



Texas Tech University
Department of Civil Engineering
Water Resources



Can Developing Nations Adapt Climate Change and Mitigate their Emissions?

A Case Study: Nepal

Climate Science Policy and Solutions

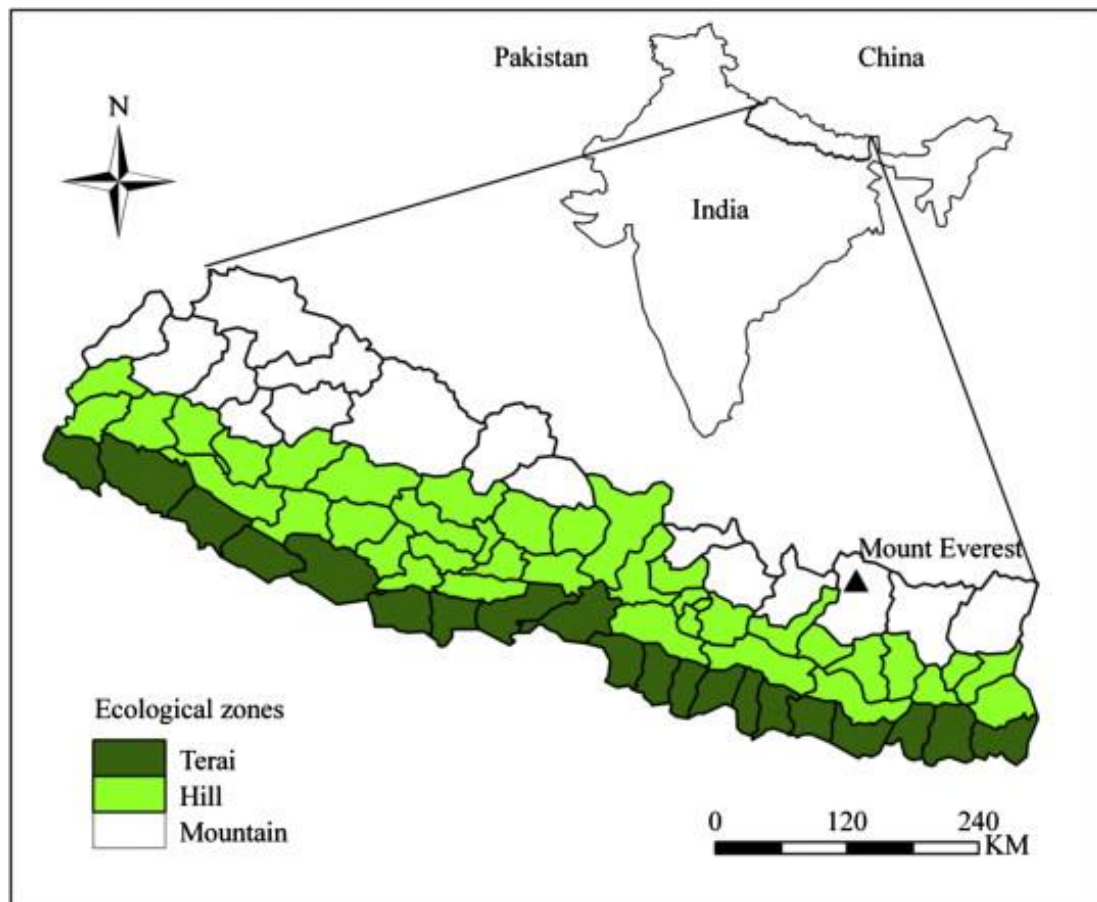
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1. Country Background

Nepal is a least developed, agrarian mountainous country situated in the central Himalayas. With three major ecological regions: The Terai (23% of total area), the Middle mountains (42% of total area) and the High mountains (35% of total area), Nepal has an altitude ranging from 60m in the south to 8848m in the north (Mt. Everest, the highest peak on the Earth). Further, based on climatic variability and geology, there are five physiographic zone: High Himal, High Mountain, Middle Mountain, Siwalik and the Terai. Each of these zones have variation in temperature and precipitation patterns with maximum being at the lower belts of Terai. Nepal has a temperate climatic feature with mean annual temperature between 3 to 25 degrees Celsius and mean annual precipitation of 150-3000 mm. Nepal has basically four main seasons: Pre-monsoon (Mar-may), Monsoon(Jun-Sep), Post-monsoon(Oct-Nov) and Winter (Dec-Feb). Nepal covers only about .1 percent of total land mass of the world but the variation in climate and topography has made Nepal rich in biodiversity falling in the 25th position globally. Nepal support around 118 ecosystems, 75 vegetation types and 35 types of forest. The fig 1.1 represents the climate features at each ecological belts in Nepal.



Physiographic Zone	Ecological Belt	Climate	Average Annual Precipitation	Mean Annual Temperature
High Himal	High Mountain	Arctic/Alpine	Snow/150 mm -200 mm	<3°C-10°C
High Mountain				
Middle Mountain/Hills	Middle Mountain	Cool/Warm	275 mm -2300 mm	10°C-20°C
Siwaliks	Churia/Terai	Tropical/Sub-tropical	1100 mm -3000 mm	20°C -25°C
Terai				

Source: WECS (2005)

Fig 1.1: Nepal with different Ecological Belts and their climatic features

With the increasing concentrations of GHG in the atmosphere, the average temperature has increased at a rate of .06 degrees Celsius in the decades of 1970s and 1990s, and the western and central parts of Nepal are facing a decline in precipitation of ,700 mm/decade while there has been increase in the eastern parts. In the recent decades, Nepal has been categorized as highly vulnerable to climate change by several vulnerability assessments, and Maplecroft, 2010 found Nepal to be the 4th most vulnerable countries in the world in regards to climate change.

