Geospatial Portal as an important SDI building block for Disaster Response and Recovery

Birendra BAJRACHARYA
birendra.bajracharya@icimod.org

Key words: Geospatial Portal, SDI, Disaster response

Abstract

Geospatial information systems provide technologies and tools to generate knowledge and provide added value in decision support to identify problems and assess alternative course of actions. Spatial data infrastructures (SDI) have evolved to address the issues on coordinated development, access and use of geospatial information, and minimize the resources wasted in duplication of efforts. The traditional view of formal organizations as the producers and suppliers of geospatial information and the users as the passive recipients of information is rapidly changing with the recent phenomenon of volunteered geospatial information where the users also participate in information production. The emerging technologies of social media, crowd sourcing and mobile devices have broken the traditional barriers of organizations, professional domain and geographic borders. The increasing use of these technologies is redefining how we work and share information from local to global scales and opened new opportunities for collaboration in developing SDI. This has been clearly demonstrated in the recent Nepal Earthquake with the death toll reaching close to 9,000 and about 2.8 million people displaced. In a disaster of this scale, the urgent need for help and support is no doubt tremendous and the demand for information rises exponentially. Enormous amount of information started pouring in from the social media and crowd sources both from within the country and outside such as damage assessment from satellite images, mapping landslides and road blocks, and generation of base maps of affected districts. While such efforts have contributed the disaster response in many ways, they have also revealed many gaps and associated challenges. Collecting, managing, processing, and disseminating timely and reliable information becomes key to emergency management and multitude of recovery and reconstruction operations. To address this need, ICIMOD with its national and international partners has developed an Information Platform (Geospatial portal) to act as a unified information hub and and a single-gateway for validated data and information related to the earthquake. As the country moves forward from relief to the reconstruction phase, ICIMOD is working on extending the platform to cater the information needs with combination of analytical features. It is hoped that such a unified platform with geospatial tools will greatly support the efforts of reconstruction by enablng judicious planning and decision making on resource allocation and mobilization and will help foster coordination among various actors on the ground.

Geospatial Portal as an important SDI building block for Disaster Response and Recovery

Birendra BAJRACHARYA
birendra.bajracharya@icimod.org

1. SDI AND DISASTER

Natural hazards such as floods and landslides have been regular features in Nepal which cause loss of life, property and infrastructure every year. Hundreds of people are displaced due to loss of their homes and means of livelihood. There has been an increase in the frequency and magnitude of these events in recent years in the region which are mostly attributed to impacts of climate change (ESCAP 2015; Gurung et. al. 2014; Thomas et. al. 2013). The recent Nepal Earthquake on 25 April and major aftershock on 12 May 2015 have brought the long feared destruction in the country. The death toll reached close to 9,000 in Nepal with another 23,000 injured, more than 785,000 homes damaged or destroyed, and about 2.8 million people displaced.

In a disaster of this scale, the urgent need for help and support is tremendous and the demand for information rises exponentially. Information is needed to support multitudes of response operations that include: finding human casualties, carrying out search and rescue missions, relief distribution and construction of temporary shelters, damage assessment and mobilization of volunteers, and coordination with multiple organizations both within and outside the country. Location information is crucial for these actions and the role of Geospatial information and technologies for disaster management is well recognized. Timely, up-to-date and accurate spatial information describing the situation is of utmost importance for successful emergency response (Bhanumurthy et. al. 2008; Mansourian et.al. 2005; Rajabifard et. al. 2004). Information about different needs in different locations and the available resources are important for efficient allocation and dispatch of relief operations. However, availability of and access to reliable, accurate and up-to-date information under such situation are major challenges.

The concept of spatial data infrastructure (SDI) evolved in early nineties to address the issues of lack of coordination in the development, access and use of geospatial information, and resources wasted in duplication of efforts. SDI encompasses a framework of technology, policies, standards, and human resources required for acquiring, processing, storing, disseminating, and effectively utilizing geospatial information (Nebert, 2004). Spatial data resources play an important role in decision-making during the response phase of an emergency situation and sharing of information increases efficiency, provides a better method for communication and collaboration among the different actors among the emergency forces (Snoeren et. al. 2007). The dynamic nature of an emergency situation calls for timely updating of a variety of information from different organizations as no individual agency can produce and update all the required information which calls for partnership, data sharing and data exchange. Therefore SDI and its components can play a major role in order to facilitate emergency management by providing secure, fast, reliable access to the spatial data needed by those involved in emergency response (Rajabifard et. al. 2004; Snoeren et. al. 2007).

