Recent trends and potential climate change impacts on glacier retreat/glacier lakes in Nepal and potential adaptation

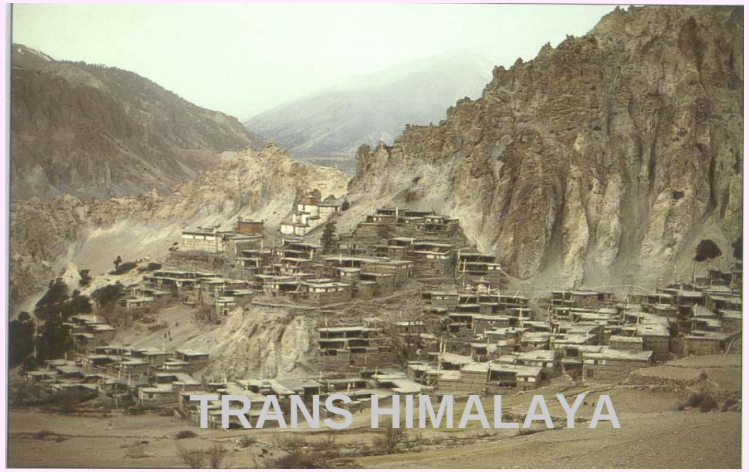
Madan Lall Shrestha
and
Arun Bhakta Shrestha
Department of Hydrology and Meteorology, HMG-Nepal

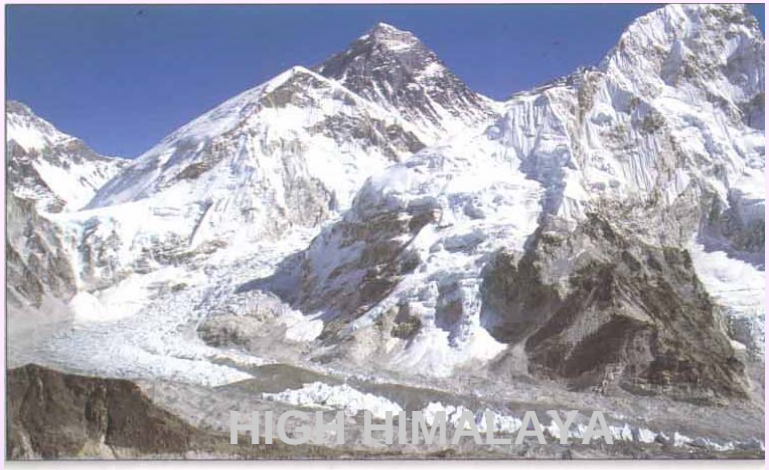
Global Forum on Sustainable Development: Development and Climate Change
11-12 November 2004
Tour Europe, Paris La Defense, France

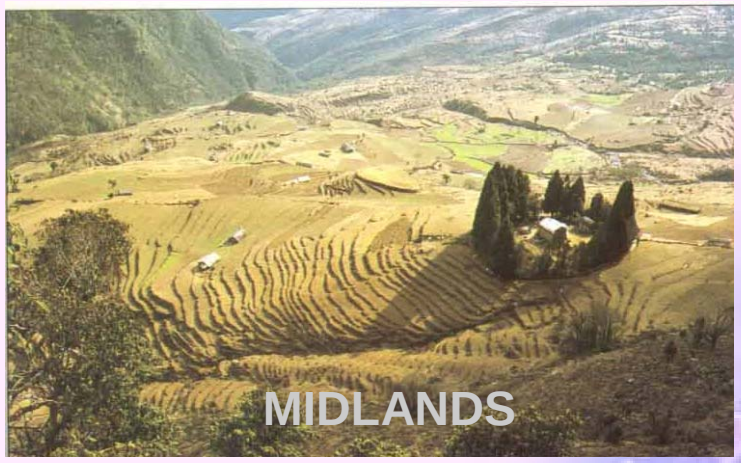
1. Introduction

- Nepal is a land locked country between India and China
- Within the 147,181-km^2 area of the country, physiographic region range from tropical forests in the south to the snow and ice covered Himalayas in the north.
- A very wide range of climate: subtropical in the Terai in the south to arctic in the high Himalayas in the north
- Population:23.2 million; Growth rate 2.24%
- Annual per capita GDP at factor cost US$224 (2000/01; current Price)

