



FIGURE 1. RAPHSTRENG AND THORTHORMI GLACIAL LAKES ARE THE SITE OF THE UN-SUPPORTED PROJECT AIMED AT DRAINING GLACIAL LAKE WATERS AT THE POINT OF OUTFLOW LOCATED CENTER RIGHT (PHOTO: KEVIN MCMANIGAL).

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## FIELD INVESTIGATION OF GLACIAL RETREAT IN THE LUNANA VALLEY, ROYAL KINGDOM OF BHUTAN

### THE RESEARCH PROJECT

In June 2010 our international research team set out to investigate the impacts of glacial retreat in the Lunana Valley in north-western Bhutan. The high mountain glaciers of this valley serve as a vital source of water for local residents and the overall water budget in the Pho Chu River, a tributary to the Brahmaputra River. In the warming of the current inter-glacial period, the glaciers at the head of Lunana Valley, similar to elsewhere in the Himalaya, are experiencing rapid recession. The effects of warming on these glaciers — namely the Luge, Thorthormi, Raphstreng, and Bechung Glaciers — have been observed by local residents, comparative satellite studies, and field surveys with repeat photography and GPS. The Lunana Valley is facing multiple risks associated with this glacial ablation, including the formation of large proglacial lakes such as Luge Tsho, which was responsible for the 1994 glacial lake outburst flood (GLOF) event that caused considerable damage downstream.

Our project aims to develop a baseline data set and protocols for long-term glacier monitoring, to assess water-related problems and vulnerability to GLOF hazards, and to evaluate strategies for local adaptation. This research effort was made possible through the generous support of the following: American Alpine Club; Association for Nepal and Himalayan Studies Senior Scholar Fellowship; Bhutan Foundation; The University of Montana; and the Ugyen Wangchuck Institute for Conservation and Environment. By incorporating a ground-validated analysis with an assessment of human dimensions of glacial recession, we aim to engage mountain people in developing culturally-appropriate science-based solutions and adaptive strategies for reducing risk and vulnerability in this watershed. This project also represents an initial effort to build capacity among Bhutan's scientific community in the area of long-term monitoring of glacial change.

### THE FIELD CAMPAIGN

The route to Lunana Valley follows the infamous Snowman trek, known to be one of the most challenging treks

in the world. Indeed, the journey proved to be arduous and required a great deal of logistical planning, arrangements, and coordination. From the end of the jeep track near Gasa, the trek took eight days, with one rest day while the pack-horses were being shod. Nearly all travel days were spent hiking 8-10 hours. The weather was dominated by heavy rain with some snow and brief periods of clearing. The temperatures ranged from warm and humid in the lower elevation rainforest to below freezing on the high altitude mountain passes. Frequently, these weather extremes were experienced in a single day, as the steep terrain often required ascending and descending over 2000 meters. The alpine scenery was mostly draped in clouds, which affected the repeat photography of the glaciers, although some photo stations were successfully established.

Upon reaching Lunana Valley, the team spent several days trying to access Thorthormi Glacier from the advanced base camp at the village of Thanza. The hike up the moraine to the outlet of the lake took two hours each way, with the actual glacier being another 15-20 kilometers further. A major finding was that the glaciers have receded abruptly and down-wasted hundreds of meters into steep sided gorges filled with glacial lakes. The terrain and distances from base camp made it impossible to actually reach the terminus of Thorthormi glacier. However, the team was able to survey the lateral and terminal moraines with GPS and establish a dozen photo stations for repeat photography. We also surveyed about twenty large glacial erratics that can serve as a baseline for measuring movement at the moraine dam.

During the approach to Thanza, the team conducted interviews with local residents. Many of the villages were relatively empty at this time because locals were participating in the seasonal collection of *Cordyceps sinensis* or caterpillar fungus, which has become a significant contributor to the local economy. Also, the majority of yak herders and traders who cross over the Himalaya range into Tibet were absent. Nevertheless, nearly two dozen interviews and informal conversations were carried out that provided insight into local water issues related to glacial retreat. The team also

had the opportunity to interact with the field researchers of the Bhutanese Department of Energy who are stationed in Thanza. Their projects center on monitoring glacial lake levels and out flows, as well as the ongoing installation of a Glacial Lake Outburst Floods (GLOF) early warning system for downstream villages.

On the outgoing trek, the team met and passed many administrators and workers traveling up-valley for an ambitious United Nations-funded GLOF mitigation project. Over 300 people have spent the last four summers in Thanza working to drain Thorthormi Lake. The project is well-funded and managed on site; however, the workers have little technical and logistical support and are often not adequately prepared as they make the trek into the mountains. Many workers are from lowland areas of southern Bhutan and have never experienced high altitude mountain conditions. Unfortunately, a few fatalities have been reported that have apparently been related to high altitude sickness.

The team continued without further incident until Gasa on the last day. Heavy rains had partially washed out the dirt road, covering it in thick mud. The horseman refused to go any further, and several hours were spent ferrying loads across the slide until the entire mountain collapsed, making passage impossible. Luckily, the team had just finished the final crossing, and no one was injured. After soliciting the help of a farmer's tractor to transport gear, and navigating a few minor landslides, the team finally made it safely out of the mountains.

## OUTCOMES AND FUTURE CONSIDERATIONS

The field mapping of the glacial moraines with GPS help to establish the former extent of the glaciers from multi-temporal satellite analyses and will be essential in calculating the speed of their retreat. Overall, the local testimonies corroborate the alarmingly fast rates of glacial wastage and demonstrate the wealth of indigenous knowledge with regard to the changing local environment. The interviews also identify a number of issues stemming from the UN GLOF mitigation project, including the impact of workers living in a highly sensitive watershed. Additional field research is needed to establish connections between observed conditions and local adaptation. This will require an increased commitment and a more comprehensive consideration of field logistics, emergency procedures, and support in this physically challenging research setting. Considering that the minimum trek into the Lunana Valley is ten days, it is recommended that at least six weeks be devoted to field campaigns.

The timing of future field work in Bhutan also needs careful consideration. Research during the monsoon season from June to August is clearly less than ideal because the weather makes travel conditions precarious and the mountains are also shrouded in clouds, rendering repeat photography of glaciers nearly impossible. Another obstacle is the timing of the *cordyceps* season that virtually empties the villages in the summer months. With these considerations in mind, plans are underway to design the next field investigation into local responses and adaptations to glacial fluctuations, and to develop a long-term integrative glacial monitoring program for Bhutan.



FIGURE 2. NORBU WANGDI OF THE UGYEN WANGCHUCK INSTITUTE FOR CONSERVATION AND ENVIRONMENT CONDUCTS AN INTERVIEW WITH A LOCAL RESIDENT IN THE LUNANA VALLEY, BHUTAN (PHOTO: KEVIN MCMANIGAL).