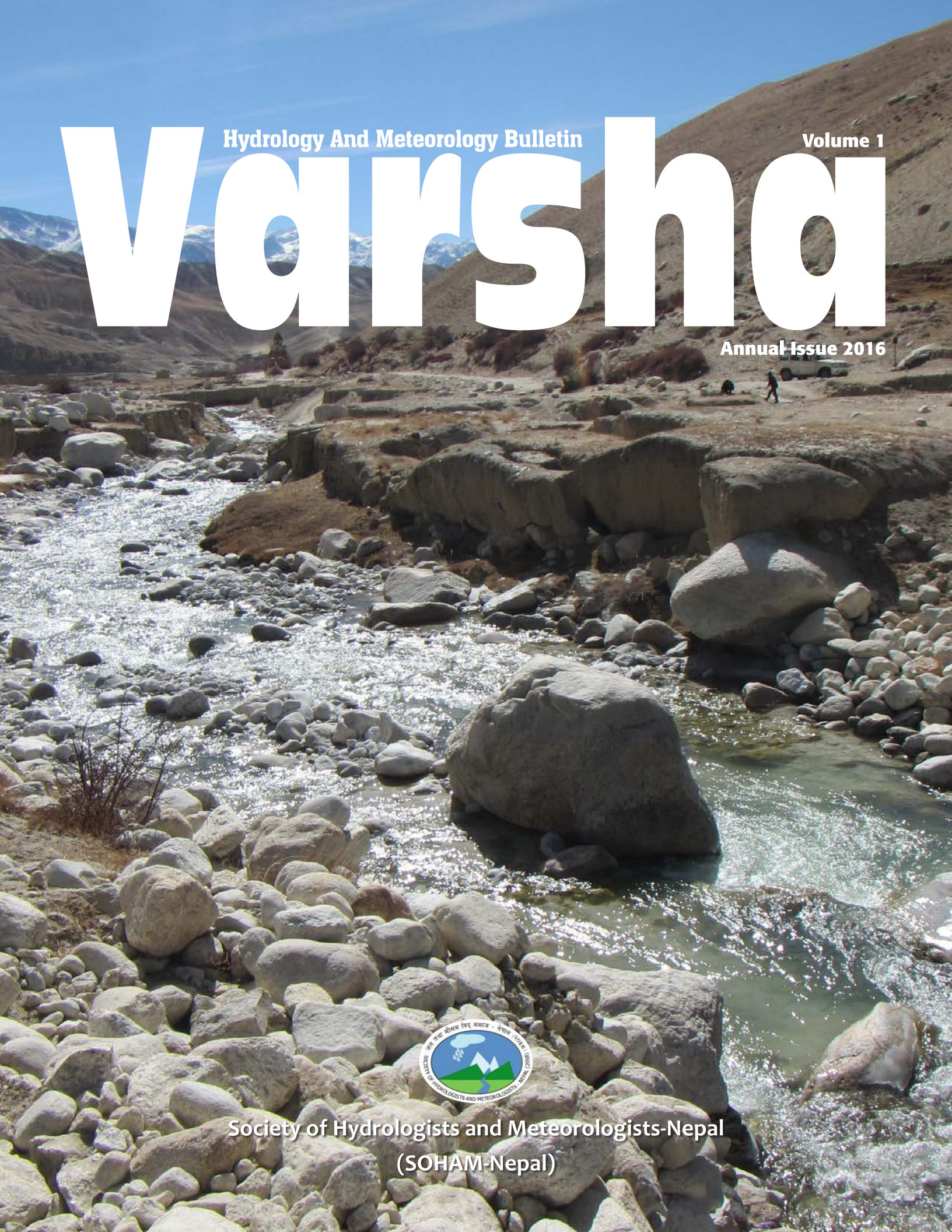

Hydrology And Meteorology Bulletin

# Varsha

Volume 1

Annual Issue 2016

Society of Hydrologists and Meteorologists-Nepal
(SOHAM-Nepal)

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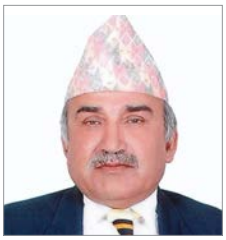

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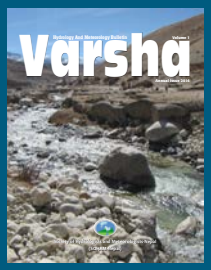


VARSHA
*Hydrology and Meteorology Bulletin*
Vol. 1, Annual Issue 2016

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# Foreword

It's a matter of great pleasure to bring out the first issue of *Hydrology and Meteorology annual Bulletin,* VARSHA, an initiative of Society of Hydrologists and Meteorologists-Nepal. The new publication is a compilation of articles on hydrology, meteorology and subjects relating to them. It also furnishes an outlet for new development stories being proceed at various parts of the world in the field of environmental science. In this context, writers are encouraged to input topics to be covered in future issues possibly in Nepali as well as in English which I hope, will stimulate debate and exchange ideas.

The world is now at the beginning of 21$^{st}$ century. And the globe, which is a home for all living creatures, is being affected seriously by increment of hydro-meteorological disasters taking lives of several people every year. Hence, it will be an obligation to furnish the people with information leading to such disasters and further, to make them aware towards safety for their life and property with better understanding hydro-meteorological phenomenon. VARSHA in this respect expects to fulfill the gap to some extent and at the same time I hope, the publication will inspire and encourage hydrologists and meteorologists to explore their innovative learn relating to hydro- meteorology.

Finally, I express my best wishes for the success and continual publication of VARSHA.

Mani Ratna Shakya
Chief Editor

# Contents

# Glaciological study and preliminary findings in Nepal

Dr. Rijan Bhakta Kayastha

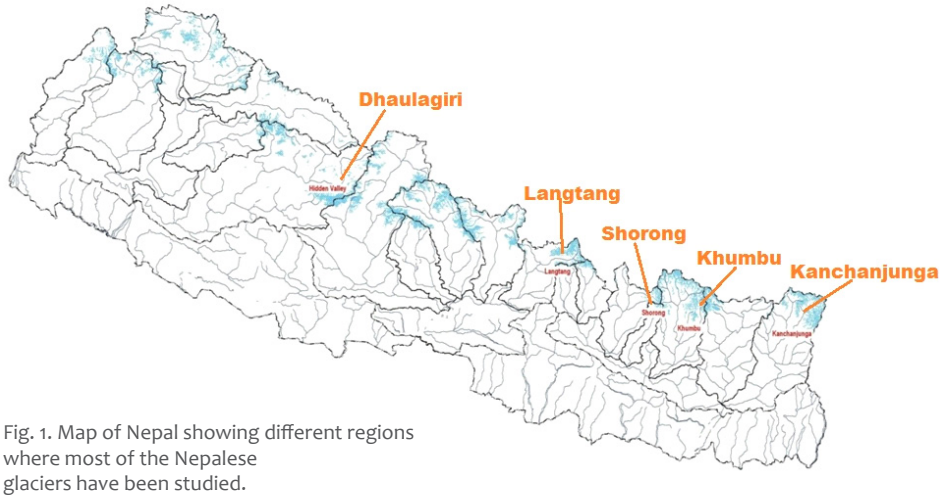


Fig. 1. Map of Nepal showing different regions where most of the Nepalese glaciers have been studied.

Water resources known as most important natural resources of Nepal are abundant throughout the country in the form of snow covers, glaciers, rivers, springs, lakes, and groundwater. Snow cover in Himalayas provides huge natural storage of freshwater where as glaciers, permafrost, and glacial lakes are main forms of water storage in the country. At the same time, snow-melt discharges from Himalayas maintain the water levels in downstream rivers which provide support for livelihood in the country. However, the incident of Glacial Lake Outburst Flood (GLOF) that occurs, though occasionally in the country solicit severe natural disaster taking lives of several people. In this context, an event that took place on 4 August 1985 at Dig Tsho Glacial Lake in the Khumbu region destroyed Namche Hydropower Plant completely and the destructive nature of GLOF was recognized first and foremost in the country by the concerned officials of then His Majesty's Government of Nepal (HMG/N). By this event, the government realized the importance of studying snow, glacier and glacial lakes for their proper utilization in order to save live and property of the people and, also to acquire the maximum benefit of water resources in country. Hence, after this catastrophic GLOF event then HMG/N initiated a glacial lake study through the Water and Energy Commission Secretariat (WECS).

The regular monitoring of snow and glacier is an important task for assessing the potential of water resource which is useful to examine the effect of global warming and to know the possible changes that may occur due to climate change in future. Glacier monitoring also helps knowing the stage of development of glacial lake essential for assessing the vulnerability of outburst of the glacial lake. Based these

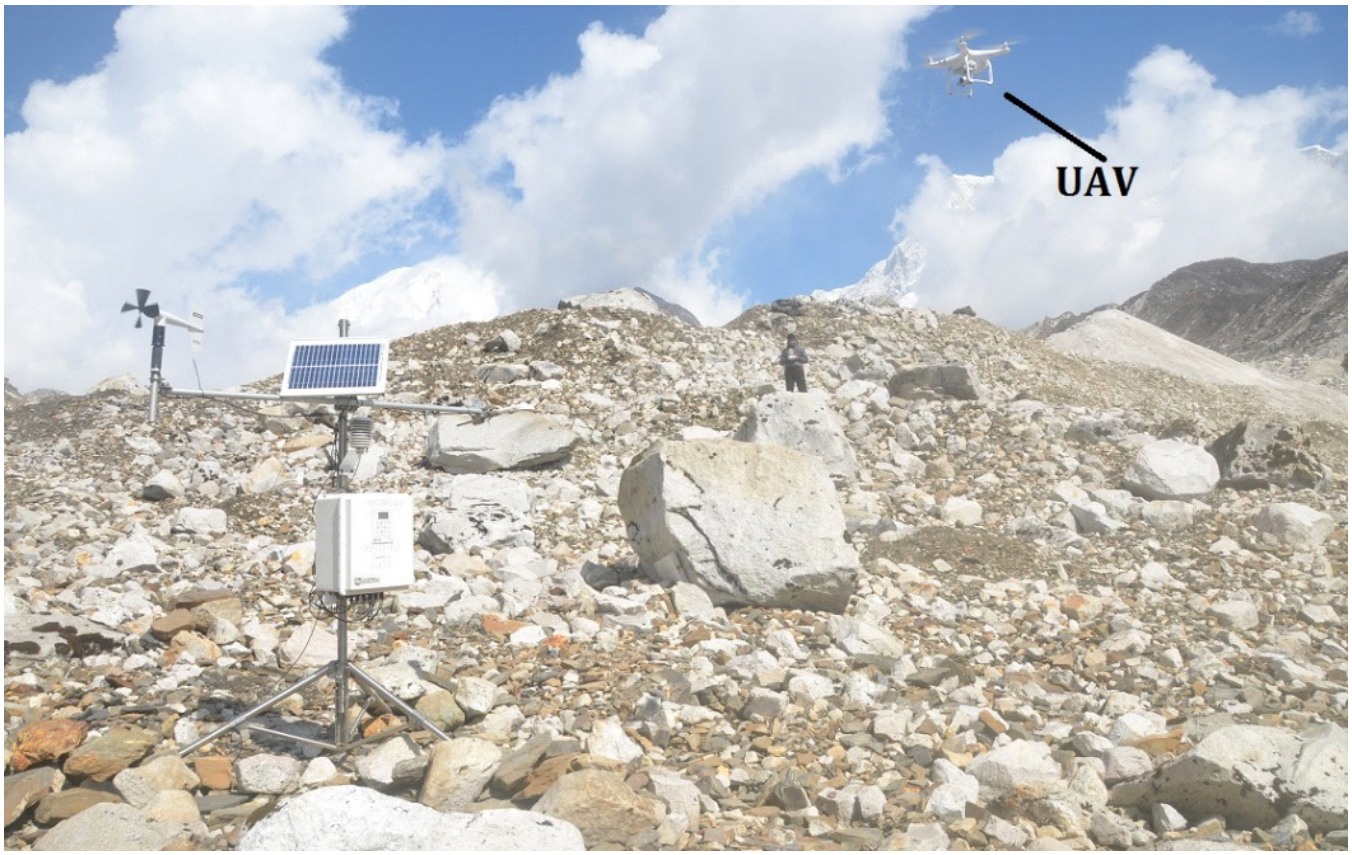


Fig. 2. Use of UAV on the study of Ponkar Glacier in Manang district, Nepal in March 2016

activities, a fruitful cooperation between then HMG/N and the Federal Republic of Germany holding from 1987 to 1997 resulted establishment of "Snow and Glacier Hydrology Unit (SGHU)" a sub-division in the Department of Hydrology and Meteorology (DHM) of then HMG/N. At present almost all snow and glacier hydrological studies in Nepal have been carried out by DHM such as Tsho Rolpa GLOF Risk Reduction Project and Community based Flood and Glacial Lake Outburst Risk Reduction Project (CFGORRP).

Before these efforts have been made by the Government of Nepal, preliminary glaciological studies had been carried out by European scientists in the Mount Everest region during the 1950's. But the study could not continue for a long time. Later on, in the 1960's Japanese scientists started their research on Nepalese glaciers in cooperation with mountaineering expedition teams which is on its way till now. In this context, the first systematic study of glaciers in Nepal have been carried out by Japanese scientists since 1973, under the Glaciological Expedition to Nepal (GEN) together with the Government of Nepal. In Phase I (1973-1979) of GEN, the role of the Asian summer monsoon in the glacier regime in Nepal was intensively studied and, in Phase II (1981-1982) ice core studies along with hydro-meteorological observations were carried out in Langtang Valley, Rasuwa district. In the process, Hydro-meteorological data have been obtained almost continuously in Phase III (1985-1992) and through all phases, ground and aerial observations were carried out on the distribution and variation of glaciers in the Nepalese Himalayas (Fig. 1). The results obtained in the fields of glaciology, meteorology, hydrology and geomorphology have been published as about 140 scientific research papers. After the Phase III of GEN Japanese scientists have been continuing their glacier research intermittently in Nepal which is running at present as well.

By the time past, the time has altered and the Himalayan, Cryosphere, Climate and Disaster Research Center (HiCCDRC),

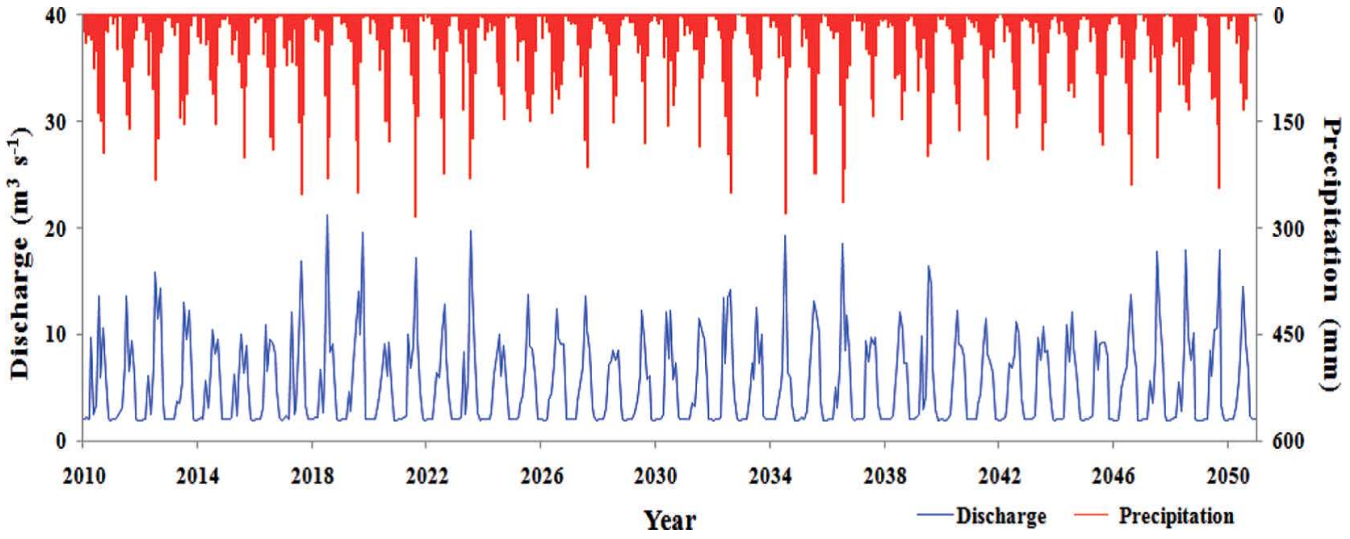


Fig. 3. Distribution of discharge and precipitation in Langtang River from 2010 to 2050

Kathmandu University (KU) established in 2009, as one of the pioneer institutions has been currently involving in research activity on snow, glaciers, glacier lakes, water induced disaster, and climate change in Nepal. The center is currently running two years M. S. program by Research in Glaciology under the Department of Environmental Science and Engineering, School of Science. The main purpose of this program is to produce young researchers in the field of glaciology from South Asian countries helping a development in the field of water resources in the region. The HiCCDRC has two major projects in the field of glaciology which has started research on the Himalayan glaciology and run the graduate program on glaciology in Kathmandu University. These two projects are namely:

- Cryosphere Monitoring Project (CMP) and,
- Contribution of High Asia Runoff from Ice and Snow (CHARIS) Project.

The CMP under Kathmandu University is financially supported by the Norwegian Ministry of Foreign Affairs, the Royal Norwegian Embassy, Kathmandu, Nepal through the cooperation with International Centre for Integrated Mountain Development (ICIMOD). The other national partners of the project are Water and Energy Commission Secretariat (WECS), Department of Hydrology and Meteorology (DHM), Government of Nepal and, Tribhuvan University. However, the CHARIS Project is funded by the United States Agency for International Development (USAID) through the University of Colorado, Boulder, USA.

The CMP-KU with its partner institutions initiated the monitoring of Nepalese glaciers since 2011. Yala and Lirung Glaciers in Rasuwa district and Rikha Samba Glacier in the Hidden Valley, Mustang have been studied with the installation of automatic weather station and hydrological station in the downstream. These glaciers and associated river basins are studied through in-situ mass balance measurement and modelling, glacio-hydrological modeling, hydro meteorological measurements and using GIS and remote sensing techniques. The CHARIS Project has collected water samples from different locations in the Langtang Valley and sent to the laboratory of the University of Colorado, Boulder to collect knowhow of the amount of snow melt, glacier ice melt, ground water and rain water in the river water. Recently the HiCCDRC has expanded its research on debris-covered Ponkar and Pangri Glaciers in Manang district as well through the CHARIS Project. Four rain gauges in total with temperature sensors, two automatic weather stations and one hydrological station have been established in Dudh Khola and Ponkar Glacier in order to continue the glaciological, hydrological and meteorological study in the river basin. A part of the Ponkar Glacier is also studied

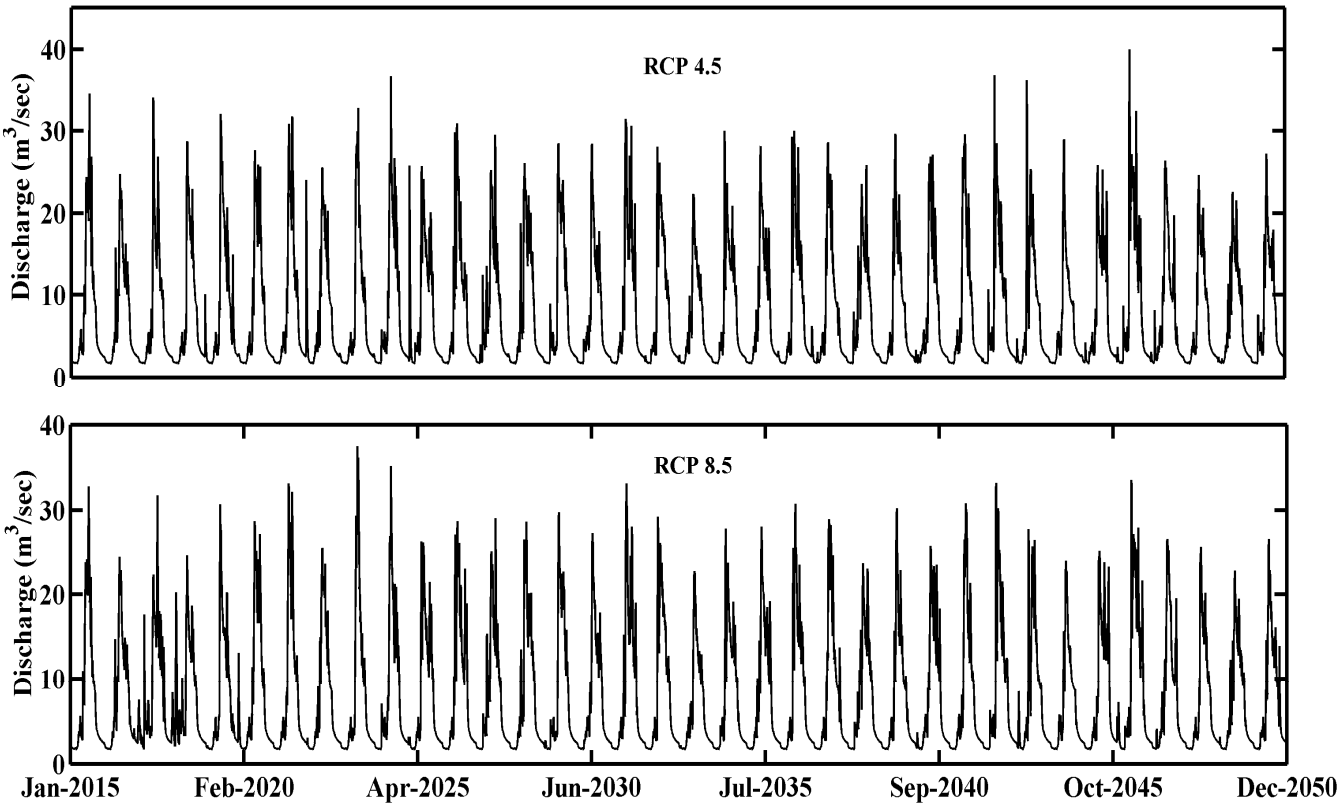


Fig. 4. Projected discharge for the period (2015-2050) in Sangda River, Mustang RCP4.5 (upper panel) and RCP8.5 (lower panel)

by using the Unmanned Aerial Vehicle (UAV) in March 2016 (Fig. 2). This is the first time use of UAV by Nepalese scientists on glaciological study in the Nepalese Himalayas.

The research made in these areas have been published, and some interesting major results are as follows:

- mass balance of Yala Glacier from November 2011 to November 2012 is -0.98 m w.e. and equilibrium line altitude was 5455 m a.s.l.,
- the contribution of snow and ice melt in the discharge of Langtang River is from 50 % to 55 % and distribution of discharge of the Langtang River will not change much in future as shown in figure 3,
- the contribution of snow and ice melt in the discharge of Sangda River is from 16 % to 19 % and distribution of discharge of the Sangda River will not change much in future as shown in figure 4,
- the distribution of temperature at different debris layers are studied on Lirung Glacier in Langtang Valley, Rasuwa district figure 5 to gain the knowhow of energy conducted from surface to debris ice interface and use for melting ice and different factors controls it.
- Likewise, GlabTop Model was applied for estimating glacier ice thickness distribution and bed topography of Everest region, Nepal. This model was applied to the Ngozumpa, Khumbu and Imja Glaciers of the Everest region. Maximum Ice thickness and 50 % of the total ice volume was found in the lower part of the glaciers with gentle slope as shown in figure 2. Total ice volume of three glaciers was estimated to be 14.5 ± 3.63 km3. The model was evaluated in Mera Glacier of Hinku Valley with Ground Penetrating Radar (GPR) data. Although the model has ± 20 - 30 % uncertainty, the model is useful tool to estimate the ice thickness distribution in the Himalayan glaciers.

Other glaciological studies are also being conducted in various regions of Nepal, such as snow cover modelling of Langtang River catchment, Nepal using SeNorge Model under the research project called SnowAMP (Snow Accumulation and Melt Processes) built up in the

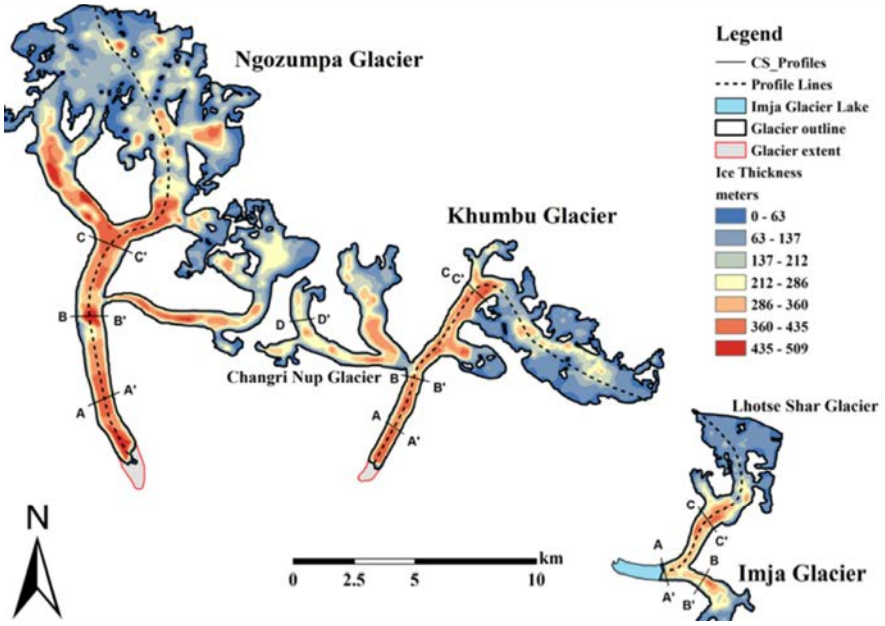


Fig 5. Spatial Ice thickness distribution of major glaciers of Khumbu and Gokyo Valleys

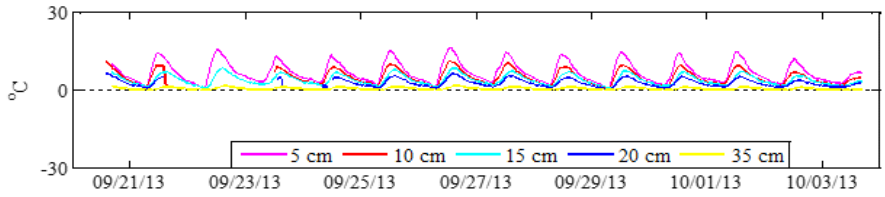


Fig. 6. Debris temperature profile at different debris thicknesses from surface to debris/ice interface on Lirung Glacier, Langtang Valley, Rasuwa district, Nepal

framework of a collaboration among the Norwegian Water Resources and Energy Directorate (NVE), International Centre for Mountain Development (ICIMOD), Kathmandu University (KU), the Department of Hydrology and Meteorology (DHM), and Tribhuvan University (TU). During this process, modelling evolution of glaciers in Hidden Valley, mass balance and energy balance of Yala Glacier in Langtang Valley also have been conducted. Besides it, under the M. S. by Research in Glaciology program, Glacio-hydrological modeling of two river basin of Afghanistan (Salang and Upper Kabul) and three river basins of Pakistan (Hunza, Gilgit and Shigar) have been studied.

**Dr. Rijan Bhakta Kayastha** holding D.Sc degree from Nagoya University, Japan (Mar. 2001, Glaciology; Hydrology, Meteorology) is an associate Professor of Department of Environmental Science and Engineering (DESE), School of Science (SOS), Kathmandu University (KU) and, since October 2009 to this date is Coordinator of Himalayan Cryosphere, Climate and Disaster Research Center (HiCCDRC). He is associated with number of research activities currently in Nepal relating to Glaciology and has published several research papers in national and international journals.

