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Young Researcher

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WATER-INDUCED DISASTER IN NEPAL AND THE ROLE OF CITIZEN SCIENTIST

Abstract

This article focuses on the water-induced disaster (landslide and flood) condition in Nepal. The past and present water-induced disaster condition in the country has been analyzed, the importance and means for the database have been explored, gaps in water induced-disaster mitigation have been identified, the role of citizen scientists in data generation is visualized, and the efforts of S4W-Nepal have been signified.



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INTRODUCTION

The Himalayan region represents an active tectonic zone, and about 35% of the Himalayan belt lies in Nepal. The 147,515 km² territory of Nepal can be divided into three main geographical regions; the Himalayan region covers 15% of the total area, the hilly region covers 68%, and Terai, also known as the food basket of the country covers 17% of the total area. The Himalayan terrain is formed by the complex geological process, which is still continuing to shape the Himalayan region.

Such geological activities together with the hydrometeorological process have caused various types of hazards that eventually pose vulnerability to people, infrastructure, and natural resources. Thus, the larger population in the region has been exposed to multi-hazards, like earthquakes, landslides, soil degradation, flood, deforestation, loss of biodiversity, and drought.

Water-borne disasters like landslides, floods, soil erosion are common during the monsoon period in the entire Himalayan region. Snow avalanches are common, and glacial lake outbursts occasionally occur in the Himalayan region. These disasters have a significant impact on the natural system, settlements, and infrastructure in Nepal. In the past decades, climate change has been observed worldwide. For the future, predictions indicate average temperature rise, change in precipitation patterns in space and time, melting glaciers, sea-level rise, etc. with a large band of uncertainty. Likewise, extreme drought, intense rainfall, severe flood events, etc. are also predicted to occur more often under climate change conditions. Different aspects of disasters like a landslide, dam outburst flood, the occurrence of landslides due to bank erosion by the river and slope instability, floods, and infrastructure failure causing landslides and floods, etc. are different sorts of water-induced disasters. Himalaya is extremely vulnerable to natural disasters due to its geology, steep slopes, high relief, and monsoon climates and among the different natural disasters, landslides are important geological events in many parts of the world (Pathak, 2016a).

EFFECT OF PAST WATER INDUCED DISASTER

Water induced disaster (landslide and flood disaster) has greater and regular impacts among all other disasters, which is evident from the highest mortality (66%) for the period between 1990 and 2014 (Figure 1). Several events of water-induced disasters have increased the number of deaths, displacement of large numbers of families with damages to thousa-

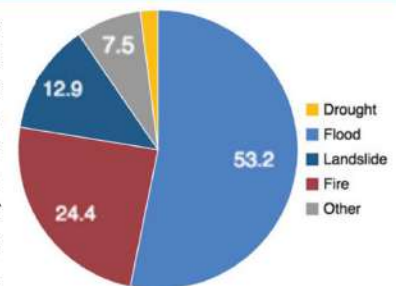


Figure 1: Disaster mortality in Nepal between 1990 and 2014 (UNISDR, 2015)

nds of houses. It is quite convincing that these disasters are the major disasters in the country with an eminent impact on the people. Nevertheless, the earthquake disaster has a much greater and long term impact on all sectors of life even though it happens in a longer time interval. Even a single earthquake event can have more death, destruction of houses and infrastructure, as well as greater economic losses than the total due to other disasters in several decades.

THE WATER INDUCED DISASTER

Landslide and debris flow

Landslides are common in all physiographic regions of Nepal, i.e. from the Chure range in the south to the Higher Himalayan region in the north. The analysis of landslide data in different regions of Nepal shows that in general, most of the landslides have occurred in elevation class between 500 m and 2000 m. Physiographically, landslide occurrence is more in Middle Mountain and High Mountain regions. Likewise, the topographic slope is another important factor for the occurrence of landslides, and the slope angle between 20 and 40 degrees is most sensitive for the landslide occurrence. Geologically, most slope instability issues are in Siwalik and Lesser Himalayan regions. Generally, we believe that the vegetation-covered areas are the stable ground; in contrast, the analysis of the data shows that in most of the cases, landslides occur in the forest area. It indicates that the vegetation is effective to provide ground stability only against the shallow slope failure, while for the deep-seated failure plane, especially below the root zone of the vegetation, large scale landslides may occur with significant damages to the forest land that may impose risks to other elements like settlement, agriculture land, and infrastructure at the downslope. An analysis of landslide vulnerability in eastern Nepal shows that many landslides have increased vulnerability to forest