1.1 Evolutions in SDI

Development of SDI includes multiple actors, multiple concerns and interests, multiple points of view, and multiple challenges. SDI has a dynamic nature due to the rate of technological advancement and changing user needs (Rajabifard et. al. 2006). The evolution of SDI has seen different approaches. In the product-based model, the main aim of an SDI initiative is to link existing and potential databases whereas the process-based model puts emphasis on facilitation through development of a communication channel of knowledge infrastructure and capacity building. The composite product-process approach tries to balance the advantages drawn from both, enabling the SDI initiatives to be more versatile (Feeney et. al. 2001).

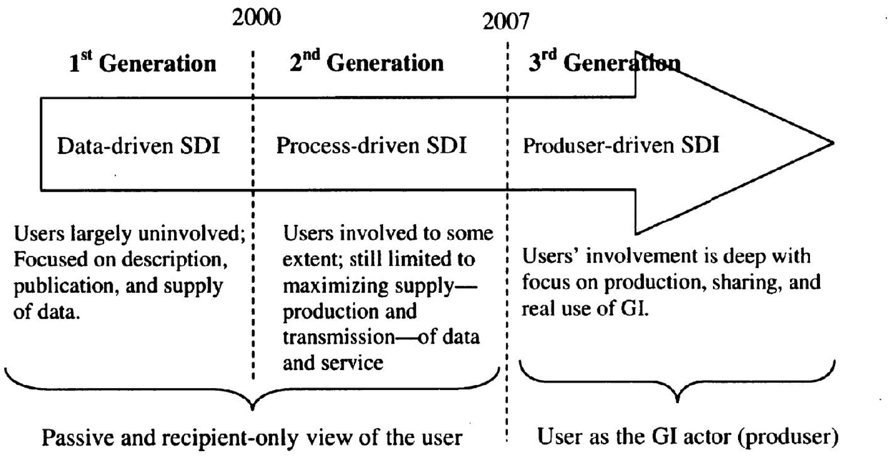

Figure 1. Evolution of SDI (Adapted from Rajabifard 2004 in Budhathoki et.al. 2008)

The traditional view of formal organizations as the producers and suppliers of geospatial information and the users as the passive recipients of information is rapidly changing [figure 1] with the recent phenomenon of volunteered geographic information where the users also participate in information production (Budhathoki et.al. 2008).

Figure 2. Convergence of technologies

The emerging technologies of social media, crowd sourcing, cloud computing and mobile devices and their convergence [figure 2] have broken the traditional barriers of organizations, professional domains and geographic borders. The increasing use of these technologies is redefining how we work and share information from local to global scales and has opened new opportunities for collaboration in SDI development. SDI can be realized at different levels (local, national, regional, global) and involves an array of stakeholders both within and across organizations including different levels of government, private sector and a multitude of users.

1.2 Social media and crowd sourcing during disasters

Real-time recording and the proactive approach of the user are the strengths of social networks for information gathering during disasters. Timeliness in capturing and communicating an event, a problem or an opinion enables the users to contribute in a participatory and collaborative way which can help the problem solving processes to be undertaken more quickly (Capineri et.al. 2015). The growing use of smartphones with GPS and camera facilities has enabled the common citizens in real-time data collection at the location and in monitoring of the events which are very important in emergency management. These mobile phones can be used effectively in collecting data for relief operations and damage assessment.

The developments of Open Street Map, Google Earth and a variety of other web-based mapping services have provided the ability for volunteers to assist in disaster response situations through mapping and other spatial analysis. The distributed mapping environment makes it possible to produce large number of maps within a very short time which is one of the greatest benefits to disaster management and this has already been demonstrated during the Haitian Earthquake (Zook et. al. 2010). Volunteered Geographic Information is gaining increasing relevance as a source of information which complements the authoritative spatial data and has been contributing in SDI development in the areas which have poor GIS data coverage (Goodchild, 2007).