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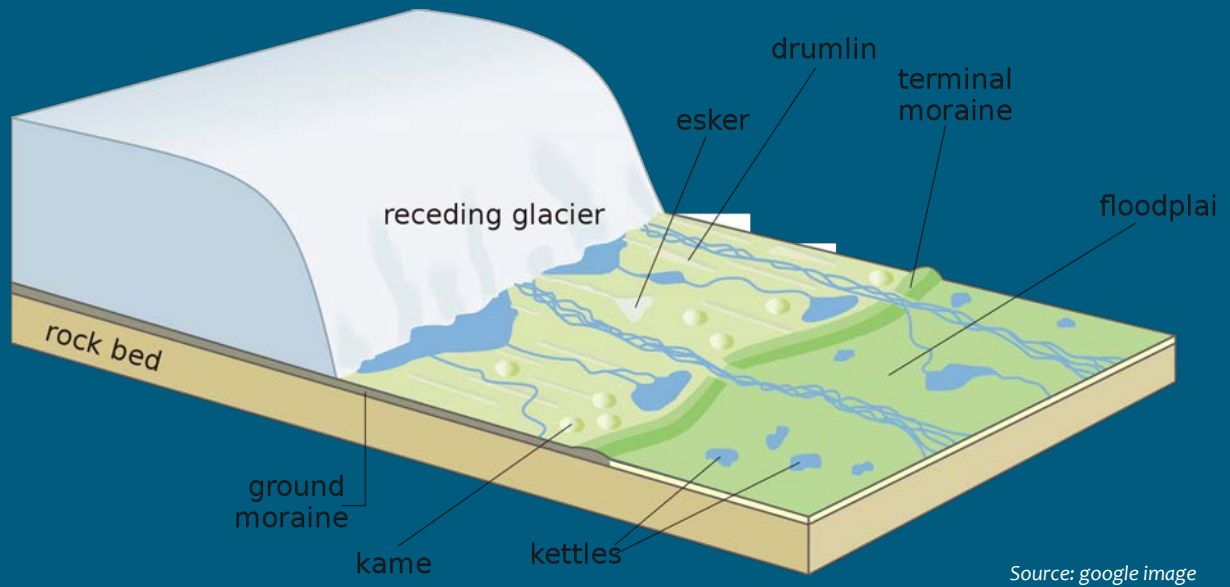
# Formation of Glacier




*Source: google image*

A glacier is a persistent body of dense ice that is constantly moving under its own weight. It forms where the accumulation of snow exceeds its ablation (melting and sublimation) over many years, often centuries. The story begins, when snow remains in the same area year-round, where enough snow accumulates to transform into ice. Each year, new layers of snow bury and compress the previous layers. This compression forces the snow to re-crystallize, forming grains similar in size and shape to grains of sugar. Gradually the grains grow larger and the air pockets between the grains get smaller, causing the snow to slowly compact and increase in density.

Generally after about two winters, the snow turns into firn, an intermediate state between snow and glacier ice. At this point, it is about two-thirds as dense as water. Over time, larger ice crystals become so compressed that any air pockets between them are very tiny. In very old glacier ice, crystals can reach several inches in length. For most glaciers, this process takes more than a hundred years.

Glaciers slowly deform and flow due to stresses induced by their weight, creating crevasses, a deep crack or fracture. It is the largest reservoir of fresh water on Earth. On Earth, 99% of glacial ice is contained within vast ice sheets in the polar regions, but glaciers may be found in mountain ranges on every content. Glaciers cover about 10 percent of Earth's land surface.

*Contribution: SOHAM Desk*

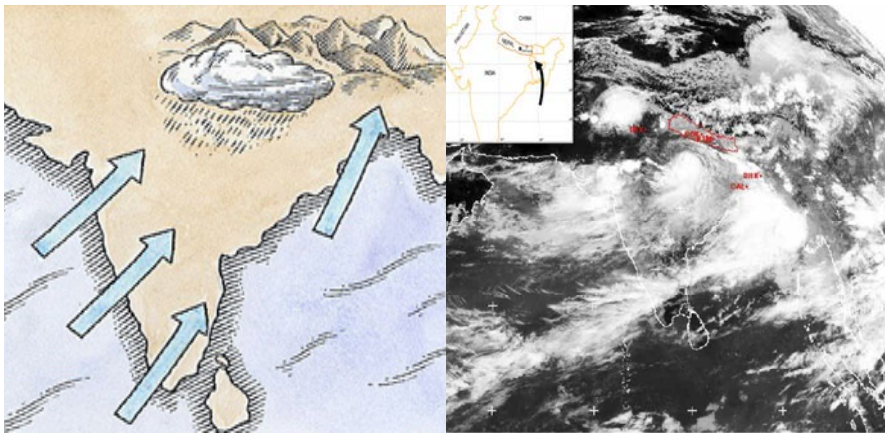
# नेपालको मौसमी गतिविधिलाई प्रभाव पार्ने दुई वायुमण्डलीय प्रणाली : मनसुन र पश्चिमी वायु

मणिरत्न शाक्य


पृथ्वी स्वयम् घुम्दै सूर्यको परिक्रमा गर्ने क्रममा उत्तरी गोलार्द्ध सूर्यबाट जत्ति नजिकिन थाल्छ त्यत्ति त्यस क्षेत्रमा गर्मी बढ्न थाल्छ । त्यस्तै सूर्य जत्ति टाढिन थाल्छ त्यस क्षेत्रमा त्यत्तिकै चिसो हुनथाल्छ । यसैको फलस्वरूप उत्तरी गोलार्द्धस्थित नेपाललगायत दक्षिण एसियाको विभिन्न स्थानमा सोहीअनुरूप गर्मी वा जाडोयाम सुरू हुनथाल्छ । यसरी देखा पर्ने गर्मी वा जाडोयामसँगै त्यस क्षेत्रमा चल्ने वायुमण्डलीय प्रणालीमा फेरबदल हुन गई गर्मीयामको सुरूवातसँगै मनसुनी वायुको आरम्भ हुनथाल्छ भने जाडोमा पश्चिम वायुको प्रभाव देखापर्न थाल्छ । यही वायुमण्डलीय प्रणालीमा आधारित रही नेपाललगायत दक्षिण एसियाको विभिन्न स्थानमा समयानुसार मौसमी गतिविधि फेरबदल हुने गर्छ । जसले गर्दा करिब छ महिना मनसुनी गतिविधिबाट प्रभावित भइ नेपाललगायत दक्षिण एशियामा ग्रीष्मकालीन मौसमी गतिविधि देखापर्ने गर्छ भने अर्को छ महिना हिउँद्कालीन मौसमी गतिविधि देखा पर्ने गर्छ ।

**मनसुन र मौसमी गतिविधि**

गर्मीयामको सुरूवातसँगै सूर्य उत्तरी गोलार्द्धतिर नजिकिने हुँदा त्यस क्षेत्रमा सूर्यको किरण छोटो दूरीबाट पृथ्वीको सतह पुग्ने गर्छ । यस्तो बेला नेपाललगायत दक्षिण एसियाको भू-सतह तात्न थाल्छ र समयानुसार तापमान बढ्दै जान्छ । तर यही बेला पानीको सतह अर्थात् हिन्दमहासागर र आसपासको क्षेत्र भने तुलनात्मक रूपमा भू-सतहभन्दा ढिलो तात्ने कारण चिसो भइरहेको हुन्छ । यस्तो अबस्थामा तातो भू-सतह माथिको हावा हलुँगो भई माथि उठ्न थाल्छ जस्ले गर्दा त्यस क्षेत्रमा वायुमण्डलीय चापमानमा ऱ्हास आउन थाल्छ । तर त्यही बेला हिन्दसागर र आसपासको क्षेत्रमा भने उच्च वायुमण्डलीय चापमान भइरहेको हुन्छ । यसरी भू सतह र समुद्री सतहबीच वायुमण्डलीय चापमान फरक हुने बेला उच्च वायुमण्डलीय चापीय क्षेत्र हिन्दमहासागरबाट न्यून चापीय क्षेत्र दक्षिण एसियाको मनसुनी वायु भूभागतिर तेजिलो हावा बहन थाल्छ, जसलाई मनसुन भनिन्छ ।



भू-उपग्रहबाट प्राप्त मनसुनी बादलको तस्विर

चट्याङ

मनसुन हिन्दसागरमा उत्पत्ति भई दक्षिण एशियाको विभिन्न स्थानमा फैलिने क्रममा हिन्दमहासागरबाट यो वायु दक्षिण पश्चिम दिशाबाट भारतको दक्षिण भेग प्रवेश गर्छ । र त्यहाँबाट उत्तर पूर्वतिर बढ्दै बङ्गालको खाडी भएर उत्तर पूर्वी भारत र बङ्गलादेश प्रवेश गर्छ । नेपालमा यो वायु दक्षिण-पूर्वी दिशाबाट भित्रिने गर्छ र बिस्तारै उत्तर पश्चिमतिर लाग्दै अन्ततोगत्वाः पाकिस्तानतिर लाग्छ । मनसुनी बहाब सामान्यतया यसरी बहने हुँदा नेपालमा मनसुनको सुरूवात सर्वप्रथम पूर्वतिर हुने गर्छ । यसो भए पनि अरब सागरबाट उत्पन्न हने मनसुनी वायुले पनि नेपालमा त्यत्तिकै प्रभाव पारिरहेको हन्छ ।

नेपालमा औसत जुन महिनाको दोस्रो हप्तातिर पूर्वी भेगमा मनसुन सुरू हुने गर्छ । तर मनसुन सुरू हुनुअगाबै सामान्यतया मार्च महिनादेखिनै वायुमण्डलीय तापमान वृद्धि भई वायुमण्डलमा सापेक्षिक आर्द्रता न्यून हुन जान्छ र यसले सुख्खा मौसमी गतिविधि निम्त्याउने गर्छ । साथै यस्तो बेला वायुमण्डलीय चापमानमा फेरबदल हुनाको कारण एक ठाउँबाट अर्को ठाउँमा हावा चल्न थाल्छ । यस्तो मौसमी गतिविधिलाई मनसुन पूर्वार्द्धको समय अथवा प्रि-मनसुनको रूपमा लिने गरिन्छ । मौसमी दृष्टिकोणले मनसुन पूर्वार्द्धको समय सुख्खा मौसमी गतिविधि हुने र बढी हावा चल्ने कारण नेपालको विभिन्न स्थानमा आगलागीको प्रकोप देखापर्ने गर्छ । आगलागीबाट विशेषगरी नेपालको तराई क्षेत्र बढी प्रभावित हुने गर्छ । तराई क्षेत्र समथर मैदान भएको र समथर मैदानमा बढी हावा चल्ने कारण बढी आगलागीको चपेटामा पर्ने गर्छ । पुनश्चः यो समय हावाहुरीको कारण धुलो उड्न गई वायुमण्डल अत्यधिक मात्रामा प्रदुषित हुने हुँदा मानिसले परसम्म देख्न सक्ने क्षमतामा कमी आई भिजिविलिटि अत्यन्त न्यून हुन जान्छ जसले गर्दा हवाई सेवालगायत अन्य विभिन्न किसिमका यातायातका साधन सञ्चालनमा समस्या उत्पन्न हुनेगर्छ ।

एकातिर यो बेला बढी गर्मी हुने तथा हावा चल्ने गर्छ भने अर्कोतिर भू-सतह तात्तिएर वायुमण्डलमा देखापर्ने अस्थिरताले आकाशमा एक किसिमका बादल निर्माण हुने गर्छ जसलाई ' क्यूमलोनिम्वस' भनिन्छ। यो बादल ठाउँ र समयानुसार १०औँ कि.मि. वा सोभन्दा बढी आकाशको माथिल्लो भागमा फैलिने गर्छ । धेरै उचाईसम्म फैलिनुको साथै बाक्लो हुनाको कारण यो बादलको स्वरूप कालो हुन्छ । यस्तो बादल मनसुन पूर्वार्द्धको समय नेपालको विभिन्न स्थानमा प्रत्येक दिनजस्तै देखापर्ने गर्छ ।

यो बादल आकाशको धेरै माथिसम्म फैलिने हुँदा यस बादलको माथिल्लो भाग अत्यन्त चिसो भई त्यहाँ बरफको टुक्रा, हिउँ, असिना आदि भइरहेको हुन्छ भने तल्लो भागमा प्रशस्त मात्रामा पानीको थोपा भई रहेको हुन्छ । पुनश्चः यो बादल संवाहन प्रक्रियाबाट उत्पति हुने हुँदा यस बादलभित्र जोडले हावा तल माथि चलिरहन्छ। यसरी बादलभित्र हावा तल-माथि चलिरहने कारणले गर्दा यस बादलभित्र रहेको पानीको थोपा, बरफ, हिउँ, असिना आदि एक-आपसमा घस्रन थाल्छ जसले गर्दा बादलभित्र घनात्मक र ऋणात्मक चार्ज विकासित हुनथाल्छ। बादलभित्र यसरी विद्युतीय चार्जहरू एक-आपसमा आकर्षण र सम्पर्कले आकाशमा बिजुली चम्किन्छ, जसलाई चट्याङ भनिन्छ।

सुरूको अवस्थामा चट्याङ आकाशमा मात्र देखापर्ने गर्छ र त्यति डरलाग्दो हुँदैन । तर कालान्तरमा जब हुरी, बतास र भारी वर्षासँगै छिटो-छिटो बिजुली चम्कने र क्षण क्षणमा मेघ गर्जनको आवाज सुनिन थाल्छ तब चट्याङको प्रकोप बढ्दै जान्छ । आकाशमा बिजुली चम्कने बेला वायुमण्डलमा अत्यधिक मात्रामा ताप शक्ति पैदा भई क्षणभरमै वायुमण्डल आकस्मिक रूपमा तात्न थाल्छ । वैज्ञानिक अध्ययनअनुसार आकाशमा एकचोटी बिजुली चम्कने बेला वायुमण्डलीय तापमान एक्कासी बढेर ३० हजार डिग्री सेल्सियस

वा सोभन्दा बढी पनि पुग्न सक्छ भने एकचोटी चट्याङ पर्ने बेला १०औँ हजार अम्पिर वा सोभन्दा बढी करेण्ट उत्पत्ति हुने गर्छ । वैज्ञानिक अध्ययनअनुसार आकस्मिक रूपमा क्षणभरमै वायुमण्डलीय तापमान यत्ति धेरै बढ्ने कारण त्यस क्षेत्रको वायु एक्कासी तातिएर आयतन बढ्न थाल्छ र त्यही क्षण वायु पुनः खुम्चिन थाल्छ । र यस्तो परिस्थितिमा त्यस क्षेत्रमा एक किसिमको विस्फोटनको आवाज निस्कन्छ जसलाई मेघ गर्जन भनिन्छ । यही कारणले गर्दा चट्याङ पर्ने बेला आकाशमा बिजुली चम्कनुको साथै मेघ गर्जनको आवाज सुनिने गर्छ । पुनश्चः यही बेला बादलभित्र चलिरहेको तेजिलो हावा जब बादलबाट बाहिर निस्कन थाल्छ तब पृथ्वीको सतहतिर हुरी, बतासको साथै भारी वर्षा हुन थाल्छ । यस्तो बेला भारी वर्षासँगै हिउँ, असिना पनि झर्न थाल्छ । यही कारण चट्याङबाट भौतिक संरचनाको क्षति हुनुको साथै मानिसको ज्यान समेत जाने तथा थुप्रै हानी नोक्सानी हुने गर्छ । तसर्थ यो डरलाग्दा प्राकृतिक प्रकोपको रूपमा लिइन्छ । नेपालको भौगोलिक स्थिति र भू-बनोटको कारण यस्तो बादल देखापर्ने बेला सामान्यतया तराईको विभिन्न स्थानमा भारी वर्षा हुने गर्छ भने पहाडी भेगमा असिना पर्ने र उच्च पहाडी भेगमा हिमपात हुने गर्छ ।

मनसुन पूर्वार्द्धको समय यसरी वायुमण्डलमा विभिन्न प्राकृतिक प्रक्रिया देखापर्ने र यसले थरीथरीका प्राकृतिक प्रकोप निम्त्याई मानवीय जीवनमा हानी नोक्सानी पुऱ्याउने हुँदा यो समय अत्यन्त जोखिमपूर्ण मानिन्छ । तर मनसुन सुरूवातसँगै देशभर जब वर्षा हुनथाल्छ यसले पानीको आपूर्ति गरिदिन्छ जुन नेपालजस्तो पहाडी मलुकको लागि वर्षा बरदानतुल्य छ । तर यो बेला भारी वर्षाका कारण खोलामा बाढीको प्रकोप देखा पर्नाले विपत्ति आइलाग्ने गर्छ । सामान्यतया नेपालमा मनसुन पूर्वी नेपालबाट सुरू भई पश्चिमतिर लाग्ने हुँदा मनसुनी गतिमा निर्भर रही एक हप्ता वा सो भन्दा केही दिनपछि मनसुन पश्चिम भेगतिर भित्रिने गर्छ ।

नेपालमा औसत सेप्टेम्बरको अन्ततिर मनसुन अन्त हुने गर्छ । तर विगत केही वर्षदेखि विभिन्न मौसमी प्रक्रियाको कारण मनसुनको समाप्ती अक्टोबरतिर हुन थालेको मौसमी तथ्याङ्कबाट देखिन्छ ।

## पश्चिमी वायु र मौसमी गतिविधि

मनसुनको समाप्तीसँगै सूर्य बिस्तारै दक्षिणतिर लाग्ने हुँदा उत्तरी गोलार्द्ध स्थित एसिया महादेशमा जाडो सुरू हुन थाल्छ । यो बेला भू-सतह बिस्तारै चिसिन गई हिउँदयामको आगमन हुनथाल्छ । यस्तो बेला दक्षिण एशियामा चल्ने वायुको दिशामा पनि परिवर्तन हुन गई मनसुन कालमा दक्षिण पूर्वबाट चल्ने हावा पश्चिमबाट चल्न थाल्छ । निरन्तर रूपमा पश्चिमबाट पूर्वतिर चल्ने यस्तो हावाको बहाबलाई पश्चिम वायु भनेर भनिन्छ ।

पश्चिम वायु युरोप महादेशबाट सुरू भई पूर्वतिर वहने क्रममा एसिया महादेशको विभिन्न भू-भाग जस्तै टर्कि, सिरिया, इराक, इरान र यससँग जोडिएको अन्य भूभाग हुँदै अन्ततोगत्वाः पश्चिमी वायु दक्षिण एसियाको अफगानिस्तान, उत्तर पाकिस्तान र भारतको उत्तर पश्चिम भेग हुँदै नेपाल भित्रिने गर्छ । त्यहाँबाट बङ्गलादेशतिर लाग्ने गर्छ । यसरी बहने पश्चिमी वायु त्यस क्षेत्रस्थित आटलाण्टिक सागरको साथै मेडिटरेनियन, ल्बाक र क्यास्पियन सागरबाट प्रशस्त मात्रामा जलवाष्प आपूर्ति भई ओसिलो भएको खण्डमा वायुमण्डलमा सापेक्षिक आर्द्रता


पश्चिमी वायुको नेपाल प्रवेश

नेपालको तराईमा लागेको शित लहर कुहिरो

वृद्धि हुन गई वायुमण्डलीय चापमानमा ऱ्हास आउन थाल्छ । यसरी वायुमण्डलीय चापमानमा ऱ्हास आएको खण्डमा मौसम बदली भई वर्षा हुने गर्छ । यस्तो मौसमी प्रक्रियालाई 'वेस्टर्न डिस्टरवान्स' भनिन्छ ।

पश्चिम वायु युरोप महादेशको चिसो भू-भागबाट बहने भएकोले यो वायु अत्यन्त चिसो हुन्छ । यही कारण यो वायु जहाँजहाँ बहन्छ त्यहाँ चिसो मौसमी गतिविधि भित्रिने गर्छ । यसै सन्दर्भ जाडोयामको प्रारम्भमा पश्चिमी वायु त्यति सक्रिय नहुने हुदाँ मौसम त्यति चिसो हुन पाउँदैन । तर समयानुसार जब हावाको गति बढ्न थाल्छ र पश्चिमबाट चल्ने वायु उत्तर पश्चिम दिशा तिर धल्किँदै एसिया महादेशको उत्तरी भेगस्थित हिमाली भू-भाग हुँदै बहन थाल्छ यसले कठ्याङ्ग्रिने चिसो मौसमलाई निम्त्याउन थाल्छ । जाडोयामको बित्दो समयसँगै नेपालमा यस्तो मौसमी गतिविधि देखापर्ने गर्छ । जसनुसार, सामान्यतया पुसको अन्त्यतिर वा माघको सुरूवातसँगै नेपालमा यस्तो मौसमी गतिविधिले सताउने गर्छ । पुनश्चः यस्तो चीसो हावा बहने बेला वेस्टर्न डिस्टरवान्सको कारण वर्षा भएको खण्डमा नेपालको उच्च पहाडी भेगमा हिउँ पर्न थाल्छ भने पहाडी भेगमा वर्षा र तराईको समथर मैदानमा बाक्लो कुहिरो लाग्ने र शितलहर चल्ने गर्छ । नेपाललगायत दक्षिण एसियाको विभिन्न स्थानमा वेस्टर्न डिस्टरवान्सको कारण हिउँदयाममा कम्तिमा पनि तीन-चारपटक वर्षा भई मौसममा फेरबदल हुने गर्छ । हिउँदयाममा एकातिर यस्तो मौसमी गतिविधि देखापर्न गर्छ भने अर्कोतिर आकाशमा क्यूमलोनिम्बस बादल उत्पत्ति हुन गई भारी वर्षा हुनुको साथै चट्याङ पर्ने गर्छ ।

हिउँदे वर्षा पहाडी मुलुक नेपाल जहाँ पर्याप्त मात्रामा सिँचाई सुबिधा उपलब्ध हुन सकिरहेको छैन त्यहाँको लागि वरदानतुल्य छ । यसले पानीको आपूर्ति गरिदिन्छ भने जाडो मौसमी गतिविधि भित्र्याई हिउँदे बालीलाई राम्रो पारिदिन्छ । तर प्राकृतिक हदको कारण यसले निम्त्याउने प्रकोप भने अभिशाप सिद्ध हुन्छ । यसै कारण हिउँदयाममा प्रत्येक वर्ष नेपालको विभिन्न स्थानमा कठ्याङ्ग्रिने जाडो तथा शितलहरले थुप्रै बाली नाश हुनुको साथै मानिसको ज्यान समेत जाने गर्छ ।


## सारांस

मनसुन र पश्चिम वायु नेपाललगायत दक्षिण एशियामा प्रत्येक वर्ष देखापर्ने प्राकृतिक प्रक्रिया हुन जुन निरन्तर रूपमा चलिरहन्छ । समयानुसार यी नै दुई फरक दिशाबाट चल्ने वायुमण्डलीय प्रणालीको कारण नेपालमा मौसम फेरबदल हुने गर्छ । साँच्चै भन्ने हो भने, यस्तो बदलिँदो मौसम नै नेपालको विशेषताको रूपमा लिन सकिन्छ जुन बरदानतुल्य छ ।



**मणिरत्न शाक्य** काठमाण्डौ विश्व बिद्यालयमा भिजिटिङ्ग फ्याकल्टीको रूपमा कार्यरत हुनुहुन्छ । साथै नागरिक उडय्यन प्राधिकरण र अन्य हवाई सेवासँग आबद्ध हुनुहुन्छ । यसअघि उहाँ जल तथा मौसम विज्ञान विभागमा उपमहानिर्देशक तथा मौसम पूर्वानुमान महाशाखाको प्रमुख हुनुहुन्थ्यो । वायुमण्डलीय भौतिकशास्त्रमा स्नातकोत्तर गर्नुभएका मौसमविद् शाक्यले U.K Met Office, बेलायतबाट मौसम भबिष्यबाणीमा भू-उपग्रहको प्रयोगबारे तालिम लिनुको साथै संयुक्त राज्य अमेरिकाबाट मौसम परिवर्तनसम्बन्धी ज्ञान आर्जन गर्नुभएको छ । उहाँका थुप्रै लेखहरू प्रकाशित भइसकेका छन् भने यस वर्ष उहाँलाई युवा बौद्ध समुह, नेपालले बुद्ध धर्मसम्बन्धी उत्कृष्ट लेखको लागि सम्मान तथा पुरस्कृत गरेको छ ।

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# Challenges of drought monitoring in Nepal

Dr. Hemu Kharel Kafle

## Introduction

Drought is one of the most complicated and least understood natural hazards, affecting more people than any other hazards (Wilhite, 2000). Drought first appears as a simple weather phenomenon relating to rainfall below normal within a normal part of climate for the extended period of a time usually a season or more. Then, it develops as an extreme climatic event and turn into a hazardous phenomenon which can have a severe impact on communities and water dependent sectors (McKee et al., 1993). Drought causes devastating impacts on agriculture, water supply and the environment (Dow 2010; Popova et al. 2014; Yu et al. 2014) that lead to economic losses (Below et. al 2007, Wilhite 2000; Wilhite et al. 2007). In the United States according to the National Climatic Data Center, the losses from drought exceed US$210 billion during 1980-2011, and account for about 24% of all losses from major weather disasters.

Growing bringal plant with dried out bringal fruit due to drought

Internationally, especially for the developing world, drought has devastating impacts on local populations through food insecurity and famine.

Precipitation is a major weather element that controls the persistence of drought condition. At the same time, high temperature, low humidity and high wind speed play significant role in aggravating the drought phenomenon. Increases in drought are driven primarily by reductions in precipitation with increased evaporation from higher temperatures modulating the changes. In some regions, increases in precipitation are offset by increased evaporation. When coupled with potential climate change, which may impact regionally and exaggerate the


Barren field (bari) and dried out paddy plant (byad) during drought

influence of natural variability, the extremes of climate may become more pronounced (Easterling et al., 2000; Palmer and Raisanen 2001). Therefore, droughts are projected to become more frequent and severe with increase in extreme climatic events (Trenberth et al. 2014). In this context, studies on drought and its management have been momentous with the severity of impact of climate change in the globe.

## Status of drought condition in Nepal

Nepal is an agricultural country and more than 70 percent of it's population works in the agriculture sector, accounting for 38 percent of the GDP. However, due to lack of proper and sufficient irrigation facilities, almost 76% of this agricultural land is rainfed and, therefore, is highly vulnerable to changing climatic conditions. There are major human impacts associated with the precipitation regimes of Nepal. Since the 1990s, droughts have resulted in food deficits which have caused serious nutritional crises. Of the 75 districts in Nepal, 40 had experienced food deficits. In those districts alone, half of the children under the age of 5 were stunted with restricted growth, 39% were underweight, and 13% were severely malnourished (World Food Programme 2009).

Drought has also emerged as a source of vulnerability in rainfed agriculture particularly in the drier western part of Nepal (Ghimire et al. 2010; Gumma et al. 2011; Wang et al. 2013, Kafle,2014) as favorable weather conditions for agricultural production have largely been absent in recent years. The scarcity of water has impacted farming and animal husbandry as well as everyday household chores and personal hygiene, causing considerable hardship. Due to continueous decline in rainfall, most of the farming land has become barren and fallow. Cropping pattern has also been found to be changed, for example: khet land has become bari land and bari land has become barren. In land where 2-3 crops were harvested, now only one crop has been growing. Growth of plant has been found to be affected as well as outburst of dieses and drying of fruit in the tree (as shown in Figure 1) has also been reported due to drought in some part of the country.

The depletion of water sources has forced drought affected areas to import both food and water. When water problems are serious, people migrate temporarily during dry months and then return when monsoon rain restore water availability, but when it is serious they migrate abandoning their land behind.

Moreover, due to water unavailability people have to travel long distances for collecting drinking water which takes large number of time. This has affected the education of children as they have to go fetching water during their school time or sometimes at night time as well which disturb their school activity. In some houses it has been found that children have to take care of home and cook food when their parents are out for fetching water. Sometimes in villages, people

A girl collecting water from a smal puddle for drinking water purposes due to the shortage of water during drought in Panchkhal VDC.

collect water from the puddle that left behind due to dried up river without knowing the quality of water. Due to which, people are facing health problems like diarrhea, dysentery, worms (more in children), typhoid and fever.

