Impact of advanced technology on effectiveness of Disaster Management activities in Sri Lanka

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Abstract *— Disasters have been a part and parcel of Sri Lankan way of life being an island exposed to vast Indian Ocean. Global warming and climate change has increased the floods, droughts, storms, earthquakes, landslides etc. Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems (IPCC, 2014).*

Sri Lanka does not seem to reap the benefits of the availability of advanced technologies in managing disasters in all stages of its cycle namely, impact, response, recovery, reconstruction, prevention, mitigation and preparedness. The land slide at Koslanda, Uva province in November 2014 and flash floods in most parts of the country in May 2016 proved that effective mechanisms are not in place for disaster preparedness, response and recovery in Sri Lanka.

The observation in traditional disaster management activities using man power of Military has led to the increased awareness on utilizing technology to minimize damage to human lives and property. The researcher therefore tries to solve the problem of lower levels of effectiveness in present day disaster management activities in Sri Lanka which results in more loss of lives and damages to property. The solution proposed is that the disaster managers shall adopt more of advanced technologies in the various stages of disaster management such as impact, response, recovery, reconstruction, prevention, mitigation and preparedness.

The researcher has identified following specific research objectives.

a. To do an in depth study in to the advanced technologies available for disaster management activities in the world and observe the suitability, customization into local culture, attitudes and structures.
b. To critically evaluate existing mechanisms and plans in place in Sri Lanka for Disaster Management.
c. To develop a model of technology packages (Mission capability packages, MCPs) that can be used in disaster management activities particularly in Sri Lanka and in general in developing countries.

In this paper researcher focuses on the advanced technologies related to four types of disasters chosen for the study, namely floods, droughts, landslides and cyclones and the ways and means such technologies can be used in Sri Lankan disaster management activities.

Keywords: Disaster Management, Advanced Technology, effectiveness

I. INTRODUCTION

Disasters have been a part and parcel of the Sri Lankan way of life, as an island exposed to vast the Indian Ocean. Global warming and climate change has increased floods, droughts, storms, earthquakes, landslides etc. Human influence on climate system is clear, and the recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impact on human and natural systems (IPCC, 2014).

Disasters have taken away more lives in the last ten years than the thirty year war. Damages to property and cost of loss of livelihood are few times the gross national product of the country. Sri Lanka has many disasters all year around. Prominent among them are Cyclones, Floods, Landslides and Droughts. The Boxing Day tsunami in 2004 was a rare occurrence but it caused the loss of approximately 30,000 lives and colossal damages to property and public infrastructure. Every year these natural disasters cause loss of lives, livelihood and damages to property and public infrastructure. Sri Lanka does not seem to reap the benefits of the availability of advanced technologies in managing disasters in all stages of its cycle namely, impact, response, recovery, reconstruction, prevention, mitigation and preparedness. The most recent land slide at Koslanda, Uva province in November 2014 proved that effective mechanisms are not in place for disaster preparedness, response and recovery in Sri Lanka.

II. ADVANCED TECHNOLOGIES USED IN DISASTER MANAGEMENT IN THE WORLD

A. *Remote Sensing*

Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object in contrast to on-site observation. Remote sensors collect data by detecting the energy that is reflected from Earth. These sensors can be on satellites or mounted on aircraft (both manned and unmanned). Remote sensors can be either passive or active. Passive sensors respond to external stimuli. They record natural energy that is reflected or emitted from the Earth's surface. The most common source of radiation detected by passive sensors is reflected sunlight. In contrast, active sensors use internal stimuli to collect data about the Earth. For example, a laser-beam remote sensing system projects a laser onto the surface of Earth and measures the time that it takes for the laser to reflect back to its sensor.

Remote sensing has a wide range of applications in many different fields. In disaster management it has been widely used in tracking cyclones, droughts, landslides and flooding. These data can be used to assess the impact of a natural disaster and create preparedness strategies to be used before and after a disaster (Fig.1). Remote sensed data such as MODIS (Moderate resolution Imaging Spectroradiometer), ASTER (*Advanced Space borne Thermal Emission and Reflection* Radiometer), Landsat and Radarsat are also used to produce maps on disaster risk. Digital terrain data received from GTOPO30 (Global Digital Elevation Model by US Geological Survey), SRTM-DEM (Shutter Radar Topography Mission- Digital Elevation Model) or LIDAR (Light Detection and Ranging) are used for hydrological and flood modelling.

