CLIMATE CHANGE RISK AND VULNERABILITIES (in the Bhutanese Context)

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Country Profile

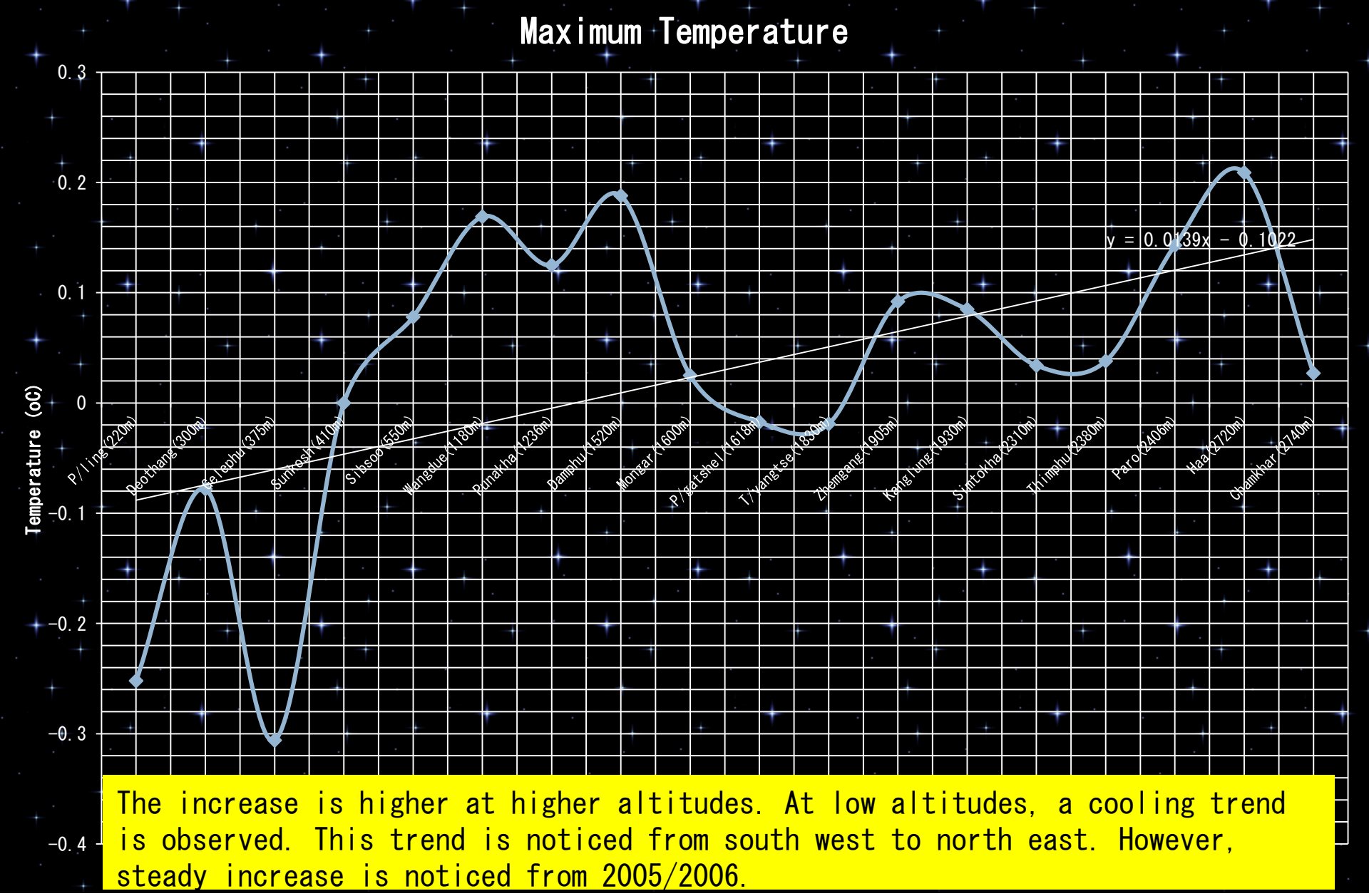
Country area –38,394 Km2

- Population –694,000 (projection for 2010
- Population density –18 persons/Km2
- Location: Bordered by Tibet Autonomous Region of China in the north, Indian state of Assam in the south and east and West Bengal in the west and east.

- Three broad geographic areas and corresponding climatic zones:
  - **Southern foothills**
    - Hot and humid, temperatures ranging from 15 to 30oC throughout the year and precipitation between 2,500 and 5,550 mm.
  - **Inner himalayas**
    - Rise to 3,000 m, has broad valleys, is the economic and cultural heartland. Characterised by a cool temperate climate with annual average precipitation of 1,000 mm.
  - **Higher himalayas**
    - Norternmost high mountain ranges with elevations up to 7,550 m, under perpetual snow, sparsely populated and have an alpine climate with average annual precipitation of 400 mm.