In a current scenario of ongoing drought, this year in Karnali region,the water level of RARA lake (located in Jumla and Mugu districts) has dipped by 1.5 meters due to which the river feeding this lake has dried up causing shortages of drinking water (Kantipur News, 3/24/2016). There has been no rain since last July and farmers have lost half their crops. Local residence, Lotai Lama, who lives in Simkot in Humla district, says: "We don't have big dreams, we just want to survive forgetting human rights, political and other democratic rights ... we do not even know if we have two meals a day, whether we will live or die" (Asia News.it). Similar kind of situation has been reported in most part of the country leaving Nepali people suffer from drought soon after the earthquake of 2015 and the long months of the Indian blocked on exported goods.

## Constraints and challenges

Although, it is not possible to avoid droughts, they can be predicted and monitored, and their adverse impacts can be alleviated by regular monitoring of potential regions at high risk of drought. Drought monitoring and forecasting systems are major components of drought risk management as they can provide early warning of drought's onset and end, determine its severity and deliver that information to a broad clientele in many climate- and water-sensitive sectors in a timely manner. With this information, the impacts of drought can be reduced or avoided in many cases.

Despite urgent needs in the agricultural communities, Nepal lacks even the fundamental components like assessing, monitoring and predicting drought in a reliable manner. Tools that comprehensively monitor the extent, severity and likely duration of drought at local to regional scales are essential for protecting agricultural economies and livelihood and are widely used in Western countries. Notable among these is the drought monitor suite in the USA (www.drought.gov), which consists of weekly, detailed numerical and qualitative maps of drought severity. The maps are created using input from hundreds of experts representing dozens of local, state and federal agencies and from satellite remote sensing data that provide critical synoptic views of crop extent, crop type, and estimates of crop water use. Transferring this kind of approach to Nepal would be highly beneficial, yet is unfeasible.

Some individual efforts on assessing drought (Sigdel and Ikeda, 2010; Shakya and Yamaguchi, 2010; Kafle, 2014, Dahal et al., 2016) and its impact ((Bhatt et al., 2014; Shrestha et al., 2014; Devkota et al., 2015) on local commodities have been made by researchers, but to this date no scientific drought monitoring systems have been implemented by any government institutions in Nepal. Nepal Academy of Science and Technology has been carrying out drought research since last four years and focussing on suitable drought monitoring tools in national scale. Some of the reasons for not having proper drought monitoring system in Nepal are the lack of sufficient hydrological and meteorological measurement stations, poor access to satellite data, insufficient rainfall prediction capability, and shortages of well-trained staff (GWP, 2014).

## Conclusion

Being a humid country, Nepal is not as vulnerable to drought as dry land countries such as Israel and Africa. However, due to lack of proper management of water resources and also the lack of proper policy and tools in managing drought, we are facing lots of severe problems in recent years. Proper drought

management system will increase society's coping capacity, leading to greater resilience and also reduce the need for government or donor interventions in the form of disaster assistance. Development and implementation of a suitable drought monitoring and forecasting system in national scale is possible using remote sensing datasets and it should be right away. There are few global drought monitoring systems; Global integrated drought monitoring and prediction system (GIDMaPS) (Hao et al., 2014) and Global drought monitoring and Prediction System (DMAPS) (Luo et al., 2008) that can be implemented directly for the first step towards developing monitoring system in Nepal. Afterwards we can improve our monitoring and predicting capabilities by further research in this field. This will improve our drought prediction skill for better water and crop management, which will leads to reduction in water demand and increase in water conservation. Extensive research on historical drought conditions in Nepal and its impact on every sector as well as drought monitoring and forecasting tools in national scale are necessary to predict future drought condition and better preparedness to cope with this situation of drought in future. Besides education and awareness programs, concern about drought should also be carried out more frequenltly among local stakeholders and general public. Moreover better policy in handling drought activity by goverment of Nepal could lead to encourage general people in chosing their carrier in agriculture that will help in food production. Thus, extensive research in drought management, better drought monitoring tool, better policy and increased awareness about drought will certainly help in proper drought management in Nepal.

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# हावापानी सूचक र यसको उपयोगिता

डा. जनकलाल नायबा श्रेष्ठ
सुमनकुमार रेग्मी

हावापानीले लामो समयको वायुमण्डलीय औसत अवस्थालाई जनाउँछ । विश्व मौसम सङ्घका अनुसार कुनै पनि ठाउँको सामान्यतया कम्तीमा ३० वर्षको वायुमण्डलीय तथ्याङ्कको औसतले त्यस ठाउँको हावापानी अवस्था इङ्गित गर्छ । नेपालको भौगोलिक विविधताको दृष्टिकोणले उत्तर दक्षिणको औसत चौडाई करिब १९३ कि. मि रहेको छ भने दक्षिणतिर नेपालकै सबभन्दा होचो भु-भाग (झापाको केचना ५६ मिटर) रहेको छ साथै उत्तरतिर अग्लिँदै चुरिया पर्वत, महाभारत पर्वत र त्यसपछि हिमालय पर्वत रहेको छ । यसले गर्दा ठाउँअनुसार हावापानीको फरक अवस्था अनुभव गर्न सकिन्छ भने नेपालमा उष्ण प्रदेशिय हावापानीदेखि ध्रुवीयलगायत विविध प्रकारका हावापानी अनुभव गर्न पाइन्छ ।

हावापानीसम्बन्धी अध्ययनका लागि साधारणतया पृथ्वीको जल तथा भुस्थलदेखि वायुमण्डलको १६ कि. मि. माथिसम्मको गतिविधिको समग्र अध्ययन आवश्यक हुन्छ । यसका लागि भू-स्थल तथा वायुमण्डलीय हावापानी केन्द्र स्थापना गरी विविध प्रकारका मौसमी तथ्याङ्क सङ्कलन गर्ने गरिन्छ । नेपालमा वि. सं. २०२३ सालदेखि नै विभिन्न किसिमका हावापानी केन्द्रहरू स्थापना गरी सञ्चालनमा आइरहेको छ । हाल नेपालमा ४३८ हावापानी केन्द्रहरू नेपाल सरकारको जल तथा मौसम विज्ञान विभागअन्तर्गत चालु अवस्थामा रहेको छ ।

हावापानी अवलोकन गर्ने क्रममा विभिन्न सूचकहरूमध्ये हावाको गति, दिशा, आर्द्रता, वर्षा, तापक्रम, र घामको समय वा सौर्य शक्ति मुख्य मानिन्छ । यसको मापन मौसमी केन्द्रहरूको वर्गीकरणको आधारमा विभिन्न समयमा अवलोकन गरिन्छ । उदाहरणका लागि वर्षाको मापन २४ घण्टामा एक पटक बिहानको ८:४५ बजे लिने गरिन्छ भने स्वचालित केन्द्रहरूमा कम्तिमा १०-१० मिनेटको फरकमा हावापानी तथ्याङ्क अवलोकन हुने गर्छ । त्यस्तैगरी तापक्रम विहानको ८:४५ वजे र बेलुका ५:४५ वजे दिनको दुई चोटि अवलोकन गर्ने गरिन्छ । सिनोप्टिक केन्द्रहरूमा भने तीन-तीन घण्टाको अन्तरमा हावापानीका सूचकहरूको अवलोकन गर्ने गरिन्छ । यसले हावापानी सूचकहरूको छोटो समयको उतारचढाबको सहजै ज्ञात हुन्छ । नेपालमा मात्र नभई विश्वमा नै हावापानी अवलोकन गर्ने यस प्रकारको निश्चित समय विश्व मौसम सङ्घले तय गरेको हो । यसको मुख्य कारण विश्वभरका हावापानी केन्द्रहरूबाट लिइएका तथ्याङ्कमा एकरूपता रहोस् र हावापानी तथ्याङ्क विश्लेषण सहज होस भन्ने नै हो ।

दैनिक रूपमा अवलोकनबाट प्राप्त हुने मौसमी तथ्याङ्कहरूको आधारमा वायुमण्डलमा हावाको गति र दिशा, आर्द्रता, तापक्रमको अवस्था, वर्षाको स्थितिजस्ता हावापानीका मूलभूत सूचकहरूको विश्लेषण गरिन्छ । नेपाललगायत दक्षिण एशिया र आसपासका क्षेत्रहरूमा एकै समयमा लिइएको मौसमी आँकडालाई मौसमी नक्सामा विश्लेषण गरी मौसम पूर्वानुमान समेत गर्ने गरिन्छ । यस्ता तथ्याङ्कले हवाई, कृषि, जलस्रोतजस्ता विविध क्षेत्रहरूमा अत्यन्त महत्व राख्छ । यसै सन्दर्भमा केही प्रमुख तथा महत्वपूर्ण हावापानी सूचकहरू र त्यसले पार्ने प्रभाव र उपयोगिता संक्षेपमा उल्लेख गरिएको छ ।

सिनोप्टिक केन्द्र, काठमाडौ

## हावा

हावापानी सूचक मध्ये हावा एक मुख्य सुचक हो । तर यसबारे नेपालमा कमै लेखहरू प्रस्तुत भएको देखिन्छ । हावा जब तात्न थाल्छ, हलुगो भई माथि उठने प्रक्रिया सुरू हुन्छ भने यसको विपरित चिसो हावा सतहतिर झर्छ । त्यस्तै गरी हावाको बहाब बढी चाप भएको क्षेत्रबाट न्यून चापीय क्षेत्रतिर हुन्छ । मुख्यतः एउटै स्थानको विभिन्न उचाईहरूमा हावाको गति र दिशा समान हुँदैन भने जतिजति उचाई बढ्दै जान्छ, त्यति-त्यति निश्चित उचाईसम्म हावाको गति पनि बढदै जान्छ । यही कारण बेसीमा भन्दा लेकमा बढि हावा चल्ने गर्छ भने हावाको वेग र दिशालाई खासगरी प्राकृतिक भू-बनोटबाट असर पारेको देखिन्छ । त्यसैकारण ठाउँअनुसार हावाको प्रवाह घटी बढी हुन जानुका साथै दिन र रातको समयमा समेत हावाको गरी र दिशामा फरक हुन जान्छ । दिउँसोको समयमा हावा वेसिबाट लेकतर्फ बहन्छ भने रातको समयमा यसको ठीक उल्टो हुन्छ । नेपालको तल्लो भू-भाग अर्थात खोंचहरूजस्तै कर्णाली-चिसापानी र बागमती-कर्मैयामा उत्तरबाट दक्षिणतिर राती जोडले सिट्ठी बजाएको आवाजमा हावा बहनु तथा मुस्ताङ, जोमसोममा पश्चिमी हावा बिहान ९/१० बजेबाटै तीब्र गतिबाट चल्नु उदाहरणहरणको रूपमा लिन सकिन्छ ।

हावापानी अध्ययनको निमित्त उच्च वायुमण्डल अवलोकन मौसमी केन्द्र आवश्यक हुन्छ । नेपालमा हाल यस्तो केन्द्र सञ्चालनमै छैन । काठमाडौंमा सन् १९७८ फेब्रुअरीदेखि १९८० मे सम्म करिब ३ वर्ष विश्व मौसम सङ्घको प्राविधिक सहयोगमा उच्च वायुमण्डल मौसमी केन्द्र स्थापना गरी विभिन्न उचाईको हावाको गति र दिशाका तथ्याङ्कहरू सङ्कलन गरिएको थियो । जसनुसार सन् १९७८ (वि. स. २०३४/३५० को एक वर्षको उच्च वायुमण्डलिय हावाको अवलोकनबमोजिम काठमाडौंमा १२ किलोमिटरको उचाईमा मार्गदेखि वैशाखसम्म प्रायः पश्चिमी हावा ९० देखि १८० किलोमिटर प्रतिघण्टा बेगमा चलेको देखिन्छ । तर जेष्ठ र कार्तिक महिना मनसुन सूरू हुनुभन्दा अगाडि र मनसुन सिद्धिएको महिनामा भने पश्चिमी हावाको गति १८ देखि ५४ किलोमिटर प्रतिघण्टा रहेको छ । त्यस्तै मनसुनमा अर्थात असारदेखि आश्विनसम्म पूर्वी हावा १० देखि २० किलोमिटर प्रतिघण्टामा बहेको देखिन्छ (Nayaju, 1984) । यसरी तीव्र गतिमा ९० किलोमिटरभन्दा बढी बहने पश्चिमी हावालाई उष्ण कटिबद्ध परिवर्ती पश्चिमी तेजी हावा (Subtropical Westerly Jet Stream) भनिन्छ । जसको चौडाई करिब १०० किलोमिटर र गहिराई करिब

५ किलोमिटर हुन्छ र यसलाई एक प्रकारको हावाको बाढी (Jet Stream) भन्ने चलन छ ।

यस्तै काठमाडौँमा करिब ६ किलोमिटरको उचाईमा मार्ग महिनादेखि बैसाखसम्म पश्चिमी हावा करिब ५० किलोमिटर प्रतिघण्टा रहेको भने जेष्ठ-कार्तिकमा २० किलोमिटर प्रतिघण्टा रहेको छ । मनसुन अवधि असारदेखि आश्विन महिनासम्म पूर्वी हावा १० किलोमिटर प्रतिघण्टा बहेको देखिन्छ । यस्तै काठमाडौँको करिब ३ किलोमिटरको उचाईमा मार्गदेखि बैशाखसम्म सामान्य वा १० किलोमिटर प्रतिघण्टा र मनसुन महिनाहरूमा ५ देखि १० किलोमिटर प्रतिघण्टा दक्षिणपुर्वी तथा पूर्वी हावा बहेको देखिन्छ (Nayaju, 1984) । यसरी माथिल्लो हावामा उपरोक्त किसिमका हावाको दिशा र बेग देखिएता पनि भुस्थलमा भने हावाको दिशा र बेग फरक भएको अवलोकन गरिएको छ । उपरोक्त वर्णन गरिएका उष्ण कतिवन्ध परिवर्ती पश्चिमि तेजी हावा (Subtropical Westerly Jet Stream) मनसुन सुरू हुनुभन्दा एक महिना अगाडिदेखि हावाको गतिमा कम हुनुका साथै नेपालमा मनसुन सुरू हुने बेला यो हावा Tibetan Plateau को उत्तर तर्फ सरेको हुन्छ । यसलाई मनसुन सुरू हुने एक मुख्य कारण मानिन्छ ।

मनसुन सुरू हुने बेला भारतको केरला र श्री लङ्कामाथि करिब १४-१६ किलोमिटरमा पूर्विय तेजीहावा (Easterly Jet Stream) देखापर्दछ र उक्त पूर्वी हावा मनसुन सकिने बेला लोप भएर जाने गर्छ । यस्तै नेपालमा मनसुन सक्रिय हुने बेला अन्तरकेन्द्रित क्षेत्र (Inter Tropical Convergence Zone) भारतको दक्षिण भागबाट सरी भारतको उत्तरी भाग अर्थात नेपालको चुरेपहाडसम्म पुगेको देखिन्छ । त्यतिबेला नेपालमा भारी बर्षा हुन्छ । यसरी ITCZ उत्तर दक्षिण सर्ने कारण वर्षामा फरक हुन्छ । मनसुन सूरू हुनुअगाडि उत्तरपश्चिमको भारतको थार मरूभुमि (Thar desert) मा तापिय चक्रबात (Heat Low) हुनु र तिबेतन प्लेटु (Tibeten Plateau) मा तिबेतीय चक्रबात (Tibetan anticyclone) प्रक्रियाबाट मनसुन अवधिमा वायुमण्डलको गति हिन प्रक्रियाहरूबीच सम्बन्ध देखिने र यी प्रक्रियाहरू फेरबदल तथा तल माथि भइरहन्छन् जसबाट मनसुनी वर्षामा प्रतिकुल असर परेको हुन्छ ।

यिनै प्राकृतिक कारणले गर्दा बङ्गालको खाडीबाट नेपाल प्रवेश गर्ने मनसुनी हावाको बहाब सहज हुन्छ । यसरी प्रशस्त बाफ लिएर आउने दक्षिण पूर्वी मनसुनी हावा करिब दश-बाह हजार फिट, (३-४ किलोमिटर) सम्ममा सक्रिय भएको हुन्छ । यही हावा नेपालको प्राकृतिक भू-बनोटजस्तै चुरिया पहाड, महाभारत पहाडमा ठक्करको प्रभावबाट बर्षा हुने गर्दछ । साधारणतया पूर्वी नेपालमा मनसुन प्रवेश गरेपछि प्रायः काठमाडौँ पुग्न २ दिन र नेपालको सुदुरपश्चिमसम्म पुग्न करिब एक हप्ता लाग्ने हुन्छ । यो सबै हावाको गतिमा निर्भर रहन्छ । त्यस्तै चैत्रदेखि जेष्ट महिनामा वर्षा प्रायः मेघ गर्जन (Thunderstorm) बाट हुने गर्छ । जेष्ठ महिनामा हावाको गति कम हुनु पर्वतारोहण कार्यका लागि उपयुक्त समय मानिन्छ तीब्र गतिमा बहने हावाले पर्वतारोहण कार्यमा जटिलता निम्त्याउँनको साथै हवाई उडानमा समेत प्रत्यक्ष्य प्रभाव पार्दछ । खासगरी उच्च भेगमा (High Alitude) भएका नेपालका हवाई अड्डाहरू विशेषगरी जोमसोम, जुम्ला जस्ता ठाउँहरूमा हावाको वेग अति तीब्र भएकोले हवाई उडान र अवतरण (Landing and Take off) गर्न समस्या भै पटक पटक हवाई उडान रद्द (Flight Cancel) हुनुको साथै दुर्घटनाको जोखिमसमेत बढ्न गएको छ । जहाजको उडान र अवतरणको समयमा जहाजको दायाँ वा वायाँबाट जहाजतर्फ हानिने वायु (Cross Wind) ले जहाजको सन्तुलन बिग्रेर दुर्घटना समेत निम्त्याउन सक्छ । हावाको बहाबको आधारमा जहाजले खपत गर्ने इन्धनको मात्रा तय हुने गर्दछ जसको कारण विमान चालकले वायुको अवस्था हेरी जहाजलाई सकभर कम इन्धन खपत हुने गरी आफ्नो हवाई मार्ग तय गर्ने गर्दछन ।

## वर्षा

हावापानीको अर्को प्रमुख सुचकको रूपमा वर्षालाई लिन सकिन्छ । जलस्रोत र यसको उपयोगमा समेत वर्षाको निकै घनिष्ट सम्बन्ध रहेको छ । वर्षाको तथ्याङ्कको आधारमा पानीसम्बन्धी योजना तर्जुमा गरिन्छ भने वर्षा विश्लेषण (Aerial Rainfall Analysis) गरी नदीको बहाव (River Flow) हेर्ने गरिन्छ । यसको साथै वर्षाको पानीको आधारमा बाढी भविष्यवाणी (Flood Forecasting) सम्भव हुन जान्छ । ठूलठूला बाध (Dam) बनाउनुपर्ने अवस्थामा सम्भावित उच्चतम बाढी (Probable Maximum Flood) को लागि सम्भावित उच्चतम वर्षाको अध्ययन गर्नुपर्ने हुन्छ । जसबाट बाँधको समयावधि (Life Size) निर्धारण तथा Design तयार गर्न मद्दत पुग्छ । यसको बिस्तार अध्ययन नगरी ठूलठूला बाँध बनाएमा यसबाट पर्न सक्ने धनजनको क्षति अकल्पनीय हुनसक्छ । इ. स. १९९३ मा इन्द्र सरोवरमा २४ घण्टामा ६०० मिलिमिटर भन्दा बढी बर्षा भएको कारणबाट इन्द्र सरोवरको पानी परिवाह (Over Flow) हुनाको कारण खोलामा बाढी आउनाले कुलेखानी जलविद्युत आयोजनाको Pen-Stroke नै बिग्रेर करोडौँको क्षति भएको थियो ।

वर्षामा पनि वर्षाको तीव्रता (Intensity of Rainfall) जस्तो कि ५, १०, १५, ३०, ६० मिनेटमा के कस्तो वर्षाको प्रक्रिया छ सोहीबमोजिम ढल डिजाईन गर्नुपर्ने हुन्छ । ढल बनाउँदा त्यस क्षेत्रको ढलको घेराइ सानो र ठूलो गर्नुपर्ने अभियान्त्रिक कायदा (Engineering Technique) अपनाउनुपर्ने हुन्छ । त्यस्तै पुलको उचाई निर्धारण गर्न पुल बन्ने क्षेत्रमा क्षत्रीय वर्षा विश्लेषण (Aerial Rainfall Analysis)

गरी के कति उक्त स्थानमा पानीको वहाव प्रवाह (Runoff) हुन्छ, अधिकतम बहाब निर्धारण गरी पुलको उचाइ निर्धारण गर्नुपर्ने हुन्छ । पुलको उचाइ आवश्यकभन्दा बढी भएमा आर्थिक भार बढ्ने र उचाइ कम भएमा बाढीले बगाइ धनजनको क्षति भएको पाइन्छ ।

नेपालको कृषि प्रणाली वर्षामा निर्भर (Rain-fed condition) रहने भएकोले हावापानी (Climate) सुहाउँदो दुई तीन बाली लगाउनुमा सिँचाइको प्रमुख भूमिका हुन्छ । अहिले नेपालमा पूरक सिँचाई (Suplementary) मात्र सीमित भएको देखिन्छ । तर नेपालको कृषि क्षेत्रमा सही विकास गर्न प्राकृतिक स्रोत प्रणाली सुधार गदै सिँचाइको विकास गर्दै लैजानु आजको आवश्यकता हो । त्यस्तै सिँचाइको योजना तर्जुमा गर्न वर्षाको पूरा विवरण अध्ययन गरी वर्षाको तथ्याङ्कको आधारमा कहाँ कस्तो बालीनाली लगाउने हो योजनामा बनाउनुपर्छ । वर्षा राम्रो भएमा बालीनाली उत्पादन राम्रो हुने र राम्रो वर्षा नभएमा उत्पादनमा ह्रास आउने गर्दछ । नेपालको अन्नबालीको विकासमा छोटकरीमा भन्नुपर्दा गत वि. स. २०२९ देखि २०६९ (ई.सन् १९७०/७१ देखि २०१०/११) सम्मको धानबालीको उत्पादन र मनसुन वर्षा केलाएर हेर्दा वि. स. २०२९, २०३३, २०३६, २०३९, २०४३, २०४९, २०५१, २०५४, २०५६, २०५९, २०६३ र २०६६ उपरोक्त वर्षहरूमा नेपालमा सामान्य मनसुन वर्षा भन्दा कम वर्षा हुँदा धानबालीमा मात्र केकति नोक्सान भयो भनी हेर्दा वर्षमा रू पाँच अर्बभन्दा बढी नोक्सान भएको देखिन्छ । यसमा जल तथा मौसम विज्ञान विभाग र कृषि विभागले गहन अध्ययन गरी सोसम्बन्धी सेवा दिन सके १० प्रतिशत मात्र अन्नबाली कम हुनबाट बचावट भएमा करिब रु ५० करोड बचत हुनजान्छ । (Nayava, 2008)

## आर्द्रता

हावापानीको सूचकमा आर्द्रता पनि एक महत्वपूर्ण मानिन्छ जसले जलवाष्पको मात्रा के-कति छ भन्ने जनाउँदछ । त्यसैको आधारमा वायुमण्डल के-कति सुख्खा वा ओसिलो छ भनी निर्क्यौल गर्ने गरिन्छ । आर्द्रताले तापक्रमसँग घनिष्ट सम्बन्ध राख्दछ भने आर्द्रताको मात्रा ज्यादै नै घटबढ भएमा त्यसले दैनिक जीवनमा प्रत्यक्ष प्रभाव पार्दछ । गर्मीको समयमा हावामा आर्द्रता ज्यादा हुन गएमा पसिना बढी आउने तथा आर्द्रता कम भएमा पसिना सुक्ने हुन्छ । साथै पसिना आउँने प्रक्रियाले गर्मीको समयमा शरीरलाई चिसो बनाई तापक्रम नियन्त्रण राख्न मद्दत गर्दछ । गर्मीको समयमा हावामा आर्द्रता ज्यादा भए पसिना बाफ भनेर उडन सक्दैन र शरिरले आवश्यक तापक्रम बनाइ राख्न बढी मिहिनेत गर्नुपर्ने हुनाले हामिहरू वास्तविक तापक्रमभन्दा बढी तापक्रम महशुस गर्ने गर्दछौ । यस्तो अवस्था हावामा धुलो वा अन्य कणहरूमा बढोत्तरी हुने भएकोले दम या छातिको रोगलाई अझ जटिल बनाउँदछ ।

साधारणतया आर्द्रता बिहानको समयमा बढी हुन्छ भने दिउँसोको समयमा सबभन्दा कम हुने हुन्छ । हिउँदको समयमा हुस्सु वा कुहिरो लागेको वखत आर्द्रता बढी हुने हुन्छ । वर्षा हुने क्रममा वायुमण्डलमा आर्द्रता बढ्न जाने हुदा मनसुनको आगमनसँगै आर्द्रताको मात्रा पनि बढदछ तर तापक्रम केही घटछ (Riehl, 1971) । वायुमण्डलमा आर्द्रताको मात्रा बढनु भनेको जलवाष्फहरूको मात्रा बढ्नु पनि हो । मानव जीवनको साथै बोटबिरूवाका लागि पनि वायुमण्डलमा आवश्यक मात्रामा आर्द्रता हुन जरूरी छ । आर्द्रताको मात्रा ज्यादै घटबढ हुँदा यसले बोटबिरूवालाई प्रत्यक्ष असर गर्दछ । बोटबिरूवाको प्रकृतिअनुसार पनि आर्द्रताको आवश्यकता घटबढ हुने हुन्छ । भण्डारण गरिएका बालीनालीहरूमा आर्द्रताले प्रत्यक्ष प्रभाव पार्दछ । हिउँदको समयमा तराई क्षेत्रमा लाग्ने गरेको शितलहर र बाक्लो हुस्सुले आर्द्रता बढन जाँदा अनाजहरू कुहिन जाने सम्भावना रहन्छ । यही कारण अन्नको भण्डारको रूपमा परिचित तराइ प्रत्येक बर्ष शीतलहर र बाक्लो हुस्सुको समस्याले खाद्य सुरक्षामा नै सङ्कट पैदा भएको छ ।

## तापक्रम

पृथ्वीको सतहमा प्राप्त हुने झन्डै सबै ताप सूर्यबाट प्राप्त हुन्छ । २४ घण्टामा दिउँसोको समयमा अधिक तापक्रम हुने गर्दछ भने रातको समयमा वा खास गरी बिहानीपख न्यून तापक्रम हुने गर्दछ । तापक्रमबाट कुनै एक स्थानमा कति जाडो र गर्मी हुनुका साथै कुन तापक्रममा कहाँ के-कति कृषिजन्य बालीनाली उत्पादन गर्न सकिने लेखाजोखा गर्न सकिन्छ । नेपालको भौगोलिक बनावटअनुसार तराई, पहाड र हिमाल आदि क्षेत्रहरूमा तापक्रमलाई ध्यानमा राखेर हावापानी अनुकुल मिल्ने गरी कृषि अनुसन्धान परिषदको अध्ययनबाट बीउ विकास गरी प्रयोगमा ल्याइएको छ । त्यस्तै हवाई उडानमा खासगरी उडान, अवतरण र उडानपथमा तापक्रमले प्रभाव पारेको हुन्छ । तापक्रम वृद्धि हुँदा घनत्व कम हुने भएकोले यस्तो अवस्थामा उडान हुने जहाजमा लोड घटाउनुपर्ने हुन जान्छ अन्यथा बढी लम्बाईको धावनमार्गको आवश्यक पर्दछ । त्यस्तैगरी नेपालका प्रमुख एवं अधिकांश नदीनाला हिउँमा आधारित (Snowfed river) भएको हुँदा तापक्रमको मुख्य भूमिका हुन्छ साथै जल विद्युत उत्पादनमा तापक्रम वृद्धिको अहंम भूमिका रहन्छ । त्यस्तै जनसाधारणका लागि दैनिक जीवनदेखि विकास निर्माणको क्रममा समेत तापक्रमको उत्तिकै भूमिका रहन्छ । उदाहरणका लागि सडक निर्माणमा अलकत्रा ओछ्याउने कि नओछ्याउनेसम्मजस्ता विषय पनि तापक्रममा आधारित रहन्छ ।

