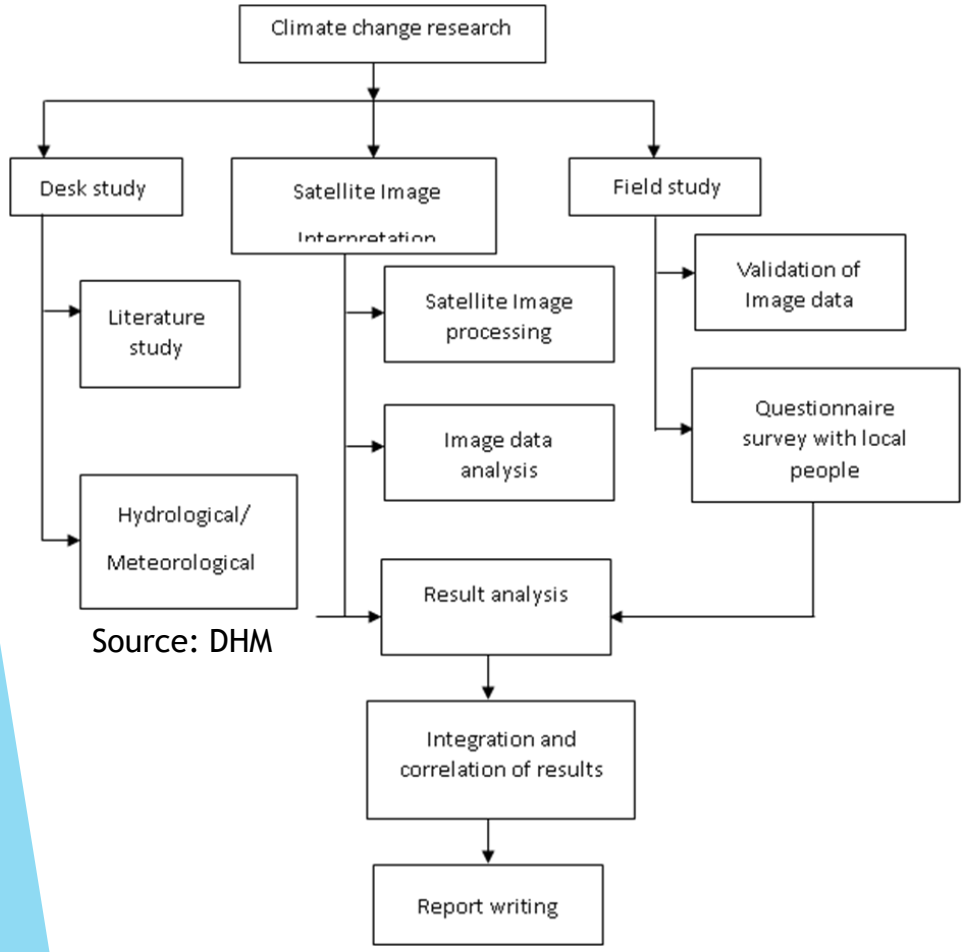
To understand the climate change trend

- ✓ Tracking recent and past changes in the glaciers of the Langtang Valley
- ✓ Analysis of temperature, precipitation and river discharge
- ✓ Documenting the current environmental effects based on interaction with the local people
- ✓ Analysis of mass movement hazards focusing on debris flow

TWO glaciers under the study

1. **Langtang Lirung Glacier**
2. **Kimjung Glacier**

Methodology of research



Source: DHM

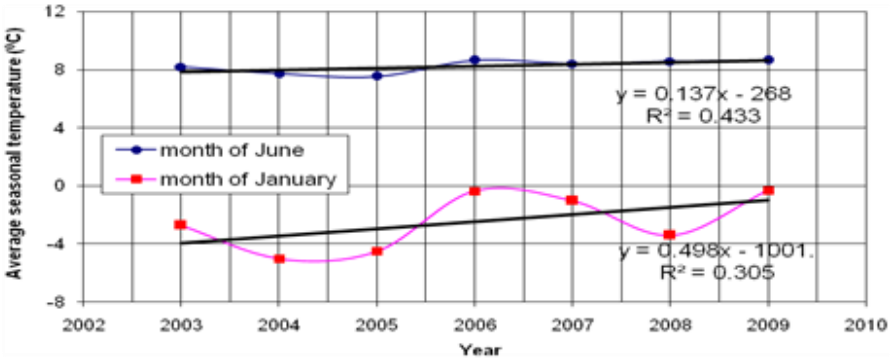
DHM: Dept. of Hydrology and Meteorology, Govt. Nepal

Based on:

