

# Mountain Ecosystems and the Global Earth Observation System of Systems (GEOSS)

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**M**ountain ecosystems are home to about 12 per cent of the world's population and provide a wide range of ecosystem goods and services. However, these goods and services may be in conflict with one another; for instance, the use of forest resources for energy and timber production may lead to a loss of biodiversity. In addition to being under pressure from human activity, mountain ecosystems are vulnerable to global climate change. Mountain glaciers are thought to be rapidly receding, which is seen as compelling evidence of climate change. However, more research and better observation is needed to fully understand the scope of this issue. Sensitive plants and animals that are already specially adapted to a severe environment may have difficulty in adjusting to changing environmental conditions. Because of their remoteness from highly populated and industrialised areas, mountains are considered ideal locations for investigating the impact of climate change on a regional and global scale. The Group on Earth Observations (GEO) supports observation systems that lead to a better understanding of such environmental issues.

GEO is a voluntary partnership of 86 member nations, the European Union, and 61 intergovernmental, international, and regional organisations. The goal of GEO is to coordinate efforts to construct a Global Earth Observation System of Systems (GEOSS) that builds on and adds value to existing Earth observation systems. It addresses critical gaps in current networks, supports their interoperability, and supports the sharing of information. International collaboration is essential for exploiting the potential of Earth observation to support decision making in a complex world. The vision for GEOSS is

to realise a future wherein decisions and actions for the benefit of humankind are informed by coordinated, comprehensive, and sustained Earth observation and information. ICIMOD joined GEO as a participating member in 2008 and is actively engaged in promoting Earth observation for the benefit of mountain communities in the Hindu Kush-Himalayan (HKH) region.

## **From observation to understanding, assessments and decision-making**

Effective decision making is the key to properly managing mountain ecosystems. GEO works to support decision making by gathering the proper observation data and supporting scientific investigations and assessments. Sustained, long-term observation is the foundation of scientific understanding and assessments, which are essential to support informed decision making. Coordinating the myriad of observation networks around the world is a monumental task. GEO works towards this through nine Societal Benefit Areas (SBAs) that encompass most areas of human activity; these areas are: disasters, health, energy, climate, water, weather, ecosystems, agriculture, and biodiversity (Figure 1).

Although GEO works within these societal benefit areas, most environmental issues are cross-cutting and there are many inter-dependencies among the areas. For instance, road and infrastructure construction in mountain regions has an effect on ecosystems, biodiversity, and water storage, and climate change affects all nine societal benefit areas. The monitoring of the goods and services provided by ecosystems is essential to track the status of natural processes and understand their capacity to provide services in the future.

The mountain systems in the HKH region provide essential ecosystem services to more than 1.3 billion

people living in the mountains and their downstream river basins. Ecosystem services are defined by the Millennium Ecosystem Assessment (2003) as “the benefits people obtain from ecosystems”. However, these services are not fully understood, as many are intangible and do not have an explicit market value. In particular, mountain ecosystem services are not fully captured in markets or valued in monetary terms, and are often marginalised from mainstream development in the plains. These services are taken for granted and do not play a role in policy decisions. In addition, existing policies and practices place demands on mountain ecosystem services, and the cost of conservation adds complexity to valuing these resources. It is important to note that mountain ecosystems not only provide services with a monetary value, but also represent a capital asset. For example, a policy that encourages the conservation of forests and soil in the mountains would result in essential water resources and services for downstream communities.

A proper valuation system for mountain ecosystems and their services is essential to guide human activity, but methodological difficulties remain an obstacle to estimating their economic value. The valuation of an ecosystem requires a clear understanding of both the socioecological and economic aspects of its services and of how these are interrelated. The basis for

understanding ecosystems lies in supporting continuous, high-quality observation.

GEO is working with regional and sub-regional organisations including ICIMOD. ICIMOD is not only providing an effective platform for fostering regional cooperation, but is also actively engaged in developing Earth observation products and services applicable to key areas of mountain development, namely, integrated water and hazard management, environmental change, and sustainable mountain livelihoods. ICIMOD’s collaboration with international partners (which has resulted, for example, in the launching of SERVIR-Himalaya by NASA and the commissioning of the WINDS receiving station by the Japan Aerospace Exploration Agency [JAXA]) provides a good basis for ICIMOD to realise the GEO vision at the sub-regional level.

GEO’s web portal ([www.geoportal.org](http://www.geoportal.org)) connects to a system of existing portals, providing an entry point to global, regional, and national Earth observation information and services (Figure 2).

I would like to recall the key message of the International Symposium ‘Benefitting from Earth Observation: Bridging the Data Gap for Climate Change Adaptation in the HKH Region’ convened by ICIMOD, GEO, and other partners in October 2010: “We look forward to a future where Earth observation information, products and

Figure 1: GEO Societal Benefit Areas



Source: GEO

services are extensively used in decisions and actions for the benefit of mountain communities in the Hindu Kush-Himalayan region". The International Symposium made the following four key recommendations, and GEO urges its regional and international partners to support ICIMOD in its endeavours to implement these.