## घामको अवधि तथा सौर्य शक्ति

कुनै पनि बोटबिरूवालाई निश्चित समयमा घामको आवश्यकता पर्दछ । अन्नबाली पाक्ने समयमा पर्याप्त घाम भएमा बाली राम्रोसँग सप्रन्छ । पर्याप्त घाम नभएमा वा घाम ज्यादा भएमा बोटबिरूवाले राम्रो उत्पादन दिन सक्दैन । विद्युत उर्जा उत्पादनमा घाम शक्तिलाई वैकल्पिक शक्ति (Alternative Energy) को रूपमा लिइएको छ । परिणामस्वरूप घाम शक्तिबाट घर

घरमा उर्जा अभियान जोडतोडका साथ चलिरहेको छ । तर यसका लागि घाममा अवस्था हेरी कति सूर्य शक्ति उत्पन्न हुने सक्छ भन्ने अध्ययन जरूरी भएको देखिन्छ ।

आजको विश्व भुमण्डलीय तापमान वृद्धि तथा जलवायु परिवर्तनले आक्रान्त छ । नेपाल पनि यसको चपेटाबाट अलग छैन । नेपालमा सरदर प्रतिवर्ष ०.०४७६ डिग्री सेल्सियसका दरले तापक्रम बढ्दै गएको वैज्ञानिक अध्ययनले देखाएको छ (जल तथा मौसम विज्ञान विभाग, २०७१) जन सबै ठाउँमा एकनासको छैन । पहाडमा खासगरी १५०० देखि २००० मिटरमा तापक्रम सामान्य भन्दा निकै वृद्धि भएको तर सोभन्दा माथि तापक्रम वृद्धिदर कम हुनु एक अनुसन्धानको विषय बनेको छ । तापक्रम वृद्धिको कारणले केही वर्षको अन्तरालमा उच्च हिमाली क्षेत्रबाट हिउँ पग्ली हिउँको भण्डार नै सकिने भन्ने भयाभह स्थितिको आँकलन समेत गरिएको छ । पछिल्लो दशकमा देशका धेरै स्थानमा अधिकतम तापक्रम अहिलेसम्मको उच्च मापन गरिएको छ । सबैजसो ऋतुहरूमा तातोपन बढिरहेको र खासगरी हिउँदमा यो दर अन्य ऋतुको तुलनामा बढी भएको र अधिकांश दिन रात न्यानो भइरहेको छ भने चिसो दिन तथा रातहरूको सङ्ख्यामा कमी आइरहेको छ (जल तथा मौसम विज्ञान विभाग, २०७१) । यसरी तापक्रममा आएको वृद्धिले हावापानीका अन्य सूचकहरूमा समेत उतारचढावको स्थिति देखापरेको छ भने वर्षाको प्रकृति समेत फरक भएको छ । भारी वर्षाका घटनाहरू वृद्धि हुनु र वर्षाको दिनहरू क्रमशः घट्दै जानु चिन्ताको विषय भएको छ । देशको अन्य भूभागभन्दा खासगरी पश्चिम नेपाल पटक-पटक खडेरीको मारमा पर्नुले भविष्यको चिन्ता र चासो बढाइ दिएको छ । यस अवस्थामा जलवायु परिवर्तनको मारबाट जीवनयापन सहज बनाउन कृषि र जलस्रोतको समुचित उपयोगको निति अवलम्वन गर्न हावापानीको तथ्याङ्क सङ्कलन र विश्लेषणले महत्वपूर्ण भूमिका खेल्दछ ।

जलवायु परिवर्तनलाई मध्यनजर राख्दै जल तथा मौसमसँग जोडिएको विविध विषयहरूमा सही र प्रभावकारी सेवा प्रवाह गर्न जल तथा मौसम विज्ञान विभागले विश्व बैङ्कको सहयोगमा तीन अर्बको लागतको Building Resilence to Climate- Related Hazards-BRCH नामक पञ्चवर्षीय परियोजन कार्यान्वयनमा ल्याएको छ । उक्त परियोजन कार्यान्वयनको सिलसिलामा हावापानी विज्ञानको विकासको क्रम राज्यको तल्लो तहसम्म पुगि जनता बढीभन्दा बढी लाभान्वित हुन सके मात्र यसको उपादयेता प्रष्ट हुन जान्छ ।

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**डा. जनकलाल नायवा श्रेष्ठ** राष्ट्रिय तथा अन्तर्राष्ट्रिय स्तरमा गरी करिब पाँच दशकदेखि मौसम विज्ञानमा दखल राख्नुहुने नेपालका एक अग्रज लेखक तथा हावापानी विषयका वैज्ञानिक हुनुहुन्छ । उहाँ तत्कालिन श्री ५ को सरकार अन्तर्गत जल तथा मौसम विज्ञान विभागको सेवा सुरू गर्ने एक संस्थापक सदस्य समेत हुनुहुन्छ । उहाँले सन १९६७ मा मौसम विज्ञानमा post graduate उपाधि हासिल गर्नुभई सोही वर्ष तत्कालीन जलस्रोत तथा जलवायु विज्ञान विभागबाट सेवा शुरू गर्नुभएको हो । राष्ट्रिय तथा अन्तर्राष्ट्रिय स्तरमा उहाँका हावापानी विज्ञान विषयका विभिन्न अनुसन्धानमुलक लेख तथा कृतिहरू Scientific Journal मा प्रकाशित हुँदै आइरहेका छन् । उहाँले The University of Birmingham बेलायतबाट सन् १९७४ मा Meteorology and Climatology विषयमा स्नातकोत्तर उपाधि हासिल गरी The Australian National University अष्ट्रेलियाबाट सन् १९८२ मा The Climates of Nepal and their implications for Agricultural Development विषयमा विद्यावारिधीसमेत गर्नुभएको छ । जल तथा मौसमविद् समाज-नेपालको अध्यक्षसमेत सम्हालिसक्नुभएका उहाँ हाल स्वतन्त्र अनुसन्धानकर्ताको रूपमा सक्रिय हुनुहुन्छ ।

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**सुमन कुमार रेग्मी** जल तथा मौसम विज्ञान विभागमा वरिष्ठ मौसमविद्को रूपमा कार्यरत हुनुहुन्छ । उहाँ जल तथा मौसमविद् समाज नेपालको वर्तमान महासचिव समेत हुनुहुन्छ । विगत दुई दशक देखि मौसम विश्लेषण तथा पूर्वानुमानमा विशेष दखल राख्नुहुने उहाँ नेपालको गणितिय मौसम पूर्वानुमान गतिविधि सुरू गर्ने एक हस्तीसमेत हुनहुन्छ। उहाँले त्रिभुवन विश्वविद्यालयबाट मौसम विज्ञानमा स्नातकोत्तर उपाधि हासिल गर्नु भएको छ। राष्ट्रिय तथा अन्तर्राष्ट्रिय क्षेत्रमा उहाँका लेखहरू निरन्तर रूपमा प्रकाशित हुँदै आइरहेका छन् ।

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# Citizen Science in Assessing Ecosystem Services:

## A Study from Upper Mustang, Nepal

Prem Sagar Chapagain, PhD

### Introduction

An ecosystem is a dynamic complex that integrates both human and ecological systems together, having of plant, animal, and microorganism communities and the nonliving environment. These all interact together as a functional unit. Humans are an integral part of ecosystems and get various resources and services for their livelihood and well-being. Ecosystems provide a variety of benefits to people. Ecosystem services are the various products and services that benefits people obtain from ecosystems. There are four broader types of such services, i.e. provisioning services, regulating services, supporting services, and cultural services. The provisioning services include food and water; regulating services include regulation of floods, drought, land degradation, and disease; supporting services include soil formation and nutrient cycling; and cultural services include recreational, spiritual, religious and other nonmaterial benefits (MEA, 2005).

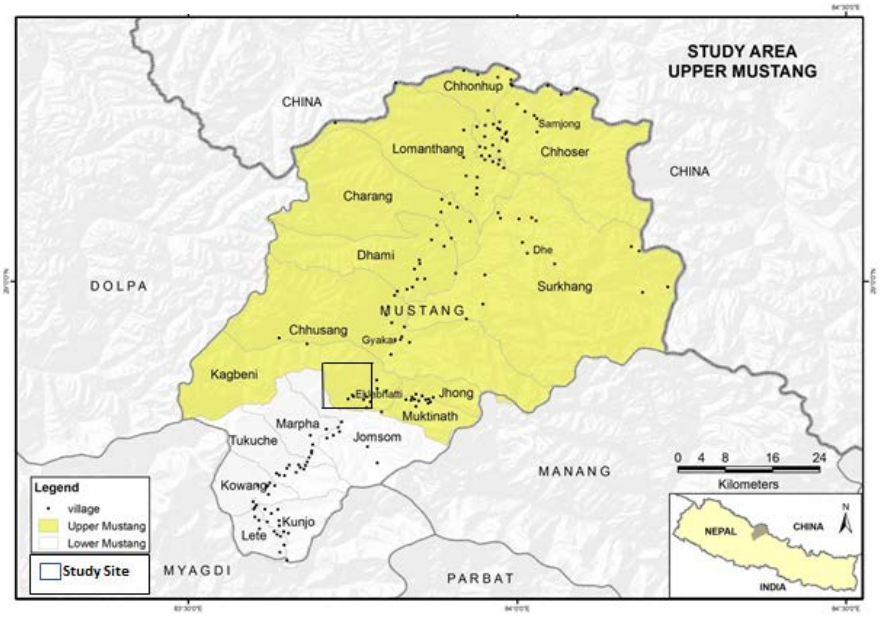


Figure 1: Study Sites

*Source: Chapagain (2012)*

Mustang is one of the 75 districts of Nepal located in the trans-Himalayan region. Local livelihoods of the people have been depended upon different ecosystem services. The water, agricultural land, and pastoral land were reminded as the major ecosystem services of the region upon which local livelihood were depended. The access, ownership and utilization of those resources determined households' socio-economic situation. However, mountain communities

get connected with the outside world over the time and thereby different sorts of ecosystem services get importance. In the case of the Mustang, the natural landscape and rich culture heritage of the region attracted a large number of trekkers in the region and it has become an important source of livelihood. So local people also change their interest in valuing and utilizing those resources over the time. The changes in the interest of the local people have not only governed by income, but also by other several factors, primarily by the climate variability that affects the availability of water for irrigation.

For broader understanding the changing scenario of the ecosystem services it is important to engage with local people for assessing the ESS in an integrated way so that citizen's science can be incorporated in research and policy making. Citizen science refers to the participation and collaboration of local people in scientific research. Such participation helps in better coordination with local people in data collection, monitoring and sharing the idea that local people might have already collected or known (<http://education.nationalgeographic.org/encyclopedia/citizen-science/> 11 April 2016 accessed). It is an engagement of non-scientist in scientific research. Involvement of community highly contributes, collaborate and co-create knowledge that provides ample opportunity to researchers and policy makers to engage with different interest and opinions of the community (Buytaert, 2014; Hollow, et.al., 2015). The ongoing research on ecosystem services and its role in improving livelihoods in the Mustang is a part of the research project that SoHAM Nepal has been undertaken in collaboration with Imperial College London and Birmingham University UK. Mustang in Nepal is one of the four study sites. The other research sites are in Peru, Ethiopia and Kirgizstan.

## Study area, Methods and materials

Mustang district is located in the north-western part of Nepal (Figure 1). It is located behind the Annapurna Mountain Range that block Monsoon. Thus, mustang has dry climate having less than 200mm annual rainfall. The study village lies from 3000 to 3300 meters above mean sea level. Agricultural and livestock rearing is the major livelihood. People grow limited crops such as potato, barley, wheat, and buckwheat together of rearing cow, goat and yak. As it the rain shadow region, irrigation water is the lifeline for agricultural production.

The study is emphasized on citizen science approach in data collection in which local community are involved from the right beginning of the project for selecting research sites, selection and installation of water flow monitoring stations, and installation of whether station. Furthermore, data on ESS are collection with household survey, focus group discussion, and key informants interviews. Detail household survey was carried out in 2014 in Dhakarjong and Phalyak villages of Kagbeni VDC where 36 household were surveyed. A detail data on farming system and water demand and supply has been collected and analyzed. It has also explored the changing emphasis on selection crops and their changing focus to other ESS and changing focus to the available livelihood opportunity. Attention has given on discovering and understanding the local knowledge on changing

Figure 2: Local people assessing and mapping the ESS

scenario of ESS particularly water availability situation and local peoples' interpretation behind it. Furthermore, data on the changing situation of precipitation, water availability and its impact are also collected using focus group discussions, key informants interview. Four FGD were conducted involving Mukhiyas, village men and women, village leaders, farmers, local entrepreneurs. Mukhiya is the traditional village leader selected by villagers. It is a strong institution that maintains traditional rules and regulations of managing ESS including water in the villages.

## Major Ecosystem Services in the study Area

### Water

Water is a lifeline. Water is a critical factor in Mustang as it is the rain shadow area and gets least precipitation. Without water, no agricultural is possible. The major source of water for irrigation and drinking to the study villages is Lumbak stream. Local people claim that about two decades ago there used to have a lot of snowfall that accumulates on the mountain and gradually melted and supplied water to the villages. Local people have experienced that the snow was remained on the ground for two to three weeks that provided moisture to agricultural and pastoral land.

Figure 3: Lumbak River, snow at mountain on November, 2015.

Water resource in Mustang has been gradually became scared due to climate change. The available water become a highly contested among individual, local communities and social group (NTNC, 2008). People claim that changes noticed since last two decades on amount, timing and frequency of precipitation. Precipitation either occurs earlier or later than the agricultural season. Importantly, the amount of precipitation has been decreasing and thus less accumulation of snow on the mountain where Lumbak River starts. The less snowfall on the water source results less water to the villages in the dry season (see figure 3). This decreasing amount of water affected agriculture system.

The available river water is divided to two villages in which Phalyak gets water for three days and two days by Dhakarjong in a rotational basis. The available water to each village is shared by farmers based on traditional Dhongba system. Initially, there were 22 Dhaongba in Dhakarjong and 24 in Phalyak who used to share the available water in the Lumbak River. One dhongba equals to 12 hours of water right. It is like a family that when family split the water right is also divided. Now, different households have different amount of dhongba. The farmers who have agricultural land far from the water storage pond is highly deprived as irrigation water takes time to reach to farmland and water leakage is high in sandy-gravel canal. This decreasing water availability has directly affected farming and cropping system. The major problem local people have been facing is that how much irrigation water is available and how much area can be irrigated with the available water. What can be the best options for utilizing the available water in an optimum way? To answer this question, the research team in collaboration with local people has installed a water flow monitoring equipment at Lumbak that automatically record the 24 hours flow data so that the amount of water at the source of stream in different seasons can be communicated to local people.

## Agricultural land and crops

Agriculture is the major livelihood source of people. They grow potato, barley, wheat and buckwheat. Agricultural land refers to khet in Mustang where kheti (cultivation) can be done. About two third of the farmers are large land holders who have more than one hectare of farm land. The medium size refers to land having half to one hectare and small holders refer less than half hectare land owner (Table 1).

The average holding and average cultivated area is different. Farmers have abandoned agricultural land primarily due to the shortage of irrigation water secondarily due to labor shortage and migration of the farming households.

One hectare equals to 19.65 ropani. A large land area previously cultivated has abandoned now (Figure 4). The people first abandoned the land away from the village and water storage pond and gradually coming closer towards the village as the water shortage increasing. The large land holder has relatively abandoned bigger area compared to medium and small holders (see Table 1). It has clearly seen that the stone and bush fence wall has gradually shifting closer towards the settlement. The increasing climate uncertainty on one hand and gradual development of local market and road access attracted local farmers towards alternatives crops. In addition, migration of youth reduces labor availability that also reinforce to less labor intensive crops. In this situation, farmers switch over to apple farming. Local perception of using agricultural land for growing cereals has been gradually motivated by available market opportunity. Local people have started looking after comparative advantages in the context of precipitation, temperature and labor variability. About one third of the total cultivated area has converted to apple within last ten years (Table 2, Figure 5).

Table 1: Land holding size by household (area in ropani)

| Farm size category | HH | Total land | Percent | Average holding size | Cultivated land | Barren land | Average Cultivated area /HH |
|---|---|---|---|---|---|---|---|
| Small | 13 | 71.7 | 10.01 | 5.52 | 69.64 | 2.05 | 5.36 |
| Medium | 11 | 184.5 | 25.76 | 16.77 | 168.76 | 15.7 | 15.34 |
| Large | 12 | 473 | 66.04 | 39.42 | 383.93 | 89.07 | 31.99 |
| Over all | 36 | 716.2 | 100 | 19.89 | 609.33 | 106.82 | 16.93 |

*Source: Field Survey, 2011-2013. Note: One hectare equals to 19.65 ropani.*

Table 2: Apple plantation area by farm category

| Farm size category | Total cultivated land | % agricultural land | % HH | Apple plantation area | % of apple plantation area |
|---|---|---|---|---|---|
| Small | 69,64 | 18 | 48 | 4.92 | 7.06 |
| Medium | 168,76 | 31 | 30 | 40.97 | 24.28 |
| Large | 383,93 | 51 | 22 | 147.1 | 38.31 |
| Total | 609,33 | 100 | 100 | 192.99 | 31.67 |

*Field survey, 2013/014*

It has clearly observed that large farm holders have planted apple on 38% of their land followed by 24 percent of medium holders. However, the small holder have planted apple only on 7 percent of their cultivated land and focused on producing cereal crops. As given in Table 2, there are about 50 household of small holders who have only about 20 percent land area. But there are about 20 percent households of the large farm holders who have 51 percent land area. Furthermore, most of the small holders live in the village. However, many large and medium size farm holders do not live in the village and thus leave many of their farm land with apple plantation and such plots are well faced with stone and mud wall in the village (Figure 5). This shows that the trend of apple plantation will increase as large and medium land holders are motivated for it and they also have land area.

## Landscape, culture and tourism

Mustang has a unique trans-Himalayan landscape. It has arid cold climate. The beautiful valley along the Kaligandaki River and its tributaries in Mustang has small patches of agriculture land where local people are settled with their traditional houses and culture. The Buddhist people have rich cultural heritage, monasteries and gumbas. The beautiful high mountain such as Dhaulagiri, Nilgiri, and Tilicho are on the southern side present amazing natural beauty that attracts tourists.

The Lower Mustang is along the Annapurna trekking route which is one of the famous trekking routes in the world. After opening the Annapurna Conservation Area in 1984, the number of tourist has gradually increased in the route. For instance, about 14000 tourists were visited in 1980 in Annapurna region that increased to 36000 in 1990, 75000 in 2000. After 2000, the flow has decreased but again increased from 2006 and reached to 113000 in 2013 (Table 3).

Unlike Lower Mustang, tourist requires special permission for Upper Manang. The permission fee is also comparatively high but tourists flow to upper Mustang has been also gradually increasing. This increasing flow of tourists has provided alternative livelihood opportunities there too. The people along major trekking route and settlements in the lower Mustang have primarily focused on tourism business and services and valued it compared to their traditional livelihood bases. Tourist mainly visit in March-April and Sept-October seasons during the time major agricultural activities such as sowing, weeding irrigation and harvesting take place. Male members more focused to tourism services while female with outside labor take care of farming. Like in the adjoining Upper Manang Valley, It is common in Mustang also (Chapagain, 2008).

Figure 5: Apple plantation area with stone and mud wall fance in Phalyak

Figure 4: Abandoned agriculture land, Nilgiri, Tilicho mt in the South

Table 3: Number of trekkers in Annapurna, Manang and Jomsom

| Year | Total tourist to Nepal | No of tourist to Annapurna-Manang | No of tourist to Upper Mustang * | % of total to Lower Mustang-Manang |
|---|---|---|---|---|
| 1980 | 162,897 | 14,332 | | 8.8 |
| 1990 | 254,885 | 36,361 | | 14.3 |
| 2000 | 463,646 | 76,407 | | 16.5 |
| 2005 | 375,398 | 36,224 | 661 | 9.6 |
| 2010 | 602,867 | 74,161 | 2162 | 12.3 |
| 2011 | 736,215 | 85,314 | 2950 | 11.6 |
| 2012 | 803,092 | 102,570 | 2965 | 12.8 |
| 2013 | 797,616 | 113213 | 2862 | 14.2 |
| 2014 | 790118 | | 3883 | |

*Source: MCTCV, 2006, 2010, 2011, 2013, 2014*, 2015.*

Many things have motivated local people to switch their interest towards new crops and emerging tourism opportunity. The labor intensive nature of traditional farming, constrains of growing limited crops, migration of youths and well-off households to cities, development of road access to cities in the southern hills are noticed as the major stress to their livelihood. Importantly, the variability in precipitation time and amount poses major constraints on water availability for irrigation that poses major challenge in farming. However, at the same time many livelihood opportunities observed there. Less labor intensive but more income generating crops i.e. apple, vegetables have now started to grow. These crops especially apple has possible to grow with less water compared to cereal. The development of road make easy to transport agricultural products to cities. More importantly, the whole region has become popular tourist destination so that local people get opportunity to involve on it directly or indirectly.

## Conclusion

Mustang is trans-Himalayan district. It has harsh climate and poor accessibility where majority of the local people still depend on agriculture for their livelihood. The recent climate change, as observed and experienced by local people, imposes stress as the amount and timing of precipitation decreased and thus decreased the water for irrigation. Irrigation is the lifeline without which no crops can be grown. In addition to climatic stress, migration of youth and their increasing interest to off-farm activities threats the traditional livelihood activities as it was. The major ESS people valued in the past were water, agricultural land and pasture land. These ESS are still important but the comparative preference has been gradually shifting as number of livestock has drastically decreased. Preference in growing crops has changed from cereal to cash crops i.e. apple and vegetables. Importantly, the upcoming tourism opportunity has highly preferred and local people have participated on it with their labor, products and services.

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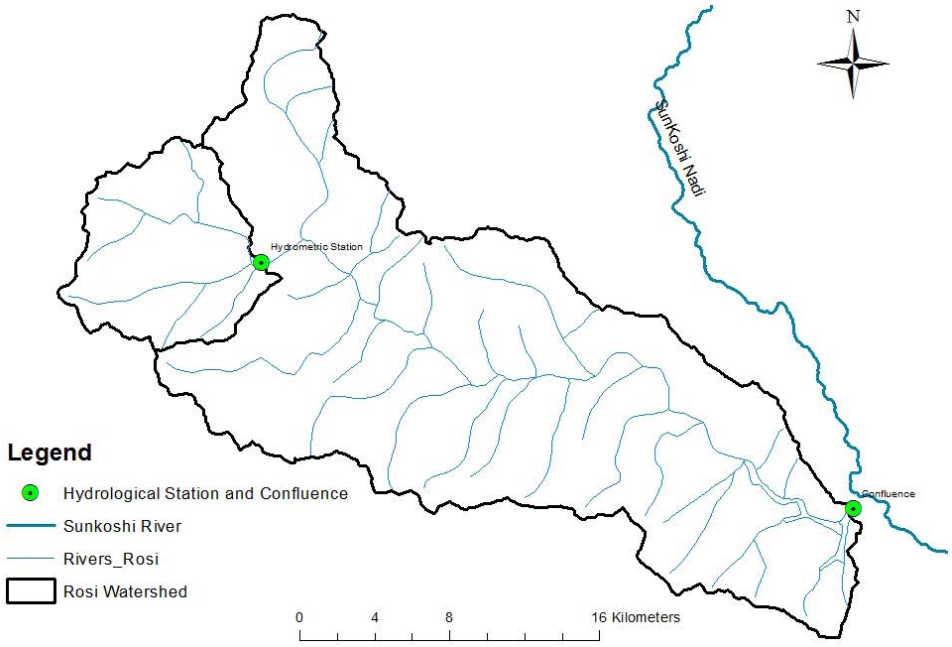
# रोशी जलाधार क्षेत्रः
## एक स्थलगत सर्वेक्षण

नारायण गौतम




चित्र नं १: रोशी जलाधार क्षेत्र तथा यसको अन्य नदी प्रणाली

### पृष्ठभूमि

काठमाडौँबाट करिब ३५ किलोमिटर दक्षिण–पूर्व मध्यपहाडी क्षेत्रबाट सुरू हुने रोशी जलाधार एक महत्वपूर्ण नदी क्षेत्रअन्तर्गत पर्छ । यस नदी क्षेत्रबाट जलविद्युत उत्पादन, खानेपानी व्यवस्थापन, सिँचाइ तथा रिक्रेशनसम्बन्धी कार्यहरू हुँदै आइराखेको पाइन्छ ।

पहाडी क्षेत्रबाट उत्पन्न रोशी खोला सिन्धुली दुम्जास्थित सुनकोशी नदीमा गएर मिसिन्छ तथा उक्त स्थानबाट हेर्दा रोशी जलाधार क्षेत्र करिब ४६६ वर्ग कि. मि. फैलिएको पाइन्छ । रोशी खोलाको माथिल्लो क्षेत्र खोपासीमा पनौती हाइड्रोपावर सञ्चालित छ । वि. सं. २०२२ मा निर्मित यो हाइड्रोपावर देशकै पुरानो भएको तथा यसको पूर्ण क्षमता २.४ मेघावाट रहेको छ ।

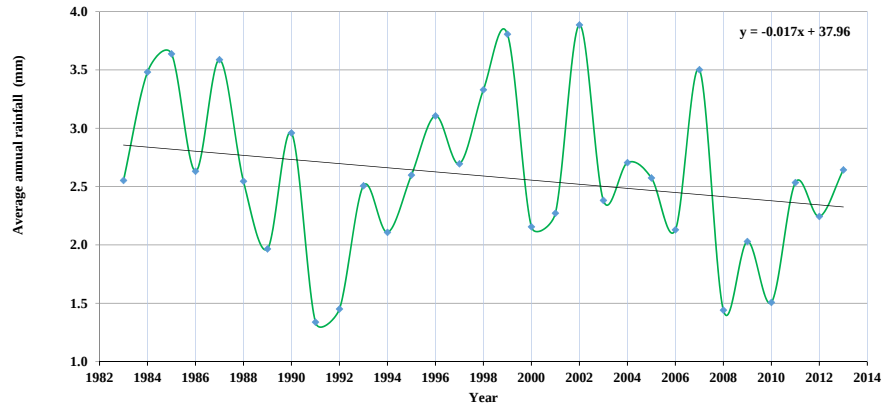
राजधानीबाट नजिकको नदी क्षेत्र भएको एवं स्थानिय जल तथा वातावरणिय अवस्थाहरू के कस्तो हुनसक्छ भन्ने जिज्ञासाका साथ यस पंक्तिकारले रोशी जलाधार क्षेत्र अर्न्तगत काभ्रे, पनौती तथा सिन्धुली, नेपालथोकमा स्थलगत सर्वेक्षण सम्पन्न गरेको थियो । उक्त कार्य मिति २०७२ माघ ३-७ सम्ममा सम्पन्न भएको तथा यो लेख मूलतः सोही स्थलगत कार्यानुभवमा आधारित भई तयार पारिएको हो ।

स्थलगत अध्ययनमा विभिन्न समयमा हुने पानी बहाबको स्थिति, स्थलगत सर्वेक्षण, पानीको तापक्रम, हावाको गति निरीक्षण लगायतका कार्यहरू गरिएको थियो । यी कार्यहरू सम्पन्न गर्न विभिन्न प्रकारका उपकरणहरू जस्तै Current meters, Theodolites, Anemometers तथा Thermometers प्रयोग गरिएका थिए ।

