ICT for Disaster Management: Real life examples

There are many sound practices in the Asia-Pacific region in applications of information, communication and space technology for effective and efficient disaster risk reduction and management. The following are some real life examples.

Drought -- Afghanistan, 2008

Afghanistan during late 2007 and early 2008 witnessed well-below normal rainfall and winter snowfall and thus experienced the most severe drought disaster in the past 10 years, caused severe food insecurity conditions. Using satellite data in conjunction with ground truth information, the United Sates Department of Agriculture (USDA) estimated 2008-2009 wheat production in Afghanistan at 1.5 million tons, down 60 percent from last year.[1] The loss of crops and pasture was measured by various remote sensing satellites, while it was quantified by comparing the current growing season with the past ten consecutive seasons, two of which were serious drought years (2000-2001 and 2001-2002).

The satellite based drought early warning system and timely reporting of food and water insecurity helped Afghanistan to get considerable support to the extent of $400 million to cover sizable wheat import and food aid needs for approximately 4.5 million affected Afghans from International donors, financial agencies and other governments.

Glacial lake outburst floods – Nepal and Bhutan

Glacial lakes have formed in many places in the area left at the foot of retreating valley glaciers. An inventory compiled by International Centre for Integrated Mountain Development (ICIMOD) identified 8,790 glacial lakes within selected parts of the Hindu Kush-Himalayas. Some 204 of the glacial lakes were considered to be potentially dangerous and liable to burst out leading to a glacial lake outburst flood (GLOF). There have been at least 35 GLOF events in Bhutan, China and Nepal during the 20th century [ICIMOD & UNEP reference]. Using multi-date satellite data, the ICIMOD and UNEP studies investigated the impact of climate change on glaciers and glacial lakes in two major glacial hotspots in the Himalayas: the Dudh Koshi sub-basin in the Khumbu-Everest region in Nepal, and the Pho Chu sub-basin in Bhutan. The focus was on the changes in number and size of glacial lakes forming behind exposed end moraines as glaciers retreat, and the resulting potential threat of GLOFs.

[1] www.pecad.fas.usda.gov/highlights/2008/09/*mideast_cenasia_drought*

Fig 5.4.1 left: Dig Tsho glacial lake in 2009 after the GLOF event of 1985; satellite image of the Bhutan Himalayas (Source: NASA/GSFC/METI/ERSDAC/JAROS, and U.S./Japan ASTER Science)

In poorly accessible mountain locations, satellite remote sensing has been found as a basis for GLOF monitoring, early warning and mitigation efforts besides adaptation to the local situation when replicating in other areas. Some key findings were derived from satellite observations, such as Glacial Lakes and Associated Floods in the Hindu Kush-Himalayas (ICIMOD, 2010), Facing the Challenges: Climate change adaptation in the greater Himalayas (ICIMOD, 2009), Impact of Climate Change on Himalayan Glaciers and Glacial Lakes: Case Studies on GLOF and Associated Hazards in Nepal and Bhutan (ICIMOD and UNEP, 2007), Terrain Classification, Hazard and Vulnerability Assessment of the Imja and Dudh Koshi Valleys in Nepal - Impact of Climate Change on Himalayan Glaciers and Glacial Lakes: Case Studies on GLOF and Associated Hazards in Nepal and Bhutan (ICIMOD, 2007).

Flood Monitoring and Early warning -- Japan

Operational use of information technology for monitoring, data collection and transmission, integration and analysis, decision supporting and dissemination of flood related early warnings and forecasting is well established in Japan.[2]

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[2] OECD Reviews of Risk Management Policies, OECD 2009, ISBN 978-92-64-05639-8

Rainfall and river level information that obtained through radar, rain gauges and telemeters at about 1,300 spots all over the country, are transmitted directly to the Japan Meteorological Agency (JMA) and the Ministry of Land Infrastructure Transport and Tourism (MLIT). Warnings about heavy rain that could cause serious flooding are issued by the JMA, while hydrological assessments are provided by the MLIT. The MLIT or the prefectures provide flood warnings on selected rivers, lakes, marshes or sea coasts. Real time disaster prevention information such as river water level, rainfall and dam storage levels, is displayed on the website: http://www.river.go.jp and updated every 10 minutes.

