

APPLICATIONS OF SPACE BASED TECHNOLOGY (SBT) AND INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) TO STRENGTHEN DISASTER RESILIENCE

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ABSTRACT: Space-Based Technology (SBT) and Information and Communication Technology (ICT) are emerging as important tools for strengthening disaster resilience through collecting and sharing reliable disaster-related data and information. While through SBT, data can be collected from the top over a large area, the ICT can provide house-level data from the ground in real-time. SBT, especially remote sensing is one of the fastest means for acquiring data for analysis of pre-disaster and post-disaster situations. Satellite data with its favourable synoptic view and repetitive coverage offers a possibility for mapping and monitoring in disaster affected areas through emergency observations undertaken by various regional and international initiatives such as Sentinel Asia and International Charter for Space and Major Disasters. Data acquired by SBT are being used for rapid damage assessment. On the other hand, ICT such as latest generation of mobile phones and their state-of-the-art applications have brought revolutions in mapping even in remote locations as well as disseminating early warnings to the “last mile”. Mobile phones can determine and provide locations to its users and recent advances in mobile phone applications have made it possible to users to collect, manage, and share geo-spatial data. With geo-spatial data handling capabilities, the latest generation of mobile phones can be used very effectively for Community-Based Disaster Risk Management (CBDRM), including early warnings and possibly emergency evacuations at local level, given the high penetration of mobile phones to most of the developing countries in recent years.

This paper examines the possibility of augmenting the capacity of the local governments as well as at the communities in Bangladesh to collect and share reliable data and information related to hazards and exposures at local level to strengthen their disaster resilience and support for disaster preparedness and timely post-disaster response, recovery, and reconstruction for reduction in loss of life and damage to property.

1. INTRODUCTION

A number of regional and international initiatives have been taken up by the space agencies as well as multilateral forums to establish mechanisms for making satellite data and products available for emergency response purposes. At regional level, the ‘Sentinel Asia’ initiative has been providing free satellite images for emergency responses during a major disaster event in the Asia-Pacific region. The Sentinel Asia is a voluntary and best-efforts-based initiative among the regional space agencies and disaster management agencies for humanitarian assistance purpose through applications of remote sensing and Web-GIS technologies in the Asia-Pacific region. The Asia-Pacific Regional Space Agency Forum (APRSAP) proposed Sentinel Asia in 2004, when it was realized that the rapid technological advances in the region could provide life-saving benefits, if satellite data and products could be delivered quickly via the internet to disaster management agencies in the affected countries. Sentinel Asia became operational in 2005 to provide satellite data acquired through emergency observations, but starting from 2013, its scope has been expanded to cover the entire disaster management cycle - the preparedness/mitigation phase before a disaster, response phase during a disaster, and relief/recovery phase after a disaster as shown in [Figure 1](#). For faster delivery of satellite data and products to end-users, a wide range of satellites such as earth observation, communication and navigation satellites have been brought into operation since 2013 (Kaku & Held, 2013).