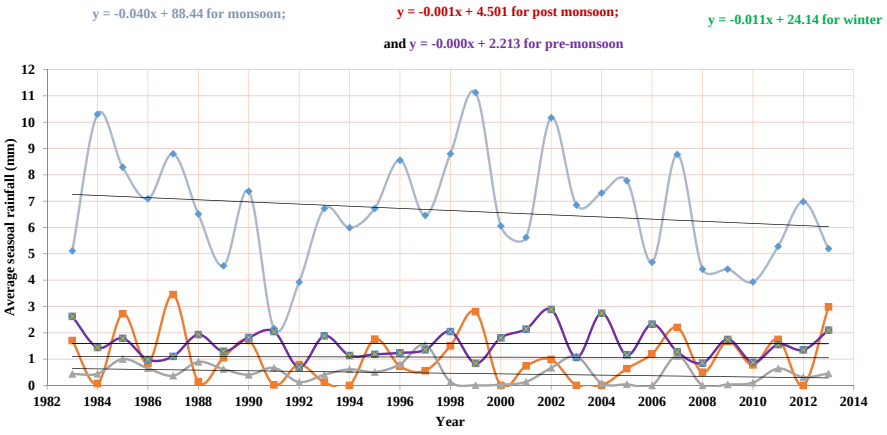
### जल तथा वर्षासम्बन्धी तथ्याङ्कीय विश्लेषण

उक्त अध्ययनका क्रममा रोशी खोलाको बहाब करिब २.५ क्युबिक मिटर प्रतिसेकेन्ड पाइएको थियो भने खोलाको पानीको तापक्रम ११-१७ डिग्री सेन्टिग्रेड पाइयो ।

चित्र नं २: सिन्धुली नेपालथोकस्थित रोशी जलाधार क्षेत्र




चित्र नं ३: सिन्धुली नेपालथोकस्थित वर्षाको वार्षिक प्रवृति




चित्र नं ४: नेपालथोकस्थित वर्षाको मनसुन, पोष्ट मनसुन, हिउँद तथा प्रि–मनसुन प्रवृति

यसै सन्दर्भ स्थलगत कार्य गरेको स्थान नेपालथोकबाट प्राप्त वर्षाको ३१ वर्षको मौसमी तथ्याङ्क पनि विश्लेषण गरिएको छ । जसअर्न्तगत वार्षिक, मनसुन, पोष्ट मनसुन, हिउँद तथा प्रि-मनसुन रहेका छन् । यी नै तथ्याङ्कहरूबाट प्राप्त तस्विरीय प्रस्तुतीहरू चित्र नं ३ तथा ४ मा देखाइएको छ । उपरोक्त प्रस्तुतिहरूको विश्लेषणले उक्त स्थानमा सम्पूर्ण पाँचवटै ऋतुहरूमा हाल वर्षाको स्थिति घट्दो क्रममा रहेको पाइयो । चित्र नं ४ मा देखाइएबमोजिम उक्त जलाधार क्षेत्रमा मनसुनी वर्षाको योगदान अत्यन्त महत्वपूर्ण देखिन्छ ।

चित्र नं ५ मा पनौतीस्थित रोशी खोला बहाबको वार्षिक प्रवृत्ति तथा सन् १९८३ देखि १९८७ सम्मको वार्षिक वर्षाको प्रवृत्ति एकैसाथ दर्शाइएको छ । जल तथा मौसम विज्ञान विभागबाट प्राप्त तथ्याङ्कमा आधारित उक्त नदी बहाबको प्रवृत्ति घट्दो क्रममा रहेको पाइयो भने छोटो अवधिको भए तापनि वार्षिक वर्षा तथा नदी बहाबको प्रवृत्ति एक-आपसमा सम्बन्धित रहेको देखिन्छ ।

## जलवायु एवं वातावरणसम्बन्धी स्थानीय भावना

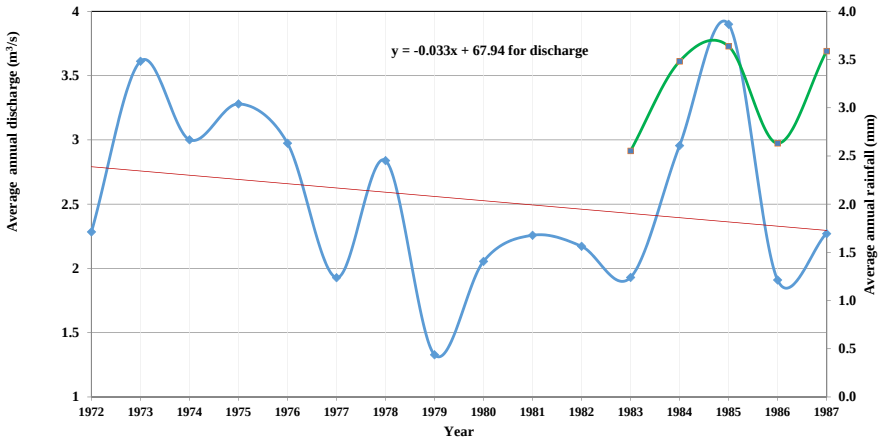
स्थलगत सर्वेक्षणमा नेपालथोकमा रहनुभएका स्थानीय बासिन्दासँग जलवायु एवं वातावरणसम्बन्धी संक्षिप्त अर्न्तक्रिया पनि भएको थियो । उक्त अर्न्तक्रिया तीन खण्डमा विभाजन गरिएको थियो । जसअर्न्तगत युवा समूह (अधिकतम १५ वर्ष), महिला समूह (अधिकतम ५१ वर्ष) तथा जेष्ठ नागरिक समूह (अधिकतम ७६ वर्ष) का स्थानीय बासिन्दाहरू सहभागी भएका थिए । स्थानीय बासिन्दासँग सोधिएका प्रश्नहरू तथा उहाँहरूबाट व्यक्त भावनाको सारसंक्षेप जस्ताको त्यस्तै यस लेखअन्तर्गत तालिका नं १ मा समावेश गरिएको छ ।

तालिका नं १ : स्थानिय वासिन्दासंग गरिएका प्रश्न–उत्तरको निचोड

| प्रश्न | युवा समुह | महिला समुह | जेष्ठ नागरिक समुह |
|---|---|---|---|
| तपाईंहरूको विचारमा यो स्थानको जलवायु कस्तो रहेको छ ? | "पहिलेको तुलनामा गर्मी बढेको तथा लामखुट्टे बढेको पाइन्छ ।" | "पहिलेको तुलनामा जाडो कम भएको महशुस भइराखेको छ ।" | "अचेल गर्मीमा बढी सास्ती पाइन्छ ।" |
| पहिलेको तुलनामा अहिले यहाँको वातावरणीय अवस्था के-कस्तो रहेको छ ? | "पहिलेको तुलनामा अहिले वातावरणीय प्रदूषणको साथसाथै चेतना पनि बढेको देखिन्छ ।" | "वातावरणीय प्रदूषणले बालीनालीमा असर पारेको जस्तो लाग्छ ।" | "प्लास्टिकजन्य पदार्थ तथा चाउचाउका खोलले वातावरणीय प्रदूषण बढाएको देखिन्छ ।" |
| विगत र वर्तमानमा कृषि उत्पादनको अवस्था क-कस्तो रहेको छ ? | "खासै राम्रो ष्पभब नभएता पनि अहिले विभिन्न प्रकारका बालीनालीहरू उत्पादन भएको देखिन्छ ।" | "पहिलेको तुलनामा अहिले उत्पादनमा सुधार आएको देखिन्छ । यसपाली केराउ खेती पनि गरियो । यसको उत्पादन के-कस्तो हुन्छ त्यो हेर्न बाँकी नै छ ।" | "विगतको तुलनामा अहिले खेतीपातीमा विविधीकरण भएको देखिन्छ ।" |
| माथि उल्लेखित विषयवस्तुबाहेक तपाईंहरूको भन्नु केही छ कि ? | "तपाईंहरूको अध्ययनले केही सकारात्मक निचोड निकालोस् भन्ने हामीलाई लाग्दछ ।" | "पहिले रोशी खोलाको पानी खाइन्थ्यो । हाल घरघरमा पानीको धारा छ । रोशीमा पानी दिनमा तथा रातमा घटबढ भइराखेको हुन्छ ।" | "जापानले बनाइदिएको रोडको अलावा अन्य कुराहरू हामी आफैं गर्न अग्रसर हुनुपर्‍यो । हाम्रो बसोबासमा भूकम्पले नराम्रो असर पार्‍यो । राज्यतहबाट नेपालीको स्तर गुन्द्रुक ढिँडो खाने अवस्थाबाट माथि उठ्ने कार्यक्रमहरू ल्याउनुपर्‍यो ।" |

## निष्कर्ष

नेपालथोकमा रहेको वर्षामापन केन्द्रबाट प्राप्त सन् १९८३ देखि २०१३ सम्मको विभिन्न ऋतुहरूको वर्षाको विश्लेषण गर्दा घट्दो क्रममा पाइयो । त्यसैगरी पनौतीस्थित जलमापन केन्द्रबाट प्राप्त सन् १९७२ देखि १९८७ सम्मको नदी बहाबको प्रवृत्ति हेर्दा घट्दो क्रममा रहेको पाइयो । यी दुवै विश्लेषणबाट उक्त जलाधार क्षेत्रमा वार्षिक वर्षा हुने परिमाण घट्दै गएको पाइन्छ । यद्यपि यी तथ्याङ्कीय आँकडाका अलावा यस नदी क्षेत्रको अन्य मौसमी तथा वातावरणीय तथ्याङ्कहरू विश्लेषण गरी वर्षा र नदी बहाबको घट्दो क्रमका कारणहरू के-कस्ता हुनसक्छन् भन्ने बृहत अध्ययन गर्न जरूरी रहेको देखिन्छ ।




चित्र नं ५: पनौतीस्थित रोशी खोला वहाबको तथा वर्षाको वार्षिक प्रवृति

यस सर्वेक्षणअर्न्तगत युवा, महिला तथा जेष्ठ नागरिकहरूलाई छुट्टाछुट्टै समेटी गरिएको अर्न्तक्रियामार्फत सम्पूर्ण तहका स्थानीय बासिन्दाको भावना समेट्ने कोशिश गरिएको छ । स्थानीय बासिन्दासँग गरिएको अर्न्तक्रियाले विश्वव्यापी रूपमा फैलिएको गर्मीपन (warming) को असर यस क्षेत्रमा पनि परेको हुनसक्ने देखिन्छ । यद्यपि स्थानीय जलवायुको असर पनि विश्लेषण गर्नुपर्ने देखिन्छ । यस क्षेत्रमा पाइएको गर्मी तथा लामखुट्टे बढ्ने प्रवृत्ति गर्मीपनको नकारात्मक पक्षहरू हुन् भने परीक्षणको रूपमा लगाइएको केराउ खेती सफल भएमा सकारात्मक पक्ष हुनसक्ने देखिन्छ । समग्रमा जलवायु एवं जीविकोपार्जनसम्बन्धी स्थानीय चासोलाई यथासम्भव समेटी कार्यहरू अगाडि बढाउनु बढी सान्दर्भिक हुने देखिन्छ ।

**नारायण गौतम** त्रिभुवन विश्वविद्यालयअन्तर्गत त्रि-चन्द्र क्याम्पस मौसम विज्ञान विभागका प्रमुख हुनुहुन्छ । उहाँले त्रिभुवन विश्वविद्यालयबाट मौसम विज्ञानमा स्नातकोत्तर गर्नुभई रूर्की विश्वविद्यालय भारतबाट जल विज्ञानमा स्नातकोत्तर गर्नुभएको छ । जल तथा मौसम विज्ञान विषयमा थुप्रै लेखहरू प्रकाशित गर्नुभएका विज्ञ, उहाँ हाल विभिन्न वैज्ञानिक अन्वेषण कार्यमा व्यस्त हुनुहुन्छ ।

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# Things to do before, during and after flood

**Introduction**
A flood is an overflow of water that submerges land which is usually dry. It can happen on flat or low lying areas when water is supplied by rainfall or snowmelt more rapidly than it can either infiltrate or run off. Flooding may also occur as an overflow of water from water bodies, such as a river, lake.

The natural behavior of water is that it moves from higher ground to lower ground. It means if there is a higher ground adjacent a lower ground, the lower ground is a lot more likely to experience floods. Additionally, floods can develop in any place where rain falls. At the same time, any plain low-lying area adjacent a river, lake is also more likely to have floods anytime.

**Types of floods**
Some would like to see the causes of floods as types of floods but here, we shall look at three major flood types: Flash floods, Rapid on-set floods and Slow on-set floods.

**a) Flash floods**
It occurs within a very short time (2-6 hours, and sometimes within minutes) and is usually as a result of heavy rain, dam break or snow melt. Sometimes, intense rainfall from slow moving thunderstorms can cause it. Flash floods are the most destructive and can be fatal, as people are usually taken by surprise. There is usually no warning, no preparation and the impact can be very swift and devastating.

**b) Rapid on-set floods:**
Similar to flash floods, this type takes slightly longer to develop and the flood can last for a day or two only. It is also very destructive, but does not usually surprise people like Flash floods. With rapid on-set floods, people can quickly put a few things right and escape before it gets very bad.

**c) Slow on-set floods**
This kind is usually as a result of water bodies over flooding their banks. They tend to develop slowly and can last for days and weeks. They usually spread over many kilometers and occur more in flood plains such as low-lying areas.

**Benefit of floods**
Floods are dangerous, as they take life of several people and damage property. Again, there is also something good about floods, especially those that occur in flood plains and farm fields. Flood waters carry lots of nutrients that are deposited in the plains, which is an asset for agriculture. Hence, farmers like such soils as they are perfect for cultivating crops.

## Things to do before, during and after floods

Floods are natural disasters. Hence, it is important to think of them and prepare for them before they happen. Here are a few things to do before, during and after the floods.

### Before the floods

a. Know about your local relief centers and evacuation routes.
b. Keep emergency numbers and important information handy, as well as emergency supplies, kits, first aid items. These may include water, canned food, can opener, battery-operated radio, flashlight and protective clothing.
c. Fold and roll up anything onto higher ground (or upper floors of your home), including chemicals and medicines.
d. Make sure everything that is of importance is secured (jewelry, documents, pets, and other valuables).
e. Plant trees and shrubs and keep a lot of vegetation in your compound if you are in a low-lying area as that can control erosion and help soften the speed of the flowing water.

### During the floods:

a. Flash floods occur in a short spate of time. As soon as they start, be quick, keep safe and ensure that children and elderly are safe by leaving the house to a higher ground.
b. Turn off all electrical appliance, gas, heating and the like if there is a bit of time.
c. Leave the area before it gets too late. Do not drive through the water as moving water can sweep you away.
e. Stay away from power lines or broken power transmission cables.
f. Try to keep away from flood water as it may contain chemicals or other hazardous materials.

### After the floods:

a. Make sure you have permission from emergency officers to get back inside your house.
b. Keep all power and electrical appliance off until the house is cleaned up properly and an electrical personnel has confirmed that it is OK to put them on.
c. Make sure you have photographs, or a record of all the damage, as it may be needed for insurance claims.
d. Clean the entire home, together with all the objects in it very well before you use them again. They may be contaminated.
e. Wear appropriate gear (mask and gloves) before cleaning begins.

Source : http://eschooltoday.com/natural-disasters/floods/types-of-floods.html

*Contribution: SOHAM Desk*

# Current Status of Community Based Flood

## Early Warning Systems in Nepal

Gehendra Gurung
Sumit Dugar

### Flood Risk in Nepal

Flooding in river basins of Nepal is primarily influenced by the monsoon (NCVST, 2009) which lasts from June to September. Analyzing the historical records made available by the Department of Hydrology and Meteorology (DHM) it indicates that about 80% of total river flow occurs during the monsoon season (Gautam and Dulal, 2013). The South Asian monsoon also dipicts that about 80% of annual rainfall in average occurs during monsoon season (ICIMOD, 2014), which has high variation across East, Central and West Nepal in magnitude, duration and intensity at macro and micro scales across the country (NCVST, 2009).

In Nepal, past flood events include the destructive 1993 Central Nepal floods (NCVST, 2009), the Koshi embankment breach in 2008 (Dixit, 2009), the 2009 floods in Far-West Nepal and the 2013 Mahakali catastrophe (Paudel et al., 2013) that caused massive loss in livelihoods of people residing in the Terai plains. In the Karnali basin, significant floods have occurred in 1983, 2009, 2013, and in 2014(Zurich, 2015).

The peak monsoon discharge of rivers can be greater than a factor of hundred or even thousand as compared to low winter flows as indicated by the datasets provided by DHM. For example, monsoon discharge for Karnali during floods that triggers warning is around 10,000 m3/sec, whereas winter discharge is usually below 500 m3/sec (Zurich, 2015). Similarly, for rain-fed rivers such as the West-Rapti the peak monsoon discharge is around 8,000 m3/sec whilst the winter discharge is around 11 m3/sec.

### Community Based Early Warning System (CBEWS)

According to UNISDR, early warning system is a set of capacity needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organisations threatened by hazards to take necessary preparedness measures and act appropriately in a sufficient time to reduce the possibility of harms or losses. People centred Community Based Early Warning Systems basically comprise of four key elements (UNISDR, 2006)

- Knowledge of Risk - providing communities relevant information on hazard such as flood, its characteristic and the elements in risk including lives and properties
- Monitoring, analysis and forecasting of hazard - collecting relevant information on river levels, rainfall depths and forecasting flood
- Communication and dissemination of alert and warning - providing relevant information to communities and relevant stakeholders in a timely manner using multiple communication channels
- Capabilities to respond to respond to the warning received

Areas flooded near Rajapur in Bardiya district after 2014 floods in Karnali Basin [Credit: CSDR]

-capability of the community members, institutions and stakeholders to respond towards early warnings to make rational decisions regarding protection, evacuation, search and rescue.

## History of CBEWS

Community Based Early Warning system was piloted by Practical Action in 2002 for East Rapti River in Central Nepal by constructing watch/observation towers embedded with a siren system to warn people regarding incoming floods (Practical Action, 2008). The rudimentary concept of "watch and warn" suffered from problems associated with the limited range of the siren system and logistics required to construct watch towers in each communities. Similarly, the lead-time after the warning was not sufficient to save lives and properties from the flood in a timely manner.

After learning lessons from the nascent "watch and warn" concept, CBEWS was piloted in West Rapti and Babai river basins in West Nepal from 2008 where linkages between upstream and downstream were explored via active community participation. In the case of institutional and governance setup at the national, sub-national and local level, Department of Hydrology and Meteorology (DHM), Government of Nepal led the process (Practical Action and Mercy Corps, 2012).

Gauge data from upstream were checked with water level downstream at community levels through community participation and the communities were empowered with information on danger and warning levels of flood. They were made aware of the river height X metre at River Gauge at 4 pm would result A meters inundation at community Y by 8 pm. Later, manual stations were replaced by automated sensors that captured water level and rainfall data in real time. By 2010, CBEWS was expanded to the Karnali basin and the river system had real time precipitation and gauge height data transmitted to DHM servers in Kathmandu by telemetry system.

From watch and warn, to manual monitoring, community based EWS has evolved to telemetric data transmission with support from the Department of Hydrology and Meteorology in the span of ten years. However, limited density of hydro-met stations have indeed hindered the effective EWS coupled with challenges associated with maintenance of the existing hydro-met stations. Also, many of these stations fail to function during extreme rainfall and flood levels due to sort of power supply. Also not having contingency and safe, failure modes have impacted the sustainability of the system.

## Successes

Whilst earlier CBEWS projects support local monitoring of river levels using watch towers and intra-community warning in East Rapti and Narayani rivers in Central Nepal and, later in Babai, West Rapti and Karnali river systems in Western Nepal communities were formally linked to the upstream monitoring stations operated by the Department of Hydrology and Meteorology (Practical Action, 2010; Practical Action and Mercy Corps, 2012).

The manual flood monitoring systems were upgraded to mobile based telemetry system, and the data was readily shared and, warnings were issued accordingly via automated text messages to the established mobile phone numbers of relevant stakeholders when the water level reached the danger level. Also, radio broadcasting by FM stations regarding flood related messages during the monsoon

increased the community's access to timely information. Community members now had access to telephone numbers of gauge readers, local police stations and other stakeholders along with community volunteers under the Disaster Management Committees (DMCs) that aided in preparation and evacuation during floods (Practical Action, 2010). Establishment of communication channels between gauge readers and communities have made them aware of the information sources, thereby making them proactive and willing to access the relevant information themselves during floods. However, upstream, monitoring needs to be stringent avoiding false and unnecessary warnings that might lead to chaos and confusion downstream during floods. Nevertheless, when sirens are sounded during the monsoon, communities at least have 4-5 hours preparation time to collect important items and evacuate to higher locations for shelter. In short, vulnerable flood prone communities residing near the riverbanks are now able to receive timely information regarding water levels and are constantly informed about the ongoing situation during the monsoon.

The effectiveness of the EWS was demonstrated during the 2010 monsoon in Banke district, mid-western Nepal where the upstream gauge reader observed the increase in water level in the West Rapti river due to upstream incessant rainfall and informed the downstream communities. The Chief District Officer (CDO), army, police then, alerted the local people that led to safe evacuation of flood prone communities at the Binauna VDC (Practical Action, 2010).

Establishment of CBEWS factored by awareness raising campaigns such as mock drills, street dramas, community sensitization and capacity building programs have been critical in enhancing community engagement of the Disaster Management Committees (DMC)s leading to empowerment, mobilisation and identification of resources and capacities already in the community. DMC members are now actively involved in decision making, risk-vulnerability and capacity mapping, identification of suitable sites for construction of small scaled mitigation structures, safe shelters, raised hand pumps and culverts, thereby increasing community's engagement towards reducing the risk from floods. Focus on early warning, preparedness has improved while community ownership has increased sense of cooperative environment within the DMCs, which now is responsible for regularly contacting gauge readers and other stakeholders during the monsoon to extract timely information and disseminate the same to the communities. However, the synergies between DMCs and CBEWS will not be sustainable in the long run if local government authorities, District Disaster Relief Committees (DDRC), DHM and Disaster Management Section under Ministry of Home Affairs (MoHA) do not coordinate each other. Since neither the community nor the government alone can sustain CBEWS, mutual cooperation is paramount for functioning of the system, and institutionalization of the system will be critical for the long-term sustainability, community in focus for saving their lives and properties.

## Limitations and the need for forecasting

Early Warnings are real-time observation based upon river discharge and water levels upstream, and once the water level reaches the warning and danger levels, message generated by the automatic stations are transmitted to the server in Kathmandu, and this information is transmitted to the District Emergency Operation Center (DEOC) and District Disaster Relief Committee (DDRC) at the sub-national level. Similarly, gauge readers who are responsible for data collection from the gauge stations transmit information to relevant stakeholders, communities, local government officials, Red Cross society chapters, NGOs through telephone once water level reaches the warning or danger levels. This has led to save lives and livelihoods of people residing in the downstream communities. Currently, Early Warning Systems are operational in Karnali, West Rapti, Babai, East Rapti, Narayani, Kankai and Koshi Basins. However, there are challenges in the existing early warning systems as the early warnings are based upon real-time observations, not forecasts, having low lead time especially for mountainous catchments where the river flow is fast.

## 2014 Floods in West Nepal

In mid-August 2014, heavy rain lashed the foothills of the Karnali River basin and communities downstream of the Karnali, West Rapti and Babai were largely affected by floods. According to DHM records, Chisapani station recorded the highest ever flood stages at approximately 16 m and rainfall at 500 mm in 24 hours ever since hydro-met records began in the station. This year's flood demonstrated that early warnings helped to save lives downstream of the Karnali and West Rapti basins. However, the hydrological station at Babai River was washed away during the flood and re-thinking is required to build resilience and redundancy to worst case scenarios (Zurich, 2015).

Karnali Hydrological station at Chisapani

## Challenges and Opportunities

Despite having hydrological and meteorological stations in major river basins, there exist challenges to forecast floods in Nepal. Ideally, weather forecasts and real-time rainfall monitoring coupled with hydrological models could provide flood estimates well in advance. However, rainfalls to runoff models do not exist for major river basins that utilize weather forecast and simulate discharge and provide warnings few days in advance. Geographical and topographic challenges along with difficulties in real time and manual data acquisition poses challenges for flood forecasting. Though satellite images and forecasts made available by models are useful, spatial and temporal coarse resolution have been problematic in terms of interpretation of data. Despite these constraints, Department of Hydrology and Meteorology (DHM) in association with Practical Action has been working on Community Based Early Warning Systems in the major basins to address the aforementioned challenges. Much need to be done in terms of flood forecasting through use of advance technologies for which information generated from the various models must be robust to the existing geographical and topographical context, easily understandable by the relevant stakeholders who can then relay the information to the communities for effective response to the warning information.

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# Contrail,
## a natural phenomenon

Contrails are a short form of condensation trails or vapor trails seen in the sky. These are lined shaped clouds sometimes produced by aircraft engine exhaust, typically at aircraft flying altitudes 25000 to 40000 feet above the earth's surface. Contrails are composed primarily of water in the form of ice crystals. The combination of water vapor in aircraft engine exhaust and the low surrounding temperature that often exists at these high altitudes allows the formation of the trails.

Depending on the temperature and humidity at the altitude the contrails form, they may be visible for only a few seconds or minutes or can persist for hours and spread to several kilometers with resembling natural cirrus, cirrocumulus and cirrostratus cloud.