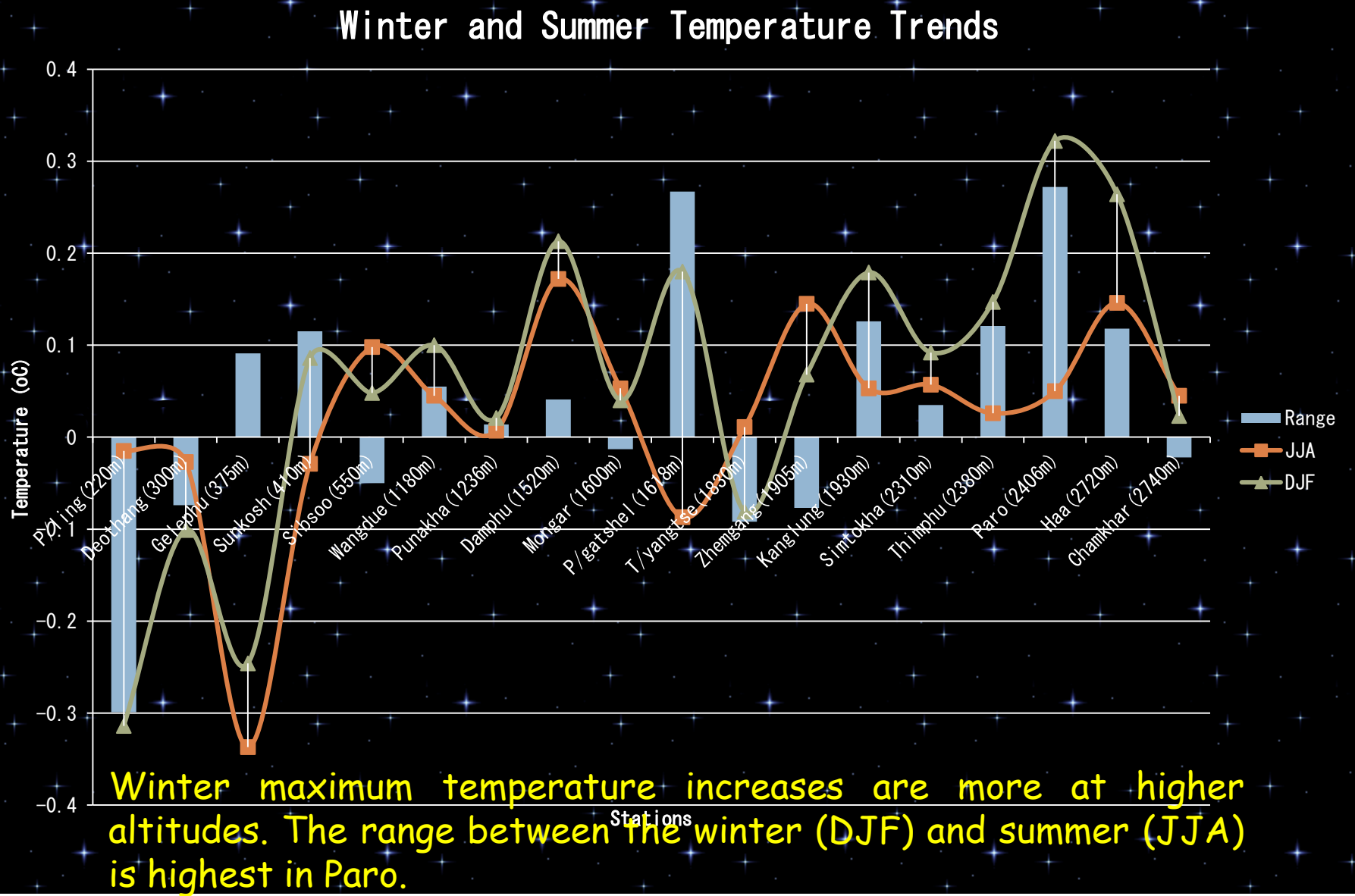
Climate Patterns & Variability

- Climate mainly determined by the the summer southwest monsoon from the Indian Ocean (late June through late September), and variations in topography and elevation.
- Monsoon accounts for 60% to 90% of the country's total precipitation.
- There are substantial disparities in temperatures and precipitations from one valley to another.
- The south-western and southern valleys are the warmest zones.
- Below freezing temperatures in the winter occur in the central, west-central and northern mountains.
- The southern valley of Bhutan receives the highest annual precipitation, while low precipitation occurs in central and northern Bhutan.
- The monsoon precipitation of Bhutan occurs more or less in opposite phase with that of India: when the monsoon is strong over Bhutan, it is weak over India and *vice-versa* (Quadir *et al.*, 2006).



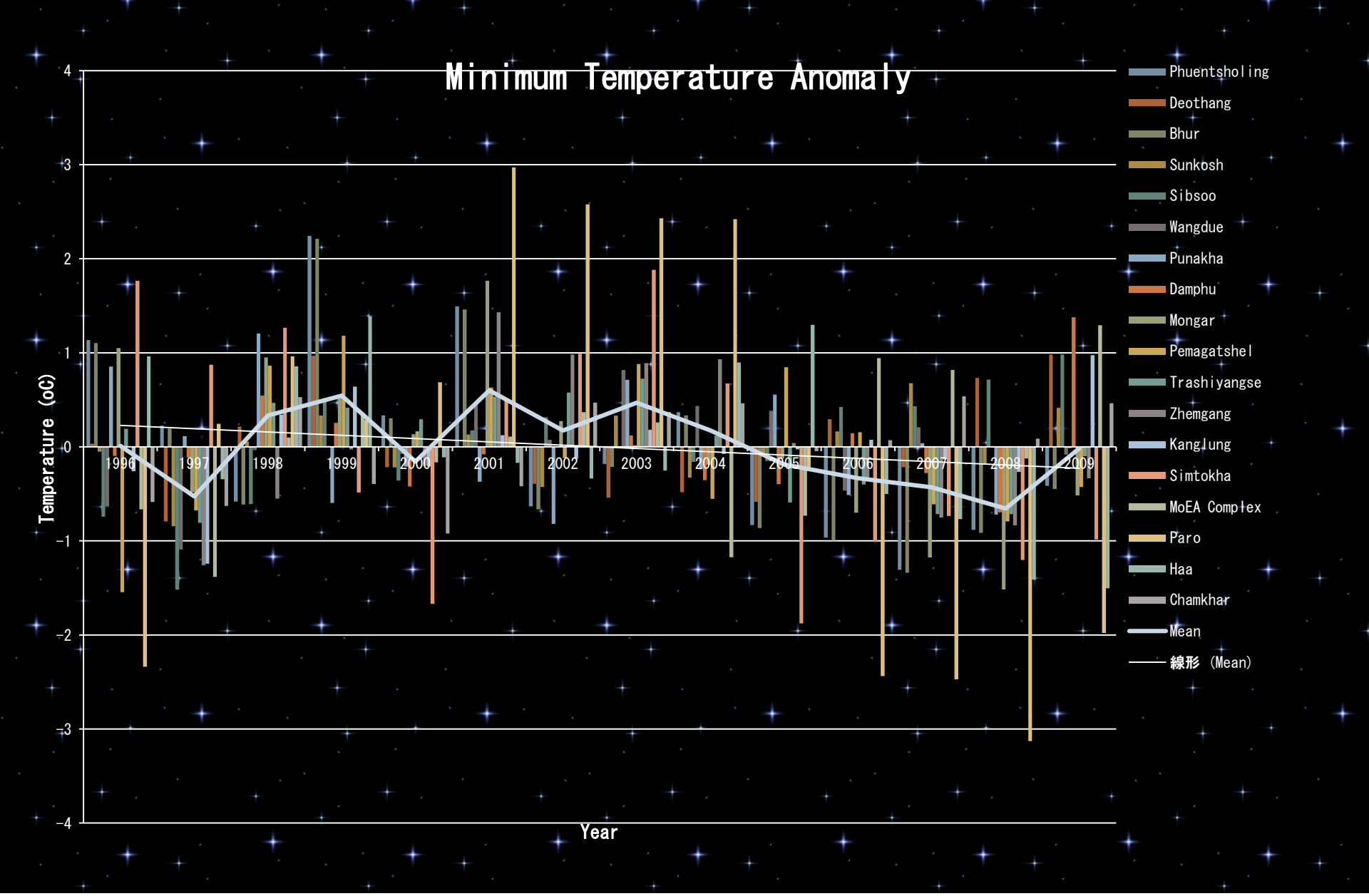
The increase is higher at higher altitudes. At low altitudes, a cooling trend is observed. This trend is noticed from south west to north east. However, steady increase is noticed from 2005/2006.

Observed Climatic Trends - Temperature



Winter maximum temperature increases are more at higher altitudes. The range between the winter (DJF) and summer (JJA) is highest in Paro.