- Empower youth to enable them to use Earth observation information for climate action in their communities.
- Foster regional and international cooperation to bridge the data gap in the HKH region and build synergies among national, regional, and global initiatives for integrated approaches and cross-cutting collaborations.
- Provide increased access to, and ensure increased use of, Earth observation for the integrated analysis of emerging mountain development issues.
- Continue regional and international support for sustained capacity building efforts in the HKH region.

One of the tasks under the GEO Work Plan is entitled 'Vulnerability of Mountain Regions' and is conducted through the SHARE (Stations at High Altitude for Research on the Environment) project. SHARE is working to promote continuous scientific observations in key high-mountain regions to contribute to knowledge on regional and global climate change. The specific aims of SHARE are to improve scientific knowledge on climate variability in mountain regions by ensuring the availability of long-term, high-quality data. To meet this goal, a global mountain observation network on

atmospheric composition, meteorology and glaciology, hydrology and water resources, biodiversity, and human health has been established. SHARE is also planning activities that include the design of mitigation and adaptation strategies to counter the effects of climate change in mountain regions. SHARE's work has resulted in more than 150 scientific publications since the project began in 2003.

## Earth observation applications and limitations

Many of the observations that are needed to understand mountain ecosystems (field monitoring to track glacier advances and retreats, species observation, and stream gauges) require involved in situ work and a long-term commitment. However, because of the physical demands of reaching high-altitude areas and dealing with risky mountainous terrain, it is difficult to perform regular ground-based surveys. The use of remotely sensed data (both airborne and satellite) provides a great deal of information and improves our ability to monitor mountain ecosystems. Remote sensing satellites are impartial recorders of the story and are useful across different geographic boundaries and scales.

Using satellite data for updating or generating glacier inventories has been explored for many years. For instance, synthetic aperture radar (SAR) interferometry has the ability to measure glacier displacement. However, the topographic relief in mountainous areas makes the use of SAR imagery a challenge. The Gravity Recovery and Climate Experiment (GRACE), a joint partnership between NASA and the German Space Agency DLR, maps variations in the Earth's gravity field. These measurements yield information about the distribution and flow of mass within the Earth. The gravity variations that GRACE studies include runoff and ground water storage on land masses and variations in ice sheets and glaciers.

Airborne laser altimetry systems can measure surface elevation changes (including those of glaciers) with high accuracy. The altimetry system consists of a Global Positioning System (GPS) receiver, a laser, and a gyroscope. The GPS records the position of the plane at regular time intervals as it flies over a glacier, the laser system continually measures the distance between the plane and the glacier surface, and the gyroscope measures the direction in which the laser is pointing. By combining data from these instruments, elevation profiles of the surface of the glacier are created that are accurate to less than a metre.

Figure 2: The GEO web portal, [www.geoportal.org](http://www.geoportal.org)





International Symposium on Earth Observation jointly organised by GEO and ICIMOD in Kathmandu, October 2010

Optical sensors, such as Landsat, SPOT (Système Probatoire d'Observation de la Terre), and CBERS (China-Brazil Earth Resources Satellite), make it possible to monitor several ecosystem parameters. Landsat's nearly four decades of accumulated Earth imagery data provide an historical record that, combined with continuous updates, make it possible to interpret and anticipate changes to the Earth's surface with far greater certainty than ever before.

While Earth observation systems can provide valuable information that cannot be realistically derived from other sources, they do have their limitations. For instance, although Landsat has been operating since 1973 and provides invaluable information on ecosystem characteristics, the ability to detect glacial change from these data is limited by spatial resolution and it is not possible to track many biodiversity indicators from this source. Similarly, many of the other systems are special purpose or short-lived, so their utility for long-term monitoring is limited. Only by using a variety of systems and the recent development of new remote sensing satellites, including in situ observation, can comprehensive monitoring take place – it is towards this that GEOSS is working.

## Conclusion

Despite their important contribution, mountains do not receive the attention they deserve in the development agenda, and the importance of the ecosystem services provided by mountains is not properly recognised. GEO supports the initiatives of ICIMOD and others by building

the global capacity to integrate Earth observation data and information with data and information from other sources, thereby improving the understanding of mountain systems in order to identify sustainable solutions. It is also necessary to foster linkages and synergy with other mountain regions such as the Alps and the Andes for mutual learning and exchange. GEO, with its global mandate to create a Global Earth Observation System of Systems, is working together with regional and international partners to bridge the existing gaps in observation systems in mountain areas to facilitate the sharing of data and provide decision support tools to a wide variety of users for sustainable mountain development in the HKH and other mountain regions.

## Reference

Millennium Ecosystem Assessment (2003) Ecosystems and Human Well-being: A Framework for Assessment. Washington, DC, USA: Island Press