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Glacial hazards and risk management in the Himalayas - lessons learnt and outstanding issues

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Since the Glacial Lake Outburst Floods (GLOFs) from Dig Tsho in Nepal in 1984 and Luggye Tsho in Bhutan in 1994 there has been variable interest in addressing the issue of glacial hazards in the Himalayas. Tsho Rolpa in Rolwaling in northern Nepal has been the best studied of all Himalayan glacial lakes, beginning in 1992. Since the completion of interim remediation of the lake in July 2000 very little has been done to progress work to achieve a permanent solution. Early assessments were based largely on experience from Peru where such outbursts have been familiar to the authorities since 1941. In 1997 a media frenzy helped to create panic largely arising from inopportune comments from supposed 'experts'. This highlighted a key issue in that at that time there were no guidelines for the assessment of glacial hazards; statements made varied from those based on scientific observations through to emotive and very subjective prognostications; in some quarters the latter approach is still the way statements are made. Yet from the Government's perspective, with a responsibility to manage the threat to vulnerable communities, who is to be believed?

This led to a research programme funded by the British Government to investigate and develop methods for the assessment of glacial hazards in a more objective and scientific manner. The outcome of this was the publication of the first international guidelines on glacial hazard assessment in 2003.

Further developments, particularly using high-level analytical techniques with ASTER and SPOT5 remote sensing data, have led to semi- and automatic terrain classification, use of Digital Elevation Models to be able to derive topographic profiles correlated to geomorphological and structural glaciological profiles, and being able to determine

where glacial lakes may develop in the future. This was based upon back-analysis of glacial lake formation in Bhutan since the 1950s, and which has been tested elsewhere in the Himalayas since and independently verified. Furthermore, the integrated analysis of different datasets has permitted a much more robust method of determining technical parameters that can be modelled to test stability.

The use of Multi-Criteria Analysis was introduced in 1998 and has subsequently been developed by which a glacial hazard score for any given glacial lake can be derived based upon a set of quantitative and objective trigger potential and threshold parameters. This led to the determination of an overall glacial hazard ranking and prioritisation that can be used by non-technical government officials as an aid to hazard management.

In parallel has been the development and increased use of numerical hydrological modelling in order to determine what effects a GLOF would have downstream, should one occur. However, what is needed is more ground truth verification of such models, as uncertainties in some of the input parameters can result in unacceptably high levels of inaccuracy in the model outputs, rendering the models ineffective.

It is clear that a more integrated approach to glacial assessment is required utilising the various remote sensing and ground-based technologies that can be used to provide objective inputs to a glacial hazard assessment scheme.