2. THE NEPAL EARTHQUAKE EXPERIENCE

2.1 Global Geospatial Community coming together

The Nepal Earthquake of 25 April demonstrated how the advances in Information and Communication Technology (ICT) have made it possible for the global community to join hands together during the events of disasters of this magnitude. Seven minutes after the event, a red alert for international assistance was issued by the Global Disaster Alert and Coordination System (GDACS) and the first reference maps were also produced on the same day in order to facilitate response efforts. The EU Copernicus Emergency Management Service was also activated on the same day and provided the first reference maps the day after. (JRC 2015).

The US Geological Survey (USGS) compiled satellite imagery for the disaster area from different space agencies and made accessible through its Hazard Data Distribution System (HDDS). In terms of satellite imagery, DigitalGlobe made the most significant contribution by making high resolution satellite imagery of the affected areas freely available online to all groups involved in the response effort. DigitalGlobe activated the subscription service FirstLook that provided emergency management and humanitarian workers with fast, web-based access to pre- and post-event images of the impacted area from its WorldView and GeoEye satellites (DigitalGlobe 2015). Many images were also made available by

National Aeronautics and Space Administration (NASA), Canadian Space Agency (CSA), Japan Aerospace Exploration Agency (JAXA), Planet Lab, ImageSat International and Skybox Imaging (UN-SPIDER 2015).

The compilation in UN-SPIDER Knowledge Portal (UN-SPIDER 2015) shows that many Crowd Sourcing communities became active to support mapping needs for relief work. DigitalGlobe activated Tomnod, the crowdsourcing platform that allowed web-connected volunteers around the globe to help disaster response teams by mapping damage from the earthquake. The Tomnod website allowed the users to participate in the Nepal campaign by tagging damaged buildings, roads, and areas of major destruction to inform disaster response teams on the ground. The Humanitarian Open Street Map Team (HOT OSM) mobilized 3679 mappers and made 62587 edits to the maps of the affected areas within five days of the earthquake. MicroMappers worked on analysis of images and text from tweets while MapAction worked on mapping of affected population. Humanity Road prepared situation reports including communities in need. Similarly United Nations Office for the Coordination of Humanitarian Affairs (UN-OCHA) implemented information platform for coordination of international humanitarian support and generated regular map products on the situation.

2.2 ICIMOD's Response Efforts

Immediately after the Earthquake, ICIMOD formed a team of GIS and remote sensing experts. While a lot of satellite images were getting available from different space agencies through the international charter, extracting meaningful information and delivering them to the government and other agencies were challenging. Responding to the requests from the Ministry of Home Affairs (MoHA), the ICIMOD team supported by a group of volunteers worked round the clock to process and analyze the latest satellite imagery for mapping pockets of settlements in affected districts and creating profiles of affected VDCs to inform relief operations. A large number of maps were printed and supplied to different agencies. Another team from ICIMOD set up an office at the airport to provide information to helicopter pilots and dispatchers, including Google Earth 3D images of flight routes to help pilots navigate unfamiliar terrain, identify and recognize destinations, and plan appropriate landing spots (ICIMOD 2015).

Landslides were another major obstacle to rescue and relief operations and there was an urgent need to assess the impact of landslides for immediate rescue efforts and monitor potential hazards. ICIMOD formed a Task Force on Geo-Hazards for monitoring landslides, glacier lakes, and river courses by analyzing the latest satellite images and communicating the findings to the Government of Nepal and relief agencies. The Task Force coordinated with the broad international team including Chinese Academy of Science, NASA, the University of Arizona, USGS, USAID and JAXA.

2.2 National Disaster Response and Recovery Platform (NDRRIP)

With all efforts going around by many national and international agencies, it was felt that a comprehensive platform is needed where all the information can be accessed and visualized through a user friendly interface to make them comprehensible for the users. In close collaboration with MoHA and technical support from Esri, ICIMOD deployed the Nepal

Earthquake 2015: National Disaster Response and Recovery Information Platform (NDRRIP). The NDRRIP acts as a unified hub for earthquake-related information for use by government ministries and departments and other stakeholders engaged in disaster recovery and reconstruction. The framework of NDRRIP as a Geospatial Portal is illustrated in figure 3.