1.Long-term hydro-meteorological data
2.Satellite image analysis of glaciers
3.Field visit on glacier sites
4.Observation of the local people and their experience on climate change

1. Temperature Data

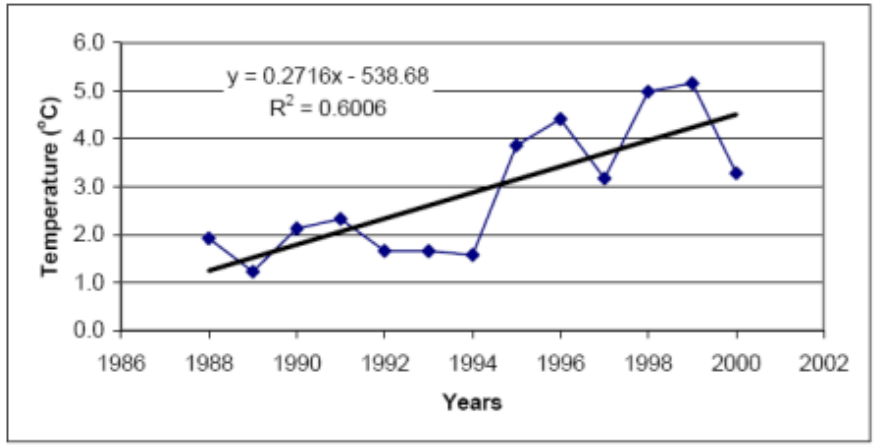
a



Variation of seasonal temperature (January and June) between the 2003 and 2009 (DHM)

- January (Winter) - Fluctuated
- June (Summer), Clear increasing trend

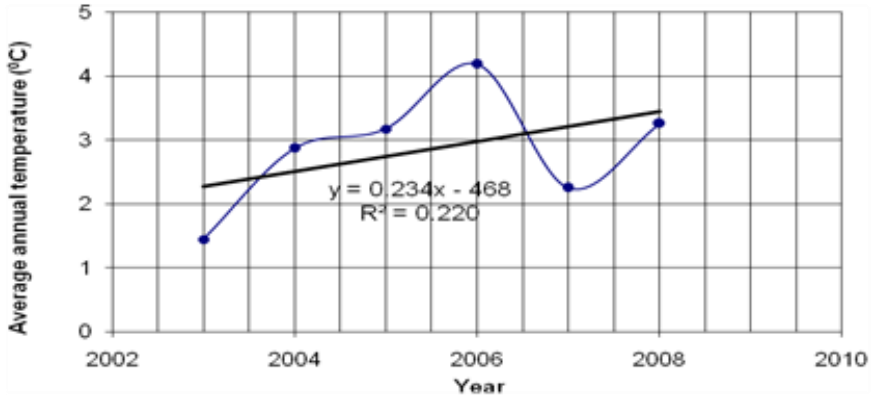
b



Variation of average temperature in Langtang (Kyanjin Gumba) area between 1998 and 2000 (WWF, 2005).

- Slope coefficient – Increasing trend

c

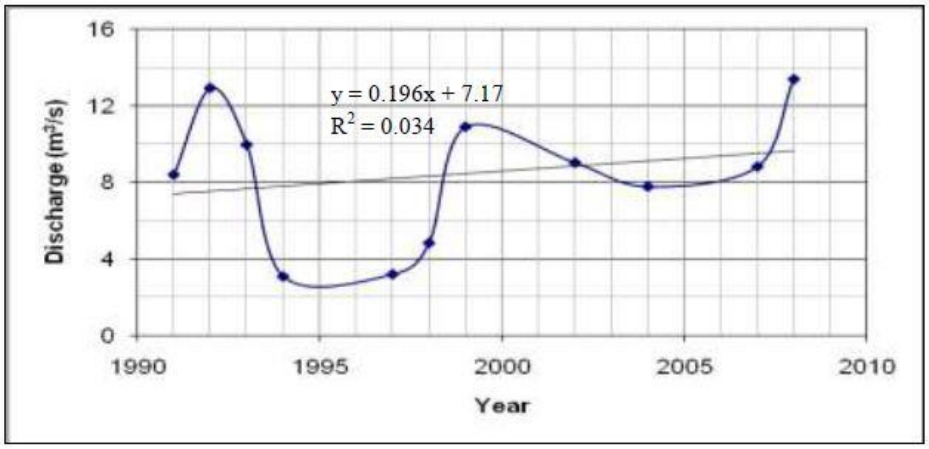


Variation of average temperature in Langtang (Kyanjin Gumba) between 2003 and 2008 (DHM)