Contrails observed from the Tribhuvan international airport on 4th April 2013 (Photo: Barun Paudel)

*Contribution: SOHAM Desk*

# जल शक्तिको रूपमा विद्युतीय प्रबिधि : नेपालमा यसको बिस्तार

जगतकुमार भुसाल

## १. ऐतिहासिक पृष्ठभूमि

### १.१ जलशक्ति

पानी घट्टको सुरुवात कहिले, कहाँबाट र कस्ले सुरु गऱ्यो भन्ने तथ्य पाउन कठिन छ । भारत खण्डमा ईशापूर्व चौथो शताब्दीमा जलशक्तिलाई पानी घट्टको रूपमा प्रयोग भएको उल्लेख पाइन्छ । युरोप र अमेरीकी खण्डमा इस्वी सम्वत् ७५ ताकादेखि सुन, जस्ता, टिन खानीमा पानीको शक्तिको प्रयोग भएको पाइन्छ (Hunt,1887) । चीनमा हानवंशमा इसापूर्व २०२ देखि इस्वी सम्वत् ९ सम्मको शासन कालमा 'पट हुईल' पम्पबाट पानी तानेर खेती सिँचाइ गर्ने गरेको उल्लेख छ (http://energy.gov/eere/water/history-hydropower) । विकासको क्रममा जल शक्ति प्रयोग गरेको भए पनि सृजनशील मानव मस्तिष्कको उपज थियो 'पानी घट्ट' । जलशक्तिको प्रयोग सन् १७७१ मा वेलायतको डाईवेल उपत्यकाको 'कमफोर्ट मिल' उद्योगको रूपमा प्रयोगमा आएको पाइन्छ ।

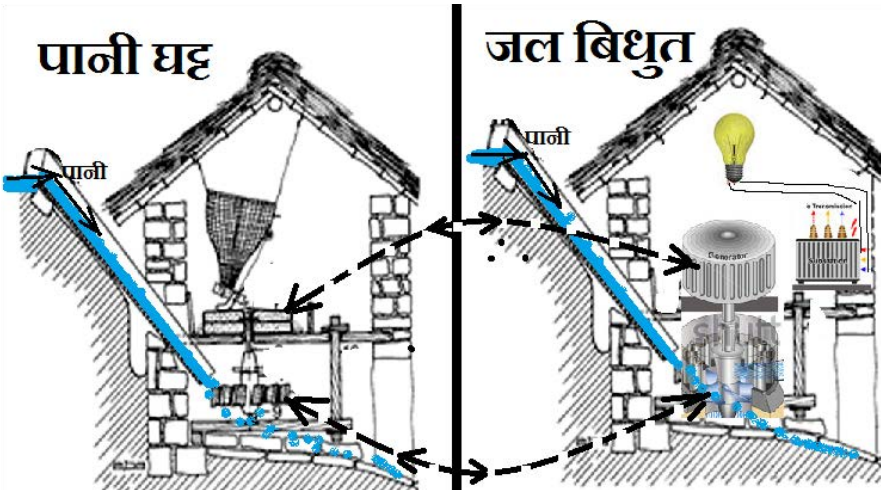
### १.२ विद्युत् (करेन्ट)

खास-खास पदार्थ रगड्दा स्थिर तरङ्ग अर्थात स्टाटिक करेण्ट उत्पादन हुँदोरहेछ भन्ने तथ्य ६०० बि सि मा ग्रीक अनुसन्धानकर्ताहरूले पत्ता लगाएको उल्लेख पाइन्छ । यिनै तरङ्गलाई पछि सन् १६०० मा वैज्ञानिक विलियम गिलबर्टले ल्याटिन भाषामा 'इलक्ट्रिसस' नाम दिएको र अर्का वैज्ञानिक थोमसन ब्राउनले अङ्ग्रेजी भाषामा 'इलेक्ट्रिसिटी' नामाकरण गरेका हुन् । विद्युतको चमत्कारीय खोज र प्रगति सन् १७५२ मा बेन फलाक्लिनको 'चुम्बकीय चङ्गा,' सन १८०० मा अलेक्जेन्द्रो भोल्टाको भोल्टिक पाइल र सन् १८३१ मा माइकल फारादको इलेक्ट्रिक डाइनामोबाट भएको हो ।

पानीघट्ट र 'पट हुईल' मा लुकेको सिद्धान्तलाई नै लिएर सन् १७५३ मा फ्रेन्च इन्जिनियर बर्नाड फोरेस्ट डे बेलिडोरले 'भर्टिकल र होरोजेन्टल एक्सिस' हाइड्रोलिक मेशिनको डिजाइन गरिदिए । फलस्वरूप १९ औं शताव्दीको अन्त्यतिर जलशक्तिको प्रयोग गरी इलेक्ट्रीकल जेनेरेटरहरू तयार गरे । सन् १८२७ मा फ्रेन्च इन्जिनियर बेनोईट फोरनेरोमले रियाक्सन टर्बाइन र सन् १८४९ मा अमेरिकन इन्जिनियर जे फ्रनसिसल फ्रनसिस टर्वाइनको डिजाइन गरे । सन् १८८० मा ऐलेन पेल्टोनले पेल्टोन हुईल बनाए भने कप्लानलेले सन् १९१३ मा प्रोपलल टबाईन डिजाइन गरेको पाइन्छ । (http://www.universetoday.com/82402/who-discovered-electricity/)।

माथिका अनुसन्धानका आधारमा पानीको गति याने शक्तिको प्रयोग गरेर यान्त्रिक मेशिनमार्फत जलविद्युतको उत्पादान गरिन्छ (चित्र १) । पानीले गति पृथ्वीको गुरूत्वाकर्षण शक्तिबाट पाउँछ ।

जलविद्युतको उत्पादनको संरचना सबभन्दा पहिलो आयोजना सन् १८७८ मा जर्ज आर्मस्ट्रोनले बेलायतको नोर्थमबरलैन्डको क्रयासाईड खोलामा बनाई विद्युत निकालेका थिए (३) । त्यो नै पहिलो जलविद्युत आयोजना थियो । लगत्तै सन् १८८० मा मिचिगनको ग्रान्ड यार्पिडसमा र सन् १८८१ क्यानडाको ओन्टरियो ओटावामा जल विद्युतको उत्पादन सुरुवात भएको पाइन्छ । सन् १८८२ मा 'नायग्रा फल' मा




चित्र १ : पानी घट्टको परिष्कृत रूप जलविद्युत आयोजना

अमेरिकाको दोस्रो जलविद्युतको उत्पादन सुरु भएको पाइन्छ । सन १८८३ ब्राजिलको पहिलो जलविद्युत आयोजना 'रिबेईरओ डो ईनफेर्नो' नदीमा स्थापना भएको हो (http://thebrazilbusiness.com/article/hydro-electricity-in-brazil) । बिजुलीको व्यापारिक उत्पादन भने १८९३ मा क्यालिफोर्नियाको नदीमा रेडल्याण्ड जलविद्युतबाट भएको भेटिएको छ ।

## २. नेपालमा जलविद्युत

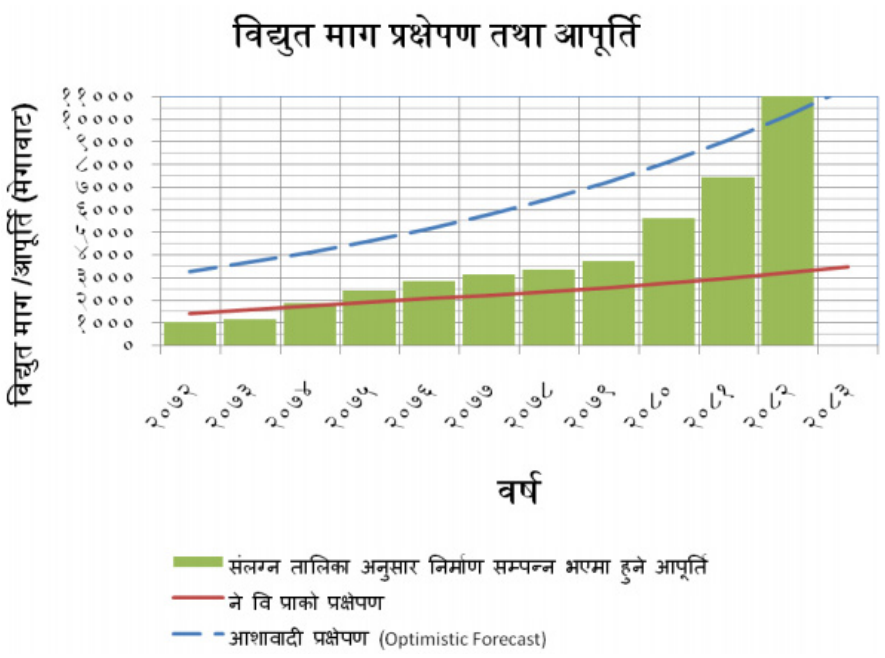
नेपालको पहिलो जलविद्युत आयोजना फर्पिङ काठमाडौंमा सन् १९११ मा ५०० किलोवाट क्षमताको बन्यो (५) । फर्पिङ पछि सुन्दरीजल र त्यसपछि पनौती क्रमशः ७०० किलोवाट र २४०० किलोवाट क्षमताको जलविद्युत परियोजना निर्माण भएका थिए । एसिया महादेशको सन्दर्भलाई हेर्दा सन् १८९७ मा भारतको दार्जलिङमा १२० किलोवाट क्षमताको आयोजनाबाट जलविद्युत उत्पादन भएको पाइन्छ (http://timesofindia.indi times.com/articleshow/1823353.cms) त्यस्तै, ताईपेको जिनङ्यान क्रिकमा सन् १९०५ मा ५०० किलोवाटको जलविद्युत निर्माण भएको उल्लेख छ । सन् १९१२ मा मेनल्यान्ड चीनमा ४८० किलोवाटको जलविद्युत उत्पादन भएको उल्लेख छ (https://www.hydropower.org/a-brief-history-of-hydropower) । जलविद्युत उत्पादन गर्ने अग्रणी मुलुकमा बेलायत, अमेरिका, क्यानडा, ब्राजिल, भारत, ताईपेपछि नेपाल आउँछ ।

सन् १९६६ मा डा. हरिमान श्रेष्ठले पि.एच.डी को अध्ययनमा नेपालमा ८३,५०० मेगावाट विद्युत उत्पादन क्षमता छ भनेर बाहिर आएपछि नेपाल जलस्रोतमा धनी र सायद तत्पश्चात यद्यपि जलस्रोतमा दोस्रो धनी देश भनेर भनिएको अनुमान गर्न सकिन्छ । तत्कालीन समयमा र कतिपय देशमा जलस्रोत अध्ययनका तथ्याङ्कको अभावमा तथा तत्कालीन प्रचलित डिजाइनमा दोस्रो धनी देश भनिए पनि वर्तमान परिप्रेक्ष्यमा दोस्रो धनी देश भन्ने आधार भेटिएको छैन । जलस्रोत अवस्थाको गणनामा नेपाल जुनसुकै श्रेणीमा परे पनि हाम्रो देश जलस्रोत र जल ऊर्जाले सम्पन्न भएकोमा दुविधा छैन । नेपाल सरकारले केही दशकअगाडि गरेको एक अध्ययनले ४३ हजार मेगावाट उत्पादन योग्य हुने सम्भावना भएको देखिए पनि हालको प्रविधि र आवश्यकताले नेपालको जल ऊर्जाको उत्पादन गर्न सकिने सम्भाव्य परिणाम ८३ हजार मेगावाट पनि नाघ्ने देखिएको छ । विद्युत विकास विभागको वि. सं. २०७२ को वार्षिक पुस्तिकामा जलविद्युत सर्वेक्षण अनुमति मागको आधारमा १०८ हजार मेगावाट नाघेको देखिन्छ । नेपाल सरकार, जल तथा ऊर्जा आयोगले अध्ययन थालेको थाहा हुन आएको छ । वास्तविक तथ्याङ्क चाँडै बाहिर आउने नै छ ।

### २.१ नीतिगत छलाङ

२०४० सालअगाडि विद्युत आयोजनाको निर्माण स्वामित्व नेपाल सरकार (तत्कालीन विद्यत विभाग) र बिक्री बितरण गर्न विद्युत कर्पोरेशन थियो । सरकारी प्रक्रिया सरलीकृत गरी विद्युतको विकास द्रूत गतिमा होस भनेर २०४१ सालमा नेपाल विद्युत प्राधिकरण ऐन ल्याई नेपाल विद्युत प्राधिकरण गठन भयो । उत्पादन, प्रसारण र बिक्री-वितरणको एकाधिकार पाए पनि आवश्यकता, माग र चाहेअनुसार विद्युत उत्पादन हुन सकेन । झन्डै एक दशकसम्म पनि ने.वि.प्रा.बाट उद्देश्यअनुरूप द्रूत गतिमा जलविद्युत परियोजनाहरू निर्माण हुन सकेनन । उत्पादनमा ल्याइएका आयोजना पनि ज्यादै महँगो हुन थाले ।

२०४७ को परिवर्तनपछि विद्युत विकास नीतिमा परिवर्तन आयो । नेपाल सरकारले विद्युत ऐन २०४९, र विद्युत नियमावली मार्फत २०५० सालपछि नीजि क्षेत्रलाई विद्युत विकासमा सहभागी गराउने नीति आयो र बर्षौ देखिको विद्युत अध्ययन, उत्पादन, प्रसारण र वितरणमा रहेको सरकारको एकाधिकार तोड्दै नयाँ आयामको सुरूवात भयो ।




चित्र २ : जलविद्युत प्रक्षेपण र आपूर्ति

### २.२ नीतिगत परिवर्तन पछि पनि अन्धकार

नीतिगत छलाङपछि अहिले दुई दशकसम्म अनुमति लिनेको र दिने होड द्रूत गतिमा भयो । तर विद्युतको उत्पादन र विकास चाहेअनुसार हुन सकेन । सडक सुविधा छ कि छैन प्रसारण लाइन छ कि छैन बिक्री कस्लाई, कहाँ हुने, कतिमा हुने, पैसा कहाँबाट, कसरी जुटाउने, वन, वातावरण र सरोकारवाला स्थानीयलाई कति सुबिधा दिने ? आदि कुरा अनुमति माग्दा र अनुमति दिँदा गम्भीर रूपमा अनुमति लिने र दिनेले नलिइएका विषय र प्रसङ्ग पनि भुल्नु हुँदैन । वन, वातावरण, खरिद - बिक्री प्रक्रिया र उत्पादन अनुमतिमा सहजीकरण नहुँदा कतिपय अनुमति प्राप्त प्रवर्द्धकले समयमा वित्तीय व्यवस्थापन गर्न नसकिरहेको अबस्था, सर्भे अनुमती नवीकरणलगायतमा देखिएका, भोगिएका समस्या पनि उत्तिकै रहे । सडक सुबिधा, प्रसारण लाइन, बिक्री सम्झौता नीजि प्रबर्द्धकका काबु बाहिरका बिषय रहेरकाले अध्ययन सकेर पनि उत्पादन अनुमती प्राप्त नहुदा खारेजीका डर र अनुमतीको खरिद बिक्रीलगायतका विकृति पनि देखा नपरेका बिषय होइनन् ।

हालको प्रतिव्यक्ति विद्युत ऊर्जा खपत १३२ किलोवाट घण्टा छ जुन दक्षिण एसियाकै दाँजोमा न्यून हो । करिब ६५५ जनता मात्र ग्रीड प्रणालीमा आबद्ध विद्युत ऊर्जाको उपभोग प्रयोग कर्तामा दर्ता छन् । यी उपभोक्ताहरूले पनि १०,१६ घण्टा सम्मको लोडसेडिङ रहेको अवस्था छ । विद्युतको मात्र १४२३ हुने अनुमान रहेको (चित्र २) अवस्थामा सरकारले वैकल्पिक ऊर्जा (सोलार र वायु) तथा भारतबाट आयत गरेर ऊर्जा सङ्कट निवारण गर्न खोजेको छ । अवधारणाअनुरूप कार्ययोजना कार्यान्वयन नहुने हो भने नेपालको ऊर्जा सङ्कट छिटै समाधान हुने देखिँदैन ।

सन् १९५६ (वि. स. २०१३ ) बाट सुरू भएको पञ्चवर्षिय योजना १२औं त्रिबर्षिय योजनासम्म आइपुगेको छ । पञ्चवर्षिय योजनामा विद्युत विकासमा

| सि.नं. | किसिम | संख्या | जडित क्षमता मेघावाट |
|---|---|---|---|
| १ | जल विद्युत आयोजनाको उत्पादन अनुमति पत्र (संचालनमा रहेको) | ४८ | ७७६ |
| २ | जल विद्युत आयोजनाको उत्पादन अनुमति पत्र (विभिन्न चरणको निर्माणमा रहेको | ९९ | २,३८२ |
| ३ | जल विद्युत आयोजनाको सर्वेक्षण अनुमति पत्र | ७९ | ५,१२८ |
| ४ | विद्युत खरिद सम्झौता सम्पन्न भएका आयोजनाहरू | १७४ | २,५६८ |
| ५ | त्बपभ बलम एबथ प्रावधान राखी न्चष्म क्षउबअत क्तगमथ सम्पन्न भएका अयोजनाहरू | ५३ | १,१०० |

*स्रोतः राष्ट्रिय ऊर्जा र सङ्कट निवारण तथा विद्युत विकास दशकसम्बन्धी अवधारणापत्र र कार्ययोजना, २०७२*

बजेटको ०.९५ छुट्याइयो भने कृषि र वनमा ९.७५ बजेट विनियोजन भयो । योजनाबद्ध विकासको क्रममा पञ्चवर्षिय योजना देखिनै जल विद्युत उत्पादन र विकास प्रथमिकतामा परेन (http://www .aarthi dainik .com . np/news_details/2727/index .html#s hash .wLn12gml .dpuf) । अर्कोतर्फ कृषिले प्राथमिकता पाउँदै आए पनि नेपाल कृषिमा पनि परनिर्भर नै हुन पुग्यो । प्राथमिकता नै नपाएको विद्युत क्षेत्रको विकास त झन हुन सकेन । फलस्वरूप आज देश पूर्वरूपमा आयातित पेट्रोलियम र ग्यास ऊर्जामा निर्भर रहेको छ ।

## ३ सारांश

२०५० सालपछि नीजि लगानीकर्तालाई जलविद्युतको विकास र व्यापारको ढोका खुल्यो । हुन त नेपालमा जलविद्युतले केवल २५ प्रतिशत मात्र योगदान पुऱ्याएको छ तैपनि लोडसेडिङको कारण देश नै अँध्यारोमा परेको अनुभूति भइरहेको छ । लोडसेडिङमा गुज्रेको पनि एक दशक नाघ्यो तैपनि लोडसेडिङको अन्त्य गर्ने नीतिले सार्थकता पाउने लक्षण देखिँदैन । के गरिएन र अब के गरिनुपर्छ भन्ने विषयमा प्रचूर गन्थन भएको छ तापनि विद्युत ऐन २०४९ ले राखेको उद्देश्यानुसार जान कर्मचारी तन्त्रको परम्परागत सोचमा परिवर्तन आउन सकेको देखिएन । राजनीतिले जलस्रोत विकासलाई भौगोलिक अवस्थाअनुसार कार्यदिशा दिन नसक्दा पनि देश अहिले चरम ऊर्जा सङ्कटबाट गुज्रिरहेको छ ।

### सन्दर्भ-सामग्री

नेपाल सरकार, २०७२, राष्ट्रिय ऊर्जा सङ्कट निवारण तथा विद्युत विकास दशकसम्बन्धी अवधारणापत्र र कार्ययोजना,

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**जगतकुमार भुसाल** Electricity Tariff Fixation Commission, Gov. Nepal तथा Society of Hydrologists and Meteorologists, Nepal का वर्तमान अध्यक्ष हुनुहुन्छ । साथै International Hydrology Program का सदस्य हुनुहुन्छ । उहाँले Roorkee University भारतबाट जल विज्ञान विषयमा स्नातकोतर गर्नुभएको छ भने जल तथा मौसम विज्ञान विभागमा ३० वर्ष कार्यरत रही जल विज्ञानसम्बन्धी लामो अनुभव बटुल्नुभएको छ । जल विज्ञान र यससँग सम्बन्धित ३५ वटाभन्दा बढी विभिन्न आयोजनामा उहाँले महत्वपूर्ण योगदान गरिसक्नुभएको छ भने ३५ वटा भन्दा बढी लेखहरू प्रकाशित गरी सक्नुभएको छ । उहासँग विदेशका थुप्रै ठाउँ भ्रमणको अनुभव छ ।

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# Hydrology and water quality in South Asia

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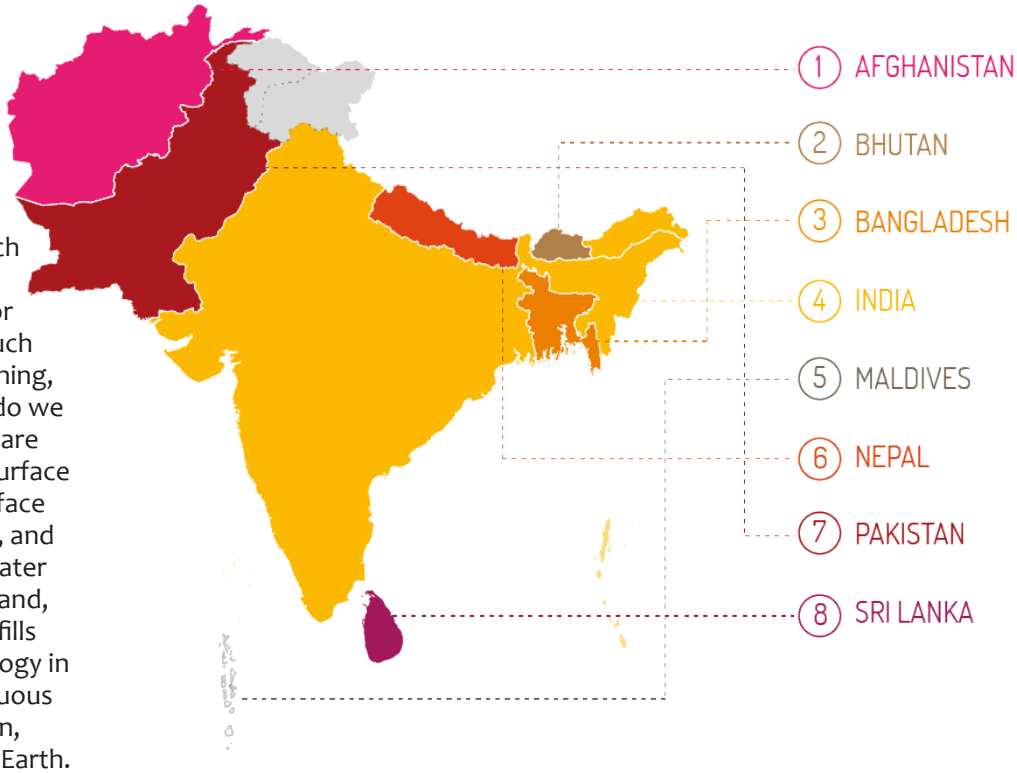


Water is a vital element in each of our lives. It is essential not only to our health, but also for numerous household tasks such as cooking, bathing, and cleaning, and drinking but, how often do we think about its source? There are two main sources of water: surface water and ground water. Surface water is found in lakes, rivers, and reservoirs where as groundwater lies under the surface of the land, where it travels through and fills openings in the rocks. Hydrology in general, describes the continuous movement of water above, on, and below the surface of the Earth. It includes water's precipitation as rain, snow, hail or dew; its journey over, around and through obstacles above, on and below the earth's surface and its eventual evaporation and return to the atmosphere. It is the largest water sources known to man.

However, water quality is the critical factor that influence on human health in South Asia. South Asia is a home to about a quarter of the global population but, has less than 5% of the world's annual renewable water resources. Insufficient drinking water supplies (quantity and quality) and deprived sanitation are ubiquitous in South Asia. Groundwater is the primary source of drinking and irrigation water in South Asia. Groundwater quality issues are common caused by entry of untreated urban wastewater and chemical-laden irrigation drainage. Natural contamination of groundwater with arsenic and fluoride is common in Bangladesh, Nepal and Pakistan, and fluoride contamination is widespread in India.

Water often carries pathogens that cause disease. Many studiesinterpretthat several communities where half of the

Table1 : Results of E-Coli from selected points

| Parameter | Tube Wells Sampling Points | | Results | Tap Water Sampling Points | | Results | WHO Standards |
|---|---|---|---|---|---|---|---|
| E-Coli | 1 | Qazi Park | Nil | 8 | 36, Main Bazar | 32 | 0 in 100ml |
| | 2 | TakkiaKhusrianwala | Nil | 9 | House # 65 Street # 67 | 7 | |
| | 3 | Shahdara Town | Nil | 10 | Malik Hospital | 11 | |
| | 4 | Paracha Colony | Nil | 11 | Madina Masjid | 23 | |
| | 5 | Qaiser Town | Nil | 12 | M Block Mirza Street | 48 | |
| | 6 | Majeed Park | Nil | 13 | MianKarimDarbar | 31 | |
| | 7 | Latif Park | Nil | 14 | House#12A Street # 3 | >300 | |

time the available drinking-water polluted with organisms whose ecological habitat is the human intestine. This verdict is very commonall over South Asia where both urban and rural water supplies are frequently contaminated with human fecal organisms. Though 85% of drinking-water in South Asia meets the target of the Millennium Development Goal (MDG) of coming from an improved source(UNICEF, 2006), this water is in factcommonly contaminated with human fecal organisms(Anwar et al., 2004: Sirajul Islam et al., 2007: Tambe et al., 2008). Human and animal wastes are a primary source of bacteria in water. These sources of bacterial contamination include runoff from feedlots, pastures, animal excretion, and other land areas where animal wastes are deposited. Additional sources include seepage or discharge from septic tanks, sewage treatment facilities, and natural soil or plant bacteria. Indeed, the frequency of water contamination with human faces is so common throughout South Asia.

According to research work conducted in Shahadra town of Lahore, Pakistan in 2007 on the tube wells and the tap water samples from the respective residential areas which reveals very astonishing results apart from the results of all the tested parameters i.e. color, odor, taste, turbidity, TDS, pH, $CO_3$, $HCO_3$, Ca, Mg, $NO_3$, Cl, and hardness levels of the water samples of the project area were within the prescribed limits of WHO, but the results of E-Coli test proved that water of Shahdra town is not suitable for drinking purposes. According to WHO standards E-Coli should be completely absent in the drinking water. Table 1.shows that the water samples tested from the tube wells of the project area were completely free from E-Coli, while the samples from the taps of household shows the E-Coli ranging from 7 to more than 300/100ml in the tap water sample. The presence of E-Coli shows that there is fecal contamination which indicate the sewage intrusion in the water supply because water mainlines are old and rusty and are laid near or beside sewer pipes hence the adulteration of impurities from these sources are contaminating drinking water supply. This fecal contamination is responsible for the occurrence of various gastrointestinal diseases, e.g. diarrhea, vomiting, etc. thus initiating the vicious cycle of various health related problems for the residents of Shahdra town. People use bottled water of suspicious quality those who can afford to buy, but majority is left to drink the available contaminated water.

Improving the quality of water throughout South Asia is challenging. Interventions to improve the water quality are generally implemented by water engineers. The health impact of these interventions is

Figure 1. Sewer pipes laid beside drinking water supply pipes at Qazi Park

Figure 2. Leakage from the main water supply pipeline at Latif Park

lesscommonly assessed. As an example, shallow tubewells were introduced and comprehensively promoted throughout Bangladesh in the 1970s as a way to improve the water quality of communities by shifting from heavilycontaminated surface water to microbiologically cleaner groundwater. However, careful studies performed at the time when tubewells were introduced into Bangladesh concluded that there was no reduction in diarrhea in households that used the new tube wells (Sommer et al., 1972: Levine et al., 1976: Briscoe et al., 1978). This is not only past example but, also in many other studies of the communitybased approaches to improve water supply. A study made in Nepal also prevails that the arsenic contamination of groundwater in the Terai regions of Nepal showed that the source was mainly geogenic due to the dissolution of the arsenic-bearing minerals. Clinical observations of patients in the arsenic affected districts revealed chronic arsenic poisoning from drinking water. Half a million people inhabiting the region are believed to have been exposed to arsenic levels greater than 50 µg/L in their drinking water (Pokhrel .D et.al 2009).We need to provoke the strictness that current interventions represent improvement and need to identify which interventions on water quality improve health and how these can be implemented on a large scale.

The problem of water quality does not finish with microbiological contamination. According to many researchers (Smith et al., 2000: Wasserman et al., 2004: Rahman et al., 2007: Wang et al., 2007:)groundwater, especially shallow groundwater in many sites in South Asia is contaminated with high levels of arsenic,long-term exposure to the high levels of arsenic in drinking-water reduce child survival, and lead to cognitive impairment, cardiovascular diseases, and cancer. Although many approaches can remove arsenic from drinking-water, there are very less proof available that these interventions can be presented on large scale and that their introduction is related with a reduction in arsenic exposure of humans and improved health. The spontaneous findings of the minimal health impact on interventions designed to reduce microbiological contamination demonstrate the importance of continued evaluation of the health impact of interventions to improve water quality.

In addition to fecal contamination, drinkingwater in South Asia can also be contaminated with industrial pollutants. The South Asian economies are developing which means that an increasingly reduced percentage of the workforce is involved in agriculture, and more of the economy is keen to industrial production.A common by-product of industrial outputs is industrial waste, a mixture of chemicals that pose significant risk to human health. This is a particular risk to South Asia because industrial growth is occurring in the setting of weak rule of law. Spending more money to reduce contamination would reduce their profits. The efforts to reduce industrial pollution of water should be evaluated, and successful models promoted.

Water quality is highly dependent on the nature of the aquifers and on the ambient climatic conditions. The water in South Asia is contaminated due to both increasing population and a warming climate risk further deteriorating the already compromised situation.

We need a new pledge to water quality. Educating the community to eradicate the

dumping and minimize release of hazardous chemicals and materials, splitting the proportion of untreated wastewater and substantially increasing recycling and safe reuse individually as well as regionally. In addition to regional perspectives strengthen regional assimilation, and trans-boundary collaboration on water management from organized planning and joint investment for new projects that ensure impartial sharing of both benefits and impacts, and from collaborated planning and joint investment into upstream watershed rehabilitation that deliver both local benefits and downstream water quality benefits. We in the research community can assist by conducting water-quality evaluations and by rigorous assessment of efforts to improve the water quality. Some actions has already been done like gathering the funding from additional regional and, national government and non-government organizations in South Asia involved in water quality monitoring. Only unity and working together in South Asian countries help to manage the water quality in the region. The unity on this contamination risks avoiding us from escalating this problem.

