



Finally, scientists are studying the phenomenon of permafrost in the Indian Himalayan region and results show it is melting, reports Rohit Mullick

# HIMALAYAS DEFROSTED

In the hottest-ever year of 2016, a team of top climatologists began research in the Indian Himalayas, one of the coldest regions in the world, believing it won't remain the same.

Their aim was to map permafrost, the ground that remains below 0 degree Celsius for more than two consecutive years, in the Himalayan mountains of Kullu in Himachal Pradesh and find out if it has begun to melt due to global warming, as is happening in the Arctic regions.

This first-ever research on permafrost in the Indian Himalayan Region (IHR) by the Indo-Swiss Indian Himalayas Climate Adaptation Programme (IHCAP) has kindled scientific interest in studying permafrost in the Himalayas and how climate change is affecting it.

In the first phase of the study, the team has successfully mapped permafrost distribution in Kullu district. It commonly occurs from an elevation of around 4,500 metres.

When permafrost melts, the land above sinks or changes shape, which leads to natural calamities like landslides, slope collapse, glacial lake outburst floods (GLOF). This damages infrastructure on the ground.

However, the most alarming aspect of permafrost thawing is the fact that when permafrost melts, the trapped carbon is released into the atmosphere in the form of methane, a powerful greenhouse gas. This sets off a vicious cycle of climate change.

According to Dr Simon Allen, a research associate at the department of Geography, University of Zurich, Switzerland, who was part of the Indo-Swiss team of scientists, it is the beginning of permafrost research in the Indian Himalayas. "While there have already been studies elsewhere, such as the Andes or Alps, it's the first time research has started in the IHR. This study can provide sound basis for formulating further permafrost measurement and monitoring projects that may extend across the wider Himalayas in future."

The Arctic regions, like Alaska, Canada and Russia have started

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**Dr Simon Allen** | research associate at the department of Geography, University of Zurich, Switzerland



feeling the impact of permafrost thawing and a great deal of research has already been done in the mountain ranges of Andes and Alps. But it has taken a fairly long time for similar studies to be conducted in the Himalayas.

Dr Dorothea Stumm, a senior glaciologist at the International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal, agrees saying that not much data is available for the Himalayas.

"Very few studies exist on permafrost and knowledge on permafrost distribution and processes is very limited for this region. It started to receive more attention



UNDERSTANDING PERMAFROST: First studies conducted in the Arctic region

in the Himalayas in the last few years only," said Dr Stumm.

According to Dr Allen, one reason why permafrost was given importance over glaciers is that the latter is the biggest source of water.

"Glaciers are a water source but study of permafrost is equally important," said Dr Allen.

With the IHCAP study, the research scenario in the country is slowly changing. Close on the heels of the IHCAP study, the Indian Permafrost Network (IPN) was created last year to promote permafrost research in the country. The National Institute of Hydrology (NIH), Roorkee, has started collaborating with ICIMOD to exchange technical know-how and expertise in permafrost studies in the Himalayas.

According to Dr Renoj Thayyen, a scientist at NIH and coordinator of IPN, studying permafrost has been a missing component of the Himalayan cryosphere. But now, progress is being made.

"A lot of activity has started to happen in this direction. We have begun field measurement and modeling studies in collaboration with Carleton University of Canada and ICIMOD in Ladakh. We are exploring the possibility of taking up studies with IHCAP," said Dr Renoj.

landscapes, hazards, natural systems, and livelihoods. However, there are no existing studies on the impact of thawing permafrost in the Himalayas.

**What could be the long-term impacts of permafrost melting in the Himalayas for people living there?**

For the Himalayas, it is difficult to say what the effects are and how many people will be affected. However, from other parts of the world, we know that permafrost thaw affects the stability of infrastructure, increases natural hazards (slope instabilities, debris flows, rock fall), and influences hydrology, which affects vegetation and ecosystems. For example, some areas become drier, while others become wetter, which can change biodiversity and plant communities. Greenhouse gases might also be released. Further studies are needed to better understand permafrost distribution, processes, and how permafrost thaw impacts people and



natural systems.

**What is the status of permafrost research in the Himalayan region falling under Nepal?**

Mapping permafrost is difficult because we cannot see permafrost at the surface. However, we can map features, such as rock glaciers, which indicate the likely presence of permafrost.

ICIMOD has conducted a study mapping rock glaciers in randomly distributed areas in the Hindu Kush Himalayan region. There are other institutions that have initiated similar studies, such

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as IHCAP. ICIMOD and its partners (e.g., the Indian National Institute of Hydrology) also monitor ground surface temperature at study sites in Nepal and India, which give some information about the possible presence of permafrost underneath.