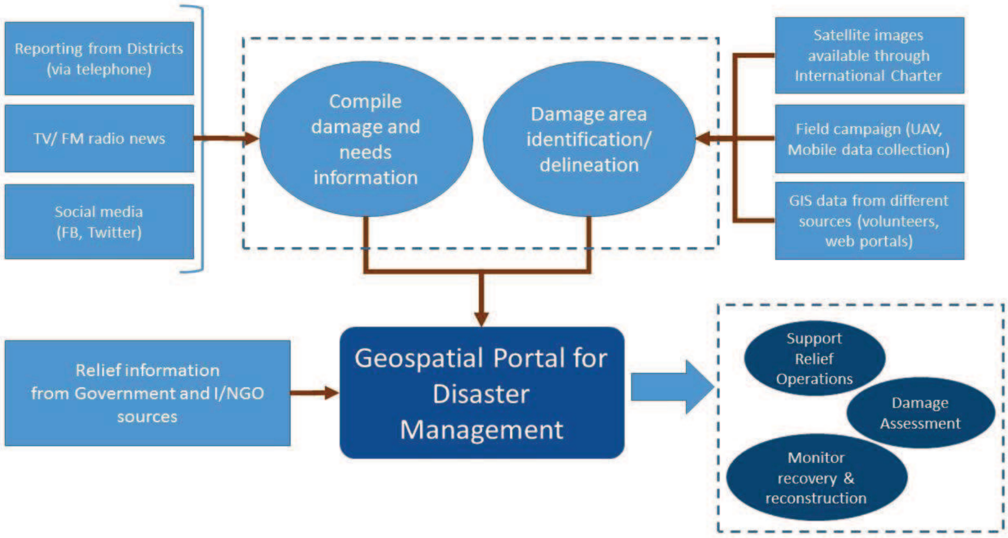

Figure 3. Framework for information synthesis and use

Figure 4. NDRRIP Portal

The portal provides key facts and figures at national, district, and VDC/municipality levels with interactive maps, charts, and infographics [figures 4 and 5]. The facts and figures are also provided under different thematic areas such as infrastructure, health, education, cultural heritage, agriculture, and geohazards. Story map journals for each affected district and selected themes provide the status of casualties, damage, and response efforts. The other highlights of the portal are - interactive ”before” and ”after” visualizations using high resolution satellite imagery; information on geohazards, including field data on landslides with 3D visualization; and incident reporting for disaster events in near real-time through crowd sourcing.