Observed Climatic Trends - Temperature

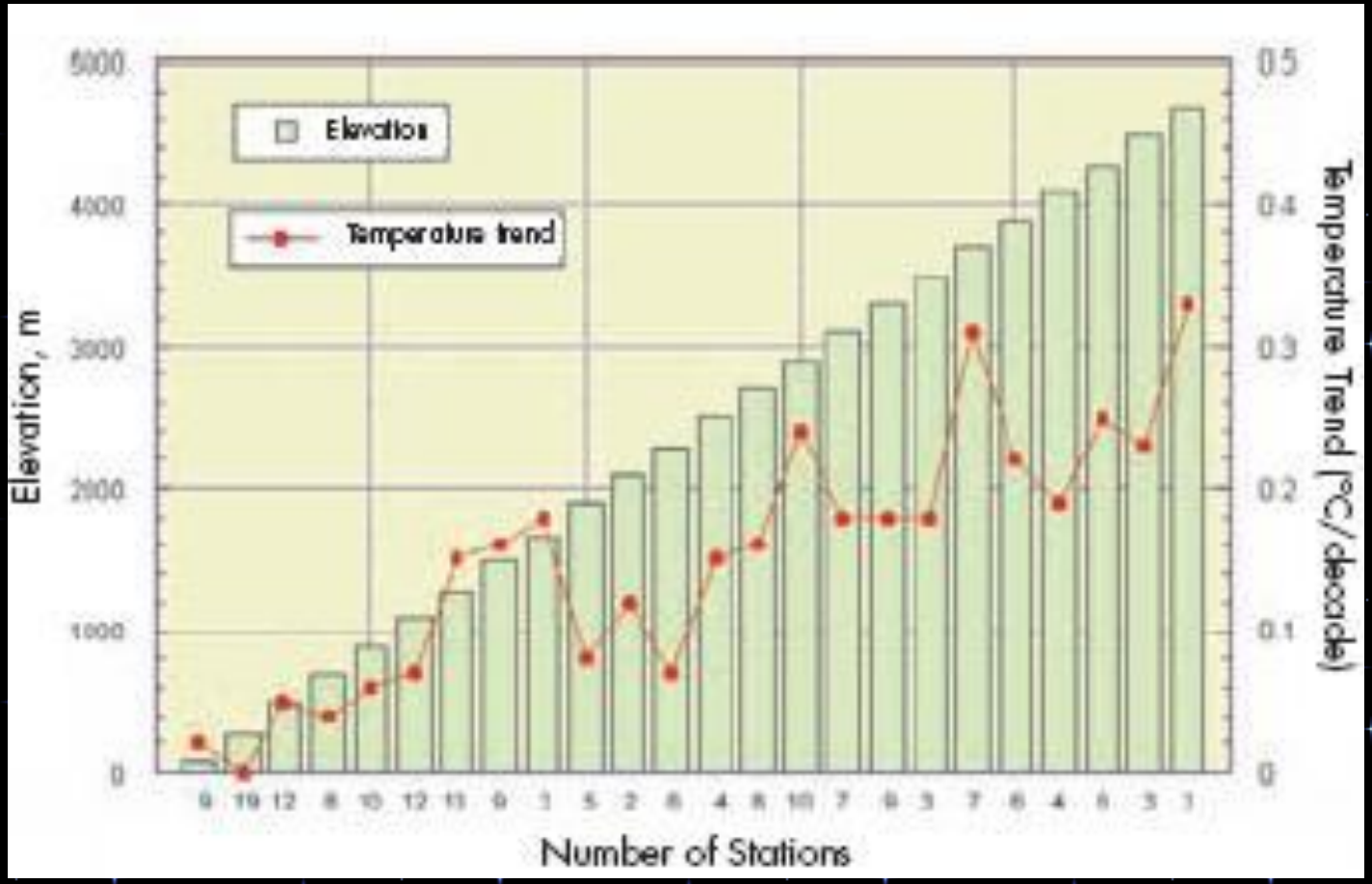


Observed Climatic Trends - Temperature

Climate Modeling

- Regional climate models indicate temperatures in the Indian sub-continent to rise between 3.5 and 5.5ºC by 2100, and on the Tibetan Plateau by 2.5ºC by 2050 and 5ºC by 2100 (Rupa Kumar et al. 2006).
- In early 2011, downscaling on Bhutan specifically performed with PRECIS by START / ADPC under an ADB consultancy predicts +3°C by 2050 (less than 0.1/decade).
- Because of the extreme topography and complex reactions to the greenhouse effect, even high resolution climatic models cannot give reliable projections of climate change in the Himalayas.
- Various studies suggest that warming in the Himalayas has been much greater than the global average of 0.74°C over the last 100 years (IPCC 2007a).
- Warming will be significant in arid regions of Asia and the Himalayan highlands, including the Tibetan Plateau (Gao et al. 2003; Yao et al. 2006)

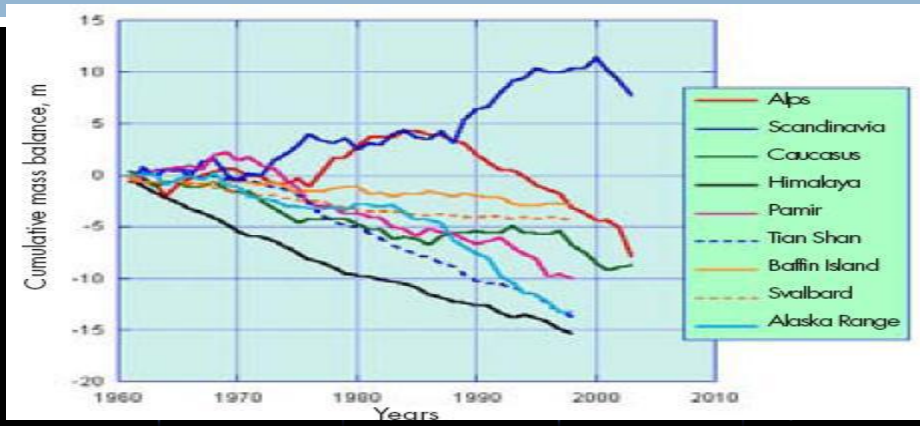
- Warming in Nepal and on the Tibetan Plateau has been progressively greater with elevation (Figure 1).



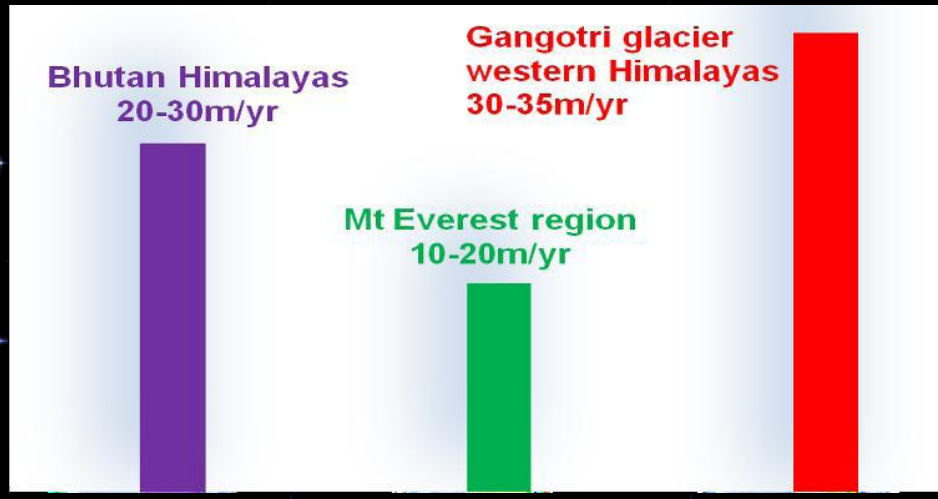
Climate Modeling

Issues – Glacier Retreat

- Tarina Glacier retreat rate was 35 m per year from 1967 to 1988 (Ageta et. al. 2000);
- Retreat rates as high as 26.6 m per year were reported for 103 debris free glaciers in the Bhutan Himalaya over a period of 30 years from 1963 to 1993 (Karma et; al., 2003);
- Jichu Dramo Glacier retreated by 12 from 1998 to 1999 (Naito et. al., 2000);
- The retreat rates are higher for glaciers in Bhutan Himalaya than in eastern Nepal (Karma et. al., 2003);
- 8% shrinkage estimated using 66 glaciers in 30 years from 1963 to 1993 (Karma et. al., 2003);
- Luggye Glacier retreated by 68.5 m per year from 1967 to 1994; and
- Raphstreng Glacier retreated on an



Rapid retreat of greater himalayan glaciers compared to the global average.



