

Information series on geographical information and remote sensing systems in mountain environments

Geographical information and remote sensing systems play a special role in the Hindu Kush-Himalayan region in support of informed decision making. This series of information sheets presents information on basic technologies, approaches, and applications related to geographical information and remote sensing, and used or developed by ICIMOD, as a background for understanding for policy makers, development workers, and others.

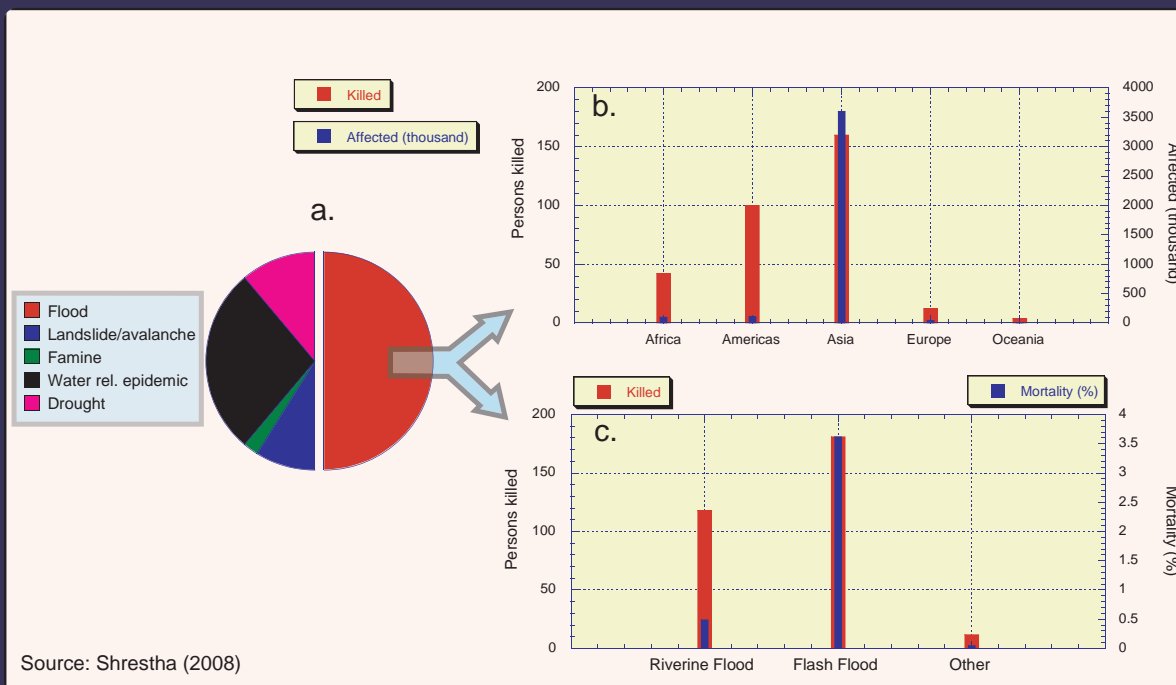
The Hindu Kush-Himalayan region is one of the world's most complex, dynamic, and intensive hotspots of risk from natural hazards – including earthquakes, floods, flash floods, landslides, droughts, and wildfires. This region is home to fragile ecosystems that are very sensitive to changes in climatic conditions and exceptionally vulnerable to natural hazards. Over the past two decades, both the number of natural disasters that have occurred in the region and in the downstream areas it affects, and the number of people that have been affected by them, has steadily increased. The human, environmental, and socioeconomic costs and consequences of these disasters have been considerable.

Space-based information for Disaster Preparedness and Risk Management

Governments around the world have made commitments to take action to reduce the risk of disaster, and have adopted guidelines to reduce vulnerabilities to natural hazards. These are summarised in the Hyogo Framework for Action. The Framework underscores the need for, and identifies ways of, building the resilience of nations and communities to disasters by encouraging them to become more resilient to the hazards that threaten their development gains. In keeping with the spirit of the Hyogo Framework, ICIMOD is helping to integrate geospatial tools and space-based information and techniques into ICIMOD's thematic programmes to help reduce environmental vulnerability and promote disaster resilience in the region.

The Hindu Kush-Himalayan region – A hotspot for natural hazards

According to the United Nations' International Strategy for Disaster Reduction. Asia has the highest number of fatalities from natural disasters of any region, and within Asia, the countries of the Hindu Kush-Himalayas have the greatest number of disasters and casualties. There are several reasons for this vulnerability: the mountains are young and dynamic and still tectonically very active; the intense monsoon rainfall leads to flooding and landslides; and the extreme relief contributes to instability of both the land itself and infrastructure built on it. Problems associated with receding glaciers, and degradation of natural resources, contribute to the risks.