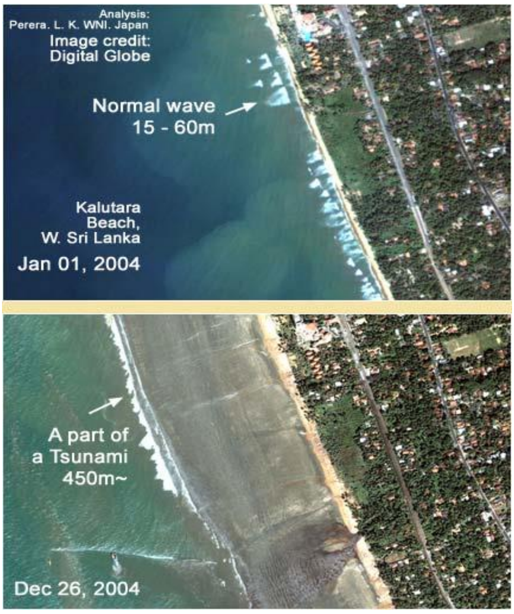

Fig .1 Kalutara beach before and after tsunami December 26, 2014

The types of satellite and airborne sensors that can be used to support phases of disaster management are many and varied. Geostationary satellites provide data for large extents of areas but with minimal spatial detail. These types of data is appropriate when monitoring weather patterns, cyclones, etc. while on the other hand high resolution imagery data (SOT, IKONOS, Quickbird) are appropriate when targeting relatively small areas. These sensors can provide great spatial details when baseline data is needed for modelling flood prone areas. Therefore it is most important to consider the spatial scale of the disaster in addition to determining the appropriate remotely sensed data types in addressing the problem of disaster management.

1) Cyclones– Tropical cyclones normally affect the coastal zones between 100 and 300 North and South of the equator. Low resolution weather satellites can be used to monitor and track cyclones as an early warning method to reduce human and property loss. GEOWARN (Global Emergency Observation and Warning) by ESA and NASA is conceived as a combination of remote sensing and satellite communications that would constitute a global system for disaster warning and relief support management.

2) Flooding– There are different types of flooding (Eg. river floods, flash floods, coastal floods and dam break floods) with their different characteristics with respect to the time of occurrence, the magnitude, frequency, duration, flow velocity and the real extent. Satellite data has been successfully and operationally used in most phases of flood disaster management. Multi-channel and multi sensor data sources from GOES (Geostationary Observation and Environmental Satellite) satellite are used for meteorological evaluation, interpretation and validation and developing numerical weather prediction models. The use of optical sensors for flood mapping is limited by the extensive cloud cover that is mostly present during a flood event. Due to this SAR (Synthetic aperture radars) and RADARSAT have been proven to be very useful for mapping flood. However the integration of GIS data and remote sensing data is a challenge. Thus, remote sensing data can be applied in flood management for the preparation of flood assessment map, generating hydrological models, flood risk map and early warning.

3) Drought – Low resolution satellite data can be used in monitoring anomalous rain cloud, rain fall patterns and vegetation cover caused by fluctuations of seasonal displacement of Inter Tropical Convergence Zone. Remote sensing data can be used to monitor rain fall and biomass deficiencies in the affected regions and issue early warnings to the respective government. African Drought Monitoring system operated by NASA is a very good example.

4) Earthquakes and Landslides – Mainly uses remote sensing for preparedness and relief phases. High resolution digital elevation model such as in InSAR (Interferometric Synthetic Aperture Radar) and LIDAR can be combined with in situ data and imaging spectroscopy (such as ASTER and MODIS) for landslide risk assessment and monitoring.

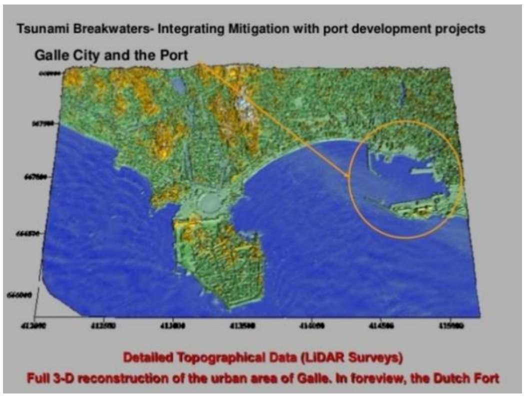

Fig 2. LiDAR surveys of Galle City and the Port

5) Challenges and limitations in remote sensing usage in disaster management

Finding the appropriate sensor in terms of spectral resolution and temporal resolution which suit the type of disaster is the main challenge. The researchers have suggested the combined use of visible sensors and microwave sensors to reduce the effect of cloud coverage.