Citizens are also warned through various means including the Internet, mobile phones, television and radio in urgent situations. The heads of the city, towns or villages are given an established guideline on the river water level as the basis to activate response plans for small and medium sized rivers, while for a large scale flood disaster, the Central Disaster Management Council (CDMC) is responsible for the response management, based on data that is collected on 24/7 basis by the Cabinet Information Collection Centre.

Floods -- Kosi River, Nepal- India, 2008

On Aug 18, 2008 an embankment of river Kosi in South Nepal breached, leading to change of the river course completely and finally resulted in one of the most severe flood disasters in Bihar, India. The flood inundated large areas of Nepal and the state of Bihar in India, affected nearly 4 million people in the two countries, and caused immeasurable sufferings to poor people in one of the most backward areas of the region. On the mission mode, efforts were made to carry relief materials to remote areas by helicopter, making the boat available in large numbers, providing the health facilities in the affected areas and in the camps. All these efforts were helped by effective use of information, communication and space technology, including efficient information management, restoration of telecom networks, efficient dynamic spatial information acquisition, setup of satellite phone in affected districts etc. The Flood Management Information System (FMIS) fulfilled its functions with institutional support from Decision Support Centre, National Remote Sensing Centre (NRSC) and Indian Space Research Organization (ISRO). More than 200 maps, which were derived from real-time and near-real-time multiple satellite data showing the dynamics of river course changes in every 3-4 days interval, supported the decision makers and response teams on the ground, and were disseminated to all the users including NGOs, international organization and contributed to the response, rescue and rehabilitation efforts.

Earthquake – Wenchuan, China, 2008 [3]

During the response to the magnitude 8.0 Wenchuan earthquake that occurred on 12 May 2008 bring 69,130 death and 17,824 missing, many high-tech tools were used for field actions or deployed to quake-hit areas, mostly for disaster information management. Within two hours after the quake, with the support of its disaster reduction information system, the National Disaster Reduction Centre prepared a map indicating basic background information about the epicentre and major affected areas and archived satellite image, and submitted it to the highest level of decision makers. In the following days, 120 assessment and monitoring maps and reports derived from satellite and aeroplane images were submitted by the Centre and its cooperative partners. They provided critical information on the severity of the catastrophe, including updates on collapsed buildings, quake-lakes and roadblocks and the identification of relocation sites. During this response period, more than 1,300 images from 23 satellites were

[3] ESCAP/CDR/2

used, including those provided by foreign space agencies, and most of them were provided free of charge. Manned aeroplanes and unmanned micro aeroplanes equipped with remote sensors flew over the quake-hit-areas to collect field information with a view to more effectively deploying rescue and mitigation forces and relocating affected people.

As disaster communication is regarded, 25,000 persons were mobilized to restore telecommunications facilities that had been seriously damaged, a total of 383 emergency telecommunications vehicles were dispatched, many of them equipped with satellite communications facilities, but due to road damage, they could not reach some of the most seriously hit areas. More than 2,000 satellite mobile handsets were deployed. The first call from the epicentre was made by a satellite mobile phone 30 hours after the quake. By 16 May, cellular mobile services in some of the most seriously hit areas had been restored via satellite. Broadband links were established by more than 1,300 satellite terminals, some of which had to be carried by pure manpower. They were used for networking, transmitting remote sensing images, holding videoconferences among decision makers and using telemedicine among field teams and major supporting hospitals.

When electronic maps were widely used by decision makers, a three-dimensional digital model was created for the efforts of eliminating the risk of a quake-lake outburst. Compass satellite positioning handsets, which were provided to most rescue teams, also provided the users of short message services (SMS), which demonstrated its extreme importance for timely deployment of rescue teams when other means of communication were not available.

Bush Fires – Australian, 2009

Most intense, extensive and deadly bushfires commonly occur during droughts and heat waves, such as the 2009 Southern Australia heat wave. To combat the frequent bushfire, a number of technical tools, including remote sensing and GIS, are used to delineate fire risk areas in South East Australia. Bushfire monitoring, management and analysis require various kinds of information such as rainfall, vegetation and their water situation, wind speed and direction, hot spots of present fire, historical fire areas, and other fundamental geo-spatial information.