People killed and affected by floods: a. types of water-related disasters; b. number of people killed and affected by floods by continent; c. number of people killed by type of flood

Using space-based data for disaster management

Two of the four key activities listed in the UN's Hyogo Framework are mapping and assessment, and early warning – both of which can best be accomplished with the support of geo-spatial and geo-ICT technology. Today, earth observation data and remote sensing technologies are key components of disaster management in terms of monitoring and hazard assessment. Methods based on geographic information systems (GIS) simplify the process of organising, manipulating, displaying, and analysing complex geographic data and information. While natural disasters are inevitable, much can be done to minimise the potential risks to people and property by developing early warning strategies and plans which help to increase resilience to natural hazards and help in the rehabilitation after the event. Remote sensing and GIS can be used together with supporting information from field-based observations for disaster management by assisting in the development of a suitable strategy and framework for monitoring, assessment, and mitigation, and helping in identification of gaps.

Using geospatial tools in ICIMOD programmes on disaster reduction

Monitoring of glaciers and glacial lakes

Climate change and retreating glaciers constitute a major hazard in the region. The most significant glacial hazards relate to the catastrophic drainage of glacial

lakes. Floods caused by the breaking of moraine dams are known as glacial lake outburst floods (GLOFs). The sudden outburst of glacial lakes can give rise to flash floods and debris flow in downstream areas. Population pressure and tourism have induced people to settle in mountain areas which are highly exposed to these natural hazards. Trekking routes often lead through unsafe areas, and trails and bridges are commonly situated directly in the floodway.

ICIMOD has regularly monitored a number of glaciers and glacial lakes using remote sensing since the mid-1990s. This monitoring has taken place in close collaboration with partners in its regional member countries who have provided local knowledge and expertise. In 2001, the first glacier and glacial lake inventory report was published for Bhutan and Nepal, followed by studies on the impact of climate change on Himalayan glaciers, glaciers, and glacial lakes as indicators of global climate change, and most recently a summary of the formation of glacial lakes across the region.

Floods

The countries of the Hindu Kush-Himalayas are particularly hard hit by recurring annual floods. While floods are a regular part of life in many countries, climate change predictions tell us that in future the region will likely experience increased flooding. There is an urgent need for a regional flood information system to support planning and help reduce loss of lives and livelihoods by reducing flood vulnerability. ICIMOD has been involved in rapid response mapping of flood inundation

in coordination with Sentinel Asia and the International Charters to provided flood information through the Mountain GeoPortal, and ICIMOD and its regional partner organisations are developing satellite-based rainfall estimation methods for the region to support flood prediction. Satellite-based rainfall estimation offers a way of predicting floods in a timely fashion, even when ground-based observation data are limited. Additional rainfall data is expected to improve model usability and effectiveness for flood forecasting. Another recent advance has been the use of geo-ICT technology in which precise differential global navigation satellite systems are being used as 'near real-time' advanced warning systems for disaster management in the region.

Earthquakes

The devastating earthquake of 2005 was a stark reminder of the lack of disaster preparedness and management in much of the region. A series of earthquakes in 2009 in the eastern Himalayas (Bhutan) were a continuing reminder of the dangers. The extent of devastation in Pakistan and Sichuan, highlighted the enormity of the problem and the need for technological intervention to reduce potential damage. Hazard, vulnerability, and risk assessment are complex tasks requiring a large amount of spatial data. Databases developed using geospatial technologies are the most effective means of managing this large volume of data and information. Geospatial tools help to integrate and analyse multiple sources of data on biophysical aspects to enable better understanding of the causes and effects in earthquake prone areas. These tools can also be very helpful for the efficient allocation of resources and coherent implementation of construction plans during the rebuilding phase. ICIMOD conducts national and regional training courses to build regional capacity so that the spatial and non-spatial information needed to build regional expertise in the potential application of geo-information technologies could be assimilated for earthquake risk assessment.