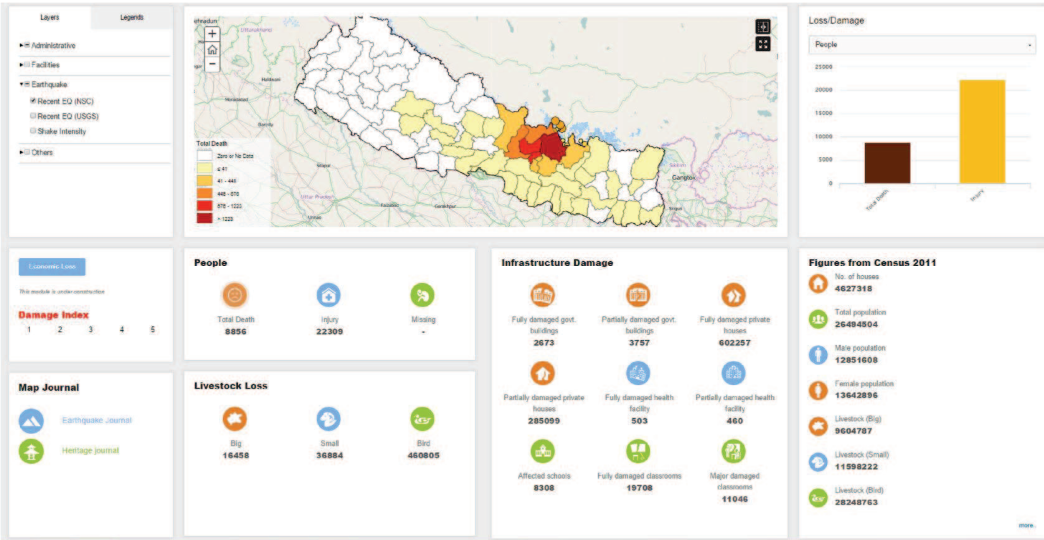

Figure 5. Interactive page for Country profile

3. LESSONS FOR SDI

3.1 Challenges in generating useful information

Right after the event, there was immediate need of base maps to locate the affected areas and dispatch relief. Maps showing location of settlements and potential sites for helicopter landing near these settlements were in high demand and ICIMOD team was fully engaged in preparing them by compiling any available information from various sources including Google Earth. The gap on GIS base layers such as settlements, road networks, health facilities, open spaces and public utilities was seriously felt as they were not available at all or the existing ones were not up to date. Preparation of basic information layers needs to be given priority for disaster preparedness in future.

The geographic coverage of Nepal and the availability of satellite images through on-line systems was unprecedented immediately after the earthquake. The international geospatial communities started preparing situation maps by using the available images. The people in Nepal were still coping with the aftershocks and finding a shelter during the rainy nights with no electricity. Downloading the huge satellite images was impossible and the ICIMOD team worked with NASA SERVIR Coordination Office in Huntsville to reduce the size of images by tiling and resampling for file transfer. Many of the images were copied on hard drives and physically delivered as more and more images became available. Basic infrastructures such as electricity and internet play a vital role during disasters which need proper back up plans. Moving towards cloud computing for hosting of data and service execution can be strategic to develop economically efficient systems (Díaz et. al. 2012) which are also resilient to such disaster events.

The high resolution images were helpful for visualization of the affected areas but extracting useful information from these images for use in a GIS platform was a big challenge. There were technical issues on geometric corrections and overlaying with other data layers. Maps showing damage assessment of buildings using satellite images were prepared by many agencies. However, the usefulness was a concern as the detection of damaged buildings accurately was not possible except for those completely collapsed. Development of algorithms for semi/automated damage assessment will be an interesting topic of research in the field of image analysis and interpretation.

The satellite images were most useful in assessment of Geo-hazards which included mapping landslides and monitoring glacial lakes. This helped in identifying settlements in hazard areas.

3.2 Consolidating information from the ground

The HOT OSM community did a remarkable work in preparing the base maps of affected areas which helped in generating value added products by other agencies. The news on damages and casualties continued to pour in from different parts of the country. However, the information are aggregated at district level and the spatial details of the damage were not available. Crowd sourced information on incidents and needs were limited to Kathmandu and were sporadic in nature. The trust and reliability of crowdsourced information is yet to be established for inclusion into government database and response attention.

Many youth volunteers got organized to mobilize relief work as well as to collect data on building and other damages. Different government departments and non-governmental organizations started campaigns for data collection from selected settlements and districts on their own and there was clear lack of coordination. The aspects of data storage, analysis and use seemed to be overlooked. Almost none of these campaigns considered geo-coding of data while collecting them. The information on who is doing what and where is important for effective distribution of relief activities by matching the demand and supply.

3.3 Delivering the information

In addition to the gaps in information collection and generation, delivery of right information to the users in right format is another important consideration. Paper maps were still the preferred format by the users going to the field and therefore printing facilities are crucial for delivering the users' need. On the other hand, the very dynamic nature of information updates during such disaster makes the on-line portals most suitable. ICIMOD's NDRRIP is one such effort to serve up-to date information.

The Emergency Operation Centre of MoHA is the authoritative body for any disaster in the country. The current human resources and ICT infrastructure of the centre clearly needs strengthening to deal with disaster of such magnitude. Interaction with the IT team showed that the staff are overwhelmed with those who came for information as well as those who came to offer assistance. The IT section being the main hub for information flow from district offices, automation of the system to integrate with the portal will make information dissemination more efficient. Without such a system in place, a lot of energy was spent in digitalizing the data from many different sources which were available only in *pdf* or *MS Word* format and storing them in proper database before serving on the NDRRIP.