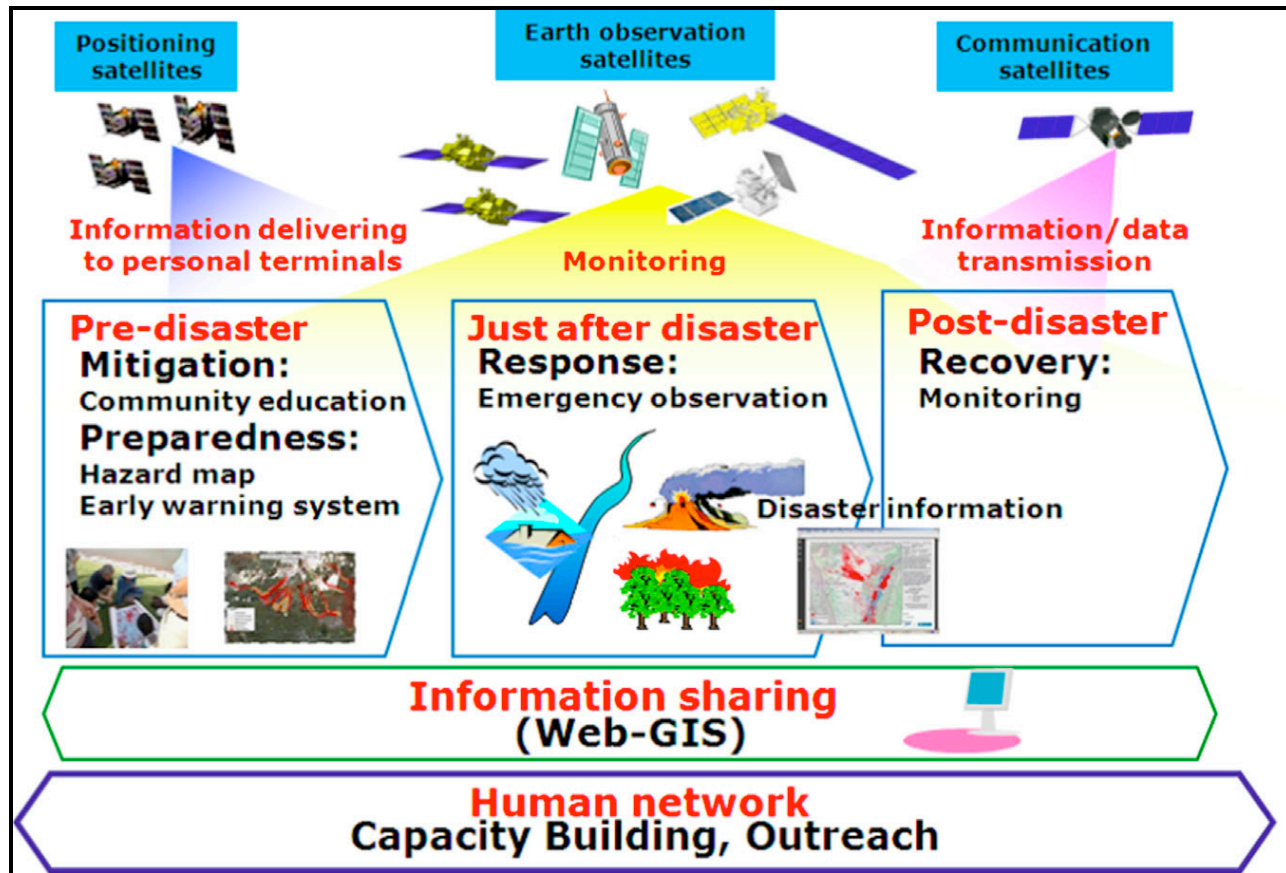


Figure 1 Framework of the Sentinel Asia Step 3 (Kaku & Held, 2013¹)

The International Charter on Space and Major Disasters is a worldwide collaboration among space agencies to make satellite data available to the disaster management authority in an affected country during an emergency. Being a global initiative, the International Charter on Space and Major Disasters has more resources in terms of number of earth observation satellites and data acquisition capabilities, including the high-resolution satellite images. Although any national disaster management authorities can submit requests to the International Charter on Space and Major Disasters for obtaining satellite data through emergency observations, but a set of procedures need to be followed by them if they are not member of Charter. However, all the 30 members countries of the Sentinel Asia can activate the International Charter on Space and Major Disasters through the Sentinel Asia, irrespective of their memberships to the Charter.

The elements-at-risks data such as buildings and infrastructures are very important for assessing their exposures, vulnerabilities and risks to various natural hazards. Unfortunately, an updated and comprehensive element-at-risk database is not often available or accessible. On the other hand, high-resolution satellite images are the most important sources of information for preparing the elements-at-risk inventory in GIS format, but they are too expensive to afford. However, open data initiative such as OpenStreetMap (OSM) can offer a solution by providing a free and editable global database based on high-resolution satellite images. OSM is a collaborative project where voluntary mappers contribute to the rapid development of the database. While it started with mapping of streets, it has already gone far beyond that to include also many relevant data necessary for disaster preparedness/mitigation, disaster response and disaster relief/recovery.

This study has been conducted in Bangladesh and the objectives are: (i) community-based OSM (OpenStreetMap) base mapping; (ii) community-based hazard/risk and evacuation routes mapping; (iii) crisis mapping; and (iv) geo-spatial data management. To accomplish these objectives, three software tools were developed: Tool 1 – the OSM mapping tool (geoMapTool) for community-based OSM base mapping; Tool 2 – a crowdsourcing tool (geoBingAn App) for community-based hazard/risk and evacuation routes mapping and crisis mapping; and Tool 3 – a web-based GIS (geoBingAn Web-Portal) for geo-spatial data management.