- Slope coefficient – Increasing trend,

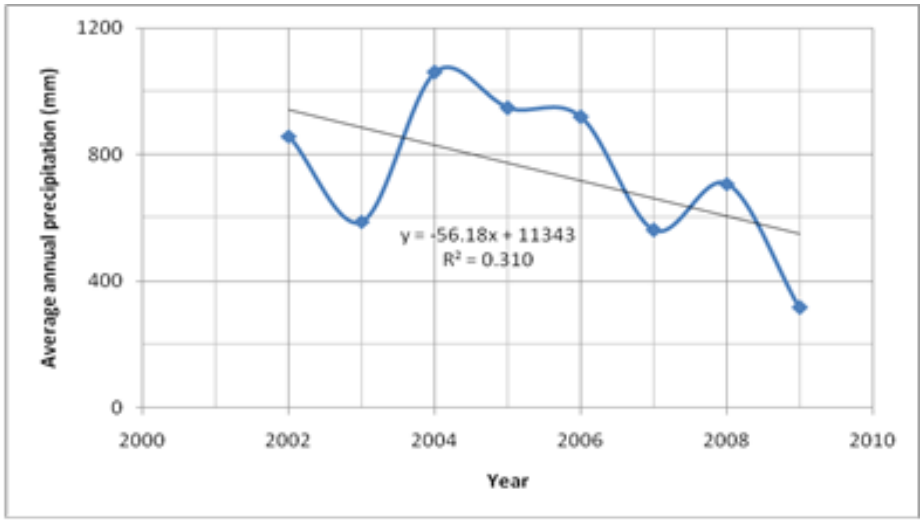
Temperature increase - 0.9˚C/yr DHM (2003-2008)
0.19˚C/yr - Aryal et al., 2013 (1993-2004)
0.116˚C/yr – Bajracharya et al., 2016 (1988-2008)

2. Hydrological Data



Variation of discharge in Langtang Khola (Kyanjin Gumba) since 1990s to 2008 (DMH)

- Average discharge over time- Increasing trend but repetition of high or low discharge
- Increase of precipitation on spring, summer an autumn



Variation of **annual precipitation** in general, in Langtang Khola watershed (Kyanjin Gumba) between 2002 and 2009 (DHM) decreases

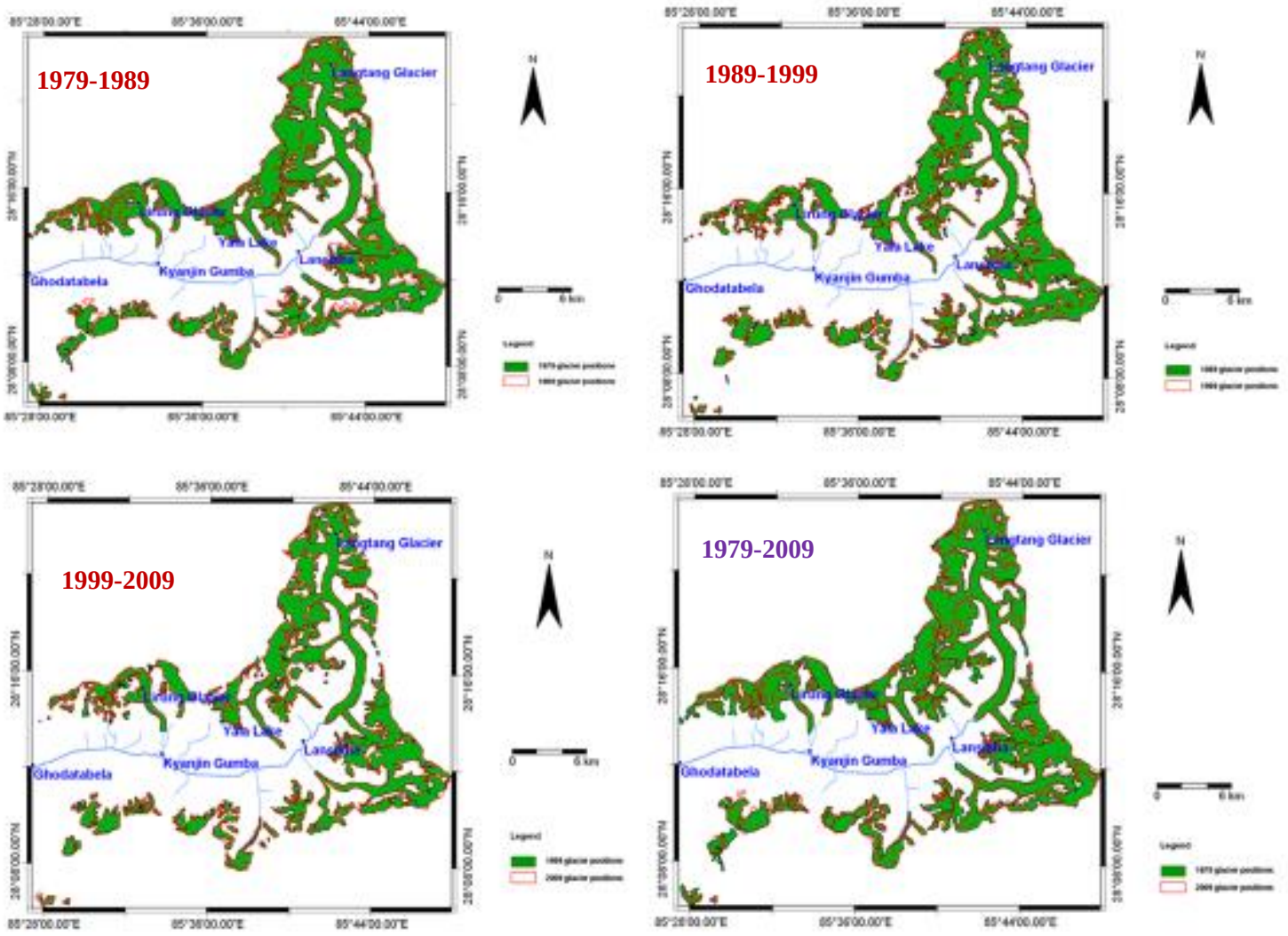
- However, total precipitation- Decreasing trend, overall discharge in an increasing trend (slide above)