The line agencies on utilities, roads, health are logically the producers and updaters of datasets during their everyday business and during an emergency situation (Rajabifard et. al. 2004). Adopting appropriate data standards and interoperability models by these agencies and data sharing will be a great support for disaster management. Geospatial portals can facilitate such inter-agency partnerships.

3.4 Moving towards reconstruction

As in any disaster event, attention from the international and national communities to the affected population slowly fades away with time and disaster management moves towards the phase of reconstruction. The information on damage and casualties become less dynamic and the demand for information also slowly dies out. However, for reconstruction planning and management, more detailed information will be needed as this has to deal with individual households. The issues related to relocation becomes even more complicated as it needs to consider economic, environmental and social aspects. Geospatial information becomes more relevant to analyze different alternatives. Similarly, monitoring the reconstruction activities and resources involved will be important to maintain transparency of the government interventions. The Geospatial Portal with appropriate geo-processing and query tools can fill this need to a great extent.

4. CONCLUSION

The April 25 Nepal Earthquake resulted into huge loss of lives and economy of the country. There was immediate humanitarian response from international community including the International Charter providing large volume of satellite information and assisting in producing map products (UN-SPIDER 2015). It was felt that extraction of useful information in an effective way from these resources is challenging due to limitations in technical infrastructure. Need for coordination in data collection from the field and use of those information for relief allocation was also seriously felt. Crowd sourcing has a lot of potential for filling the gaps in spatial data and real time event reporting. There is a growing mass of young volunteers who can contribute to SDI in a collaborative way. Partnership approach among all line agencies adopting interoperable data models with timely updating and sharing will be the best scenario for disaster preparedness. This requires implementation of a functional SDI. The costs and benefits associated with SDI development is not straight forward (Masser 2015), but its social benefits especially in assisting efficient emergency management and saving lives will go way beyond economic benefits. Geospatial Portals form essential components of SDI implementation by providing platforms to collaborate in data sharing and access. The participation by multiple agencies will promote data quality and adoption of standards. The NDRRIP has been developed by ICIMOD to fill the gap of such a platform and to support Nepal Earthquake response and recovery efforts. As the country moves to recovery, ICIMOD is working on extending the platform to cater the information needs with combination of analytical features. It is hoped that such a unified platform with geospatial tools will greatly support the efforts of reconstruction by enablng judicious planning and decision making on resource allocation and mobilization and will help foster coordination among various actors on the ground.

REFERENCES

Bhanumurthy, V., Rao, G.S., Karnatak, H.C., Mamatha, S., Roy, P.S., Radhakrishnan, K. (2008) *Emergency Management – A Geospatial Approach,* in The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. Vol. XXXVII. Part B4. Beijing.

Budhathoki, N.R., Bruce, B., Nedovic-Budic, Z. (2008) *Reconceptualizing the role of the user of spatial data infrastructure*, in GeoJournal, Vol. 72, No. 3/4, Volunteered geographgic information: key questions, concepts and methods to guide emerging research and practice (2008), pp. 149-160.

Capineri C, Calvino C, Romano A. (2015). *Citizens and Institutions as Information Prosumers- The Case Study of Italian Municipalities on Twitter.* International Journal of Spatial Data Infrastructures Research, Vol.10, 1-26.

Díaz, L., Remke, A., Kauppinen, T., Degbelo, A., Foerster, T., Stasch, C., Rieke, M., Schaeffer, B., Baranski, B., Bröring, A., Wytzisk, A. (2012) *Future SDI – Impulses from Geoinformatics Research and IT Trends,* International Journal of Spatial Data Infrastructures Research, Vol.7, 378-410.

DigitalGlobe (2015) *DigitalGlobe opens access to satellite data to support disaster response efforts in Nepal,* DigitalGlobe blog. http://www.digitalglobeblog.com/2015/04/26/digitalglobe-opens-access-to-satellite-data-to-support-disaster-response-efforts-in-nepal/

ESCAP (2015) *Overview of Natural Disasters and their Impacts in Asia and the Pacific, 1970 – 2014,* ESCAP Technical Paper, Information and Communications Technology and Disaster Risk Reduction Division, The United Nations Economic and Social Commission for Asia and the Pacific, Bangkok.