2. STUDY AREA

Bangladesh is one of the most at-risk countries in the world. Much of the country is low-lying and densely populated leaving it vulnerable to flooding. Flash flooding is common in the northern regions of the country while storm surges and coastal inundation is common along the coastline. Other hazards include: droughts, tornadoes, earthquakes, riverbank erosion, and landslides. Cyclones are the most common disaster in Bangladesh followed by flooding; however, flooding causes more damage, accounting for 58% of all damage, while cyclones cause 38% of damage. Major cyclone events were: the Bhola cyclone (1970), the 1991 cyclone, Cyclone Sidr (2007), Cyclone Aila (2009), and catastrophic floods which occurred in 1988, 1998, 2004 and 2010.

Two pilot areas were selected for Bangladesh in consultation with the Department of Disaster Management (DDM) of Bangladesh. The first pilot area is the Barguna Municipality (Figure 2), the heart of the coastal district of Barguna with an area of 12.96 sq. km and a population of 60,875. It has 9 wards and 18 mahallas. Most of the people of the area are engaged in agriculture and small businesses. The town has a cultivable area of 38,378 hectares. Barguna is highly susceptible to coastal hazards such as cyclones, storm surges, coastal flooding and salinity intrusion. Since 1970 four severe cyclones have affected the area. Cyclone Sidr alone took the lives of 1,335 people (approximately one-third of the total casualties arising from the cyclone) in 2007. The storm destroyed 1,808 km of roads, 1,797 bridges and culverts, 605 km of embankments and 413 educational institutions in Barguna district. There are two cyclone shelters and 14 km of embankments in Barguna Municipality. There is a well-established Municipality Disaster Management Committee with 120 committed volunteers under the Cyclone Preparedness Program (CPP). The second pilot area is Sirajganj Municipality (Figure 2), which is situated on the bank of the Jamuna River, the largest river in Bangladesh. Established in 1969, the Municipality consists of 15 wards and 52 mahallas with an area of 28.49 sq. km. The town has a population of 158,913 with most of the people (35.49%) engaged in agriculture. Sirajganj is also a flood prone area in Bangladesh due to its close proximity to the Baral, Ichamati, Karatoa and Phuljuri Rivers. Being on the floodplain of these rivers, the major hazards of the area are floods and riverbank erosion. Floods affect Sirajganj almost every year, causing immense suffering for the people.