2. UNDERSTANDING THE CLIMATE CHANGE

Nepal is a developing nation, and it does not have big industries and high-tech infrastructures sufficient enough to enhance the rising global temperature compared to other big nations. However, there has already been noticeable footprints of climate change. Climate change is already changing the world around us, and the least developed nations are the most vulnerable, and so is Nepal. Nepal is already facing more intense rainfall and extreme weather patterns, more droughts, floods, frequent and severe heat storms, changing temperature and precipitation patterns, wildfire, and scarcity of water. The natural ecosystem and the agricultural system has been adversely affected. The glaciers and snow ice are melting at an alarming rate.

3. STATE OF ENVIRONMENT

Nepal being a poorly developed country with lots of development to go, is not a greater contributing factor to global warming. The total GHG emission from Nepal is estimated to be 39265 Gega gram, with per capita emission of 1977 kg, relatively insignificant to the 3.9 tons

global average. Human activities, basically the overexploitation of resources leading to forest depletion and land degradation, land use changes, ill farming practices and production process, haphazard road constructions, high population growth and increased urbanization, poverty, air pollution are the major driving forces for changing climate in Nepal. And, with the increase in these activities, there has been the increasing changes in the natural state of environment of Nepal. A brief discussion on the major contributing factors and their present state is given below:

WATER RESOURCES

Nepal is rich in water resources with nearly 6000 rivers and has 3252 glaciers covering an area of 5323 sq.km, which is about 3.6% of Nepal's total area. It also has an estimated ice reserve of 481 cu.km. In addition, it has about 225 billion cubic meters per annum of surface water. However, with the changing climate and over exploitation of water resources, Nepal has been experiencing water deficit in non-monsoon seasons, and there is a decline in natural recharge of aquifers. The streams and rivers are getting thinner. This has led to the seasonal unavailability of water and water disputes in the urban and city areas. Figure 3.1 represents the water availability few decades ago vs. present scenario



Fig 3.1: Water availability few decades ago vs. present scenario

AIR POLLUTION

Majority of people in Nepal still rely on traditional way of cooking using the firewood which causes considerable indoor air pollution. In addition, the population rise and increased urbanization has polluted the atmospheric air along with increase in the concentrations of GHG.

LAND USE CHANGES

The forest is being depleted and the lands are being used in a way leading to its degradation. The most common land-use changes observed in Nepal are the conversion of natural ecosystems to permanent croplands, abandonment of croplands, pastures, shifting cultivation, or pasture, harvest of timber, and establishment of tree plantations. The graph below depicts the change in land use in the years 1986-2001 based on CBS data. It shows that the proportion of land used for

cultivation has increased in the later period while there has been a huge decline in forest area. The forest area has declined from 37.82% to 29% in the years 1986 to 2001, as shown in figure 3.2

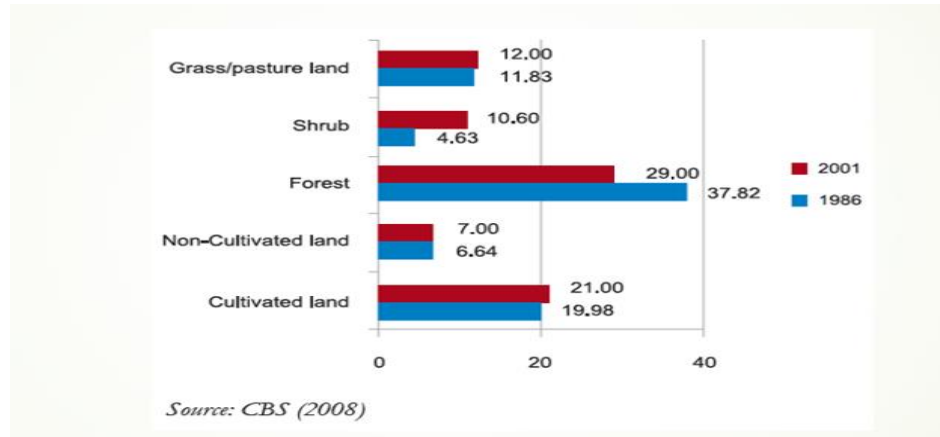


Fig 3.2: Change in Land Use Pattern

BIODIVERSITY AND FORESTS

The unique geography and climatic variations of Nepal has offered a unique biodiversity with about 342 plant species and 160 animal species. Nepal has about 39% of its land covered by forest, and is currently at risk with increasing rate of deforestation at 1.7%, well above the global average of 1.3%. Figure 3.3 shows some of the species of plants and animals in Nepal.



Fig 3.3: Biodiversity in Nepal

The graphs 3.4(a) and 3.4(b) below explain the use of forest resources and the rate they are cut down. The forest is being cut down for timber, firewood and fodder purpose with maximum use for collecting firewood, and the rate is high in hills and mountains compared to Terai. This could probably be due to the migration of people from Terai to upper belts due to weather extremities.