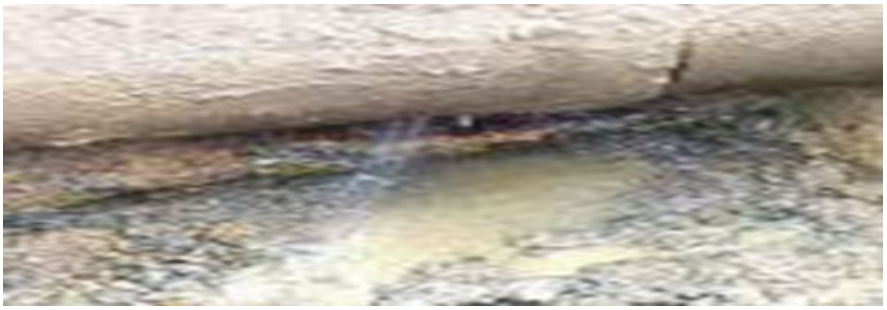

Figure 3. Leakage of sewer pipes at Qaiser Town

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**When clouds look like black smoke a wise man will put on a cloak.**

# सुरक्षित उडान र मौसमी सूचना

सञ्जयकुमार

## पृष्ठभूमि

यातायातका साधनहरू मध्य हवाई यातायातलाई सवै भन्दा सुरक्षित, सुलभ र भरपर्दो साधनको रूपमा लिइन्छ । नेपाल जस्तो विसम भूधरातल तथा डाँडा काँडाले भरिएको देशमा यसको सान्दर्भिकता तथा भूमिका अझै उच्च रहेको छ । यसको वावजुद हवाई सेवालाई एउटा सुरक्षित र विश्वसनीय साधनको रूपमा स्थापित गर्न नसक्नु हाम्रो लागि एउटा ठूलो चुनौतिको रूपमा रहेको छ । देशमा बढदै गएको सडक दुर्घटना, आर्थिक, शैक्षिक तथा सामाजिक रूपान्तरण र वैदेशिक रोजगार माथिको निर्भरतालाई दृष्टिगतगर्दा पनि मुलुकमा हवाई सेवाको आवश्यकता पुष्टि हुन्छ र यस सेवालाई अझै सुरक्षित तथा भरपर्दो वनाउनका लागि उडानसँग जोडिएका सम्पूर्ण भौतिक, प्राविधिक तथा व्यवस्थापकीय पक्षहरूलाई आ-आफ्नोतर्फबाट प्रभावकारी तुल्याई चुस्त दुरूस्त राख्नु पर्ने जिम्मेवारी नागरिक उड्डयन सेवासंग सम्बद्ध सबै पक्षले वहन गर्नुपर्ने हुन्छ ।

हवाई उडान र मौसमको सम्बन्ध नङ र मासु जस्तै रहेको हुन्छ । कुनैपनि उडान भर्नु अगाडि उडानको लागि विभिन्न किसिमको भौतिक तथा प्राविधिक तयारी गरे जस्तै गन्तव्य सम्मको मौसमको विविध पक्षको जानकारी हुनु अनिवार्य आवश्यक मानिन्छ । एउटा जिम्मेवार पाइलटले आफ्नो गन्तव्य र उडान मार्ग (इनरूट) को मौसमको विवरण प्राप्त नगरीकन उडान भर्न कदापी मिल्दैन । त्यसैले त अंग्रेजीमा भनिन्छ "No Weather Report, No Flight"। नेपालमा अहिलेसम्म घटेका अधिकांश हवाई दुर्घटनामा प्रतिकुल मौसम एउटा मुख्य कारकको रूपमा रहेको छ । हेलिकप्टर बाहेक सन् २०१४ पछि नेपालमा ४ वटा जहाज दुर्घटनामा परेका छन् । जस मध्ये तीनवटा दुर्घटनामा 'प्रतिकुल मौसम दुर्घटनाको एउटा मुख्य कारकको रूपमा रहेको' भनी दुर्घटना जाँचबुझ आयोगको प्रतिवेदनले औंल्याएको छ । यही २०७२ फाल्गुण १२ गते तारा एयरको नयाँ ट्वीनअटर जहाज पोखराबाट जोमसोम जाने कम्रमा इनरूटको उच्च टर्बुलेन्सले गर्दा म्याग्दी जिल्लाको तीर्खेढुंगा डांडामा ठोक्किई दुर्घटनामा परेको भनी प्रारम्भिक प्रतिवेदनले देखाएको छ । नेपालमा हवाई सेवा ई.सं १९५१ मा शुरू भएदेखि हालसम्ममा यसरी हवाई दुर्घटनाको संख्या १०० नाघेको छ, जसमध्ये अधिकांश दुर्घटनामा खराव मौसम एउटा मुख्य कारक तत्वको रूपमा रहेको छ । तसर्थ नेपालमा सुरक्षित उडानको लागि यहांको विद्यमान मौसमी संरचना तथा जटिलतालाई सही रूपमा आकलन गर्न सक्ने प्रभावकारी संयन्त्र र उडान कार्यमा संलग्न पाईलट, ए.टि.सि. तथा फ्लाईट डिस्प्याचरलाई अद्यावधिक तथा प्रक्षेपित मौसमको सूचना यथा समयमा सम्प्रेसण तथा वितरण गर्न सक्ने प्रणालीको व्यवस्था हुनु अति नै आव्यश्यक छ ।

उडान सम्पादन कार्यका लागि वायुमण्डलमा एउटा निश्चित स्तरको हावाको बेग तथा प्रवाह दिशा, दृश्य भिजिबिलिटी), वायुको चाप, तापक्रम, आर्द्रता हुनु आवश्यक हुन्छ । निर्धारित स्तरका यी तत्वहरूले उडान सम्पादन कार्यमा निरन्तर सहयोग पुर्‌याईरहेको हुन्छ भने यसको विपरित यी तत्वहरू मध्ये कुनै पनि तत्व असामान्य र उग्र (abnormal) हुने बित्तिकै उडान

सम्पादन कार्य जोखिमपूर्ण हुन जान्छ । खासगरी जाडो याममा तुवांलो, हिँउ, कुहिरो, हुस्सुले वाह्य दृष्यमा प्रभाव पारिरहेको हुन्छस सुख्खा मौसममा हुरी बतास, टर्बुलेन्स र वर्षा याममा घना बादल, भारी वर्षा, बिजुली चम्कने आदि समस्याहरूले उडान सम्पादन कार्यमा कठिनाई उत्पन्न गरिरहेको हुन्छ । तसर्थ कुनै गन्तव्यसम्म सुरक्षित उडानको लागि उडान मार्ग तथा आसपासको क्षेत्रको अद्यावधिक तथा प्रक्षेपित (प्रेडिक्टेड) मौसमको सूचना हुनु अनिवार्य हुन्छ ।

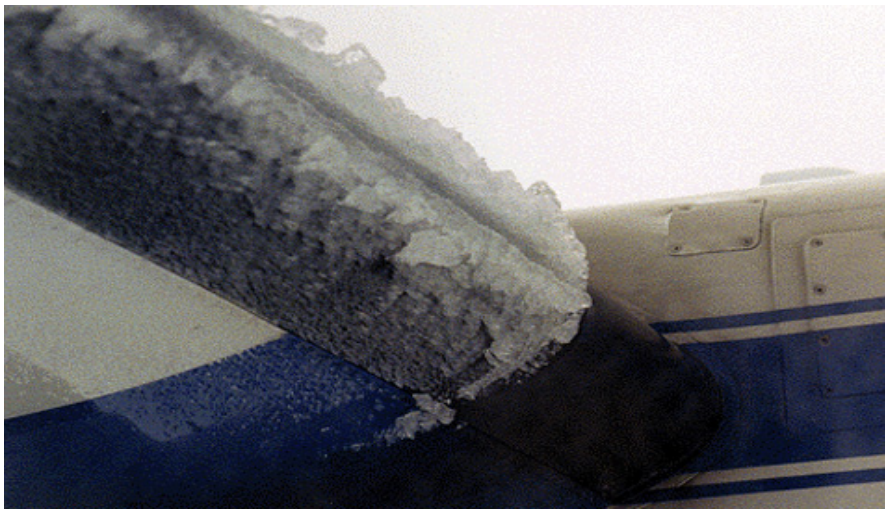
## नेपालमा उडान सम्वन्धी मौसमी सूचना आदानप्रदानको वर्तमान व्यवस्था

नागरिक उड्यन प्राधिकरण म्यानुअल कार-२ को आवश्यकता अनुसार कुनै गन्तव्यको लागि उडान भर्नु अगाडि उडानको कप्तानलाई अद्यावधिक तथा प्रक्षेपित मौसमको सही जानकारी तथा गहन विश्लेषण भएको हुनुपर्छ । त्यसैगरि आईकाओको एनेक्स–२ को भी.एफ.आर. (भिजुअल फ्लाईट रूल) प्रावधान अनुसार (पाईलट स्वयंमले अगाडिको डॉडाकाँडा बादल छलेर उडान भर्ने उडानको लागि पाइलटलाई गन्तव्य, इनरूट, उडान भर्ने र वैकल्पिक विमानस्थलहरूको वर्तमान तथा पूर्वानुमानित मौसमको जानकारी हुनु अपरिहार्य हुन्छ । साथै उडान संचालन कार्यमा संलग्न पाइलट, ए.टि.सी. (Air traffic controller), फ्लाइट डिस्प्याचरलाई मौसमको प्राप्त सूचना र आसपासको अवलोकनको आधारमा मौसमको विविध पक्ष विश्लेषण गरी विद्यमान एवं भावी मौसमी जटिलता तथा चुनौतिलाई आकलन गर्न सक्ने क्षमता तथा ज्ञान हुनु उतिकै आवश्यक हुन्छ । तालिमको अवधिमा तीनीहरूलाई आ-आफ्नो क्षेत्रको कार्य सम्पादनको शिप तथा ज्ञानको साथसाथै उडानमा मौसमको संरचना तथा प्रभावलाई विश्लेषण तथा आकलन गर्न सक्ने कूशलताको बारेमा पनि प्रशिक्षण दिने गरिन्छ । तसर्थ जल तथा मौसम विज्ञान विभागका विभिन्न कार्यालय, विमानस्थल टावर तथा वायुसेवा कंपनिको अपरेशन निकायहरूमा सेटेलाईट तथा भू-संयन्त्रमा अधारित मौसमी डाटा एकीकृत रूपमा अनुगमन, मोडलिङ्ग तथा विश्लेषण गर्ने आवश्यक उपकरण तथा वेब-बेस्ड कष्टोमाईज प्रभावकारी मौसम सम्प्रेषण तथा वितरण गर्ने संयन्त्र अपरिहार्य रहेको छ । साथै उडान संचालन कार्यमा संलग्न पाईलट, ए.टि.सि. तथा फ्लाईट डिस्प्याचरमा मौसमको संरचना तथा प्रभावको विविध पक्षको सही आकलन गर्न सक्ने तालिम, ज्ञान र अनुभव हुनु जरूरी हुन्छ ।

जल तथा मौसम विज्ञान विभागको त्रिभुवन अर्न्तराष्ट्रिय विमानस्थल काठमाडौ स्थित कार्यालयले हरेक आधा घंटाको फरकमा मेटार (METAR) मार्फत अद्यावधिक मौसम र हरेक ६ घण्टाको अन्तरालमा पूर्वानुमानित ट्याफ (टर्मिनल ऐयर फोरकाष्ट) र आवश्यकता अनुसार विशेष मौसम "स्पेसी" को जानकारी गराईरहेका छन् भने नेपालको अन्य ६ वटा विमानस्थल विराटनगर, जनकपुर, सिमरा, भैरहवा, पोखरा र नेपालगंज स्थित मौसम कार्यालयले घण्टैपिछे कन्ट्रोल टावर तथा एयरलाइन्सलाई मेटार मार्फत अद्यावधिक मौसमको जानकारी गराईरहेका छन् । विमानस्थलहरू बाहेक नेपालको अन्य ९ वटा स्थानमा अवस्थित मौसम कार्यालयको सिनोप्टिक स्टेशनहरू मार्फत प्रत्येक ३ घण्टामा आसपास क्षेत्रको अवलोकनको अधारमा मौसमको जानकारी दिने गरेको छ । जल तथा मौसम विज्ञान विभागका अनुसार नेपालको मौसम तथा जलवायु मापन तथा वितरण प्रणालीलाई आधुनिकीकरण तथा स्तरोन्नति गर्न वील्डिङ्ग रिजिल्यान्स टु क्लाईमेट रिलेटेड हाजार्ड (BRCH) परियोजना र भारतीय सरकारको सार्क स्टोर्म परियोजना अन्तर्गत कार्यहरू भईरहेका छन । यी परियोजनाहरू पूरा भईसकेपछि जल तथा मौसम विज्ञान विभागबाट हाल परम्परागत सिनोप्टिक एप्रोचमा हुदै गरेको मौसमी डाटा संकलन, विश्लेषण तथा वितरण अझबढी सही तथा प्रभावकारी रूपमा यथा समयमा सबै सरोकारवालाहरूलाई सम्प्रेशन तथा वितरण गर्न सकिनेछ भनी विश्वास लिइएको छ ।

## नेपालमा विद्यमान मौसमको चुनौती

नेपालको विद्यमान मौसमी संयत्र मार्फत केही विमानस्थल तथा आसपासको निश्चित क्षेत्रको ताजा तथा अनुमानित मौसमहरू समय समयमा प्राप्त भईरहेतापनि इनरूट तथा दुर्गम क्षेत्रको मौसमको सही र यथासमयमा जानकारी प्राप्त हुन सकेको छैन । मौसमको कारणले गर्दा हाल नेपालमा घटिरहेको अधिकतम दुर्घटनाहरू इनरूटको प्रतिकुल मौसमले गर्दा घटिरहेका छन् । यसले के संकेत गरिरहेको छ भने हाल पाईलट तथा एटिसिले पाउने गरेको अद्यावधिक र पूर्वानुमानित मौसमको सूचना या त सही र पर्याप्त छैन या त्यो सूचना समयमा पाउन सकिएको छैन र पाए पनि मौसमको जटिलता र भावी खतरालाई सही रूपमा आकलन गर्न सकिएको छैन वा सबै कुरा थाहा हुँदाहुँदै पनि दवाबमा, उडान पूरा गर्नको लागि जोखिम उठाएर पाईलटहरू उड्ने गरेका छन् । एकजना अवकाश प्राप्त अनुभवी पाईलटले नेपालमा भईरहेको हवाई दुर्घटनाको संदर्भमा यसरी भन्नु भएको छ : "उडान भर्दा मौसमको असाध्यै ख्याल गर्नुपर्छ । मौसमको जानकारी जल तथा मौसम विज्ञान विभाग तथा नेपाल नागरिक उडड्यन प्राधिकरणको जिम्मामा मात्र छोडनु हुदैन । पाइलट स्वंय पनि चनाखो हुनुपर्छ । अहिलेको सूचना प्रविधिको युगमा पहिला जस्तो आकाश हेरेर भगवान भरोसामा उडाउनु पर्ने बेला छैन । बर्षा याममा पूर्व र हिँउदमा पश्चिमबाट बादल आउंछ । कम्तीमा पूर्वमा कलकता र पश्चिममा दिल्लीसम्मको मौसम ख्याल गर्नुपर्छ । अकस्मात रूपमा



जहाजको पखेटामा हिउँ जमेको

Severe air turbulence

मौसम ज्यादै नराम्रोसंग बिग्रदैन । तसर्थ भईरहेको दुर्घटनामा मौसमको आँकलनमा कमजोरी भएकै देखिन्छ ।" नेपालमा भईरहेका दुर्घटनाको लागि कुन कुन पक्ष वढी जिम्मेवार भईरहेका छन् र के कस्तो मौसम मुख्य रूपले दुर्घटनाको कारण भईरहेको छ भन्ने कुरा एउटा खोज तथा अनुसन्धानको विषय हो । यस दिशामा आवश्यक पहल हुन जरूरी रहेकोछ ।

युरोपभित्र मौसमको कारणले घटिरहेको हवाई दुर्घटनालाई न्यून पार्न ई.सं. २०१२ र २०१३ सालमा युरोकन्ट्रोलले युरोपभित्र खराव मौसमले गर्दा उडान सम्पादन कार्य तथा एयर ट्राफिक व्यवस्थापन प्रणालीमा पारेको प्रभाव तथा जोखिम व्यवस्थापन विषयमाथि सर्भे तथा अध्ययन गरेको थियो । अध्ययनमा मेटेरियोलोजी अफिसद्वारा सम्प्रेषित विभिन्न मौसमी विवरणको गुणस्तर, शुद्धता, सान्दर्भिकता, समय र ए.टि.सी. तथा पाईलटले मौसमको यथास्थिति अनुरूप उडान सम्पादनमा गर्ने पूर्व ट्याक्टिकल मापन तथा व्यवस्थापन, प्राप्त मौसमको जोखिम तथा प्रभावको अध्ययन तथा विश्लेषण गर्ने प्रणाली र निर्णय लिन प्रयोग गर्ने सहयोगी ए.टी.सी. तथा पाईलटका साधनहरू तथा प्रकृया र मौसमका कारण घटेका केही घटना तथा दुर्घटनाहरू समेटेको थियो । यूरोपभित्र खराव मौसमको प्रभावले गर्दा हुने दुर्घटना मुख्य रूपले मौसमको निम्न ६ वटा अवयवसंग सम्बद्ध रहेको भनी अध्ययनले पता लागेको थियो र यिनको जोखिम न्यून गर्ने उपाय अवलम्न गरी मौसमको प्रभावबाट हुने दुर्घटना कम पार्न सफल भएको थियो ।

१) **Icing:** उडानको क्रममा हिमपात (icing) हुंदा जहाजको पखेटाहरूमा हिउ जम्न गई जहाजको नियन्त्रण प्रभावित भईरहेको हुन्छ । डीआईसिन्ङ्ग उपकरण जडित जहाजहरूमा आइसिङ्गको समस्याले त्यतिसारो प्रभाव पार्न सक्दैन तर सो डिभाइस नभएका स-साना जहाजहरूमा यो एउटा ठूलो समस्याको रूपमा रहेको छ । उडानको क्रममा उच्च हिमपातको स्थिति सामना गर्नुपर्दा जहाज नियन्त्रण गुमाई दुर्घटनाको धरापमा पर्न जान्छ । २०७० सालमा अर्घाखाँचीको मसिनेचौर डांडामा दुर्घटनामा परेको नेपाल वायुसेवा निगमको ट्वीनअटर जहाज यसको एउटा ज्वलन्त उदाहरण हो । अमेरिकको राष्ट्रिय परावहन सुरक्षा वोर्डको एक सर्भे अनुसार मौसमले गर्दा हुने व्यवसायिक हवाई दुर्घटनाको करिब ११ प्रतिशत दुर्घटना आइसिङ्गले गर्दा हुने गरेको छ ।

२) **Severe air turbulence:** कनभेक्टिभ बादलबाट अपर्फ्रट रूपमा उत्पन्न हुने उच्च तथा न्यून बेगको वायुचापलाई टर्बुलेन्स भनिन्छ, जसले जहाजलाई सामान्य ट्रयाकको अवस्था भन्दा एक्कासि तल माथि उचालेर उडानको एप्टिच्युड र गतिमा धेरै ठूलो परिवर्तन ल्याउन सक्छ । यदि उडान समयमै नियंन्त्रणमा ल्याउन सकिएन भने जहाज टर्बुलेन्सको चपेटामा परी दुर्घटनामा पर्नजान्छ । गएको फाल्गुण १२ गते तारा ऐयरको ट्वीनअटर जहाज पोखराबाट जोमसोम जाने क्रममा इनरूटको उच्च टर्बुलेन्समा

असिना

चटयांग परेको

परी म्याग्दी जिल्लाको तीर्खेढुंगा डांडामा दुर्घटनाग्रस्त भएको थियो ।

३) **Hail damage:** मेघ गर्जन साथ विजुली चम्किरहेको बादलको अपड्राफ्टको प्रवाहमा पानीको बूंदाहरू माथिको उच्च चिस्यानमा जमेर बनेका बर्फका टुक्रा (गोला) हरूलाई असिना (हेल) भनिन्छ । पाइलटले चालै नपाईकन हेलले जहाजको बडी, वीन्डस्क्रिन तथा अन्य भागमा गहिरो आघात पु-याएको हुन्छ । ठूलो ड्यामेज भईरहेको स्थितिलाई पाइलटले समयमै संबोधन गरी नियन्त्रण गर्न सकेन भने क्षति (ड्यामेज) ले जहाज अनियन्त्रित भई दुर्घटनाको मुखमा पर्न जान्छ ।

४) **Lightning strike:** आकासमा बिजुली चम्केको (लाइटनिङ्ग) बेला जहाज सो बिजुलीको तरङ्गमा पर्‌यो भने जहाजको एयरफ्रेममा, खासगरी र्‍याडोम्स, पूच्छरको फीन तथा नियन्त्रण संयन्त्र (कण्ट्रोल सिष्टम) मा आघात पुऱ्याउँछ । तीब्र लाईटको चमकले पाइलटलाई ककपिटमा अगाडिको वस्तुस्थिति हेर्न निकै वाधा पुऱ्याईरहेको हुन्छ । कहिलेकांही लाईटनिङ्गले गर्दा इन्जिन भित्र ट्रान्जियन्ट एयरफ्लो भई जहाजको ईन्जिन नै बन्द हुने स्थिति आउंछ, जसले उडानलाई दुर्घटना तीर डोऱ्याउंछ ।

५) **Least visibility:** जाडो याममा कुहिरो एवं हुस्सुले गर्दा देखिने सिमा (भिजीविलिटी) कम भई लामो समयसम्म विमानस्थल बन्द भईरहेको हुन्छ । उडानहरू समयमा उड्न नसकी वा उडानहरू रद्द हुनगई हवाई यात्रु, एयरलाईन्स तथा एयर ट्राफिक कन्ट्रोलरहरूलाई उत्पन्न परिस्थितिको समाधान गर्न टाउको दुखाई भईरहेको हुन्छ । उडानको लागि धावनमार्गमा एउटा निश्चित दूरीसम्म देख्न सकिने अवस्था (न्यूनतम भिजिवलिटी) आवश्यक हुन्छ । जहाजको उडान तथा अवतरणको क्रममा अकस्मात रूपमा उत्पन्न कुहिरो तथा हुस्सुले धावनमार्ग ढ्याकै छोपिदिंदा उडान जोखिमपूर्ण हुन जान्छ । २०७१ साल फाल्गुन २० गते टर्किस ऐयरको जहाज त्रिभूवन अर्न्तराष्ट्रिय विमानस्थलमा अवतरण गर्ने क्रममा धावनमार्गको बाक्लो कुहिरोमा परी दुर्घटनामा परेको थियो ।

६) **Wind gust:** उडानको तल्लो उचाईमा खासगरी जहाजले अवतरण र उचाई लिईरहेको चरणमा तीव्र वेगको हावाले उडान सुरक्षामा प्रायः खलल् पुऱ्याईरहेको हुन्छ । कुनै विमानस्थलमा जहाज अवतरण गर्दा एउटा निश्चित स्तर भन्दा माथिको क्रस वीन्ड (जहाजको दयांबायां साईडमा हान्ने हावा) र टेल वीन्ड (जहाजको पुच्छर साईडवाट धकेल्ने हावा) हुनु हुदैन । विकट पहाडी भूभागमा अवस्थित, सानो धावनमार्ग भएको विमानस्थलहरूमा तीव्र वेगको हावाले जहाजको अवतरणमा ठूलो जोखिम उत्पन्न गरिरहेको हुन्छ । उच्च तथा बदलिदो (भेरिएवल) हावाको बेग भएको अवस्थामा सानो तथा मझौला खालको जहाज अवतरणको क्रममा पाइलटले उडानलाई धावनमार्गको

जोमसोममा दुर्घटनाग्रस्त नेपाल एयरलाईन्सको ट्वीनअटर जहाज

सेन्टरलाईनसंग मिलाउन नसक्दा जहाज रन्चे एक्सकर्सन भई, धावनमार्गको दाँया वाँया गएर दुर्घटनामा परिरहेको हुन्छ । नेपाल एयरलाईन्सको ट्वीनअटर जहाज २०७० साल जेठ २ गते उच्च वायुको वेगले गर्दा जोमसोम विमानस्थलमा अवतरण गर्ने क्रममा दुर्घटनामा परेको थियो । जोमसोम, लुक्ला जस्ता विमानस्थलहरूमा मध्यान पछि तीव्र गतिको हावा वहने कारणले गर्दा उडानको लागि प्रायः बन्द गरिएको हुन्छ ।

तसर्थ नेपालको उडान मेटेरियोलोजीकल प्रणालीलाई स्तरोन्नति गर्न यहांको विद्यमान मौसमी संरचना, मौसमको अनुगमन, मुल्यांकन तथा सूचना वितरण प्रणली र उडान सम्पादन प्रकृया तथा घटिरहेको दुर्घटनाको परिप्रेक्ष्यमा सामना गर्नु परिरहेको मौसम सम्बन्धी समस्या तथा चुनौतिहरूलाई निराकरण गर्न यूरोकन्ट्रोल जस्तै नागरीक उड्यन प्राधिकरण र जल तथा मौसम विज्ञान विभागको संयुक्त अग्रसरतामा नेपालको मौसमी अवस्थाको गहन अध्ययन तथा अनुसंधान गरी आवश्यक उड्डयन मेटेरियोलोजी र एयर ट्राफिक व्यवस्थापन संयन्त्रको स्थापना गर्न पहल हुन जरूरी भैसकेको छ ।

**When the bees crowd out of their hive,**
**the weather makes it good to be alive.**
**When the bees crowd into their hive again,**
**it is a sign of thunder and of rain.**

**सञ्जयकुमार** नेपाल नागरिक उडड्यन प्राधिकरण, त्रिभुवन अन्तर्राष्ट्रिय विमानस्थलमा प्रबन्धक हुनुहुन्छ । उहाँ विगत दुई दशकभन्दा बढी समयदेखि नेपाल नागरिक उडड्यन प्राधिकरणमा सेवारत हुनुहुन्छ। उहाँले त्रिभुवन विश्वविद्यालयबाट सन् १९९४ मा भौतिक शास्त्र (एड्भान्स ईलेक्ट्रोनिक्स) विषयमा स्नातोकोत्तर पूरा गरी Asian Institute of Technology (AIT) Bangkok बाट सन् २०११ मा MBA (Finance and Sustainability) विषयमा समेत थप स्नातकोत्तर उपाधि हासिल गर्नुभएको छ । राष्ट्रिय तथा अन्तर्राष्ट्रिय क्षेत्रमा उहाँको लेखहरू निरन्तर रूपमा प्रकाशित हुँदै आइरहेका छन् ।

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# Halo

Halo is the name for a family of optical phenomena produced by light interacting with ice crystals suspended in the atmosphere. The atmospheric optical phenomena is observed when the Sun or Moon shines through thin clouds composed of ice crystals. These phenomena may be due to the refraction of light that passes through the ice crystals, or the reflection of light from crystal faces, or a combination of both effects.

Refraction effects give rise to colour separation because of the slightly different bending of the different colours composing the incident light as it passes through the crystals.

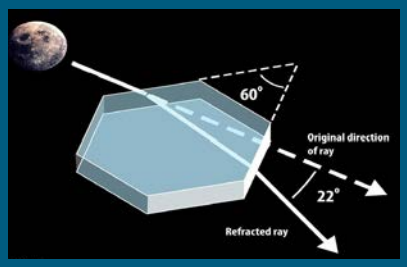
The ice crystals responsible for halos are typically suspended in cirrus or cirrostratus clouds extending high (5–10 km) in the upper troposphere.