followed by agriculture, settlement, and road (Figure 2). Google Earth's image is useful for the rapid assessment of landslides in an area, and it is especially useful in the identification of large and disastrous landslides (Figure 3). Likewise, it is quite helpful to identify the earthquake-induced landslides through comparison between the images before and after an earthquake (Figure 4). Either a new landslide can be developed or the old inactive landslide could be triggered during an earthquake.

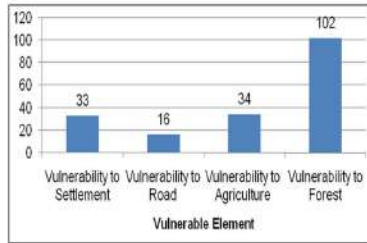


Figure 2: Elements at risk due to landslides (number of landslides is at Y-axis)

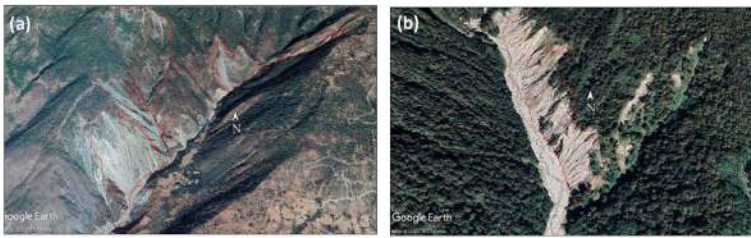


Figure 3: Landslide in (a) Okhaldhunga district located at Manebhanjyang Gaupalika; and (b) Sankhuwasabha district at Makalu Gaupalika



Figure 4: Damage to road from earthquake due to triggering of old landslide as well as development of new landslide in Dhading (left image before earthquake and right image after earthquake)

Flood

Flood is a common hazard that sometimes becomes a disastrous event due to its magnitude and presence of a large number of vulnerable elements. Such events are occurring both in the mountainous regions as well as in the Plain area. The rivers flowing through the Kathmandu valley have been heavily stressed due to encroachment as a result of



Figure 5: Flood hazard map of Kathmandu valley. The deeper blue color shows deeper water level (Pathak et al. 2009)

urbanization. The natural regimes of the rivers are not maintained to the required waterway and also the natural regime of the river is much affected. This is the reason that many regions in the Kathmandu Valley are experiencing flood problems in each monsoon period. The flood hazard map of the Kathmandu Valley shows that both the urban core areas, as well as newly urbanized areas are prone to flood problems (Figure 5).

GAPS IN WATER INDUCED DISASTER MITIGATION

In order to address the growing vulnerability due to the water-induced disaster, proper understanding of the biophysical, social, and institutional components is required. The water-induced disaster mitigation (WIDM) has been given the prime importance from the government of Nepal, however, a mounting disaster-induced loss indicates that disaster risk reduction is far from getting its due share of attention and resources (Pathak 2016b). Lack of seriousness and accountability of the decision-making authority, unavailability of the adequate database, low priority, and insufficient fund allocation for the disaster related study are some of the issues related to the inefficiency of disaster mitigation. Pathak (2016c) has pointed out some of the important measures to be considered for effective water-induced disaster management, which are listed below:

- A hazard map is not adequate for planning rather risk map is more useful
- A comprehensive disaster database will be supportive for disaster management
- Prioritization of the watershed based on the water-induced disaster will facilitate effective disaster management
- Regular monitoring and effective early warning system will reduce disaster loss
- Institutional strengthening with effective coordination and networking among government line agencies
- I/NGO should be given appropriate roles to work in coordination with the government in a supportive role. These organizations should work on various sectors as identified and prioritized by the government
- Get prepared for the worst