The Diversity







DHM

- Rich in water resources; More than 6000 rivers and rivulets; annual runoff :170 billion m3
- Hydropower potential: 83,000 MW (theoretical); 44,600 MW (economically feasible)
- Nepal is predominantly a mountainous country with more than 80 % of its territory occupied by mountains
- Mountainous environments, especially glaciers are considered to be sensitive indicators of climate change .
- Several studies in the Himalayas have found that glaciers in the region have retreated considerably in the last two decades.
- Climate change could have serious impact on the water resources of the country

2. Climate Change Projections

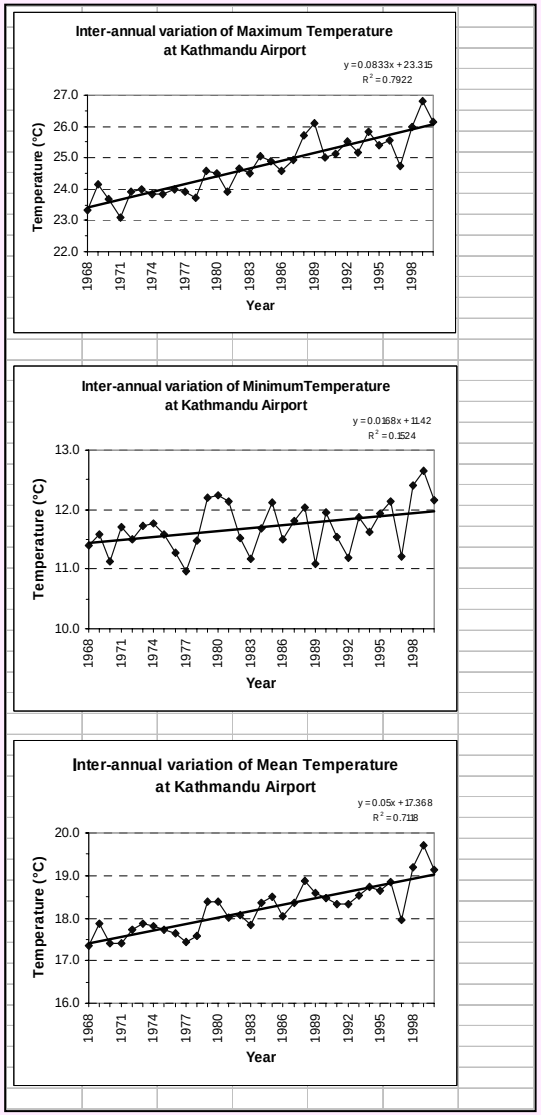
- AOGCMs predict the mean temperature increase of about 4^{o}C for the period 2071-2100 relative to the period 1961-1990. There is a general consistency among the models in their output for winter while the agreement is less for summer.

- In contrast, the consistency among models in precipitation predictions as well as the significance of projected changes are low both for the winter as well as summer seasons (IPCC, 2001; OECD, 2003; MoPE, 2004).

- Model predictions on the effect of climate change on stream flow, varies regionally and between climate scenarios.

- These climate models are unable to highlight the details on seasonal variations in runoff, although it is generally suggested that due to higher evaporation and decrease in glacier mass, the low flows are likely to decrease (IPCC, 2001).

3. Observed Climatic Trends



- Temperatures in Nepal are increasing at a rather high rate.
- Warming seems to be consistent and continuous after mid-1970s and the average warming in annual temperature during period 1977-1994 was 0.06 ^{o}C yr-1 (Shrestha et al., 1999).
- Warming is more pronounced in the higher elevations while significantly lower or even lacking in Terai and Siwalik regions of Nepal.
- Warming in the winter is more pronounced compared to other season.

- Precipitation data does not reveal any significant trends, although precipitation in Nepal is found to be influenced by or correlated to several large scale climatological phenomena, including El Niño (Shrestha et al. 2000).

- In this sense the trends in observational data is in agreement with projections made by climate models.

- There is an clear indication that the extreme precipitation events in the central Nepal are increasing in the recent decade.