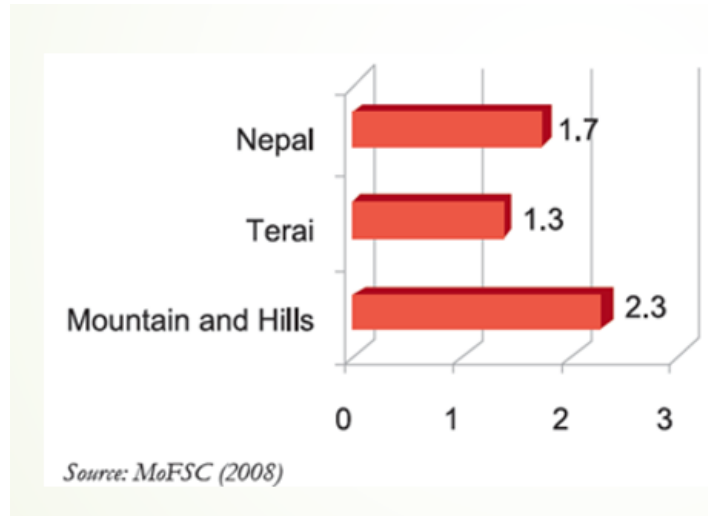


Fig 3.4(a): Annual rate of Deforestation(%)

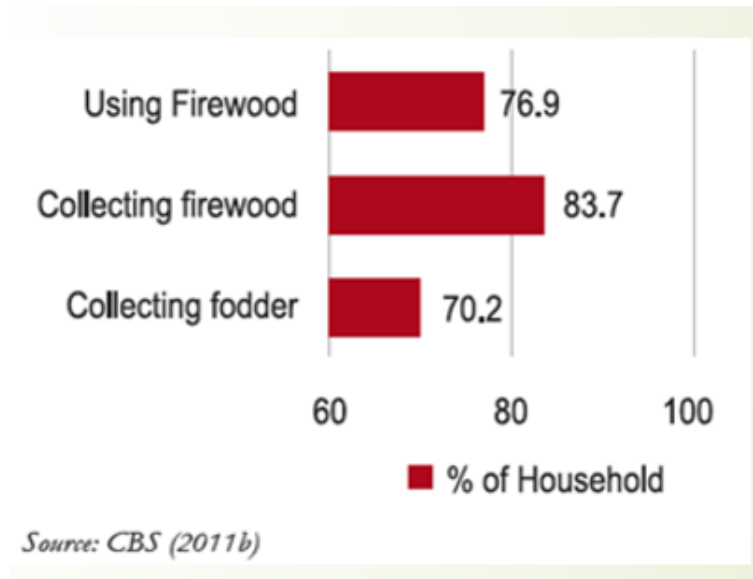


Fig 3.4(b): Use of forest Resources (%)

HABITAT LOSS

With the change in land use, increased deforestation, and changes in temperature and precipitation patterns, many of the wild species have been at the verge of extinction. Animals like tiger, rhinoceros, snow leopard, yak, pandas, and several species of plants, bird species and reptiles are losing their home and food as shown in Fig 3.5. In addition, the infrastructure projects such as road and irrigation in forest areas have forced the wild species to move from their original habitat.



Fig: Tigers in Bardiya National Park, Nepal



Fig: Elephants moving away in search of habitat

(Photo:@ Jakob Jespersen)

Fig 3.5: Habitat Loss

POPULATION GROWTH AND URBAN DEVELOPMENT

The population seems to be in a declining rate compared to 1970's as shown in graph 3.6(a). However, to a bigger surprise, despite of decrease in overall population, the population in the urban areas has been rising at an alarming rate in the past few decades as shown in fig 3.6(b).

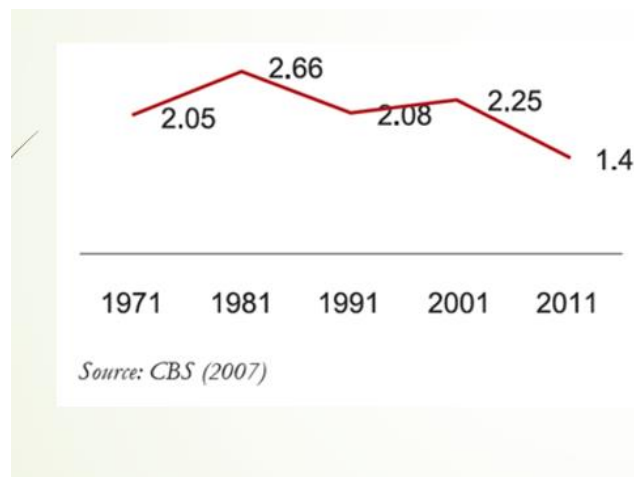


Fig 3.6(a): Population Growth Rate (%)