Increase of discharge due to rapid melting of snow

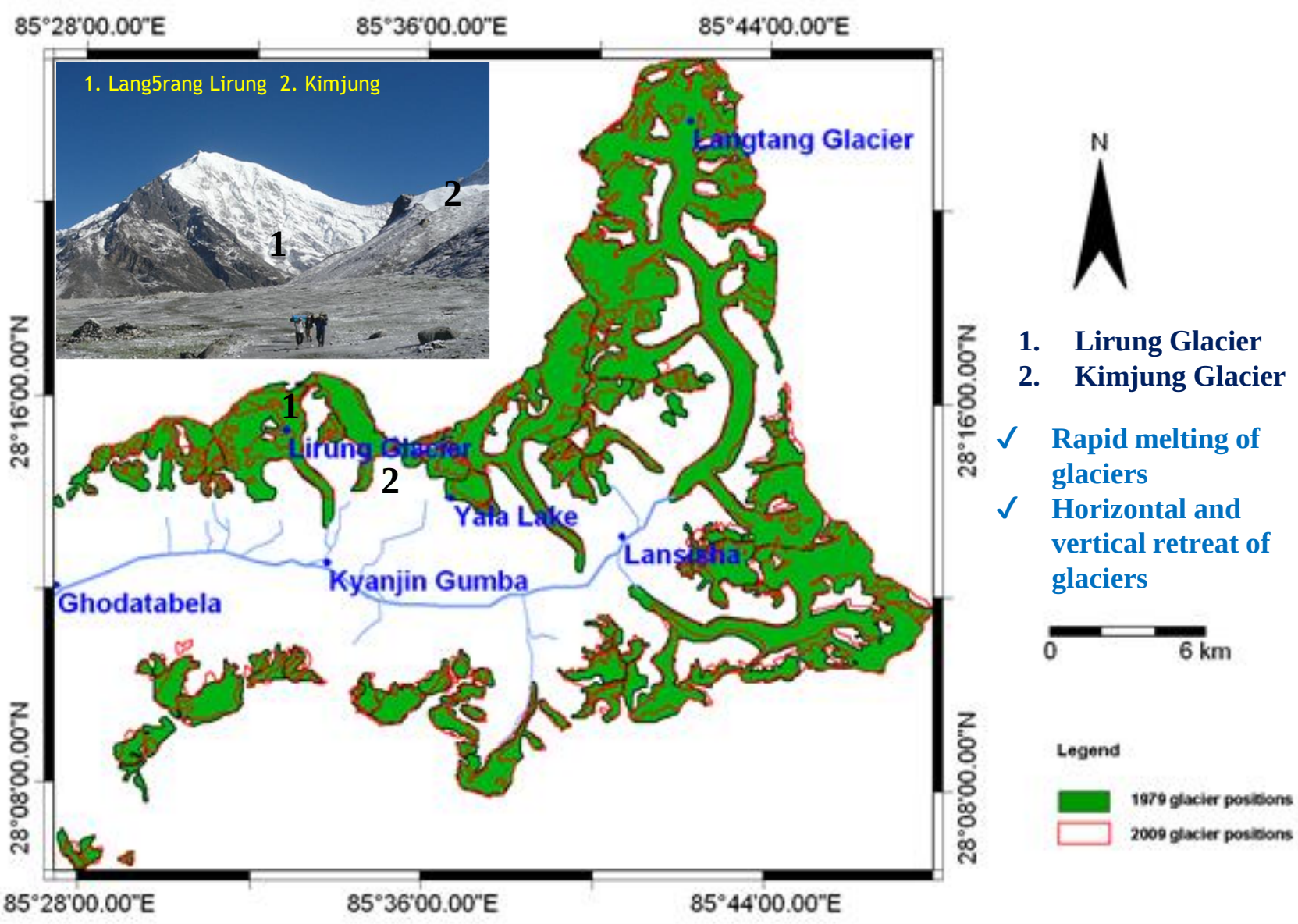
3. Glacier positions

(From 1979 to 2009)

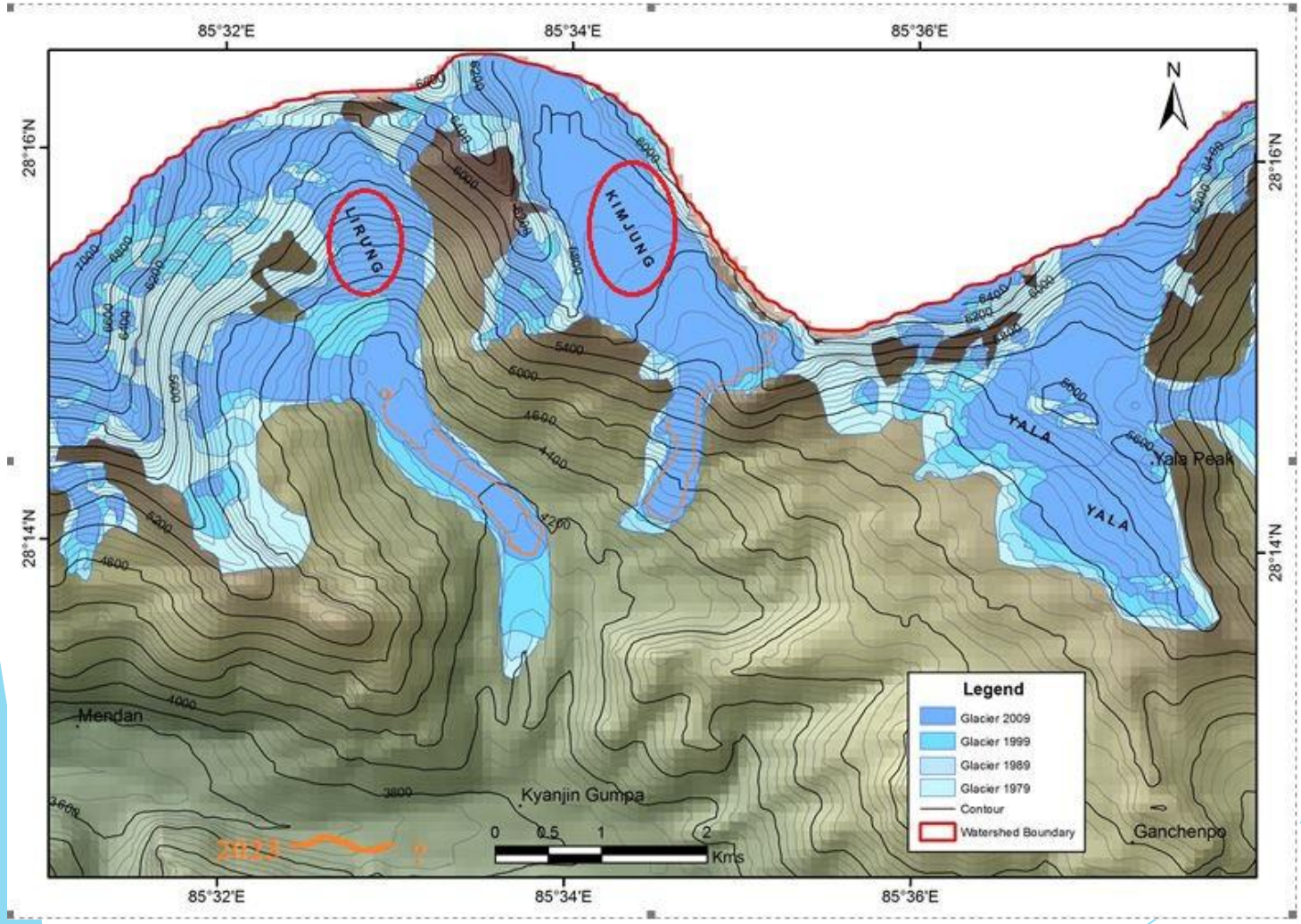
Landsat satellite image
(Landsat Enhanced Thematic Mapper Plus, ETM+ technique)



Glacier position from 1979 to 2009



Total area covered by all of the glaciers in the Langtang Khola watershed in Nepal at different years (Rai et al., 2017)



Year	Area (Km^2)
1979	192.13
1989	171.34
1999	152.22
2009	142.06
2019	????