CONCLUSION

Landslide and debris flow, as well as floods, are the major water induced disasters in Nepal. There are many stakeholders for effective disaster management, namely government, non-government organization, disaster experts as well as the local residents. The role and activities of those stakeholders are almost defined, however, the role of local residents is least brought to the mainstream of disaster management. Data required for disaster management are available on national, provincial, and district level. However, there is a scarcity of data (like precipitation and flood discharge) at the local level, especially at the community level. These data are required to assess the disaster condition and to develop models required for disaster management. The local residents can be trained and given the responsibility to measure the hydrometeorological data so that a comprehensive database can be formed at the community level. Besides, these citizen scientists can act as valuable messengers to the community regarding community awareness in disaster management. S4W-Nepal has realised the importance of citizen science and its activities are focused to bridge the gap.

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News Gallery

Climate change: Earthquake 'hack' reveals scale of ocean warming

Scientists have found a clever new way of measuring ocean warming, using sound waves from undersea earthquakes. Their new method shows the decadal warming trend in the Indian Ocean was far higher than previous estimates. The deployment of around 4,000 autonomous devices called Argo floats that capture temperature information has helped enormously, but now a team of researchers has developed a very different approach that exploits the fact that the speed of sound in seawater depends on temperature. The idea was first proposed and trialed in the late 1970s using sound waves generated by scientists.



September 17

<https://www.bbc.com/news/science-environment-54193334>

Fish exposed to noise pollution likely to die early: Study

Fish stressed by noise are less able to fight off disease while prolonged exposure can lead to an early death, according to a research published. Noise pollution leads to stress, hearing loss, behavioral changes, and impacted immunity, but how noise affects resistance to disease has remained neglected. In this research, a fish exposed to one acute noise died two days before the fishes left in the silent tank. Scientists at Queen's University Belfast found that noise affects amphibians, arthropods, birds, fish, mammals, molluscs, and reptilians.



September 16

<https://timesofindia.indiatimes.com/home/environment/pollution/fish-exposed-to-noise-pollution-likely-to-die-early-study/articleshow/8139790.cms>

Typhoon Bavi makes landfall in North Korea

Typhoon Bavi hits North Korea early on August 27 with maximum winds of 115 kilometers per hour (km/hr) after skirting the coast of South Korea overnight. Bavi was passing near Pyongyang after making landfall in a western coastal region



of North Korea, and floods were observed on the roads of Nampo. The Korea Meteorological Administration warned of strong winds continuing in the Seoul and the central region through the morning. Bavi led to the power cut, obstructed the flights and railway services in the Jeju Island of South Korea where coronavirus testing stations were also dismantled.

August 27

<https://www.smh.com.au/world/asia/typhoon-bavi-makes--landfall-in-north-korea-20200827-p55pwk.html>

Safe disposal of COVID-19 related waste challenging

Waste management and sanitation in health care institutions have become an emerging challenge to the government with the surge of COVID-19. Large quantities of waste are increasing, that include masks, gloves, gowns, and other personal protective equipment. The Ministry of



and Population (MoHP) has brought Healthcare Waste Management Directive-2077, which is under the process of endorsement for safe disposal of these wastes. As per the directive, the wastages must be categorized into infected and non-infected ones. And these two classes of wastes must be treated accordingly.

August 27

<https://risingnepaldaily.com/nation/safe-disposal-of-covid--19-related-waste-challenging>

About 60% of ice shelves of Antarctica are under the risk of fracture.

According to a study published in the journal "Nature", 60% of the ice shelves in Antarctica are at risk of "hydrofracture", meaning the flow of melted water into the fissures in the ice, enlarging them and triggering them to collapse. Due to this, the loss of Antarctic ice sheets and an increase in sea levels are prone to get accelerated. Scientists have recently announced that 28 trillion tonnes of ice have been lost from the earth's surface since 1994. Though fractures in the ice are visible in satellite imagery, manual mapping has not been practically possible.

August 26

<https://www.theguardian.com/world/2020/aug/26/antarctica-ice-shelves-risk-fracture-collapse>

Painting turbines black can reduce bird death

The death of birds due to collision with turbines has been considered one of the crucial negative impacts of onshore wind farms. Annually, 6-9 white-tailed eagles die in Norway on the premises of the Smola wind-power plant. The



RSPB hence always prioritized placing wind farms in the low-risk areas. However, an experimental study suggested that painting one of the blades of the turbine black can reduce such risk by 70% making wind power plants more nature friendly. It is expected to reduce the motion smear of the turbines, making blades more visible to the birds. However, the test is to be carried further in the Netherlands and South Africa.