Increased glacier retreat since early 1990's

Issues – Glacier retreat

- A serious concern for Bhutan whose economy is dependent on the glacial lakes which act as natural reservoirs and also help to regulate seasonal flows in the rivers.
- Bhutan ‘s accelerated development of hydropower programme has set a target of 10,000 MW by 2020. Out of this, more than 6000 MW is planned in the Punatsangchhu Basin which is located downstream of major glacial lakes.

Issues – GLOF

- Formation of supra-glacial lakes due to the accelerated retreat of glaciers with increasing temperatures. The risk of Glacial Lakes Outburst Floods (GLOFs), which pose new threats to lives, livelihoods and development, is mounting as the water levels in several glacier lakes approach critical geostatic thresholds.
- Although current disaster management policies, risk reduction, and preparedness plans in Bhutan are able to address recurrent natural hazards in the country, they are not yet prepared to deal with the new GLOF apparently caused by the impacts of climate change.
- Rising mean temperatures, attributed to climate change, are the main cause of glacial retreat and are correlated with faster rates of glacier melt. This may be the reason for accelerated melting of glaciers receding at a rate of almost 20-30

Issues – Runoff over Time and Space

- Most mountain people rely on glacier melt and seasonal flows for water supply.
- The current trends in glacial melt suggest that the low flow will become substantially reduced as a consequence of climate change (IPCC 2007a).
- Impact food production and slow down economic growth.
- Flooding may also arise as a major development issue. It is projected that more variable, and increasingly direct, rainfall runoff will also lead to more downstream flooding.

Issues – Hydropower Generation

- Increased risk of Glacial Lake Outburst Flooding (GLOF).
- Increased run-off variability ‘s of glacier retreat, more intense precipitation during monsoon and potentially decreased precipitation in winter;
- Increased sediment loading as a result of landsides, GLOF as a result of intense rainfall events.
- Increased evaporation losses from reservoirs.
- Domestic water supply is presently met from the springs and small tributaries, but main rivers will have to be tapped into to meet increasing demand. Implications on hydropower projects during the lean flow period, will be there in the long run.

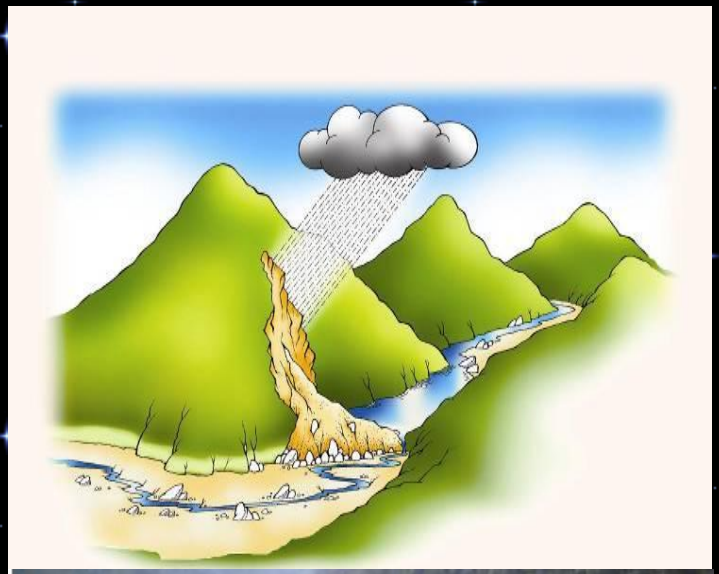
Issues – Sanitation & Hygiene

- Damage of water supply and sanitation infrastructures from increased flooding or landslide, debris flow, GLOF etc.
- - Increased O&M costs for water treatment due to degradation of water quality input.
- - Pollution induced by overwhelming capacity of low cost surface water protection system, including pathogen loading, water borne diseases propagation,
- - Water borne diseases Increased by dry spells / droughts and degradation of quality of shallow water, ponds and marshes,
- - Possible drying up of spring and stream sources in remote areas.

Issues – Landslide Dam Bursts

Landslides triggered by cloudbursts cause temporary dams blocking the path of the stream/river. Devastating floods result when the dam burst.

Change in rainfall patterns is expected to accelerate these earth movements in steep terrain.



Issues – Water Related Health Hazards

- The impact of climate change on human health may be classified into three categories:
  - direct impacts of for example, drought, heat waves, and flash floods
  - indirect effects due to climate-induced economic dislocation, decline, conflict, crop failure, and associated malnutrition and hunger,
  - indirect effects due to the spread and aggravated intensity of infectious diseases due to changing environmental conditions