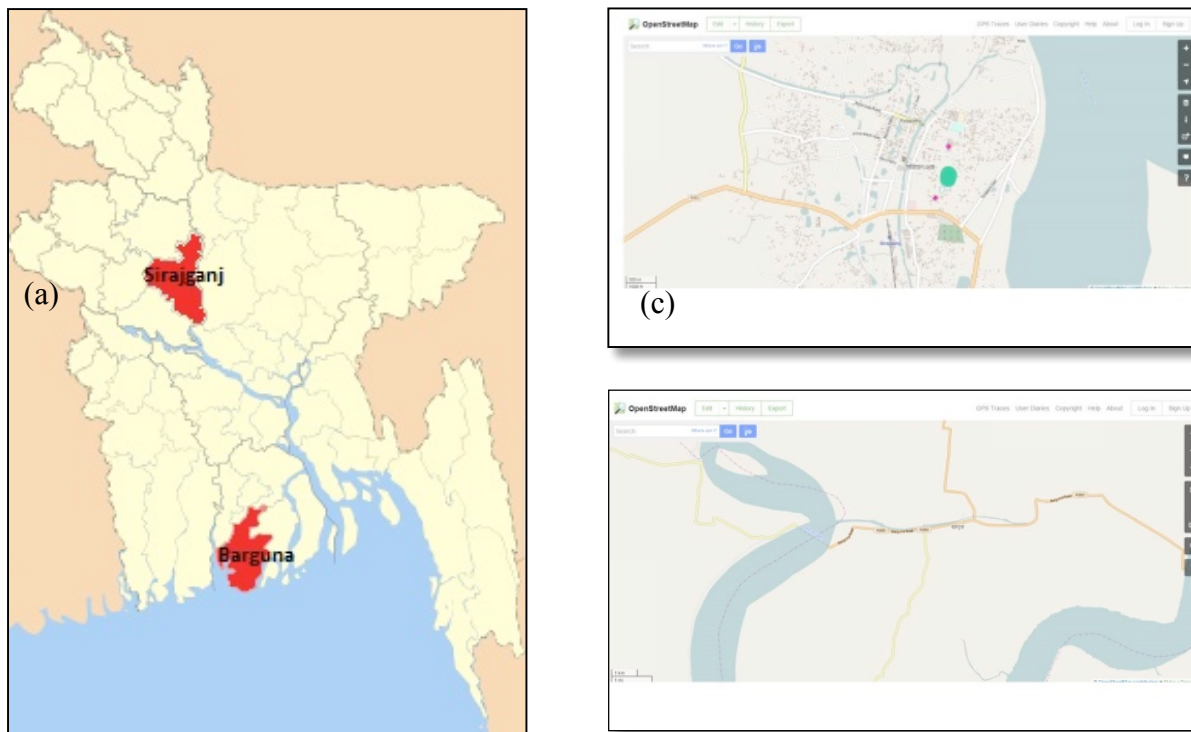


Figure 2 (a) Pilot site locations in Bangladesh; (b) Sirajganj OSM Data Coverage, (c) Barguna OSM Data Coverage

2. METHODOLOGY

Bangladesh has an active and growing OSM community; first established in 2010, the self-organized group receives international funding for OSM-directed projects and many international organizations use the OSM data for their country projects. At the local level in the pilot locations, limited electricity, poor internet access, limited access to computers and low technical capacity make the OSM desktop and field validation a challenge. Volunteers from the Cyclone Preparedness Programme (CPP) and Flood Preparedness Programme (FPP) were selected from Barguna and Sirajganj, respectively, and training courses were organized in Barguna and Sirajganj to introduce OSM mapping and the mobile application geoMapTool (Figure 3). Nearly 1,000 of the 5,000 buildings which were digitized under this study, and attribute information were added through field validations.



Figure 3. Trainings of volunteers at (a) Shirajganj and (b) Barguna

By using the geoMapTool (Tool 1), these OSM data were downloaded to the mobile phones by the volunteers and attribute information was added to digitized buildings and roads by physically verifying them (field validation). Once the volunteers finished collecting the attributes information of buildings, roads and other features, the OSM data were automatically loaded to the national server using the internet connection on the mobile phones and then synchronized with the global OSM server.

Community-based hazard/risk and evacuation routes mapping were implemented in this project and the output of the community-based OSM base mapping was used as a platform for community members to add hazard areas as well as safe evacuation routes based on their past disaster experiences. This activity involves two processes; (i) town watching, and (ii) hazard/risk mapping and evacuation planning. Town watching is an exercise to evaluate the risk to a community by a group of DRR experts together with selected community members; the risks to buildings and infrastructure with respect to hazards are usually evaluated. The hazard/risk mapping and evacuation planning are accomplished from information collected during town watching to identify evacuation centers and safe evacuation routes. Two ICT tools, namely the geoBingAn Mobile App and geoBingAn Web-Portal are the two main ICT tools developed to support these two activities. By using the geoBingAn Mobile App, geo-tagged photographs of the points of interest are collected in the field along with relevant information and the same can be viewed through the geoBingAn Web-Portal for planning and decision making at the time of a disaster. In Bangladesh, the community-based hazard/risk mapping was first accomplished in Sirajganj along with traditional town watching by recording the information manually using paper and pencils and taking photographs in the field. By using the geoBingAn Web-Portal, flood hazard-prone vulnerable buildings and infrastructure were added from the paper maps. The lessons learned from Sirajganj were used in Barguna for replicating the activity.

The crisis mapping was accomplished through mock-drills organized in Sirajganj. The geoBingAn Mobile App was used for this purpose, as it can capture and relay various types of information, such as situation reports, damage, evacuation needs, medical support, water shortages, availability of supplies, etc. Such information is collected in the form of short messages, photographs, and reports and shared through the geoBingAn Web-Portal for emergency response purposes. Two mock-drills were conducted at Sirajganj and Barguna districts of Bangladesh. Officials of the DDM, members of the districts, *upazilas* (sub-district) and union disaster management committees, local elites, volunteers and the selected members of vulnerable households actively participated in the mock drills. Both the

geoBingAn Mobile App and geoBingAn Web-Portal were used while carrying out the crisis mapping through the mock-drills.