August 26

https://www.bbc.com/news/science-environment-53909825?intlink_from_url=https://www.bbc.com/news/world&link_location=live-reporting-story

Why the Mauritius oil spill is so serious

The amount of oil spilled nearby coastal areas of south-east Mauritius is relatively low compared to big oil spills the world has seen in the past, but the damage it will do is going to be huge. Unlike most previous offshore spills, this has taken place near two environmentally protected marine ecosystems and the Blue Bay Marine Park reserve, which is a wetland of international importance. According to the UN Convention on Biological Diversity, the spot is home to 1700 species including around 800 fishes, 17 kinds of marine mammals, and 2 species of turtles. Due to bad weather conditions, the wind and water currents are not helping, rather, taking oil towards the areas that have a vital marine ecosystem.

August 13

https://www.bbc.com/news/world-africa-53754751?fbclid=IwAR03K_Q6R9m0BRfdZk0NFeOgJhsjGkgt6RN4l6ayyJXaZVTRmxY7zPasTNI

COVID-19 makes severe pollution through the plastic.

In the middle of the corona pandemic, it was felt that level of pollution has certainly decreased and the report says there was 26% less production of carbon dioxide during the lockdown but now the COVID crisis has led to the use of extensive plastic products in the form of PPE and masks. A decade long fight to boycott plastic use has been forgotten due to the COVID pandemic. Another harmful effect of masks is it is made up of polypropylene which is hard to reuse and recycle. Plastics take at least 500 years to biodegrade, killing aquatic and land animals, and microplastics have found their way into the human food chain. Hence, there is an urgent need to start momentum for proper management of safety products.



July 30

<https://www.nepalitimes.com/banner/the-covid-19-plastic-pandemic/>

Implementation of 10 years conservation action plan for conserving owl in Nepal

On the occasion of Global Tiger Day, 2020, the Government of Nepal approved 'Owl Conservation Action Plan 2020-2029' for the study and research of owls found in the country. The publication was made in the Department of National Park and Wildlife Reserve by Dr. Bishwanath Oli, Secretary of Forest and Environment. It is believed to be a great achievement to solve the hurdles in the conservation of owls in the country. Mr. Raju Acharya, an owl expert explained that owls have been facing threats of illegal trade and poaching along with habitat destruction, social norms, use of chemicals in agricultural fields, lack of rescue, and so on.

July 29

https://pahilopost.com/content/20200729183112.html?fbclid=IwAR1b3jWCqpo6wAgk7vUizrd9a8LBGcFHwDCscgJANu_IgBVptgZs8clccj0

Apple plans to be totally carbon neutral by 2030

Apple made a major commitment to fight against climate change by announcing plans to be entirely carbon-neutral by 2030. The pledge would cover its entire business, including its supply chain, manufacturing process, and the life of its products. An iPhone bought in 2030 will have net-zero climate impact, including the energy a consumer uses to power the device, according to Apple. Apple is already starting to change the materials it works with. Apple has also reduced emissions from gases used in manufacturing its electronics.



July 21

<https://edition.cnn.com/2020/07/21/tech/apple-climate-change/index.html?fbclid=IwAR26WFAywHqHdn09lgIO5cnyj286WFM7U5316uYg9FWFXpaNv9bw4MZmNc>

Is citizen science reliable for monitoring rainfall?

Citizen science is an approach of engaging the general public in scientific research which contributes to building their connections with professional scientists and increases their scientific understanding (Keyles, 2020). Smartphones For Water Nepal (S4W-Nepal) has been launching Monsoon Expedition in the Kathmandu Valley (Valley) for more than three years by mobilizing citizen science, mobile technology, and young researchers. The



Figure 1: S4W rain gauge

citizen scientists use a cost-effective rain gauge and an android phone to measure rainfall on a daily basis. S4W-Nepal rain gauge is made up of recycled clear plastic bottles (Coke or Fanta) of 2.15 liters having a uniform diameter of 100 mm (made by using concrete) and calibrated with a millimeter scale (Figure 1).