Issues – Impact on Agricultural Productivity

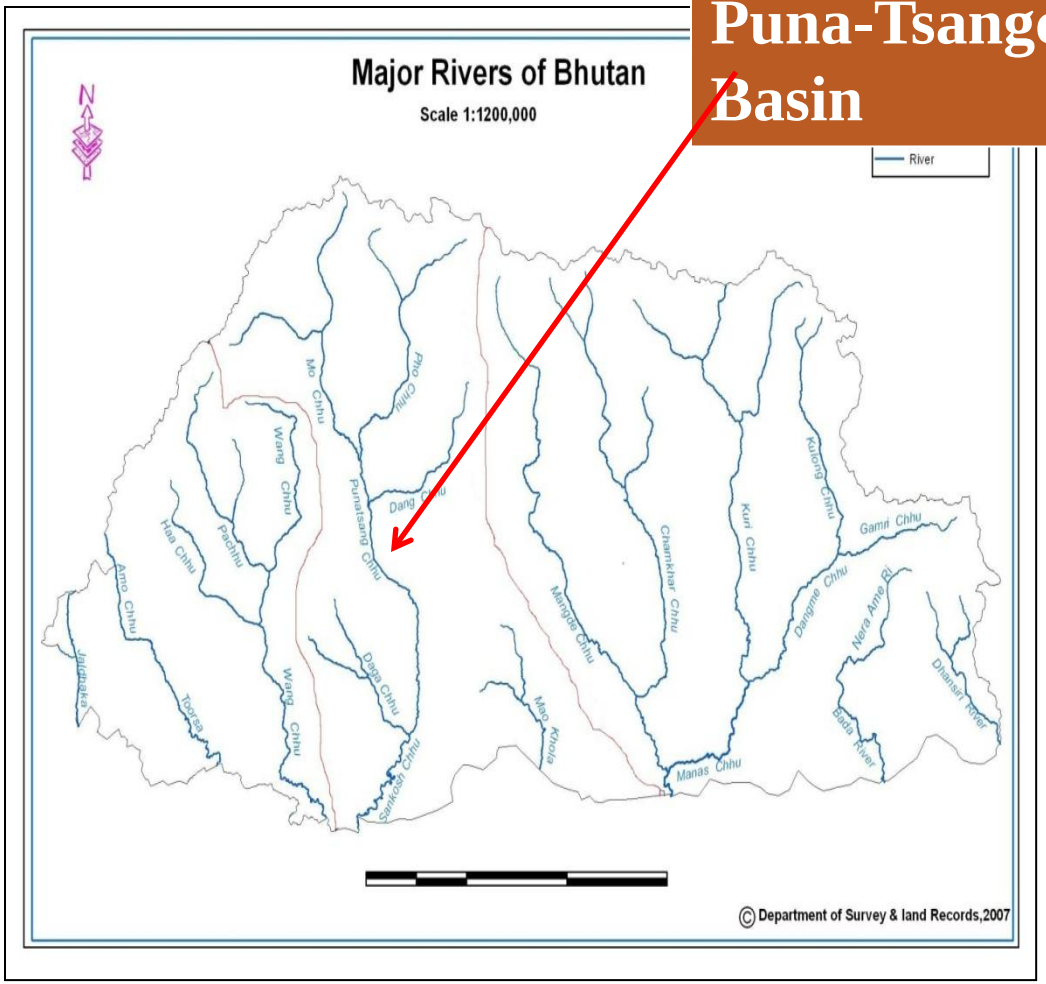
- Due to climatic vulnerability and associated risks, agricultural production systems especially in marginal areas are prone to degradation of land resources through land and soil erosion, and over-extraction of groundwater (National Water Mission, Subsistence and smallholder farmers are particularly vulnerable to climate variability and socio-economic stresses that further complicate their livelihood systems (Bates et al. 2008). It is paradoxical that too much water (floods, land slips) and too little water (droughts) both adversely affect agriculture leading to food insecurity. Extremes in temperatures (high/low) and shifts in rainfall patterns (early/late) lead to adjustments in planting and harvesting times, often resulting in lower crop productivity and food

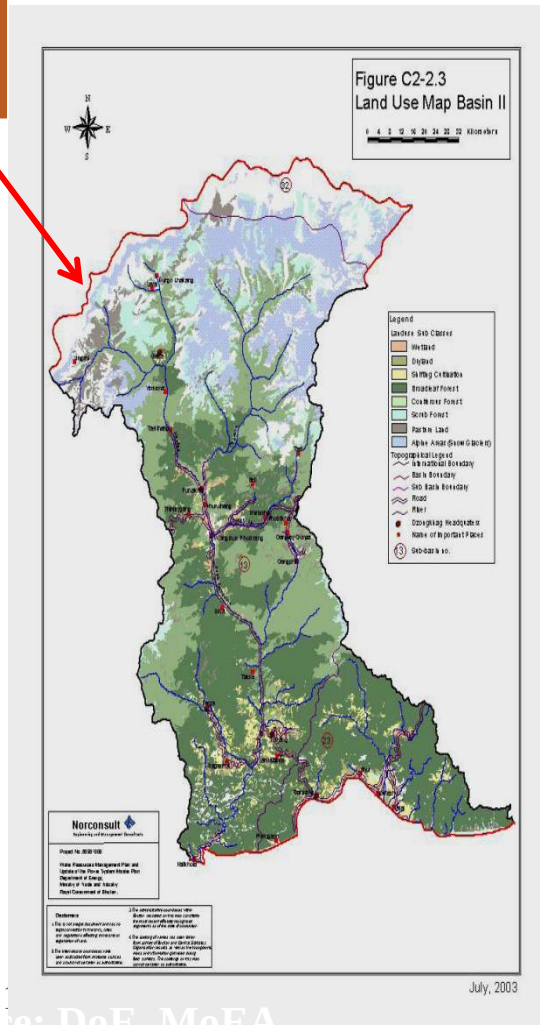
Issues – National Action Plan

- To improve understanding and increase awareness of the impacts of climate change on water resources.
- 2. To increase resilience to respond to the impacts of climate change on water resources.
- 3. Water Resources Management through adoption and implementation of IWRM and eco-efficiency
- 4. Mainstream climate change and water resources in national plans and programmes.

GEOSS/AWCI INITIATIVE

Puna-Tsangchhu Basin

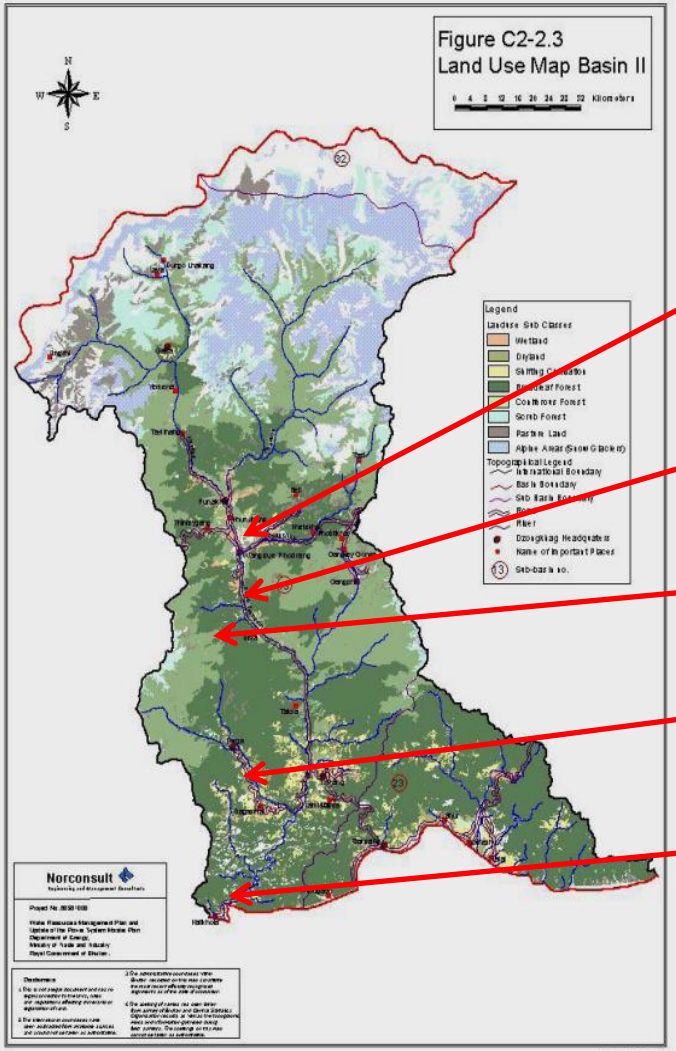




Why AWCI Demonstration Basin ?

- **Background**
  - Economic importance from both agricultural and energy generation
  - Existing threats of glacial lakes burst due to increasing glacial melt
- **Issues to be addressed**
  - Flood warning
  - Impacts on hydropower generation
  - Sediment transport
- **Objectives**
  - Determination of an adequate warning system for floods and monitoring of flow changes

Hydropower Development in Punatsangchhu



Project Name	Capacity (MW)	Status
Punatsangchhu-I	1200	Under construction
Punatsangchhu-II	900	Under construction
Basochhu - I&II	24 & 40	Completed
Dagachhu	114	Under constructi

AWCI Climate Modeling

•On our own for rainfall estimate, AMSU, SSM/I are FTPeed from NOAA CPC.