Surface area shrinkage

50.07 Sq. km

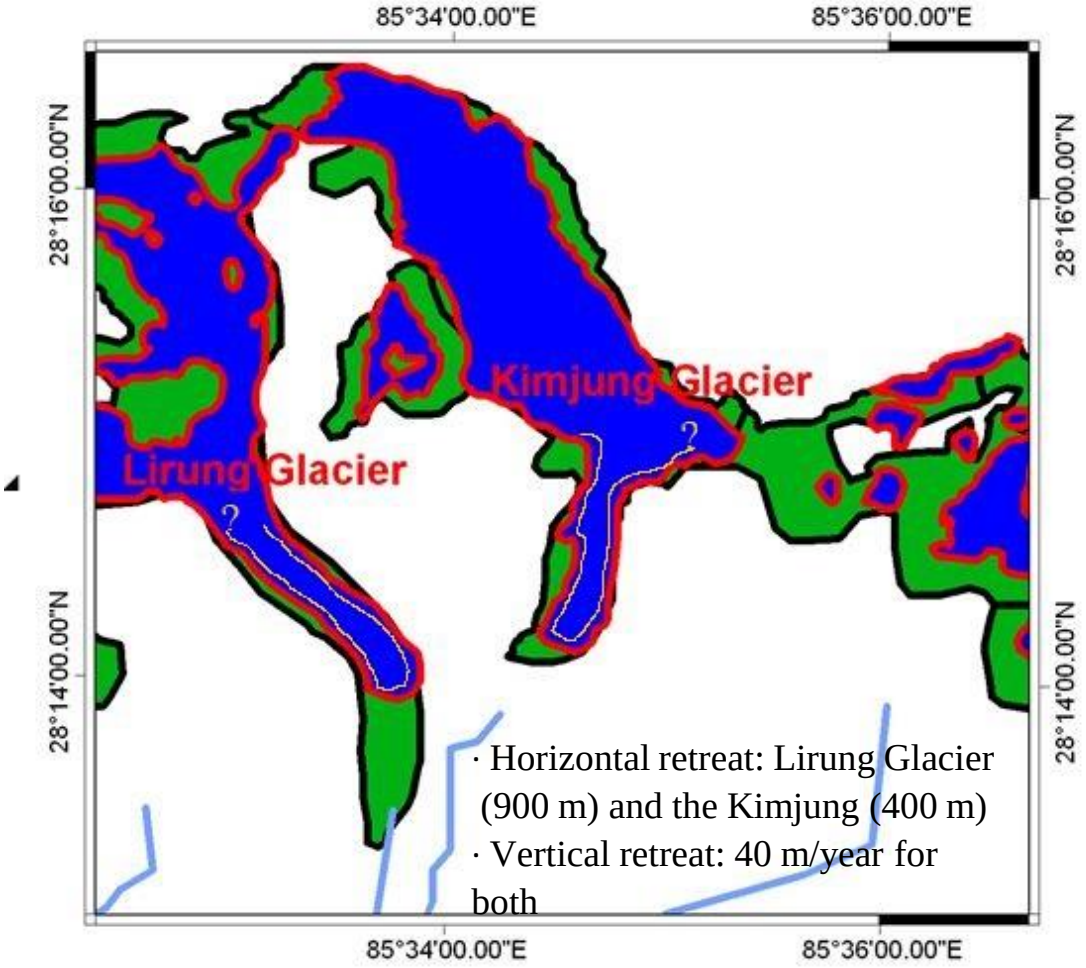
Presently shrinkage of glaciers should be more than of 50.07 Sq. km.