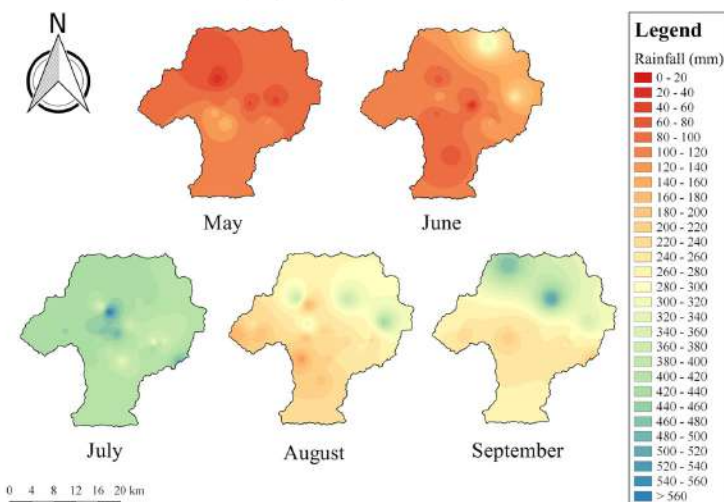


Figure 2: Monthly cumulative rainfall distribution in the Kathmandu Valley for monsoon 2019.

In the Monsoon Expedition 2019, S4W-Nepal recruited and trained 55 enthusiastic citizen scientists for monitoring rainfall in different parts of the Valley. As a result, a good set of spatial rainfall data from May to September of 2019 of the Valley was generated. In 2019, monsoon entered Nepal in the third week of June (Upreti, 2019). Heavy rainfall was observed in July in the Valley which triggered flooding in several rivers adversely affecting the settlements near the river corridors. The data generated by citizen scientists show that rainfall was highest in the month of July (mean= 417.63 mm), followed by September (mean = 287.68) and August (mean = 250.44 mm)(Figure 2).

According to Davids et al. (2019), the S4W rain gauge used by citizen scientists for taking rainfall measurements is estimated to have an error of 2.9% compared to a standard gauge. Therefore, in order to validate or standardize citizen scientists' rainfall data from S4W rain gauge, 17 co-located stations were selected to compare with the standard Department of Hydrology and Meteorology (DHM) rain gauge in the Valley. Only the overlapped data from May to September 2019 were used for statistical comparison. The data of citizen scientists were correlated with the respective DHM stations to determine their relationship.

The correlation between 10 co-located stations was found to be strong (above 0.6), 4 co-located stations were moderate (between 0.4-0.6), and 2 co-located stations were weak (below 0.4). The correlations for all stations were statistically significant at 0.01 significance level except for Sakhnu and Naikap stations. Such differences between the DHM and citizen scientists' stations may be due to the distance between stations (~1.5 KM for Sakhnu). The times series of cumulative rainfall suggests that there is a similar trend of rainfall in both DHM and citizen scientists' stations (Figure 3).

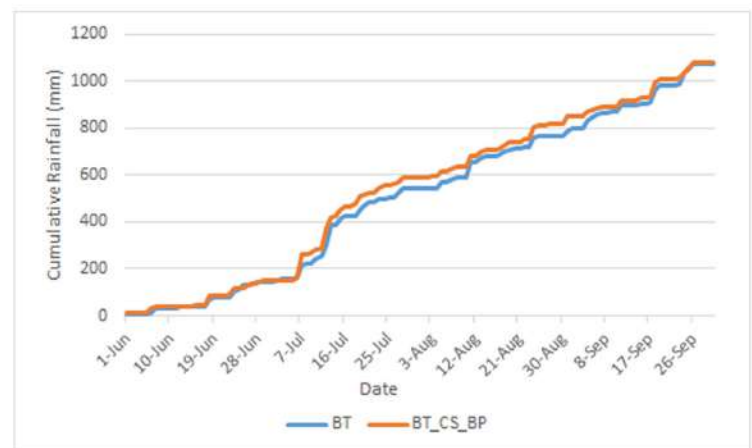


Figure 3: Time series of cumulative rainfall amount from June to August 2019 of Bhaktapur DHM station (BT) and citizen scientist station (BT_CS_BP)

Citizen science can be a feasible and cost-effective approach for collecting reliable rainfall data along with educating the citizen scientists about the need and applications of hydrometeorological data. Therefore, citizen scientist networks need to be further expanded to other regions to fulfill the hydro-meteorological data gaps in Nepal. Furthermore, citizen scientists must be educated, trained, and motivated for regular rainfall measurements since these data can make big impacts in the field of research and support better water resource management decisions.