The analytical and modeling power established on the bushfire control information system of the State of Victoria was used by fire agencies to assess and determine the risky areas prone to bushfires. As a result, the most vulnerable 52 towns were identified as high bushfire risk areas in 2009. [4] With the integrated analytical power of remote sensing and GIS, the country fire authority is constantly identifying hot spots from remotely sensed images, with information from meteorological services on precipitation and winds direction/speed estimations to support real-time decisions on mobilization and deployment ground fire fighting resources. During 2009 fire season, satellite images were used to detect, visualize and monitor active bushfires. As a result, a number of bushfires were contained before becoming disasters in Victoria, though high speed winds that reached 50 km per hour usually hampered efforts to fight the blazes.

Cyclone Sidr -- Bangladesh, 2007

Cyclone 'Sidr' with winds speed of 240-km/hr hit populous Bangladesh coast on Nov 15, 2007. *"Thousands died in the cyclone, but many more were saved due to the county's early warning system.* [5]

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[4] http://home.iprimus.com.au/foo7/firesum.html

[5] www.irinnews.org/Report.aspx?ReportId=75470

The cyclone was tracked and monitored by meteorological and oceanographic agencies at international, regional and national levels more than 48 hrs before, with satellites observed the Bay of Bengal and early warning forecasts regularly issued. The Bangladesh national early warning capacity, over the past years' efforts, was enhanced to the extent that the country could predict precisely the landfall and storm surges using local weather and topographic data, and turn the information 'actionable'. The warning messages were disseminated to 15 of Bangladesh's 64 districts through, a network of 40,000 Red Crescent volunteers, who had been trained specifically for this task, was mobilized. Accordingly more than 320,000 people were evacuated to the safer places, which resulted in reduced casualties, unlike the similar cyclonic events in the past. The warning alerts were cycled around the country, using megaphones, to order residents into the 1,800 cyclone shelters and 440 flood shelters. By the time Sidr slammed into the coast, around two million people were already sheltered.

It is important to highlight the synergy among the agencies at global/regional and national levels in sharing the information with trans-boundary origin over the complete life-cycle of 'Sidr', that ultimately empowering the local capacity to respond. As comparison, a cyclone of a similar magnitude that hit Bangladesh in 1991 killed 190,000 people and a stronger one in 1970 left 300,000 dead, and those events triggered the early warning mechanism being put in place.

Later, the ECLAC methodology on Damage and Loss Assessment (DaLA) was applied to the Cyclone Sidr in Bangladesh for post-disaster needs assessment. High resolution satellite data were used extensively for damage assessment to the different sectors. Findings of the DaLA Report were used as the basis for recovery and reconstruction efforts.
Earlier, Bangladesh invested a US$ 3-million project in 2003 to expand its water and information network pilot project into a nationwide GIS based network, by using of EO satellite information. Flood forecasts and water information is provided on its website, and also disseminated to local farmers and citizens by radio and TV broadcasts in local languages and by relaying information via a "citizen network" of cellular telephones. All these strategic investments created strong infrastructure for risk reduction, as demonstrated while responding to cyclone Sidr.

Cyclone Nargis -- Myanmar, 2008

Cyclone Nargis that struck the Ayeyarwady Delta and Yangon during April 27 to May 3, 2008, killed over 84,530 people, with 53,836 still reported missing. The storm surge of about 3-5 meters over the Ayeyarwady delta region with wind speed of 190 km/h during landfall was reported by Department of Meteorology and Hydrology, Myanmar. The Regional Specialized Meteorological Centre (RSMC) - Tropical Cyclones, New Delhi has the responsibility of issuing Tropical Weather Outlook and Tropical Cyclone Advisories for the member countries of the WMO/ESCAP Panel on Tropic Cyclone.

Nargis was detected by the RSMC over southeast Bay of Bengal, and its further intensification was indicated in the daily bulletin issued from 23 April onwards. The first special tropical weather outlook intimating the formation of depression over the Bay of Bengal was issued at 0600 UTC of 27 April, and followed in every three hour-interval from 28 April onwards till 0000 UTC of 3 May. According to operational bulletin issued by RSMC, New Delhi, there was 64 km forecast average error in 12 hrs and 112 km in 24 hrs, which are within the acceptable limit. In fact, there have been considerable improvements in tropical cyclone forecast (Fig. 5.4.2) by virtue advanced monitoring and modeling capabilities including improved sea surface data extracted from satellite images.