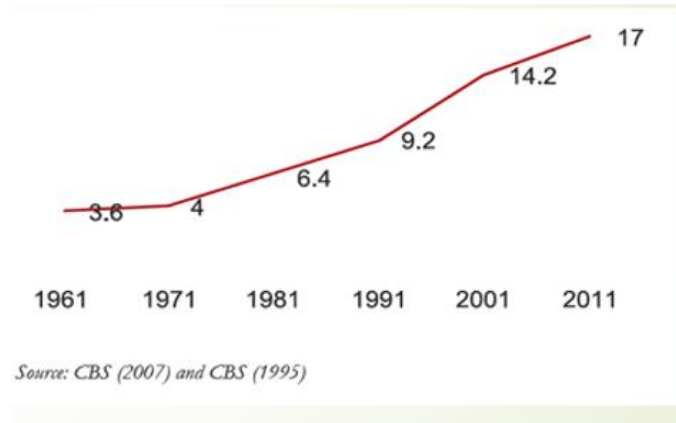


Fig 3.6(b): Share of Urban Population (%)

MOUNTAIN TOURISM

Nepal is rich in diversity with variety of floras and faunas, and the tourism is predominantly nature-based with mountains, glaciers, lakes and rivers. Tourism is the major source of economy in Nepal after Agriculture, and with the change in climate the tourism industry is at the declining phase. The length and quality of tourism seasons, destination choices and the length of stay is defined by the climatic features. With the increasing impacts of climate change, noticeable decline in tourist arrival has been observed in Nepal. The graph 3.6 below illustrates the climate change impacts on tourism:

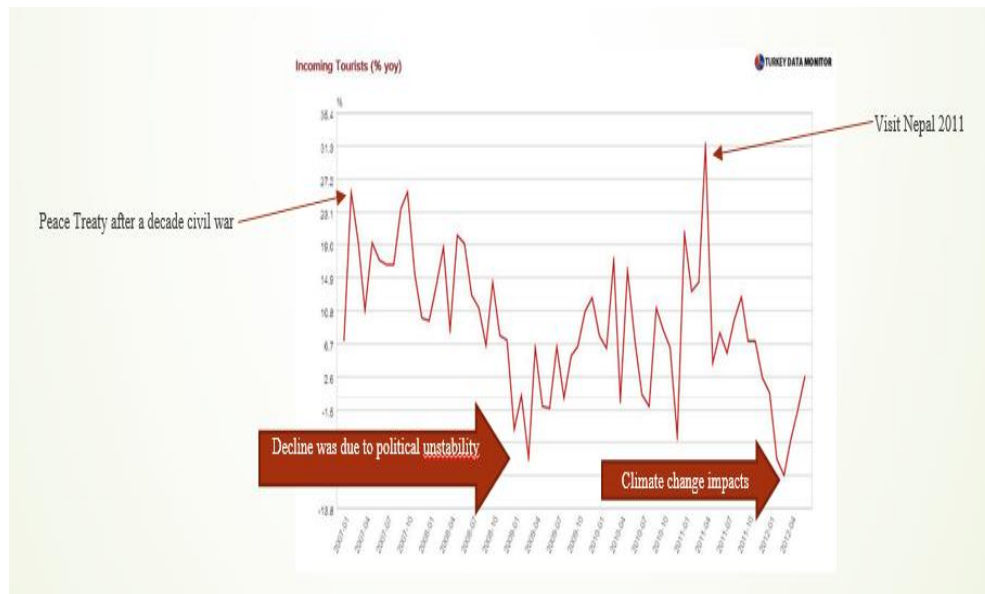


Fig 3.7: Graph showing tourist arrival in different year

4. CLIMATE CHANGE IMPACTS

The effects of climate change are observed differently across ecological regions. Low altitude Terai has increased risk of floods, droughts, debris flows, vector and water borne diseases, forest fire while Middle mountains have increased risk of landslides, flash floods, debris flow and the high Himalayas are prone to rapid melting of glaciers, GLOFs, biodiversity loss and ecosystem degradation.

WATER

Climate change has brought variations in the hydrological cycle with change in rain and snowfall patterns, snow and glacier melt, changes in soil moisture and runoff, atmospheric water vapor and evaporation. Glaciers are melting at an alarming rate with glacier lake outburst floods(GLOFs). There are significant changes in the aquifers properties, wetlands, rivers, streams and lakes leading to “too little water” and “too much water” situation. The “too little water” situation has affected the women, children and the elderly people causing long distances travel to get water, and also it has been a potential cause for spread of disease due to poor sanitation in the shortage of water. On the other side, “too much water” has threatened the public life through various floods, landslides, and damage to infrastructures. In addition, the extreme events of water availability have led to degradation of water quality thus polluting the water in both the cases. The major challenges observed are the intensified droughts, increased risk of flooding at South plains, water quality risk to lakes and rivers, and difficulty in water resource management due to irregular supply and availability of water.

The fig 4.1(a) below is from the capital city of Nepal, where people have to wait for hours of line to get a bucket of water for their livelihood. The water level has fallen down drastically in the last two decades.



Fig 4.1: Too Little Water



Fig 4.1(b): Water Pollution

With the increased unavailability of water, people are forced to get the water from deep wells, and from the unhealthy ground locations as well, as shown in fig 4.1(b). In addition to it, such wells are supposed to support a huge population thus leading to scarcity of water and the water dispute among publics.

HUMAN HEALTH

With the adverse impacts on water, people are being more prone to water-borne diseases, and the rise in temperature has made the situation favorable for different disease spreading diseases, making people vulnerable to several diseases. People have become more prone to mental illness and stress related disorders. They are at the verge of being affected by food and water-borne diarrheal disease and many other vector-borne diseases at increasing temperature and polluted air. With the changing climatic conditions, there has been decline in the food quality and the people are deprived of enough nutrients required for healthy growing. In addition, people have been suffering from natural disasters causing serious impacts on their health.