Retreat of glacier in Langtang Lirung and Kimjung glaciers (are in Sq. km)

Name of Glacier	Year	Total area of the glacier (km^2)
Langtang Lirung Glacier	1979	11.00
	1989	5.46
	1999	5.12
	2009	4.19
Kimjung Glacier	1979	5.04
	1989	4.44
	1999	4.16
	2009	4.09

Retreat of 6.81 Sq. km

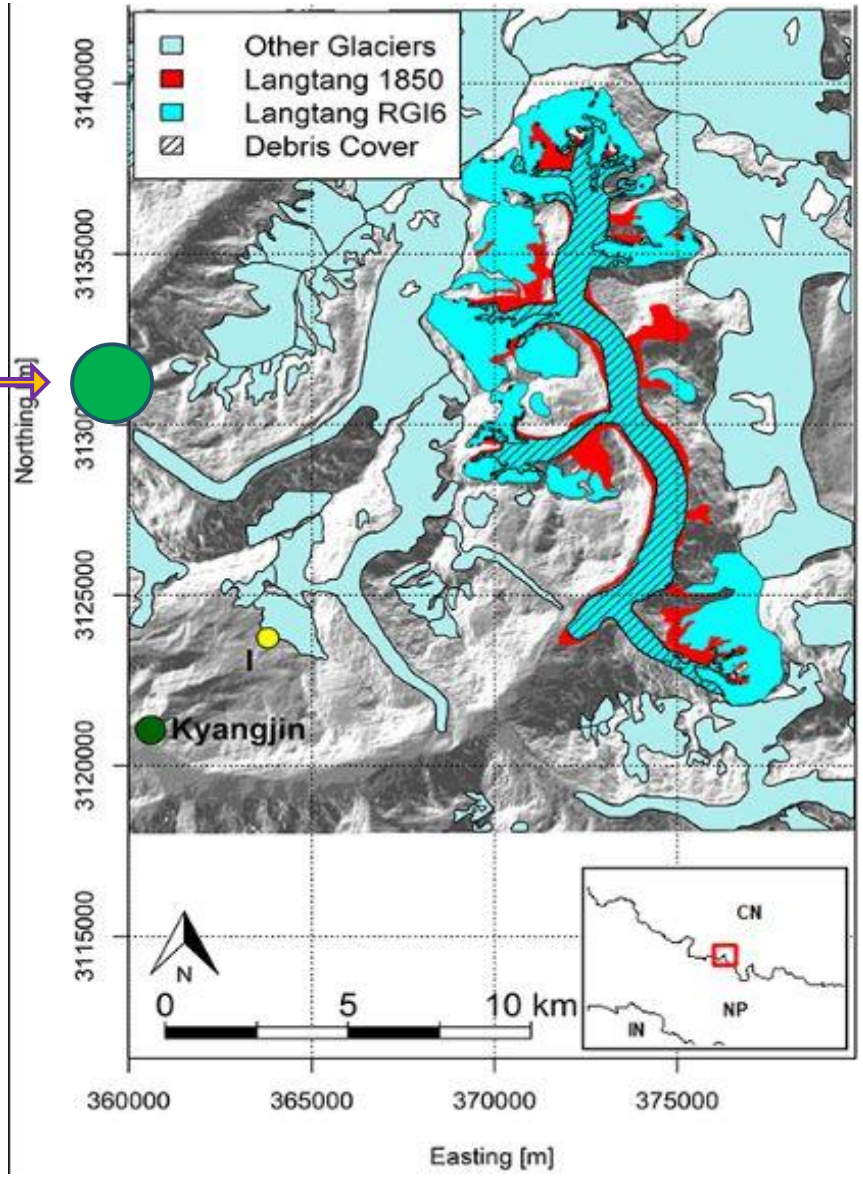
Retreat of 0.95 Sq. km



- Total loss of glacial coverage in Lirung Glacier - 62%
- Total loss of glacial coverage in entire Langtang Valley - 24% (Until 2009)
- 32% in entire valley by 2035 – projection (present study)
- 75% of glacier will disappear by 2 to 3 decades (Chaulagain, 2009)

Retreat of Langtang Glacier east of study area

Study area



Wijngaard et al., 2016

Major causes of climate change on Langtang glaciers

Green Houses Gases emission production:

- ✓ **Deforestation**
- ✓ **Black carbon by air pollution from Nepal and India**
- ✓ **Tourism**
- ✓ **Unscientific farming pattern**
- ✓ **Changing weather pattern**
- ✓ **Construction of hydroelectricity projects and roads in mountains**
- ✓ **Unsystematic settlement**