Feeney, M.E., Rajabifard, A., Williamson, I. (2001) *Spatial Data Infrastructure Frameworks to Support Decision-Making for Sustainable Development*, Paper presented at the GSDI-5, Cartagena de Indias

Goodchild, M.F. (2007) *Citizens as sensors: the world of volunteered geography, GeoJournal*, Volume 69, Issue 4, pp 211-221

Gurung, D.R., Shrestha, M., Shrestha, N., Debnath, B., Joshi, G., Bajracharya, R., Dhonju, H.K., Pradhan, S. (2014) *Multi Scale Disaster Risk Reduction Systems, Space and Community Based Experiences over HKH Region*, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XL-8, 2014 ISPRS Technical Commission VIII Symposium, 09 – 12 December 2014, Hyderabad, India.

ICIMOD (2015) Nepal Earthquake 2015 page. http://www.icimod.org/?q=17851

JRC (2015) *Nepal earthquake: JRC supports EU's response operations,* JRC News 27 April, Joint Research Centre, European Commission. https://ec.europa.eu/jrc/en/news/nepal-earthquake-jrc-supports-eu-response-operations

Mansourian, A., Rajabifard, A., Zoej, M.J.V. (2015) *Development of Web-Based GIS using SDI for Disaster Management*, in Oosterom, P.V., Zlatanova, S., Fendel, E.M. (eds) Geo-Information for Disaster Management, Springer-Verlag.

Masser, I., Crompvoets, J. (2015) *Building European Spatial Data Infrastructure*, Third Edition, Esri Press, Redlands.

Nebert, D.D. (2004) *Developing Spatial Data Infrastructures: The SDI Cookbook -2004*. Global Spatial Data Infrastructure.

Rajabifard, A., Binns, A., Masser, I., Williamson, I. (2006). *The role of sub-national government and the private sector in future spatial data infrastructures.* International Journal of Geographical Information Science, 20 (7), 727-741.

Rajabifard, A., Mansourian, A., Williamson, I. P., Valadan Zoej, M. J. (2004) *Developing Spatial Data Infrastructure to Facilitate Disaster Management,* in Proceedings, GEOMATICS 83 Conference, Tehran, Iran.

Snoeren, G., Zlatanova, S., Crompvoets, J., Scholten, H. (2007) *Spatial Data Infrastructure for emergency management: the view of the users*, Paper presented at the Third International Symposium on Gi4DM, Toronto.

Thomas, V., Albert, J.R.G, Perez, R.T. (2013) *Climate-Related Disasters in Asia and the Pacific*, ADB Economics Working Paper Series No. 358, Asian Development Bank, Manila.

UN-SPIDER (2015) *UN- SPIDER Knowledge Portal* http://www.un-spider.org/advisory-support/emergency-support/9911/earthquake-nepal-india-bangladesh-china

Zook, M., Graham, M., Shelton, T., Gorman, S. (2010) *Volunteered Geographic Information and Crowdsourcing Disaster Relief: A Case Study of the Haitian Earthquake,* World Medical & Health Policy Vol. 2: Iss. 2, Article 2.

BIOGRAPHICAL NOTES

Biredra Bajracharya is the Regional Programme Manager of MENRIS programme at ICIMOD. He is trained in Geoinformatics and Civil Engineering, and has worked extensively on spatial data infrastructure, decision support systems, and GIS and remote sensing (RS) applications in relation to natural resources, biodiversity, conservation planning, and protected area management. He has also been involved in developing various training courses on GIS/RS and has conducted training programmes in all of ICIMOD's eight regional member countries. He is also the coordinator of SERVIR-Himalaya, a joint initiative with NASA and USAID for developing earth observation, monitoring, and visualisation systems that integrate satellite and other geospatial data for improved scientific knowledge and decision-making. He has co-authored over fifty pulications and conference papers and is a life member of Nepal GIS Society.

CONTACTS

Birendra Bajracharya
International Centre for Integrated Mountain Development (ICIMOD)
Khumaltar
Lalitpur
NEPAL
Tel. + 977 1 5003222
Fax + 977 1 5003217
Email: Birendra.Bajracharya@icimod.org
Web site: www.icimod.org