A geo-spatial data management system was developed for both the national level and local level. This data management system acts as the default repository for all data collected by the geoBingAn Mobile App. Data collected by the geoBingAn App get synchronized through push notification which requires an “online” environment. Data are organized in these data management systems as (i) raster (satellite imageries and GeoTIFF files, such as hazard maps, evacuation route maps, etc.), (ii) vector (OSM features like roads, rivers, and buildings, in addition to a national government’s own GIS data in the form of a points, lines or polygons), and (iii) attribute information (building and infrastructure attributes).

3. RESULTS

Mock drills were conducted at Sirajganj and Barguna districts respectively to evaluate the effectiveness of the SBT and ICT based systems as well as to sensitize the concerned stakeholders regarding their roles and responsibilities in utilizing the SBT and ICT tools in disaster response planning and operation. The stakeholders such as the officials of the DDM, members of the District, Upazila and union disaster management committees, the offices of government and non-government agencies, local elites, volunteers and the selected members of vulnerable households actively participated in the mock drill. System review workshops in the two pilot areas were also organized to understand how the data and information collected at the community level will be used at each stage of disaster risk management. The outcomes of the workshops are listed below:

(i) Pre-disaster risk reduction stage:

- The data of OSM is highly useful as baseline information in preparing local level sectoral development as well as a risk reduction plan;
- As effective awareness-raising tools, the hazard map and evacuation map can be displayed at public places in the community to make the community people aware of their potential disaster risks and vulnerabilities and the measures that have to be taken at the family and community level for reducing disaster risks;
- In terms of resource mobilization, the hazard map can also be utilized as an effective advocacy tool for concentrating and motivating the authorities concerned with allocating resources.

(ii) Alert stage:

- As planning tools, the data and maps are very useful for the concerned authorities in preparing a disaster emergency response plan;
- They are very helpful for making decisions regarding when and where the disaster early warning will be disseminated on a priority basis and who is responsible for dissemination of the warning;
- The evacuation map is very useful for evacuation planning such as which community will be evacuated on a priority basis and taken to which safe shelter, etc. Such data and maps are also very useful for mobilizing the logistics and materials support to operate the evacuation operation;
- As part of institutional preparedness, data and maps are very useful for the concerned service-providing agencies for mobilizing resources and materials in response to an upcoming disaster.

(iii) During and post-disaster stage:

- The data and maps help a lot in operating emergency response activities in a coordinated manner, as per the emergency response and recovery plan;
- They are very helpful in preparing situation reports which are very important to the responders for ensuring needs-based support for the disaster victims;
- The data and maps are very useful for assessing losses and damage as well as very helpful in preparing the emergency needs and damage assessment reports;
- As monitoring and coordination tools, the data and maps help to ensure the required services to the disaster victims as well as the optimum use of the limited resources;
- As evaluation tools, the data and maps are very helpful for the disaster managers to understand the degree of the adverse impact of the disaster in terms of the economic value of the losses and damage.

3. RECOMMENDATIONS

Bangladesh has institutionalized community-driven approaches for disaster risk management but there is a need to include the use of SBT and ICT as tools in the community-based disaster management initiatives. Through the activities conducted under this study, sufficient awareness was created among the pilot communities, local as well as national government officials for mainstreaming the SBT and ICT in disaster risk management. However, national-level policies to promote community-driven disaster risk management in collaboration with the national disaster management agencies are essential for mainstreaming ICT and SBT as tools for disaster risk management. Policies that allow for a community to effectively capture hazard and disaster-related data and information will benefit the local governments by increasing the resilience of their communities while such policies will assist the national disaster management agencies to make decisions based on crowd-sourced data and information to increase their efficiency and augment disaster resilience.

4. REFERENCES

Kaku K. and Held A., 2013. Sentinel Asia: A space-based disaster management support system in the Asia-Pacific region, *International Journal of Disaster Risk Reduction*, Vol. 6, pp. 1–17.