CHANGE IN ECOSYSTEMS

The increase in temperature, shifting of vegetation in the higher regions, urbanization and encroachment, increased vulnerability of diseases and pests, has highly affected the forests, rangelands, wetlands, mountains and agro-ecosystems. The changes in climate and extreme events like fire, floods, storms have adverse impacts on adaptation and livelihood of several plants and animals, thus impairing the natural ecosystem. The climate change impacts on the ecosystem are observed in different ways such as degradation of species, altered natural cycles, excessive growth of unwanted weeds on grasslands, reduced production, loss of local crop diversity, etc.

The figures 4.2(a) and 4.2(b) below show some of the noticeable effects on bio-diversity and the natural ecosystem.

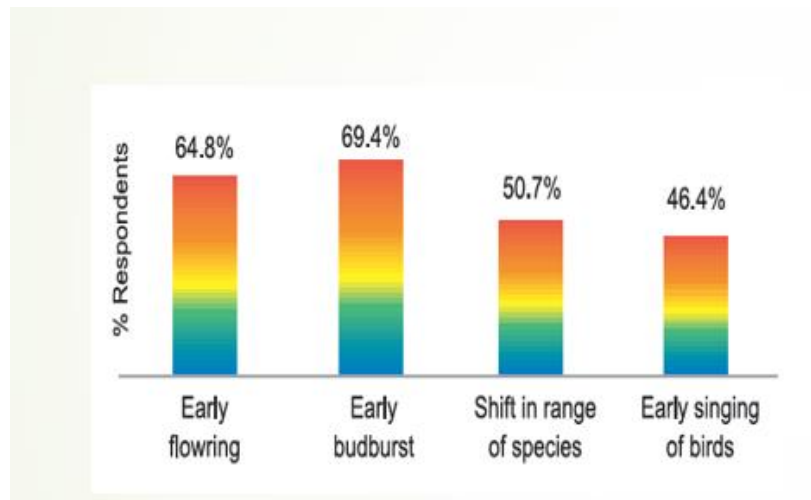


Fig 4.2(a): Impact on bio-diversity

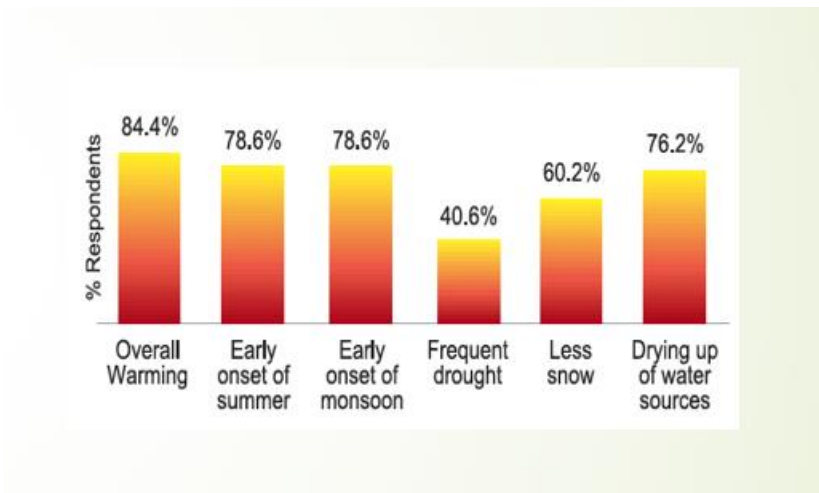


Fig 4.2(b): Impact on weather and ecosystem

GLACIERS

Glaciers are retreating with an approximate rate of around 20m/year. 330 lakes out of 2323 glacier lakes have already expanded to become larger than 0.02 sq.km and are still expanding with potential risks of reaching the critical value. The retreating of glaciers is of serious danger in context of Nepal being a mountainous country.