• Snow and glacier melt model development at UT for the AWCI demonstration basin.

• Data upload at DIAS/UT complete.

• Bias correction in progress

• ……

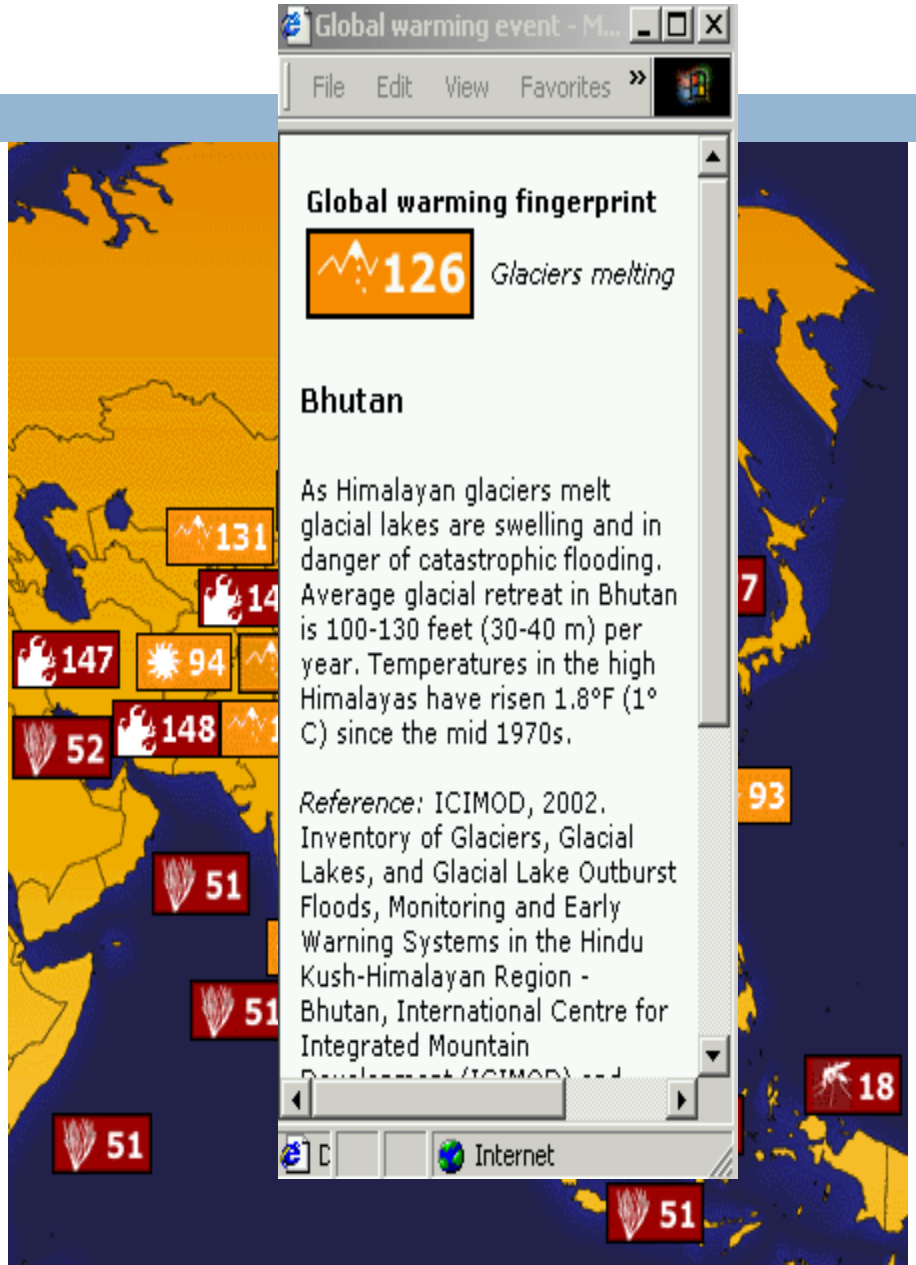
Risk Reduction

- Project titled "Reducing Climate Change Risks and Vulnerabilities in the Wangdue (DP) and Chamkhar Valleys" being implemented. It is an activity identified in the National Adaptation Programme of Action (NAPA) and includes:
  - Installation of GLOF Early Warning System
  - Artificial Lowering of Thorthormi Lake
  - Awareness campaign

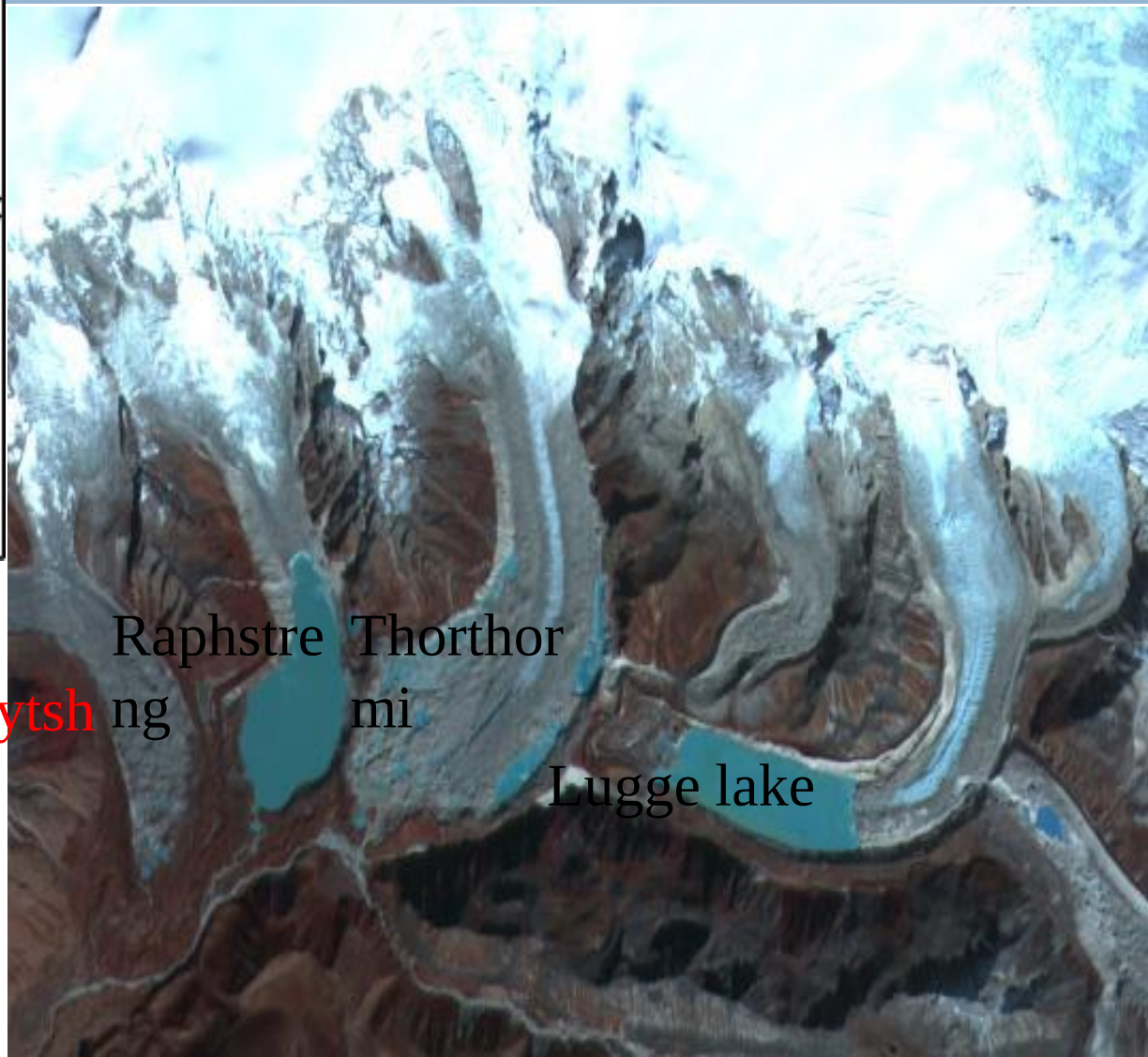
Installation of GLOF Early Warning System