## Stemming the great meltdown

*Permafrost Thawing Could Lead To Spurt In Natural Disasters*

Himalayan glaciers are melting due to global warming and climatologists believe this could also be true of permafrost in the Indian Himalayan Region (IHR). Scientists fear this may lead to climate change and a spurt in natural disasters like avalanches. Under the circumstances, the study, the first of its kind in the region, could be instrumental in understanding the phenomenon of permafrost thawing and damage control.

The Indo-Swiss study has mapped permafrost in the mountains of Kullu district of Himachal Pradesh for the first time. It concludes that it is spread over an area of 420 square kms (9% of the total land area excluding glaciers) and states that this hidden component of the Himalayan cryosphere could already be melting.

The study, which was conducted by the Indian Himalayas Climate Adaptation Programme (IHCAP), a project of the Swiss Agency for Development and Cooperation (SDC) and the department of science and technology (DST), says warm air currents are responsible for thawing permafrost in the Himalayan region.

"Given that mean annual air temperature (MAAT) over Kullu has warmed by up to 2 degrees Celsius over the past century, it is almost certain that permafrost distribution has altered substantially over recent decades," states the study.

According to Dr Simon Allen, a research associate at the department of Geography, University of Zurich, Switzerland, who was part of the IHCAP team, permafrost is thawing and this just needs to be proved with numbers.

"Rise in air temperature means corresponding rise in ground temperature, which, in turn, results in permafrost thawing. In Kullu, this is has started to happen. The permafrost in the Himalayas is melting. It just needs to be proved with further studies in the IHR," said Dr Allen.

Dr Renoj Thayyen, a scientist at the National Institute of Hydrology (NIH), Roorkee, and coordinator of the Indian Permafrost Network (IPN), says current



HIGH SLOPES: Indo-Swiss study maps permafrost in mountains of Kullu

research is being done on the hypothesis that permafrost thaw and climate change are linked in the Indian Himalayan region.

"However, we need to conduct some focused study to say something concrete about the linkages between permafrost thaw and climate change in the region. Yes, we are working with the hypothesis that both are linked but we have to wait for numbers to emerge," said Dr Thayyen.

Some studies have already pointed out that permafrost is melting in other Himalayan areas like the Khumbu region of Nepal and the Tibetan Plateau.

While Khumbu region has recorded an increase in the lower elevation limit of permafrost up to 300 metres, in the Tibetan plateau, presence of permafrost has gone up by 80 metres.

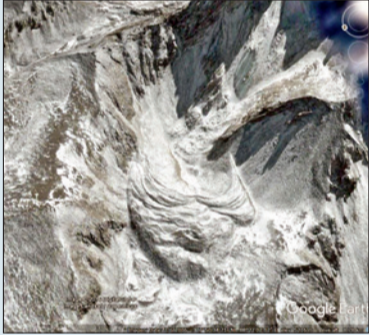
Sounding an alarm, the study further states that "Such a shift of permafrost in other Himalayan regions indicate that higher slopes in the Indian Himalayan region may also be in danger of sinking and that may result in natural hazards."

This study was initiated to identify terrain susceptible to warming and thawing of permafrost due to climate change to ascertain potential hazards. It expresses serious concern over the meltdown.

"More than half of the total mapped permafrost area in Kullu is characterized by low slope angles where debris can accumulate. Further warming of perma-

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### 'Permafrost is melting in the Himalayas'



SATELLITE IMAGE OF PERMAFROST

#### IHCAP study results

► Permafrost is distributed over 420 square kms (9% of the total area) in the mountains of Kullu district

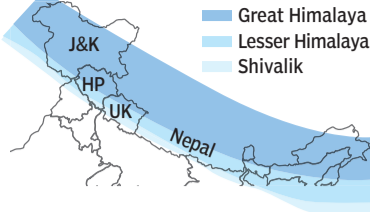
► Permafrost is most prevalent between 4,750 metres and 5,000 metres



frost can result in landslides and floods," states the report.

"Permafrost melting can also trigger rock avalanches that can damage high mountain infrastructure and lead to much more devastating and far-reaching disasters if glacial lakes are impacted, resulting in floods," adds the report.

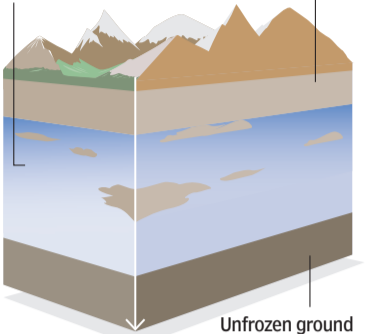
### Indian Himalayan Region



The IHR (Indian Himalayan Region) extends over 2,500 kilometers in length between the Indus and Brahmaputra river systems. Starting from the foothills in the south (Siwaliks), it extends up to the Tibetan plateau in the north (Trans-Himalaya). The IHR is responsible for providing water to a large part of the Indian subcontinent.