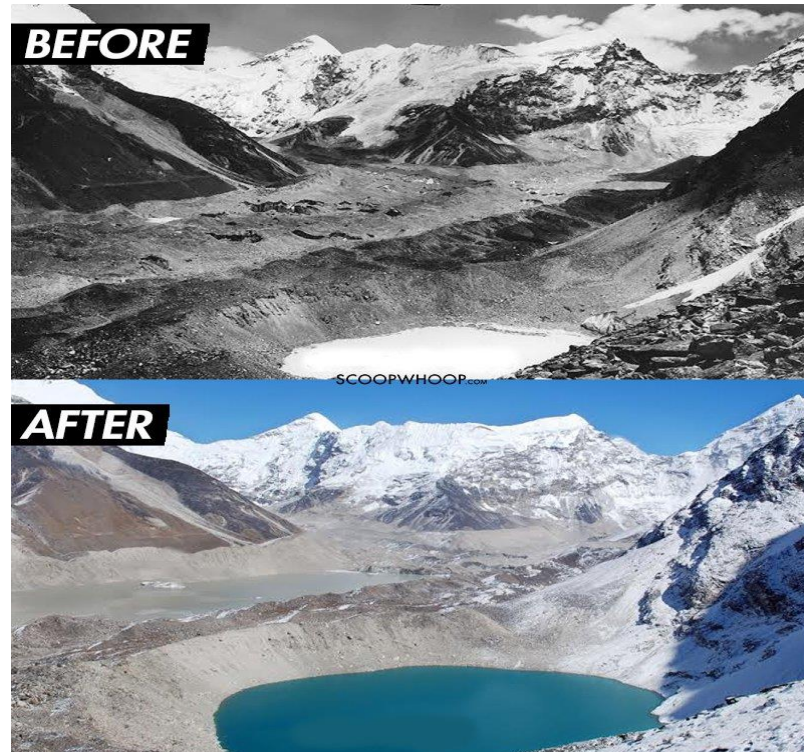


Fig 4.3: Imja Glacier in Nepal

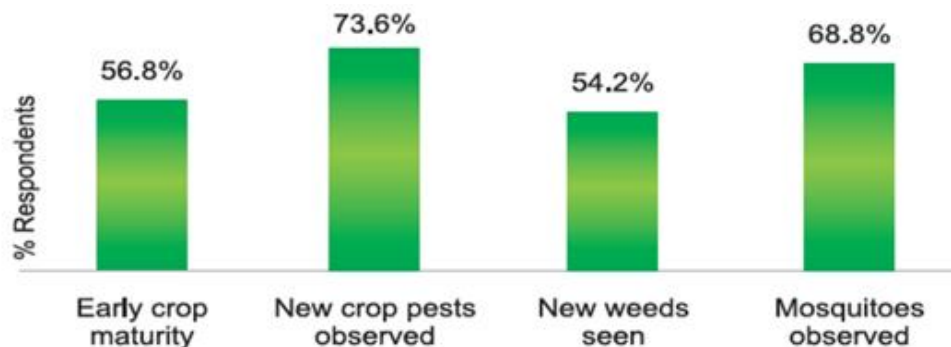
Photograph: Erwin Schneider/Alton Byers/The Mountain Institute

In 1950's Imja lake was covered with a very deep layer of ice as shown in the figure 4.3(before). Gradually, small meltwater ponds continued to grow and merge, and by the mid-1970s Imja lake was formed. Since then, the lake has continuously grown in size extending to around 1 km long by 2007. As Imja, there are several other glaciers retreating in Nepal. And, as glacier water is one of the major source of water and hydropower generation in Nepal, rapid decline of glaciers is very likely to bring serious water and energy problems in Nepal in next few decades.

AGRICULTURE

Agriculture in Nepal is both rain fed as well as the irrigation-fed. With the shifts in rainfall patterns, and the availability of surface water and the groundwater, the growth and the productivity of crops has been affected. Cultivable lands have gone dry due to droughts at some places, while they are flooded at some places due to the heavy downpours and flood. In addition, agriculture in Nepal is highly sensitive to climate change, and is highly dependent on weather conditions. An increase in temperature by 3 degrees' Celsius has can lead to rise in yearly irrigation demand by 11%. The change in climate, basically the increasing extremes in precipitation has led to loss and degradation of critical agro soil and water assets, thus reducing the crop yield and livestock production. The major climate variables affecting are: Change in frost-free season length, change in number of consecutive dry days and hot nights.

From a survey taken among the farmers, majority of the respondents blamed climate change for the new crop pests and unwanted weeds in the farm, and also they claim to have the decline in time for the crop to attain maturity, as shown in fig 4.4. Early maturity might be beneficial to some extent, but at the same time it also helps in rapid spread and growth of unwanted weeds.



Source: Chaudbary et al. (2011)

Fig 4.4: Impacts on Agriculture

FOOD SECURITY

Unstable weather patterns, extreme temperatures, drier winters and delays in the monsoon have adversely affected the crop yield causing a million people to face severe food shortages. With the changes in climatic condition, people are facing decline in their livestock production as well. In addition, the change in soil type and the weather patterns have caused the decline in nutrient content of the food. The fig 4.5 is a representative image of several other starving population.



Fig 4.5: Starving Child

NATURAL DISASTERS

Nepal is at the 4th position of risk based on the Climate Change Vulnerability Index. The geography and the landscape of Nepal is highly exposed to several kind of natural calamities such as earthquake, floods, landslides and debris flow, GLOFs, and many others. Each year, several people lose their lives due to these disasters, and it leads to a huge economic loss every year. In addition to the natural vulnerability, climate change has adversely increased the risk of such disasters in Nepal. In 2008, there was a huge flood in Koshi river taking several human lives, livestock and a large quantity of crop production. The roads were destroyed completely. Fig 4.6(a) and 4.6(b) shows some most common natural disasters in Nepal.