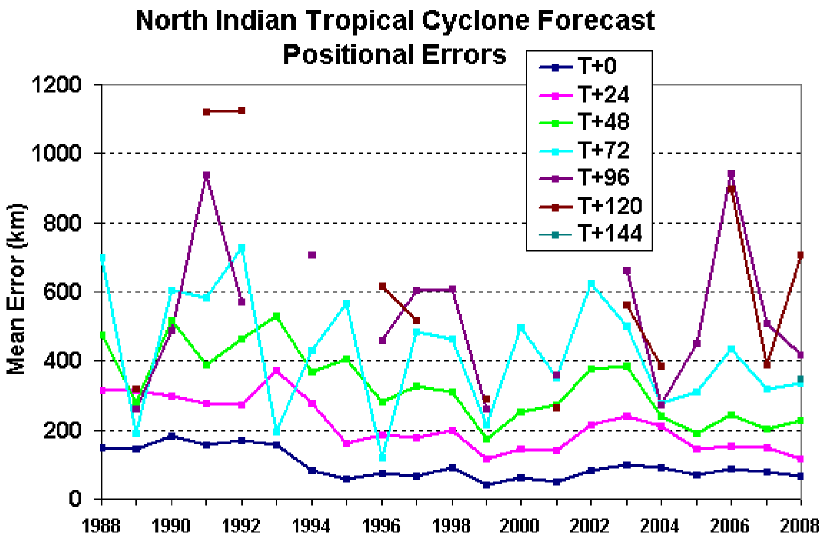

Fig 5.4.2 Improvements in cyclone forecast in North Indian Ocean
(Source: http://www.metoffice.gov.uk/weather/tropicalcyclone/observations.html)

Later, Post-Nargis Joint Assessment (PONJA) report was brought out jointly by the Government of Myanmar, ASEAN and United Nations in June 2008, which is being used for recovery and reconstruction. The PONJA was also based on UN ECLAC DaLA methodology and sector-specific damage assessment, especially agriculture and coastal sectors, were carried out based on high resolution satellite data. Some of key documents and publications on post-Nargis recovery and reconstruction also highlight the applications of remote sensing and GIS in damage assessment as well as recovery planning and reconstruction.

Earthquake -- Bam, Islamic Republic of Iran, 2003

During magnitude 6.6 earthquake struck Bam at southeastern Iran on 26 December 2003, which was responsible for the death toll of 26,27, approximately 27% of Bam's population, more than 1,600 Search and Rescue, Health and Relief personnel from 44 countries arrived to assist rescue and relief operations. Within hours of the disaster, the UN dispatched its Disaster Assessment and Coordination Team (UNDAC) to support the Government in coordinating this enormous international response. Local ground-based telecom networks were seriously damaged and thus impeded subsequent rescue and relief operations. Limited HF radio and satellite handsets were brought in by couple of international aids agencies to support the rescue and relief actions. Remote sensing and GIS tools were used for quick damage assessment and subsequently for the scientific studies on the quake mechanisms. Space information products from high resolution satellites provided through the International Charter on Space and Major Disasters that was activated by France, Germany and Portugal simultaneously, were used for highlighting the extent of damage and destruction due the earthquake. These maps were widely used in the relief operations. Further, UNOPS and IRAN requested for the data, which were later used for recovery and rehabilitation phases also.

Other space-based technologies such like three dimensional imaging systems, LIDAR, Web GIS and Mobile GIS Systems were used in the response actions. Since one third of all Iranians live in 68,000 villages across the country and most of these villages have yet to use ICT as a development tool, the government had initiated the Rural ICT Strategic Plan by establishing Rural ICT Centre as a mean for dissemination of disaster early warning information to public and emergency shelters as well.