Smoke plumes from forest fires

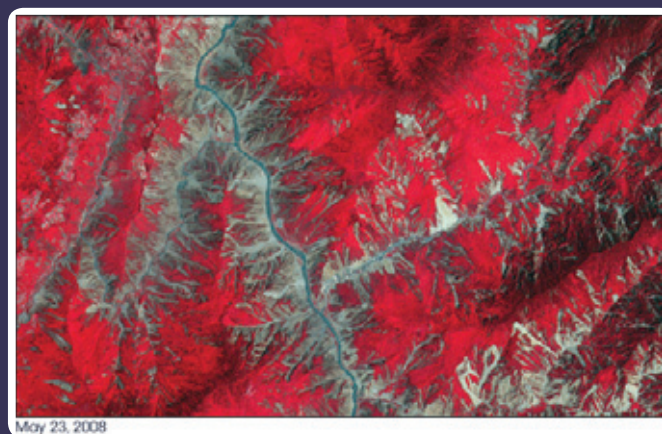
Landslide hazard mapping

Landslides are the most frequent natural hazards in the Hindu Kush-Himalayan region and cause the most destruction in terms of damage and number of human casualties. ICIMOD has conducted training on the use of GIS to map landslide hazards and vulnerability and has carried out studies on landslide mapping and risk vulnerability assessment for water induced disaster in the region.

Forest fires

Forest fires are a major environmental concern, both for the threat they pose to ecosystem biodiversity and for the human and economic devastation they usually entail. The often inaccessible terrain of the Hindu Kush-Himalayas makes satellite remote sensing ideal for mapping forest cover and providing the quantitative data needed in resource management to inform policy and decision makers. ICIMOD maps fire events on a daily basis during the fire season using satellite-based remote sensing MODIS (Moderate Resolution Imaging Spectroradiometer) data and publishes this information on the web for wider distribution. MODIS detects active fires, monitors fire progression, and estimates burned areas; it quantifies emissions from fires and estimates fire damage, as well as also being useful in monitoring the post-fire recovery of the ecosystem.

Sichuan earthquake images, acquired by the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)



Using field based observations for ground truthing

Both remotely sensed data and ground truthing verification are needed for the periodic monitoring of GLOFS. ICIMOD, in collaboration with international partners including Keio University and the Asian Institute of Technology (AIT), has established a field-based glacial lake monitoring system at lake Imja Tsho in Nepal. This system is equipped with a web cam with 24 sensor channels. The pilot Wi-Fi system transmits real time pictures of Imja Tsho; additional information on meteorological and atmospheric data are also retrieved on a near real time basis.

Activating the Sentinel Asia and International Charter, Space and Major Disasters

The 'International Charter, Space and Major Disasters' brings together the major space agencies worldwide to make satellite-based data and information available to the public during major disasters. During the Koshi Barrage breach, which triggered the Saptakoshi flood disaster in Nepal in August 2008, ICIMOD activated this Charter through the United Nations and made satellite data from various satellite agencies available to relevant organisation in the region. During the Pakistan flooding in 2010, ICIMOD prepared flood inundation maps for the three flood affected provinces (Khyber-Pakhtunkhwa, Punjab, Sindh, and Balochistan) to support the space agency in Pakistan and other related disaster management networks. This data was disseminated online through the Mountain GeoPortal, in digital (CDs/DVDs) and printed form.

The way forward

The examples show how geo-spatial and geo-ICT technology can be integrated to support planning for disaster risk reduction. The tools for policy planning and programming related to sustainable development, relief, rehabilitation, and recovery activities in post-disaster and post-conflict situations in disaster-prone countries will need to be continuously improved. To support this, ICIMOD will focus on the following:

- Test pilot remote sensing and geo-ICT based early warning systems for different types of natural disasters
- Undertake regional level multi-hazard mapping with national partners to publish a regional hazard atlas
- Continue to build regional capacity on the use of geo-spatial tools for the mapping, assessment, and monitoring of natural hazards
- Continue to support and encourage regional member countries to develop a transboundary disaster decision support cell to support each other in the preparation of both pre and post-disaster scenarios for mitigation planning and relief work.
- Continue to support capacity development in the region and develop a regional network to improve regional information management and transboundary cooperation using remote sensing and GIS.

Further reading

UNISDR (2007) *Hyogo Framework for Action 2005-2015 – Building the resilience of nations and communities to disasters*. Geneva: Inter-Agency Secretariat of the ISDR

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Ives, JD; Shrestha, RB; Mool, PK (2010) *Formation of glacial lakes in the Hindu Kush-Himalayas and GLOF risk assessment*

Shrestha, AB (2008) *Resource manual on flash flood risk management, Module 2: Non-structural measures*

Shrestha, M; Bajracharya, SR; Mool, PK (2008) *Satellite rainfall estimation in the Hindu Kush-Himalayan region*

Tianchi, L (1996) *Landslide hazard mapping and management in China*

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