Developing more frameworks and templates to use remote sensing in disaster management is a much felt need so that users do not have to re-invent the wheel every time. The challenge of providing data in a timely manner could also be a setback in using remote sensing.

Another concern is that the access to high resolution data and technical expertise to handle data may be lacking in developing countries.

6) Recent developments and Synergistic approach

Use of remote sensing in disaster management has changed from an era of mostly used for warning and monitoring to an era of usage in all phases of disaster management. The availability of Very High Resolution (VHR) data (such as IKNOS, Geoeye and Quickbird) has facilitated the use of remote sensing data in disaster management by comparing before and after images of disaster area.

Currently there are more than 20 countries that own satellites. These facilitate collaboration of data among various agencies and they collectively act during disasters to assist the respective governments. Global Land Cover Facility (GLCF) of USGS provides free downloads of high resolution Landsat data. OrbView3 is also a free archive provided by USGS. Google Earth and Microsoft Virtual Earth give access to high resolution images which has added elements of crowd sourcing. These geo spatial data portals have been practically and effectively used in recent disasters in Haiti, Philippines and Nepal. In the local context, Google has updated the images of the land slide disaster on 28th October 2014 at Meeriyabedde site within days which clearly shows the extent, the scale and the effects of the disaster (Fig. 3).

Fig.3 Meeriyabedde Landslide site on Google Earth

In order to leverage the opportunities offered by recent developments, synergies in integrated multi sensor multi-platform approach in disaster management are much essential. Synergy in different technologies such as UAV (Unmanned Aerial Vehicle), GIS (Geographical Information System), GNSS (Global Navigational Satellite System) and ICT (Information Communication Technology) is also very important. Synergies in different organizations such as Disaster Management Centre (DMC), National Building Research Organization (NBRO), Met department, Survey department and Military etc. plays a major role in effectively coordinating a disaster event. The last is the communication platforms used in dissemination of early warning and status updates in case of a disaster which has to be seamless and automatic to reach the masses within the short time span. The 2004 Boxing Day tsunami caught Sri Lankan disaster management agencies off guard and marks a significant failure in preventing at least the people from western coastal areas from harm as it struck the eastern coast approximately one hour earlier than the western coast.

B. WebGIS

The WebGIS is an internet based Geological Information System where you can find all the leading information and resources for Geographical Information Systems. Free access to all the hard to find data such as Terrain data (Eg. SRTM 30, GTOPO 30 etc.) and Land Use data (Eg. "Global Land Coverage Characterizations") and Base Maps (Eg. Landsat) and Shore Line Data (Eg. GSHHS - Global Self-consistent, Hierarchical and High-resolution Shoreline Database) are available at WebGIS.

Appropriate use of the WebGIS data needs resources such as competent technical staff, operators, users and management. These data can be made available as "Information products" with relevant inputs and integration with remote sensing data to the relevant disaster managers during a disaster. WebGIS can be effectively used mainly on floods, landslides and droughts in all phases of disaster management. Rainfall management, early warning analysis and early warning management can be developed on the WebGIS platform with minimal requirement of sophisticated application software and high end computers.

C. Sentinel Asia Program

Many of the causes and impacts of natural disasters, including droughts, are observable in real-time from space by earth observing systems. When efficiently combined with modern information-distribution methods, such data can be sent rapidly to affected communities and local emergency agencies as early-warning before the disaster occurs or as post-disaster maps to assist in recovery operations. A new project called "Sentinel Asia" was proposed in 2004 by the Asia-Pacific Space Agency Forum (APRSAF), to showcase the value and impact of earth observation technologies, combined with near real-time internet dissemination methods and WebGIS mapping tools.

The information products given to member countries are Satellite imagery (and data permitted by data providers) and value-added images with extraction of disaster stricken area, on site digital camera images, rainfall information and meteorological satellite imagery and data.