Earthquake – Muzaffarabad, 2005

Muzaffarabad earthquake scaled 7.6 was occurred on 8 October 2005 with epicenter at Muzaffarabad, Pakistan. The seismic hazard was not predicted and the earthquake was not recorded in the near-source region by strong-motion stations. The nearest accelerograms available to the epicenter is from Jammu (JMU) and Thien (THN) stations, located 226 and 300 km respectively from the epicenter. It recorded the largest event to occur along the Himalayan. Massive landslides and hundreds of aftershocks were reported after the earthquake, which is responsible for the death toll of more than 87,352.

Access to the affected areas took sometimes to respond primarily because existing telecommunication infrastructure was damaged and most of the affected hilly areas had the constraints of effective communication network. Later, RF Radio (HAM) was used as an alternative emergency communication tools, in the absence of satellite-based communication means and high speed wireless broadband, for reporting and monitoring of secondary disasters. The impact of Muzaffarabad earthquake in terms of loss of lives was also felt in inaccessible and hilly terrain where communication infrastructure constrained rescue and relief actions. Had there been satellite based emergency communication, the rescue and relief would have been supported more efficiently.

High resolution satellite remote sensing data were used primarily for damage assessment and to the lesser extent in recovery and reconstruction phase. Some of reports, such as such as Pakistan 2005 Earthquake - Preliminary Damage and Needs Assessment 2005 by ADB, Pakistan 2005 Earthquake - Early Recovery Framework 2005 and Resilient Recovery Processes (2009) by Pakistan's National Disaster Management Authority, were prepared based on the inputs taken from such applications.

Muzaffarabad earthquake is an example where a disaster-prone area needs disaster communication capacity base on regional or sub-regional cooperation approach for early warning and reporting and subsequent relief operations. The negative impact of disaster may be reduced if access capacity to communication satellite was available, and resilience of ICT infrastructure was strengthened.

The Safe Island Programme -- Maldives

The December 2004 Indian Ocean tsunami exposed the risk Maldives is facing by virtue of having its unique geography and topography. Low elevation above sea level, perennial beach erosion, and dispersal of population across very small islands, remoteness and inaccessibility of smaller islands, concentration of economic activities on tourism, high dependence on imports and high diseconomies of scale have added layers of coastal vulnerability in the country. Climate change and associated risks add to the growing vulnerability further. To addressing these challenges, Maldives has developed the Safe Islands Programme, focusing on the development of the larger islands with better economic opportunities, high environmental resilience, and incentives for voluntary migration to these islands[6].

The Safe Island programme of Maldives is an integrated effort on addressing vulnerability through strategic coastal zone management planning for climate change adaptation. To facilitate

[6] Report on Implementation of The Hyogo Framework for Action (HFA): Asia, ISDR/Gp/2007/Inf.5

Safe Island programme, high resolution satellite data have been used to the following outcomes (Reference – UNDP Maldives):

- Develop a detailed hazard risks analysis and vulnerability assessment of the selected safe islands in a changing environment
- Present a list of disaster risks
- Identify changing patterns of risk and vulnerability associated with coastal erosion trends and,
- Recommend specific mitigation measures to make the islands safer
- This includes limits and regulations to expansion in the islands taking into account vulnerabilities of the natural and built environment

The Detailed Island Risk Assessment in Maldives, prepared by UNDP Maldives with technical support from RSMI, which provided the key inputs to Safe Island programme, is primarily based on high resolution satellite data.

Disaster information management and service system – China[7]

China established a special disaster information service network operated by the National Disaster Reduction Center of China (NDRCC), under the Ministry of Civil Affairs. As the key technical supporter to the secretariat of the inter-ministry National Committee for Disaster Reduction, which is the highest decision-makers of China on disaster related affairs, the center established a 24-hour/7-day disaster monitoring mechanism for information collection, integration, analyzing and reporting.

To support decision-making at highest level, NDRCC has been operating two optical remote sensing satellites since September 2009, as the first step towards an 8-satellite constellation for environment and disaster monitoring, and developing standardized operational remote sensing products and services, including multi-hazard monitoring and assessment models and satellite operation procedures for emergency response. With the disaster reduction spatial database, a series of remote sensing products for disaster risk assessment, monitoring, impact assessment and decision-making support tools were developed, particularly those in supporting disaster relief actions for floods, drought, earthquake, low temperature and ice-snow and frozen disaster in different phases.