PURPOSE:

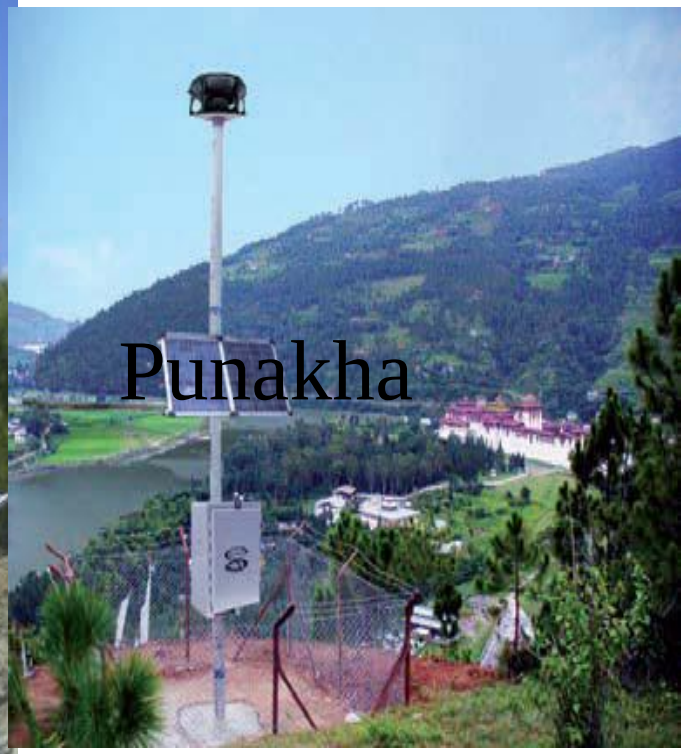
To make a comprehensive early warning system for the Punatsangchhu basin that not only cater the needs of the people in Punakha- Wangdue valley but also to hydropower and other infrastructures projects downstream



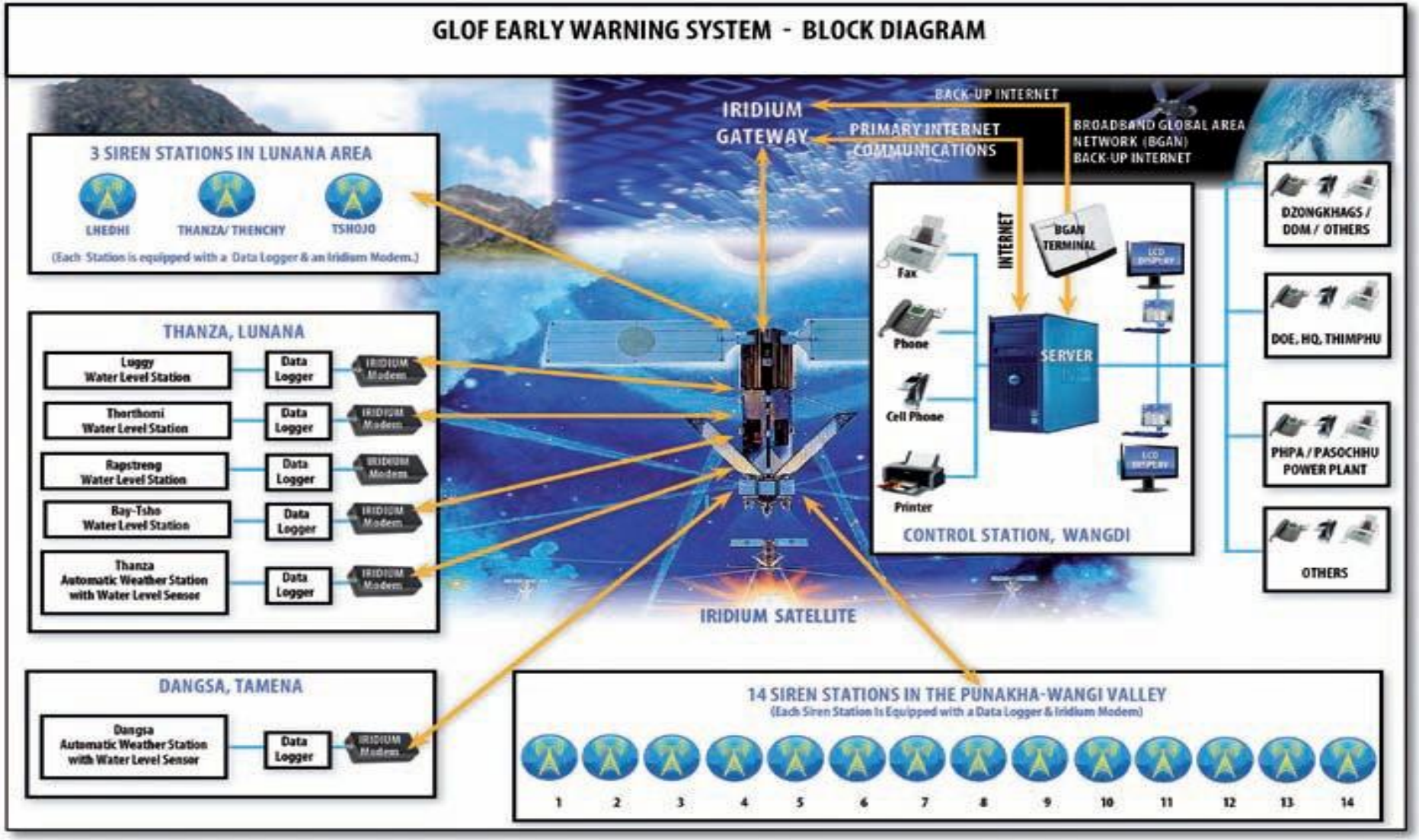
Installation of GLOF Early Warning System