Fig. 4. Nepalese Flood Refugees. (Source: A Nepal Army handout picture dated 25 August 2008)



Fig 4.6(a): Flood

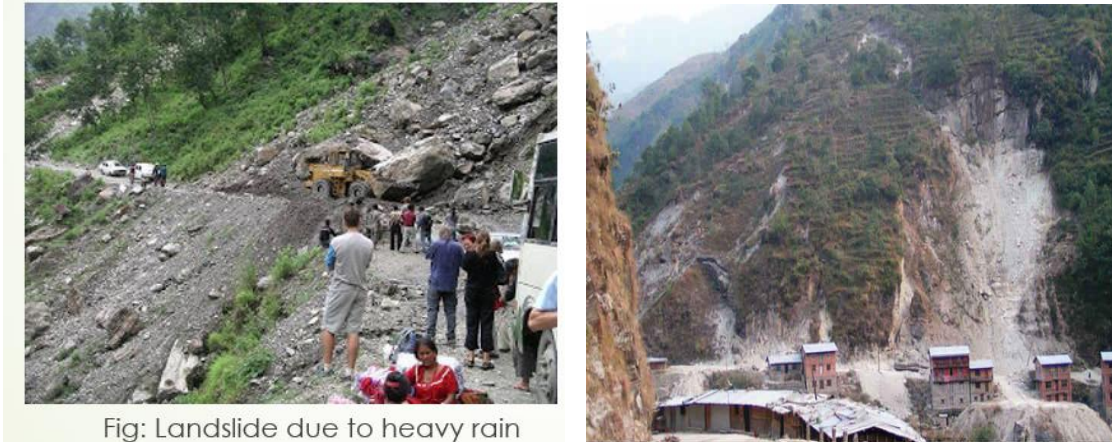


Fig: Landslide due to heavy rain

Fig 4.6(b): Landslide

URBAN SYSTEMS, INFRASTRUCTURES AND VULNERABILITY

Major cities and towns are most vulnerable and susceptible to climate change, as they have increasing rate of population on one hand, and the undesirable climate change impacts on the other. Also, the urban population is mostly dependent on extensive infrastructure system, and impact on any one of those create an imbalance on several other thus affecting the lives of people.

Fig 4.7 shows the unplanned and massive rate of urbanization.

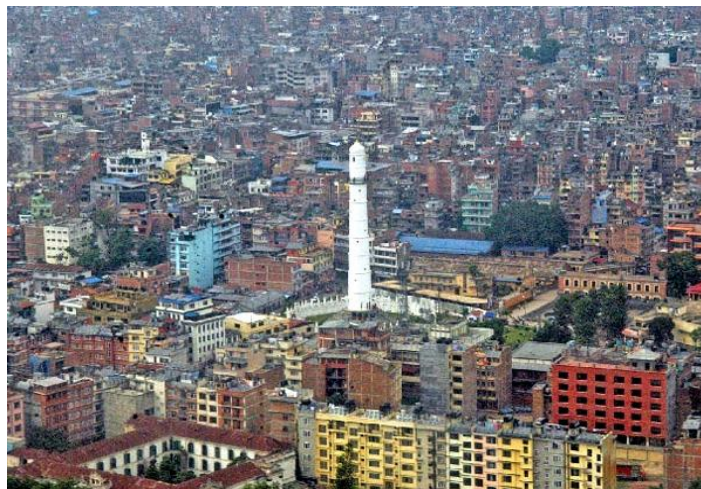


Fig 4.7: Unplanned Urbanization

SOCIO-ECONOMIC COMPLICATIONS AND HARDSHIPS ON WOMEN

Crop failure, loss of livestock and declining tourism industry has adverse impacts on people economy. Most mountain dwellers and the people on downstream are more affected than others. In addition, Nepal being primarily a male dominant society, females are supposed to be more vulnerable to climate change rather than the men's'. They have to go distant places for fetching water, grazing the cattle's' and getting fodder and firewood's, as shown in fig 4.8. Likewise, the

children and indigenous people and predominantly the underprivileged are the most vulnerable groups with limited resources to manage or adapt the changes.



Fig 4.8: Women carrying firewood

5. RESPONSES TO CLIMATE CHANGE

With the increasing effects of climate change, people have increased concern towards it, and there has been responses at individual, community, regional and national level to act on climate change. In addition, Nepal has appealed for several international committee and organizations for aid in responding to climate change so as to avoid more unpleasant results. People carry their own perceptions towards climate change and hence they need to be dealt with much care so as to avoid the Boomerang effect. The awareness program can be done in two step flow: The climate communicators to promote opinion leadership among the alarmed and the most conscious group of people, and then they can be further employed to use personal influence within their social networks.

POLICY, PROGRAM AND INSTITUTION

The constitution of Nepal has identified the right to a clean environment as a fundamental right. In addition, at least 40% of the natural forest area of the country is to be conserved as per the constitution. Several institutional plans and policies have been put forward by the government of Nepal to facilitate the implementation of plans and programs aimed at addressing climate change impact.

REDUCING EMISSIONS FROM DEFORESTATION AND FOREST DEGRADATION

Deforestation has been identified as one of the major cause for increasing greenhouse concentration in Nepal. Thus, the conservation of forest can help to maintain the carbon emission levels, and also helps in conservation of natural ecosystem thus reducing the impacts of climate change. Programs and policies like reduction of emissions from deforestation and forest degradation, sustainable management of forests are in practice so as to contribute to mitigation. People are more aware of the consequences of the deforestation, and there are programs at local and national levels to promote afforestation (fig 5.1).



Fig 5.1: Afforestation

CLEAN ENERGY, ENERGY EFFICIENCY AND LOW CARBON DEVELOPMENT PATH:

Clean energy solutions are being prioritized and are already in practice in Nepal. There have been regular investments on hydropower, and there has been an attempt to produce electricity from wind energy as well. Natural biogas and improved cooking stoves are quite familiar in Nepalese family, and the Government of Nepal provides fiscal benefits to eco-friendly vehicles. There has been increased priority on clean energy development and energy efficiency, climate adaptation and sustainable agricultural programs. Fig 5.2(a) and 5.2(b) show some of the clean energy practices in Nepal.