NDRCC also established on-site information collection and emergency communication capacities, such as un-manned-aerial-vehicle-borne remote sensing system, equipment for accessing Compass navigation satellite and communication satellites that are able to be dispatched to disaster-hit areas immediately after the stroke to collect real-time *in-situ* information for disaster damage assessment.

Earthquake – Padang, Indonesia 2009

The magnitude 7.6 earthquake hit Padang, Sumatra, Indonesia on 30 September 2009, claimed 1,115 death and 1,214 injured, 181,665 buildings destroyed or damaged and about 451,000 people displaced. Landslides caused by earthquakes and aftershocks disrupted power and communications transmission and 36 fire spots broke out in different areas of the city. Fortunately, the Padang City Fire Department organized a preparedness drill 7 months before the earthquake; it assisted the response of the government and public in the earthquake.

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[7] Brochure of the NDRCC, 2010

Most of the terrestrial telecommunication infrastructure were destroyed or degraded, communications to support search and rescue operations primarily relied on “handy-talkies” (radio devices) within the Fire Department and one survived cell phone station continuing work. With back-up generators in fire stations, mosques and the radio stations, the mayor was able to broadcast messages to the people via radio.

In the light of the practicality of amateur radio as an effective communication means in remote areas of Indonesia, the Padang city government developed the Radio Princess Catharina Amalia (Radio PCA) 107.8 FM as the centre for earthquake information service to western Sumatra. This project was funded and supported by the Netherlands government and was launched in 2008. On the other hand, the members of the Indonesian Inter-Citizen Radio (RAPI)[8], a non profit social organization in Indonesia, played an important role in the emergency communication during the Padang earthquake, by using radio device to communicate with fellow members of other communities.

Amateur Radio and CB radio are deployed swiftly for rescue and relief operation activities through the established local community networks after the Padang earthquake. To enhance the capacity of space-based emergency communication in Indonesia, an Amateur Radio satellite is under construction to expand the communication network to remote districts of the archipelagos.[9]

Space applications - Indian Ocean Tsunami 2004

December 2004 Indian Ocean Tsunami was one of the most catastrophic natural disasters the region has ever experienced. It was also unprecedented to put to use collectively by all public and private agencies the space technology application based response to this event. Satellite remote-sensing observations and satellite communications proved invaluable to the relief and reconstruction operations. High-resolution imagery from commercial satellites, mostly free of charge, helped target rescue efforts in the hours and days after the tsunami. Newly received and archived images from more than 30 EO satellites were used to compare before-and-after conditions in the ravaged areas. These data were used guide relief teams to identify infrastructure facilities destroyed or still in usable condition, to identify croplands damaged by seawater, and to assess the impact on wetlands, mangroves, forests, and groundwater. The tsunami ravaged places in Indonesia, Sri Lanka, India, Thailand and Maldives mapped with high resolution satellites were widely disseminated. Since the land-based communications infrastructure was disabled by the tsunamis, satellite links were invaluable in transmitting information among rescue and rehabilitation teams.

Since tsunami had impacted large areas, remote sensing & GIS inputs were extensively used by UN agencies, international funding agencies and also the respective government organization for damage assessment, recovery and reconstruction planning. The post-tsunami recovery and reconstruction witnesses high resolution remote sensing applications. Some of these efforts are documented in many assessment reports prepared by many such United Nations entities and other organizations, such like UNEP, FAO, UNDP, ISDR, CARE, BAPPENAS, IUCN and UNESCO.

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[8] http://www.gitews.de/fileadmin/documents/content/wp6000/GTZ-S_GITEWS_Newsletter_02.pdf

[9] <http://www.bernama.com.my/bernama/v5/newsindex.php?id=453179>

Further, the tsunami provided a strong motive for nearly 60 nations to reach accord on a 10-year programme of international cooperation on Earth observations. The agreement to establish a Global Earth Observation System of Systems (GEOSS), which was signed at the Third Earth Observation Summit in Brussels on 16 February 2005, covers the implementation of common standards, improved maintenance of Earth-based sensors, and both reduced duplication and elimination of gaps in satellite capabilities. Response to tsunami also set in motion the integration of space technology applications in disaster reduction activities in ESCAP region.