The most common halo is the 22° halo, a series of coloured arcs, or in some cases complete circles of 22° angular radius with the Sun or Moon at its centre. As the light refracts at 22° in the ice, the eye or man sees the ring of light around the sun or moon and, not elsewhere.

The order of coloration in Halo is red on the inside and blue on the outside, opposite to that of the atmospheric corona.

Atmospheric phenomenon such as Halo was used as part of weather lore as an empirical means of weather forecasting before meteorology was developed. They often do mean that rain is going to fall within the next 24 hours as the cirrostratus clouds can signify an approaching weather system.

Reason behind occurrence of Halo 22°




*Contribution: SOHAM Desk*

# Use of Weather Forecast in Aviation:

## A View Of Pilot

Anita Ale Magar

Weather and flying are completely linked together. Flying is affected by the air and the environment and, their variables such as cloud, rain and wind. But, the fickle nature of weather makes flight challenging and exciting too. When it comes to weather forecasting, it may not be precise totally, however, the information and clues on future weather prediction help in determining where to fly and whether to fly or not.

The necessity of weather prediction in aviation is fulfilled by the thousands of decisions based on everyday weather forecast generated through an elaborate process involving individual observers and complex computer programs. Forecast can be printed reports such as TAFs, AIRMET, SIGMET or graphical charts such as winds, temperature and temperatures aloft charts. These weather forecasts prepared by meteorological office can be obtained through telephone, HF(5805.5) and Air Traffic Services.

In this context, TAF (Terminal Aerodrome Forecast) is a routine forecast providing expected weather for a specific airport. One of the most important component of TAF is wind information which informs about the wind direction and speed including gust and its variability in wind direction. This information helps the pilot to calculate the distance required for ground roll after landing. It is very crucial in airports with shorter runways. Also, pilots can estimate headwind, crosswind and tailwind component for their aircraft for takeoff and landing. Likewise, pilot can also expect the type of flight whether it is a VFR/MVFR/IFR from other TAF components such as visibility, weather conditions for example, rain, fog, mist or haze. Likewise, sky condition with cloud cover in terms of amount such as scatter, broken or overcast help on planning for departing and destination airport as well as give choice on alternate airports during emergency.

AIRMET (Airman Meteorological Information) and SIGMET (Significant Meteorological Information) warn pilots about an unscheduled hazardous weather conditions such as strong surface winds, icing and freezing levels, low-level wind shear, severe icing, turbulence and clear air turbulence (CAT). Likewise, wind and temperature aloft chart depict predicted wind direction and speed and temperature at different levels. Similarly, low level significant weather prognostic charts provide pilot with a future picture of atmospheric pressure patterns and frontal regions with areas of low visibility, low ceiling, turbulence and icing if exist. Satellite image may be past or current help in prediction of future weather pattern.

For en route flight plan, these reports, charts and pictures help to select the appropriate altitude and calculate the total flight time, total fuel consumption and speed of aircraft. Forecast on temperature

parameters helps pilot to expect and avoid icing level. Pilots can expect weather phenomenon and decide about the flight. Thus, when flying from point A to point B, these reports and pictures help pilot to plan for appropriate route and altitude to fly and determine delay, divert and change in route of flight.

Weather forecast can be used for making short term decisions such as planning flights, expecting adverse weather conditions and responding with them. Or, for making longer term decisions in respect to future patterns in demand for air travel and fulfilling demand in peak season by increasing fleet. Weather forecast is not only for pilots, aircrafts and flights, but also for public, aviation industry and airliners. Thus, makes aviation more planned, efficient, commercial and safe.

In context of Nepal, we have both fixed and rotor wing flights in different parts of the country. Flights would be more planned and safe, if local weather such as METAR and long term forecast TAF for all airports and weather forecast for en route and at different flight altitude would be provided either in website or mobile apps.

**Anita Ale Magar** is a Pilot Captain (fixed wing) affiliated with Directorate General of Army Aviation, Nepalese Army since 2012. She holds Commercial Pilot Licence (CPL) from Delta Qualiflight, USA. She has completed Master of Science degree in Meteorology from Tribhuvan University.

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# मामाट्स वादल

अप्रिल १९, २०१० मा नेपालमा देखा परेको मामाट्स बादल

आकाश एक किसिमको बादलको प्रदर्शन स्थल मानिन्छ जहाँ विभिन्न किसिमका बादलको स्वरूप देख्न पाइन्छ । ती मध्य एक हो धब्बा, धब्बा वा पोका पोका झुन्डिएर रहेको जस्तो देखा पर्ने अचम्मको बादल । मौसम बिज्ञानको भाषामा यस्तो बादललाई मामाट्स वा मामारी पनि भनिन्छ जुन आकाशमा एक किसिमको क्यूमलोनिम्वस नामको वादल उत्पत्ति हुने वेला मात्र देखा पर्ने गर्छ । साच्चै भन्ने हो भने यस्तो बादल हरेक पटक क्यूमलोनिम्वस वादल निर्माण हुने वेला पनि देखा पर्छ भन्ने निश्चित हुन्दैन । बिषेश परिस्थितिमा मात्र यस्को श्रृजना हुने हुन्दा यो बादल बिरलै देखा पर्ने गर्छ ।

सामान्यतया गर्मीयामको वेला प्रचण्ड घामले पृथ्वीको भू सतह अत्यधिक मात्रामा तात्ने कारण संवाहन प्रक्रियाबाट क्यूमलोनिम्वस वादल उत्पति हुने गर्छ । र यो वादल आकाशमा टावरको रूपमा उठ्ने गर्छ । यसरी उठेको क्यूमलोनिम्वस बादलको माथिल्लो टुप्पा १०० यौ किमि अगाडीतिर फैलिएको हुन्छ । आकाशमा यस्तो बादलको फैलावतलाई एनभिल भनिन्छ जस्ले क्यूमलोनिम्वस बादल कतातिर गई रहेको हो भन्ने दिशा बोध पनि गर्छ । साथै यसले त्यस क्षेत्रमा निश्चत रूपमा हावा तेजले चलि रहेको छ भन्ने संकेत गर्छ ।

बैज्ञानिक अध्ययन अनुसार यस्तो मौसमी गतिविधि देखा पर्ने बेला एनभिलमा प्रसष्ट मात्रामा हिउँ, ससाना बरफका टुक्रा र ठूलठूला पानीका थोपा छन् भने ती गह्रुगो भई पृथ्वीको गुरूत्वाकर्षनको कारण तलतिर झर्न थाल्छ । अत्यन्तै चिसो बादलबाट झर्ने हिउँ, बरफ र पानीका थोपा बादल छाडने बितिक्कै तलतिरको तुलनात्मक रूपमा तातो हावाको सम्पर्कमा आउना साथ बाष्पिकरणको (Sublimation) प्रक्रिया चल्न थाल्छ । पूनश्चः यस्तो बेला त्यस क्षेत्रमा जोडले हावा चलि रहने कारण बाष्पिकरण प्रक्रिया तीव्र गतिमा हुन थाल्छ । यस्तो मौसमी गतिविधिले त्यहाँ एक किसिमको संवाहन प्रक्रिया आरम्भ हुन थाल्छ जस्ले गर्दा बादल पुनः माथितिर उठ्न थाल्छ । एकातिर बादलमा रहेको हिउँ, ससाना बरफका टुक्रा र पानीको थोपा तलतिर केन्द्रित भई झर्न खोज्छ भने अर्कोतिर बाष्पिकरणको कारण बादल माथितिर उठ्न थाल्छ । यस्तो अवस्थामा त्यस क्षेत्रमा एक किसिमको स्टाटिक इक्वीलिब्रिम स्थापना हुन गई बादल धब्बा वा पोकाको रूपमा देखिन थाल्छ । बादलको यस्तो स्वरूपलाई नै मामाट्स भनिन्छ । यस्तो बादलको पोका जमिनबाट हेर्दा सानो देखिए पनि यस्को ब्यास १,२ कि मि वा सो भन्दा बढी पनि हुन सक्छ । तसर्थ यस्तो बादलको सयौँ पोकाले सयौँ किलोमिटर क्षेत्र ओगति रहेको हुन्छ ।

मामाट्स बादल एनभिल रहेको ठाउमा मात्र देख्न सकिने भएकोले यो सिमित ठाउँमा मात्र देख्न सकिन्छ । तर यस्तो बादल धेरै बेर सम्म इक्वीलिब्रिम अवस्थामा रही रहन नसक्ने भएकोले यस्को आयू भने लामो हुन्दैन । सामान्यतया यो बादल निर्माण भएको १५, २० मिनेट वा सो भन्दा केहि बेर पछि हराएर जाने संम्भावना रहन्छ । यसै संदर्भ मामाट्स बादल बारे धेरै कुरा जान्न बाकि भएकोले यो अझै अध्ययनकै बिषय भएको छ ।

मामाट्स बादल क्यूमलोनिम्वसको अंश भएकोले यस्को श्रृजनाले डरलाग्दो हुरी बतास चल्नुको साथै भारी वर्षा हुने, असिना र चट्याङ्ग पर्ने संकेट गर्छ । हवाई उडानको दृष्टिकोणले यस्तो बादल अत्यन्त डरलाग्दो मानिन्छ । सामान्यतया मनसुन पूर्वाद्धको समय र मनसुनकालमा नेपाल लगायत दक्षिण एसियाको विभिन्न स्थानमा क्यूमलोनिम्वस बादल देखा पर्ने गर्छ । यही बेला मामाट्स पनि देखा पर्ने गर्छ ।

*Contribution: SOHAM Desk*

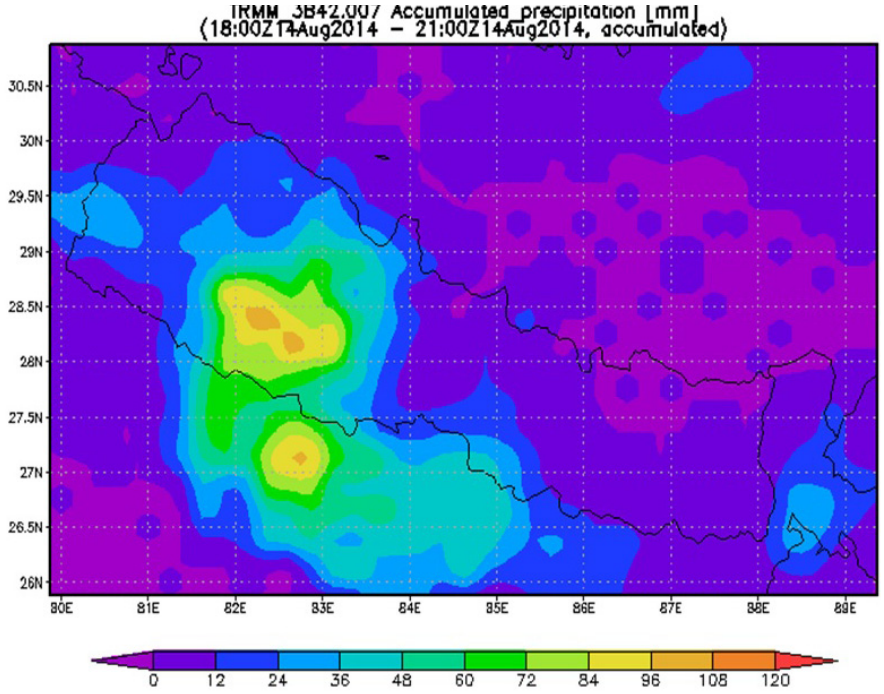
# Extreme rainfall event:
## Lessons for Disaster Risk Reduction for Nepali Urban Landscape

Shobha Kumari Yadav

The Inter-Governmental Panel on Climate Change (IPCC) report shows that the magnitude and frequency of extreme rainfall events are increasing in South Asia possibly due to climate change (IPCC, 2013). The increase in frequency of flooding with changing climate variability have been ringing warning bells for years that the devastating floods are not the result of natural disaster but, they are obviously the result of unplanned urbanization and unrestrained construction along flood plains. Extreme rainfall events are becoming increasingly frequent across South Asia, causing wide spread urban flooding. Attributing disasters and the resulting impact to a specific driver climate development or environmental change is exceptionally difficult. But, IPCC highlights that climate change is an impact on the nature of weather-related hazards leading to occurrence of more frequent and intense extreme events in the coming decades (IPCC, 2013). It will further continue to grow due to the extension of development activities leading to change in climate drivers such as increment in temperature and change in rainfall characteristics.

Nepal, in an average, receives 80% of its total rainfall during the monsoon season from June to September. Cloudbursts, landslides, mass movements and flash floods caused by the swelling rivers take a heavy toll of properties and lives disrupting livelihood of both urban and rural communities across Nepal. Intensification of floods are one of the predictable impacts of climate change and climate instability. High intense floods in Nepal are example of climate change impact due to poor urban planning. The 1993 flood of Central Nepal measuring 540 mm in 24 hours with an intensity of 70 mm per hour, 2013 Mahakali River flooding and 2014 Karnali flooding had severely affected many districts of Central, Far-Western and Mid-Western Nepal respectively. In all cases, the rainfall had devastating effects caused by human-induced factors.

In urban landscape like Kathmandu where, poorly planned roads with narrow and congested opening along with high population density make it extremely susceptible to flooding. The Kathmandu valley receives an average rainfall of 1600 mm in a year with a record of high intensity of 120 mm per hour that lasts for 10 minutes. The rain water drained through a number of rivers, streams and rivulets that discharge into the Bagmati River. The occasional torrential rain within the valley has caused flooding in core areas of the city causing loss of life and property, especially in those areas which is close proximity to rivers. In addition, migrants are settling into unplanned areas that are located in landslides or flooding-prone zones. Planners in Kathmandu Metropolis and Valley Development Authority, therefore, need to consider urban




Cumulative rainfall on 14th August, 2014 in mid-western region of Nepal

floods a critical hazard during planning future development projects. Innovative climate-resilient approaches must be incorporated as a part of the planning process. It is imperative to consider these measures in emerging municipalities of Nepal as well.

A combination of complex factors causes floods. It is, therefore, vital to improve the quality of the nation's response to floods. In this regards, there is a need to re-conceptualize responses in order to meet the challenges of adapting to floods. New methods and tools will have to be devised and internalized in the normal operation of our societal and governmental organizations. Establishment of infrastructure for day-to-day monitoring to have detailed understanding of nature and causes of floods is required. Information pertaining to geology, environment, geomorphology, hydrology and land use need to be incorporated. The existing knowledge of hydrological and meteorological characteristics further needs to expand by strengthening existing national network of hydrological and meteorological stations.

Further, institutional capacity to forecast the event and, proceed for preparedness and support need to be strengthened. Like wise, the information pertaining to flood forecast needs to be made available to individuals, families and communities at the time of disaster. This requires the establishment of a sound mechanism for data collection, analysis and interpretation. Moreover, the response to flood should be part of planning of the daily operation rather than post-facto relief. The concerned stakeholders need to heed on statutory regulations and monitoring concerning undeveloped flood plains. Consequently, there is a need to strengthen local bodies through political and legal empowerment. This will increase extent of impartial regulatory functions such as formulating rules, policies and mechanisms for adjudication as required.

Hence, integrating risk minimization strategies in planning can help reduce the damage due to disasters. Climate and disaster resilience should form an integral part of national strategies and development assistance. So it is important to strengthen all aspects of climate and disaster resilient developments including coordinating institutions, risk identification and reduction, preparedness, financial and social protection and resilient reconstruction. Proper attention should be given to build system that offer provision for checks and balances and, allow space for lateral thinking. Thus, our approach should provide the society with the pluralism in innovation, caution and regulation that needs in order to bring about steady transition in the management of the risks due to flooding.

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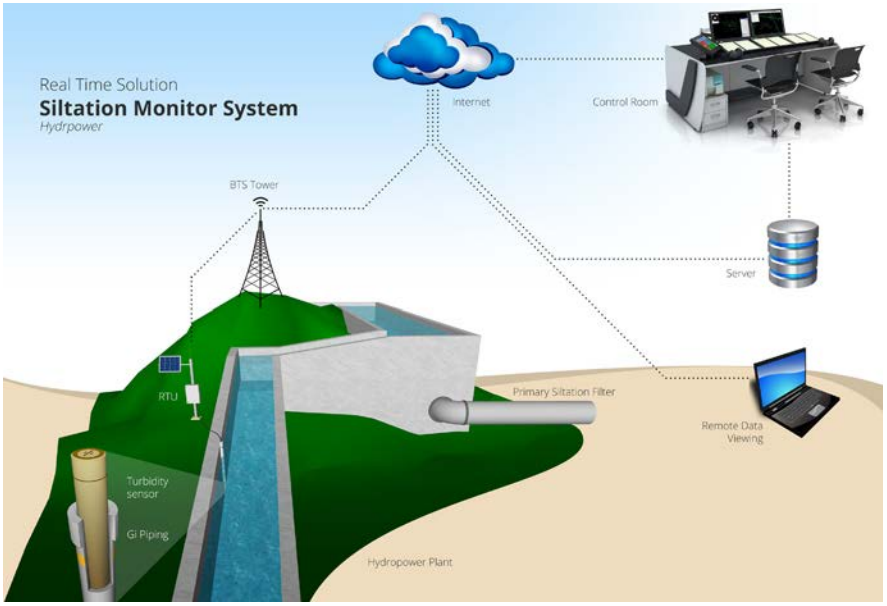
# Online Sediment Monitoring System

Sanjaya Gurung

Nepal, a mountainous country comprises with a part of the Himalaya in the Hindu Kush region is referred to as the water tower of Asia (Immerzeel et al., 2010) where most of the river flows from High Mountains to downstream areas in lower land. These rivers are nourished by glaciers in the High Mountains. There are three main river basins in Nepal namely Koshi, Gandaki and Karnali originating from glaciers and snow-fed lakes.



RTS Sediment Monitoring System

The perennial nature of rivers and the steep gradient of the country's topography provide ideal conditions and high potential for the development of hydropower. The potential is estimated at 83,000 MW, of which half 40,000 MW is considered to be technically and economically viable (MoWR, 2003). However, Nepal till date has been able to develop only approximately 680 MW of hydropower (Sangroula, 2006). But during monsoon season, the hydropower turbine is mostly affected by siltation of water. Research reveals that operation of hydropower plant even for 10 minutes with sediment concentration would result in repairing cost of about 10 times higher than the revenue generated during this operation (Bishwakarma, 2008). If sediment in water can be detected before entering into the penstock, then the sediment erosion of turbine blade can be prevented. Thus, the new technology "Total Suspended Solid monitoring system" serves the purpose and reduces the erosion


Turbidity data of Budigandaki river

problem of turbine and saves the maintenance cost.

How is sediment monitoring done? Water with sediments running through turbines cause abrasion. These situations generally arise in run-of-river hydropower plants that are more common type of plants in Nepal where the turbines are more exposed to sediment erosion. It is a fact that sediment causes more damage on turbine and cause in financial losses. To overcome with these losses, estimation of sediments concentration can be done regularly and periodically by measuring turbidity. To avoid Turbine Erosion, the estimated high concentration of total suspended sediment (TSS) can be separated from the river leaving only harmless fine silts using physical structures, the other way is to shut down the power plant for a certain period when TSS is in high concentration. The Optical Turbidity Sensors are designed to obtain periodic measurements (at 15 minutes intervals or more depending upon the user requirement) of turbidity and present the results in charts such as one shown below.

Optical turbidity Sensors are used for providing estimates of suspended sediment concentration. These instruments are installed at the intake of the power plant. When water passes through the sensor, laser scattering is measured and the scattering is processed to compute the turbidity and the sediment amount is estimated.

Time series software is an integral part of the system. It displays the charts, and it can be easily programmed to generate alert when concentration of TSS exceeds the predetermined thresholds.

This system has the following advantages

1. Continuous turbidity measurement and estimation of TSS automatically
2. Lab handling cost kept to minimum
3. Reduces site visit and labor costs

## References

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*May these greatest festivals bring all the happiness, prosperity and success in every step of your life ahead*

Society of Hydrologists and Meteorologists-Nepal (SOHAM-Nepal)

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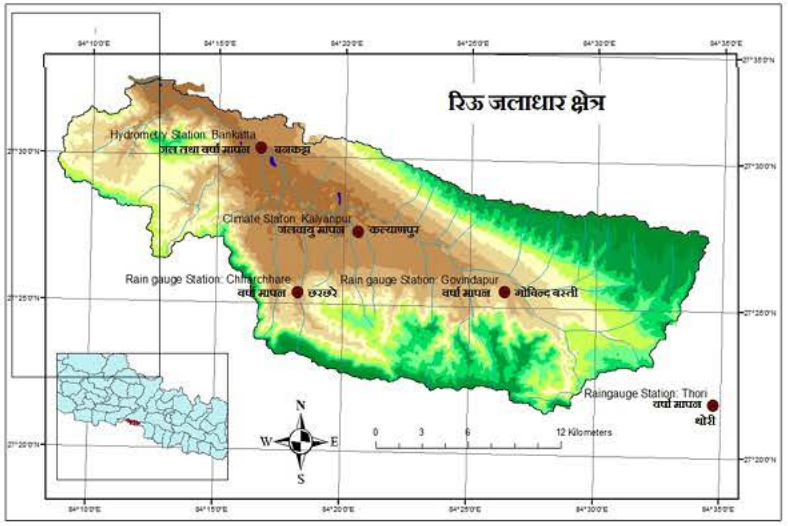
# समुदायमा आधारित बाढी पूर्वसूचना प्रणाली: रिऊ खोला जलाधार क्षेत्र, माडी

जल तथा मौसम विज्ञान विभाग




रिऊ तथा यसका सहायक खोलाहरुले ल्याउने तिब्र बाढी, गेगर तथा बालुवाले हरेक वर्ष माडी उपत्यकामा व्यापक धनजनको क्षति पुर्याई रहेको हुन्छ। जल तथा मौसम सम्बन्धी सूचना तथा पूर्वसूचनाको महत्व पूर्व तयारीमा मात्र नभई विपद व्यवस्थापनका विभिन्न पक्षमा समेत आवश्यक हुने हुदा नेपाल सरकार – जल तथा मौसम विज्ञान विभाग र संयुक्त राष्ट्र संघीय कार्यक्रम-बृहत्तर विपद जोखिम व्यवस्थापन कार्यक्रम अन्तर्गत सहश्राब्दी विकास लक्ष्य ट्रष्ट कोष (दक्षिण कोरिया सरकार र यु.एन.डि.पी.) समेतको पहलकदमीमा प्रभावित समुदाय सम्म सजिलै पुर्याउने लक्षका साथ विपद् व्यवस्थापनका लागि पूर्वसूचना प्रदान गर्ने गरी एकिकृत सूचना केन्द्रको स्थापना गरिएको हो। स्थापना, संचालन तथा मर्मत सम्भार समेतमा माडीबासीलाई संलग्न गराइदै ल्याईएको यो संरचनाबाट कृषि उत्पादन समेतमा बृद्धि ल्याई कृषकलाई सेवा पुर्याउने अपेक्षा गरिएको छ।

रिऊ जलाधार क्षेत्रफल: ४५० वर्ग किमि
बनकट्टा सम्मको क्षेत्रफल: ३१३ वर्ग किमि
जङ्गल: ३७० वर्ग किमि
उचाई: १४० मि देखि ७५० मि
औसत उचाई: ३३० मि
नदीको लम्बाई: ५० किमि

स्थापना मिति: २१ फाल्गुण २०७२

**कल्याणपुर केन्द्र**
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हावा (दिशा तथा वेग)
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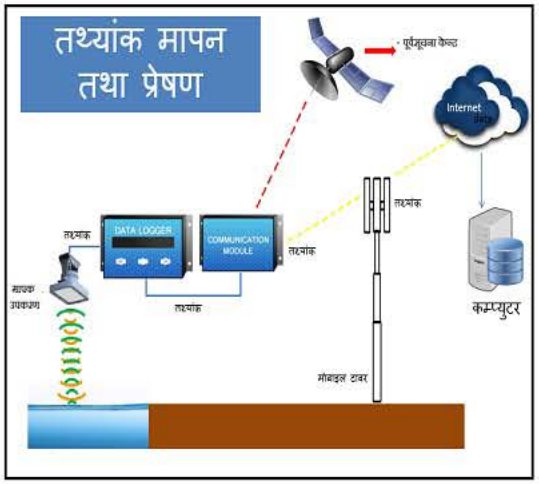


महत्वपूर्ण टेलिफोन नम्बरहरु
जिल्ला प्रशासन कार्यालय ०५६ ५२१९४४
जिल्ला विकास समिति ९८५५०५९०१०
माडी एफएम ०५६ ५६९३६१६
नेपाल रेडक्रस सोसाइटि, चितवन ०५६ ५२०१३३
माडी ईलाका प्रहरी ९८४४१३५६७६
नेपाली सेना, भरतपुर ब्यारेक ०५६ ५२०२२२
बाढी पूरवानुमान शाखा, काठमाण्डु ०१-४४३६२७२
नारायणी बेसिन कार्यालय, भरतपुर ०५६-५२६४०९
जिल्ला आपतकालिन संचालन केन्द्र ०५६-५३२८३२
सं.रा.सं.का. (UNDP) ०१-५००४१७६/७८

Website: www.hydrology.gov.np

# ANNOUNCEMENT

## Third International Conference on
# Mountain Hydrology and Meteorology for the Sustainable Development

10-11 April 2017
Kathmandu, Nepal

**ORGANIZED JOINTLY BY:**
Society of Hydrologists and Meteorologists, Nepal (SOHAM-Nepal)
Department of Hydrology and Meteorology (DHM)
Government of Nepal (GoN)
United Nation Educational, Scientific and Cultural Organization, International Hydrological Programme Nepal (UNESCO IHP-Nepal)
Central Department of Hydrology and Meteorology (CDHM), Tribhuvan University (TU)
Himalayan Cryosphere, Climate and Disaster Research Center, Kathmandu University (KU)
Nepal Academy of Science and Technology (NAST)

**IMPORTANT DATES**
Submission Abstract: 31 December 2016
Notification of acceptance: 15 February 2017
Submission of Full paper: 15 March 2017
Conference starts: 10 April 2017

**REGISTRATION**
**For domestic participants:**
Student: NPR 1500
Individual: NPR 3000
Institutional: NPR 5000
SOHAM member: NPR 2000

**For International participants:**
SAARC countries: USD 100
Non SAARC countries: USD 250

Participants are requested to send their registration fees through bank transfer
**Bank: NMB Bank (http://nmbbanknepal.com)**
**Babarmahal, Kathmandu, Nepal**
**Account Holder: SOHAM-Nepal**
**Account Number: 00100014621C**
**SWIFT Code: NMBBNPKA**

Registration fee includes conference bag, two lunches, a dinner and tea/coffee on meeting days

**PROGRAMME**
The conference will consist of a mixture of oral and poster sessions. We encourage posters that promote interaction among participants, and communications that present new research prior to peer-reviewed publication. Additional activities are to be determined including conference dinner, post-conference excursion and Exhibition stall. The meeting will also provide the opportunity to organize special sessions on specific current issues and stall exhibition. Contributions to the conference will be selected according to their relevance to the topics aforementioned.

**CONFERENCE TOPICS**
The conference will cover a wide range of topics concerning mountain hydro-meteorology, its links to sustainable development and other related issues. The meeting will be dedicated to the following topics but not limited to: Mountain hydrology and hydrological modeling, Water resources management, Isotope hydrology, Trans-boundary issues of water resources, Cryospheric changes and its impacts on water resources, Watershed management, Mountain ecosystem services, Mountain meteorology and climate, Climate variability and changes, Monsoon, Extreme weather events, Climate change and cryosphere, Disaster risk reduction etc.

**CONTACT**
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Telephone: +977-1-4105029
Web: www.soham.org.np
Conference email: conference@soham.org.np

**CALL FOR PAPERS**
SOHAM-Nepal requests all relevant professionals to actively participate in the International Conference. The deadline for the submission of Abstract is 31 December, 2016. The interested individual can send full paper by 15 March, 2017 at conference@soham.org.np. (Please visit www.soham.org.np for more Information)