Fig 5.2(a): Clean Energy Solutions in Nepal

In addition, there has been a rising interest and step towards green homes. People are more concerned in having their homes with green construction materials, passive solar design, energy efficient, and better ways of water conservation and waste management. This project is expected to bring a huge impact if adapted successfully.



Fig 5.2(b): Proposed Green Home

CLIMATE ADAPTATION:

Adaptation refers to efforts made to reduce the vulnerability of society to climate change impacts. Several adaptation plans and programs are enforced in Nepal in response to climate change. In 2010, National Adaptation Program of Action (NAPA) was prepared with priorities on community-based adaptation through integrated management of water, agriculture, forest and biodiversity. It was aimed at building and enhancing the adaptive capacity of vulnerable groups through improved systems and access to service for agricultural development. In addition, it was aimed at community based disaster management, ecosystem management, water resources management, forest and ecosystem management, and GLOF monitoring and disaster risk reduction. It is expected to promote a climate-smart urban settlement. In compliance to NAPA, there is a Local Adaptation Plan for Action (LAPA) which is aimed at implementing adaptation policies and plans at local and regional levels.

GREENING THE ECONOMY WITH LOW CARBON GROWTH STRATEGIES

The Green Economy model is likely to open windows for mitigating the adverse changes in climate. Some of the green economy concepts are promotion of community, collaborative and leasehold forests, community-based biodiversity conservation, switching into hydropower and renewable energy sources, water resources management, and realizing the value of mountain ecosystem services. In addition, we can focus on creating green jobs in mountain area with increased attention on non-timber forest products, tourism and potential green enterprises.

CONCLUSION AND RECOMMENDATIONS

With all these, there are sufficient evidences that climate change is impacting Nepal rather strangely in view of the country's state of development and also a very insignificant contribution of the GHGs. The alarming decline of glaciers mass, increasing temperature, severe weather patterns with heavy floods and longer droughts are some of the major effects Nepal has faced in the past few years. The changes in glacier reserves will have serious impacts on water resources and hydroelectricity, as most of the major rivers in Nepal are glacier-fed. In addition to the decline in major sectors of economy such as agriculture, mountain tourism, biodiversity and energy, climate change has also endangered the health, safety and wellbeing of the people. The best Nepal can do is to adapt to the impacts of climate change to minimize their effects on people and their livelihoods, and meantime adapt strategies to mitigate the emissions.

While we cannot stop change, there are ways we can limit it to less dangerous levels by reducing our emissions and by bringing the changes in our daily life. There is no single silver bullet that will solve the current climate issues, but there are several alternatives to minimize the change. We still have a choice between a little more warming and lot more warming. We still have a choice either to suffer less or suffer to the extreme and finally extinct. It is not possible to totally reverse change, without technological intervention but we can make the use of the technologies we have to mitigate the change to the amount that is feasible. And, it is always wise to start sooner. The impacts will rise greater as the changes in climate continue longer, and at some point it will become highly expensive to adapt, and some systems will not be able to adapt if the change is too much.

Adaptation and Mitigation are the widely accepted strategy to combat disastrous impacts of climate change. We must be aware of the driving forces of change and be sensitive on such activities and they need to be stopped at every levels. Meanwhile, we must be prepared to adapt the changes already observed in wise ways. However, the mitigation and adaptation are interdependent and should go in parallel. Adaptation efforts will be more difficult, more costly and less likely to succeed if mitigation actions are not taken. We should adapt a "bottom up" community planning and "top down" national strategies for fighting against the change. Every person, every society, every organization and the whole nation should be actively involved in preventing further changes and extremities. Change is irreversible but it can be controlled and there are chances that we may end up in better climatic conditions as well if we act timely and wisely.

Nepal is aware of the immense barriers to the sustainability of the country's development, such as landlockedness, climate change, natural disasters, shortfall in capacities and weak means-of-implementation. And, Nepal has been actively responding to climate change issues with an attempt to deal with the changing situation and build resilience capacity into adaptation to climate change. Traditional top-down decision-making processes have been a failure thus ending up with Least Developed Countries like Nepal, with insignificant release of GHG's compared to other developed nations, to bear the weight of action and inaction of others in climate change. For countries like Nepal, the path of success to deal with climate change could be the adaption of

multi-way strategy and integrated efforts of government, community and the individuals. Bottom-up community efforts, top-down national and governmental efforts and outside-in efforts of civil society could be the ideal solution for achieving the goals for Nepal. And, for good, Nepal has already been quite successful in adapting several local and national strategic plans to adapt the change and mitigate emissions. In addition, Nepal has been actively involved in International plans and policies including Paris Agreement to fight against climate change.

To sum up, Nepal has already agreed to fight back the climate change despite of its poor economy and poor technologies. And, when a developing country like Nepal is capable to adapt the climate changes and mitigate their emissions, there is no doubt that rest of the world can mitigate the emissions. The developed nations are required to take a lead and encourage all the developing nations to move into the green path, if we really want to save the planet for future generations.

*“The more you mitigate,
the less adaptation is required
and
the less suffering you will have to go
through.”*



Figure: Nepal and the Climate

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