4. Impact of Climate Change on Water Resources

4.1 Deglaciation

- Glaciers in Nepal Himalaya are in general state of degradation.
- The termini retreat of glaciers in Nepal range from 10s to 100 m in past few decades.
- Deglaciation in the Nepal Himalaya is well documented by study of glaciers AX010, Khumbu, Lirung, Yala, Rika Samba,
- The glaciers of Nepal are important storage of freshwater as they accumulate mass in monsoon and winter at higher altitude and provide melt-water at lower elevations.
- The melt-water contribution of glacier is particularly important during dry seasons to maintain river flow.
- About 70% of low flow of Ganges contributed by rivers from Nepal.
- The importance of glacier is not limited to Nepal as all rivers flowing through Nepal finally flow into the Ganges.

4.2 River Discharge

- A preliminary analysis of river discharge was carried for rivers of three categories: large outlet rivers, southern rivers and snow fed rivers.
- The analysis showed a that trends observed in the river discharge are neither consistent nor significant in magnitude.
- In contrast the number of flood days and consecutive days of flood events have been increasing (Shrestha et al., 2003).
- It has to be noted that the ambiguity in discharge data trend could be due to short record length and high inter-annual variability in discharge data.

4.3 Glacier Lake and their Outburst Floods

- There are 2315 glacier lakes of varies sizes, the total area of which is 75 sq. km. (ICIMOD/UNEP, 2001).
- The formation and growth of glacier lakes is a phenomenon closely related to the deglaciation in Nepal.
- Nepal has experienced more than 15 events of GLOFs. About 20 glacier lakes in Nepal are considered to be potentially dangerous
- A GLOF is characterized by a sudden release of a huge amount of lake water, which in turn would rush down along the stream channel downstream in the form of dangerous flood waves.
- GLOF is likely to be a major hurdle in water resource development in Nepal

5. Adaptation and Mitigation Measures

- Though the discharge records do not yet show concrete evidence of impact of climate change, other indications of changes like in glaciers condition is already seen.
- It is therefore rational to plan ahead for adaptation and mitigation strategies to cope with the impact of climate change.
- Some generic adaptation measures may also be applicable for Nepal. They include: proper management of the water resources system; promotion of indigenous and sustainable technologies, etc.
- For case of Nepal some specific "no regret" adaptation measures may be proposed.
  - 1. Storage type water resource management system;
  - 2. Integrated water resource management;
  - 3. Flexibility in operation;
  - 4. Larger rivers compared to smaller rivers;
  - 5. Design consideration specific to GLOF;
  - 6. Early warning and protection system;
  - 7. Flood protection measures;
  - 8. Timely drainage of glacier lakes, etc.

6. Summary

- Climate Model results are highly variable concerning projection for the south Asian region. The projections on temperature change are more or less consistent and significant.
- Overall increase in precipitation is projected, although the magnitude of change is low. Change in runoff projections generally follows precipitation although it is highly variable with model.
- Observed trends in temperature generally agree with climate model results and show significant warming in last decades. More warming is observed in high altitudes compared to low land. No significant trend is found in precipitation.
- There is an overwhelming evidence of deglaciation in the Himalayas.
- As glaciers are important source of water to the rivers of Nepal as well as India especially during dry seasons, widespread deglaciation is certain to have an impact of regional scale.
- Preliminary analysis of river flow data, however, does not show any consistent trend. This could be due to rather short length of discharge records.

7. Conclusion

- As runoff variation is directly related to glacier condition, continued deglaciation is certain to have impact on runoff in the future
- However runoff increase or degrease is dependent on the stage of deglaciation. In the initial stage there is an increase in discharge due to accelerated melting. Later, as the ice-mass is depleted the flow is likely to decline.
- It is not yet clearing which stage of deglation we are currently in. It is therefore wise to prepare for the worse.
- Furthermore, it is obvious that GLOF is a problem to water resource development. It is timely to make vulnerability assessment of different development sectors and devise Adaptation Plans.
- Some "no regret" adaptation measures may be implemented in the near future.
- But there is a limit to what natural systems and human can adapt to, therefore adaptation alone cannot be the solution.

Though difficult, we must move on