### What is permafrost?

**Permafrost** Continuously frozen ground  
**Active layer** Seasonal frozen ground above permafrost



Permafrost is defined as soil or rock that remains below 0°C for more than two consecutive years. Commonly, permafrost contains significant amounts of ice and has been frozen for millennia. In most permafrost areas, the ground thaws during summer to depths of up to a few metres beneath the surface.

This seasonal thawing layer is called 'active layer', and precludes permafrost from being directly observed. Many permafrost regions now have shorter winter season, which means that the active layer is growing thicker and warmer. Whereas glaciers and snow can readily be observed on the ground from airplanes or satellites, the measurement of permafrost is only possible at individual locations and requires boreholes or pits to be made to depths of several meters.

### Sinking ground

While research on Permafrost has finally begun at home, the Arctic regions are already feeling the impact of its melting. For example, in the Russian city of Norilsk, buildings have started collapsing as the ground beneath is shifting due to the melting of permafrost. In Siberia, giant craters are being discovered and they are caused by thawing permafrost.

Other cities across Siberia are also witnessing roads and rails caving in due to shifting grounds. According to one report, entire cities in permafrost zones could collapse in future due to climate change.

### From trickle to flood

Besides causing landslides and damage to infrastructure on the ground, permafrost melting can also lead to a phenomenon called Glacier Lake Outburst Flood (GLOF), a flood that is caused when a dam or lake opens due to pressure. Thawing permafrost can trigger an avalanche of rocks in the mountains. The powerful impact on glacial lakes can result in GLOF.



PERMAFROST TUNNEL IN ALASKA

### The danger involved

- Landslides
- Flooding
- Damage to infrastructure on ground
- Rock fall
- Slope instabilities
- Debris flow
- Changes in ecosystem
- Climate change with release of trapped greenhouse gases

## Experts link climate change, permafrost

*Dr Dorothea Stumm, senior glaciologist at the International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal, says thawing of this invisible layer causes disturbances in natural systems, infrastructure and livelihood*

**Do you think the study on the impact of climate change on permafrost in the Himalayas has been a little late?**

Permafrost is invisible at the surface. It has received more attention in the Himalayas only in the last few years. In the Himalayas, very few studies exist on permafrost. The knowledge about permafrost distribution and processes is very limited for this region and its different climatic regimes.

**Climate change has triggered permafrost thawing in the Himalayas. How bad is the situation?**

We know that permafrost distribution must be widespread in the Himalayas and from other parts of the world, we know that thawing permafrost affects various natural systems, infrastructure, and livelihoods. We must assume that climate change also affects the state of permafrost in the Himalayas, with consequences for

## 'Study is vital for Himalayan region'

*Dr Renoj Thayyen, scientist at the National Institute of Hydrology (NIH), Roorkee and coordinator of the first Indian Permafrost Research Network (IPRN) talks about India lagging behind in this crucial aspect of research*

**Why was the Indian Permafrost Network (IPN) created and what has it done till now?**

The IPN is an idea that emerged during an international workshop on Himalayan permafrost held in New Delhi last year. As part of the project, NIH has signed a memorandum of understanding with Carleton University, Canada and is collaborating with the ICIMOD, Nepal. Preparing trained manpower is the next step in promoting the permafrost research in India. We have also established contact with the International Permafrost Association for help in training and research and they are very positive.

**Studies prove that permafrost, along with glaciers has been melting elsewhere, like in the Arctic region. Can we say the same about the Indian Himalayan Region, knowing that there is a rise in the annual mean temperature?**  
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**What took so long for permafrost research in the Indian Himalayan Region to begin?**

Glaciers and snow have a dominant role in the hydrology of the region as well as for water availability across the Himalaya and trans-Himalaya. Permafrost is more im-

portant in the arid regions of the Himalaya. We still do not know its spatial extent and its overall importance in the Himalayan context other than some coarse estimates. But certainly, it is a missing component in the Himalayan cryospheric system studies.

**How important is the research of permafrost thawing in the backdrop of climate change in the Himalayas?**

It is very important as it is one of the key components of the Himalayan cryospheric system. Bringing this hidden component into the research framework is important for an understanding of the system response in the years to come.

**Are more permafrost studies planned or underway?**

Yes, field measurement and modeling studies are underway in collaboration with Carleton University and ICIMOD in the NIH experimental catchment in Ladakh. The possibility of taking up some studies with the IHCAP is also being explored.



ICIMOD