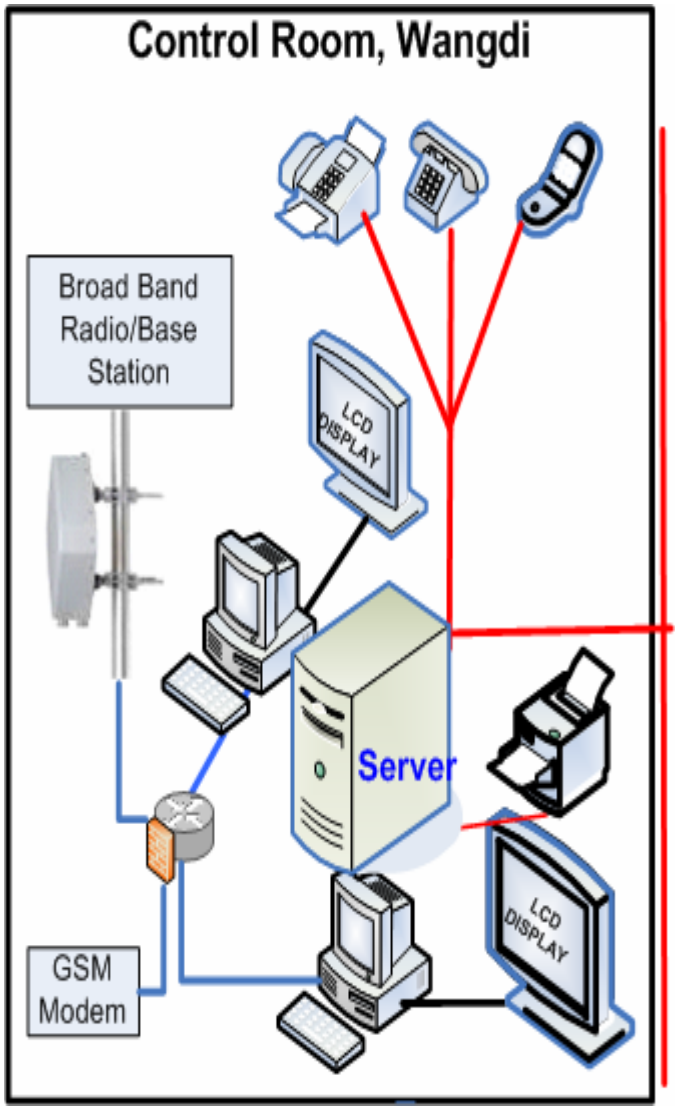
GLOF Early Warning System



GLOF Early Warning System



GLOF Early Warning System



Regional Initiatives

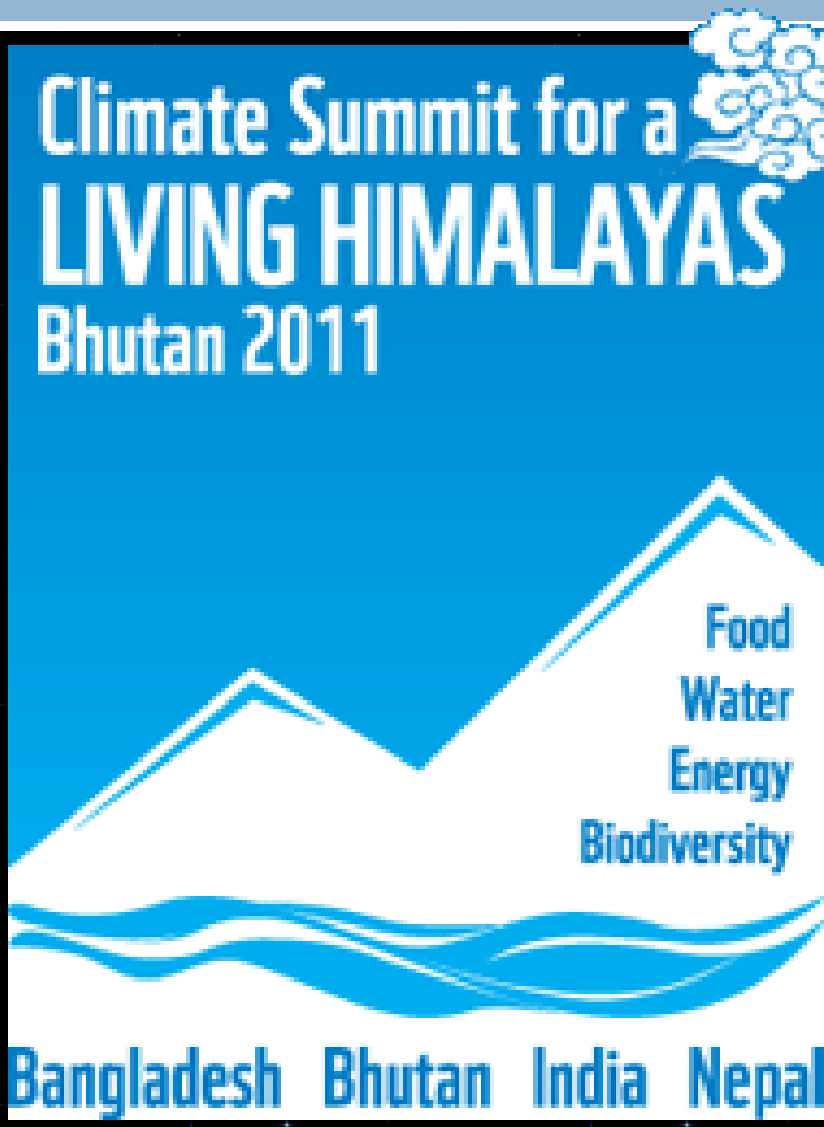
"Bhutan Climate Summit for a Living Himalayas"

Areas:

1. **Food Security**
2. **Water Security**
3. **Energy Security**
4. **Biodiversity**

18th-19th November, 2011

Thimphu: Bhutan



1. Enhancement of ecosystem management practices to minimize the impacts of climate change induced disasters
2. Develop effective approaches and actions concerning disaster management
3. Promotion of traditional water conservation techniques coupled with modern methods to increase water use efficiency
4. Lessons, good practices and appropriate technologies shared in the region to improve water use efficiency for effective adaptation
5. Networking of national centres of learning and institutes for related capacity building
6. Dissemination of success stories and best practices on climate change adaptation
7. Sharing of related knowledge products for improving the understanding of climate change impacts on water resources in the region

Framework of Cooperation

Implementation Mechanism for “Framework of Cooperation”

- The implementation of the ‘framework of cooperation’ shall be through a Coordination Group comprising nodal agencies nominated by each partner country.
- This will be supported by a network comprising of institutions nominated by each partner country for the respective thematic areas.
- The Coordination Group shall meet on an annual basis or as deemed necessary. Each partner country will host the meeting of the Coordination Group by rotation.
- The Coordination Group shall consider the proposals put forward by partner countries including their financing proposals. The Coordination Group will approve the projects and their funding proposals by consensus. The proposals may be referred to the network of institutions for conducting feasibility studies, as necessary/ appropriate and implementation of the approved projects.
- Proposals that are relevant to all the four partner countries shall be eligible for consideration.
- The resources and expertise for the implementation of the ‘framework of cooperation’ should be preferably found within the sub-region.
- The projects under the ‘framework of cooperation’ shall be implemented by the respective partner countries in a coordinated manner.
- The first meeting of the Coordination Group shall be held in Thimphu within a year from today the 19th of November 2011.

THANK YOU