Examples of causing of GHGs emission production

Settlement at Nepal-China border, Rashuwagadi

Hydropower project at Syabrubesi Bazaar, Rashuwa

Deforestation in Langtag National Park

Tourism activities at Kynjin Gumba, Rasuwa

Impacts

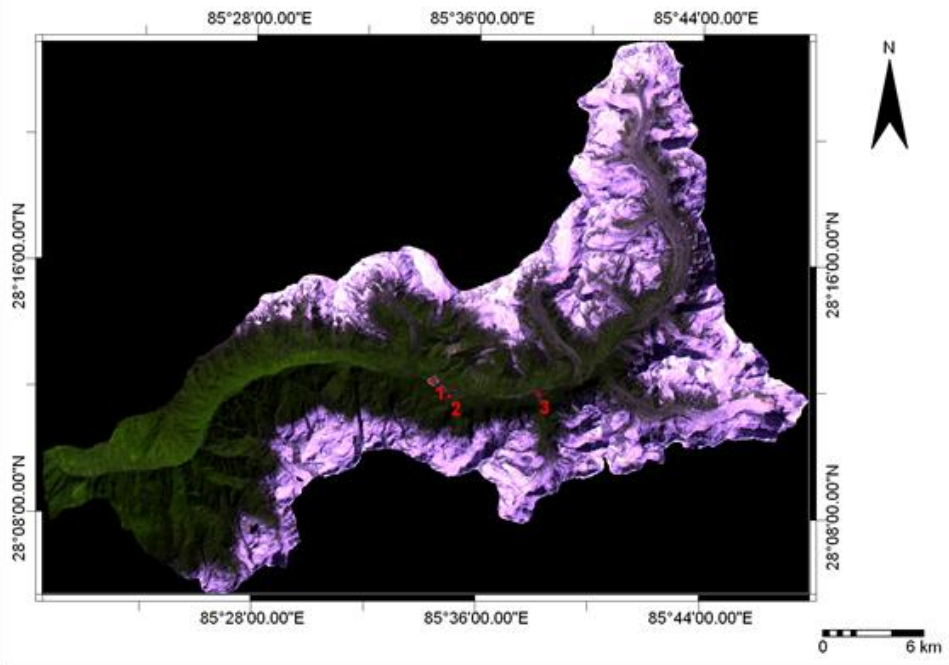
Environmental impacts

a. Now field (cirque) of Langtang Lirung glacier.

b. Langtang Lirung glacier. View to south

Environmental impacts

a



b

Debris: loose natural material consisting especially of broken pieces of rock

c

Studied debris fan number	Year	Area of debris fan (hectare)
1	1988	13.98
	2006	28.95
	2010	29.82
2	1988	13.18
	2006	18.93
	2010	22.27
3	1988	5.80
	2006	5.80
	2010	6.23

a. Locations of debris fans (1989-2010)

b. Side view of the big debris fan fed by Yala Glacier

c. Dimension of the different debris fans (see a for location)

Result: Increasing of dimension of the debris fans due to climate change over the periods. The increased melting of glaciers caused to form glacial lakes and produce high discharge to bring large debris

Langtang village before April 25, 2015

Langtang village after April 25, 2015

Avalanche with debris covered the Langtang village on April 25, 2015

Langtang village after April 25, 2015 with new settlements

Old Langtang village swept away by avalanche triggered by the 2015 earthquake

Socio-economic impacts

a. High altitude agriculture threatened by climate change (left)

b. Yaks and other animals threatened by diseases due to climate change (right_

Observation by local people in terms of climate change

- ✓ Covered by ice a decade changes to barren land
- ✓ Summer getting hotter and winter warmer than past
- ✓ Duration of winter shrinking and extremely cold days
- ✓ Decrease of precipitation rate
- ✓ Decrease of agriculture products
- ✓ Nyaks(yak family) becoming sick more frequently and losing their hairs

Conclusions

(i) Glacier retreat on 1979-2009 (last 30 years)

- Horizontal retreat: Lirung Glacier (900 metre) and the Kimjung (400 metre)
- Vertical retreat: 40 metre/year for both
- Lirung Glacier coverage area (shrinkage by 62%)
- The entire Langtang Valley watershed glacier retreat (shrinkage by 24%)
- 32% shrinkage in entire Langtang valley by 2035 – projection (from present study)
- Total increase in T : 0.9 C in Langtang valley

Based on present and previous studies show that the increase in retreat rate and melting rate of glaciers will be projected rapidly due to global warming/increase of T in the entire Himalayan region in coming years.

(i) Causes

- Increase in temperature due to the GHGs production
- Change in weather patterns (Monsoon pattern)

(iii) To reduce the **GHGs emission** production (even very negligible, **0.025%** in Nepal) and to protect the natural resources and conservation of water and to save from the global warming threat, following guidelines for adaptive measure policy should be applied:

- Lunching of community forestry and forest plantation program,
- Organic farming,
- Population control,
- Disaster mitigation program,
- Practice on biogas extension program such as green energy program, and
- Awareness program to the people to protect the environment.

Langtang (3800 m), Nepal visit
February 2023

Thank You !!!