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Water is the most basic of all resources. Civilizations grew or withered depending on its availability.

- Dr. Nathan W. Snyder

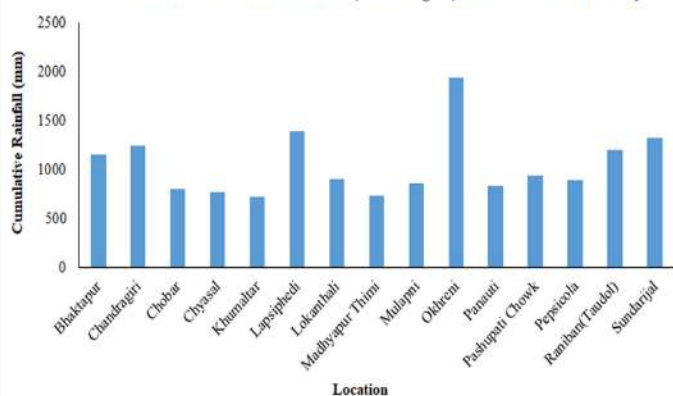


Citizen Scientist's Story

Namaste, I am Bharat Dhungana. I am currently pursuing my Bachelor's degree in Meteorology from Tri-Chandra Multiple Campus, Ghantaghar, Kathmandu. Being an enthusiastic youth, I am interested in the monitoring and management of resources. I got involved with S4W-Nepal through an outreach session conducted in my college. I have been actively collecting the daily precipitation data since last year with the help of a locally made cost-effective rain gauge. I believe that the collected data will be useful for the next generation of young researchers, especially those working for water resource management. Being a part of the S4W-Nepal monsoon campaign has made me more aware and responsible towards water resources and data collection importance.

It is very difficult and expensive to set up a complex instrument for environmental monitoring, and considering the situation, I highly appreciate the idea of a budget-friendly gauge for measurement as well as a cost-effective data transmission method through an android application ODK collect. I believe that the work of S4W-Nepal would be more fruitful if youngsters outside the valley are also approached through outreaches for collecting the data across the nation. Through my experience as a citizen scientist, the rain gauges should be monitored often and replaced in need as they tend to be leaky sometimes, resulting in faulty reading. On a final note, I would like to say, "I am very happy to be a part of S4W-Nepal, and am thankful to them for being responsible towards the environment."

Cumulative Rainfall of Monsoon (June-August) in the Kathmandu Valley



YRC Activities

- Publication of weekly 'Environmental News Refresher' and a bi-monthly newsletter 'Young Researcher'
- Carrying out citizen scientists (CS) interview and preparation of CS story.
- Research training to interested YRC members on the rainfall indices.

S4W-Nepal Activities

- Guest lecture on the topic "Characteristics of ephemeral rivers and challenges in their management from Nepalese viewpoint" by Dr. Saroj Karki on 27th July, 2020
- Guest lecture on the topic "Groundwater hydrology: a brief introduction on natural and artificial recharge" by Dr. Bijaya Shakya on 22nd August, 2020
- An experience sharing session by Dr. Jeffrey C. Davids (Water Resources Engineer) on 5th September 2020 on the title "SmartPhones4Water: Looking Back | Dreaming Ahead".
- Webinar by Priyanka Chaudhary on 22nd September 2020 on the title "Pie & AI: Bhaktapur - Urban Flood Management Using Deep Learning" in partnership with deeplearning.ai.

Water is the most critical resource issue of our lifetime and our children's lifetime. The health of our rivers and oceans is the principal measure of how we live on the land.

-Luna Leopold

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