In Sentinel Asia program, out of 98 organizations from 25 member countries, Sri Lanka is represented only by the Survey Department and Ministry of Disaster Management. Many countries have obtained membership for leading universities in their countries to the Sentinel Asia program so that Centres of Excellence in disaster management can be set up in those universities. As the main disaster management function is handled by the Military in Sri Lanka it is all but necessary to obtain Sentinel Asia membership for General Sir John Kotelawela Defense University (KDU) which is the only defence university in the country. This membership will facilitate relevant disaster management training and capacity building to be provided to Military personnel from Three Armed Forces and Police. The information products received from Sentinel Asia on Remote sensing and WebGIS data could be very effectively used by the Military disaster management teams in their pre and post disaster operations.

III. MISSION CAPABILITY PACKAGES

Mission Capability Packages (MCP) is a concept used in the United States of America Military in Network Centric Warfare. It would contain a package including concepts of operations, command and force structures, the corresponding doctrine, training and education, technology, and systems with a support infrastructure designed and tailored to accomplish specific missions. An integral part of the MCP concept is the approach proposed to synchronize the insertion of advanced technology with the ability to change the way Militaries operate so that they are able to take advantage of the opportunities afforded by technology. MCP can be adopted to ensure Sri Lankan Military manages the disasters more effectively ultimately aiming for lesser number of losses of lives, loss of livelihood and losses to public and private infrastructure.

A. MCP Process

While much has been spoken about putting technology to use, the pace of technological advances has quickened to such a degree that current methods of incorporating technology into a government organization are well below the accepted norms.

The need for technological reforms alone is insufficient because the technology insertion cycle is out of sync with military strategy development and the elements needed to implement military strategy. Speeding up the technology insertion cycle without addressing the speed of the process by which we develop military strategy, concepts, and doctrine simply makes these processes further out of sync. What is needed is an approach that synchronizes the development of military strategy with the globally available advances in technology and with the technology insertion process.

The speed at which technology can be deployed is only one aspect of the problem. When considering a situation in which new technology can be made instantly available to operational users which is very much possible with programs such as Sentinel Asia, the concern is how much of the technology's potential can be realized. In that case only minor improvements will be made, thus wasting the resources and the effort taken to introduce the new technology. This scenario would be repeated over and over as the latest technology replaces older technology. MCP process addresses this problem correctly. It provides an opportunity to make radical changes as and when they are needed.

D.Adopting MCP to Sri Lankan Military

The Sri Lankan Military is currently at odds with the conceptual changes and in accepting and implementing approaches that require changes in culture. In the Concept Development Phase, groups of individuals with the requisite operational and technical expertise shall be brought together in a safe environment with the charter to "think outside of the box." KDU offers an environment particularly well suited to this task. As concepts shape up, they would be then subjected to a series of analyses, experiments, and tests to determine if they merit adoption by the Sri Lankan Military in Disaster Management. It is essential to develop four main areas of the Mission Capability Package relevant to disaster management.

1) Collaborative module with the ability to seamlessly receive remote sensing and WebGIS data provided by the different Data Providers (such as USGS, WebGIS, Sentinel Asia).
2) Data Analysis and situational awareness module to determine the nature, scale and magnitude of the disaster through both local and remotely sensed data and decide on deploying disaster management teams.
3) Communication Module for dissemination of data to first responders (Disaster Management teams) at remote areas closer to the disaster site.
4) Module for obtaining feedback and feeding forward new information as and when they arrive to develop statistics required for recovery and reconstruction in disaster management cycle.

In order to achieve this KDU will have to invest in a set of models, simulations and ranges to support the testing of concepts, new information products, systems, equipment, doctrine, and concepts of operations and for the training and exercisers of the disaster management teams.

The last phase of the process requires the implementation of the institutional changes, technologies, and systems that are required by a MCP. Given the knowledge of this disaster situation in advance, it is important that the senior governmental and military leadership fully embrace the MCP process and stay abreast of the developments in the MCP concepts and their progress. The KDU in liaison with Office of Chief of Defense Staff and Disaster Management Centre needs to do a mission-by-mission review of how to meet the challenges faced. Since organizations continually need to accommodate change in the nature of their missions, organizations also need to be structured to facilitate the development of new MCP concepts and their translation into operational capability.

IV. CONCLUSION

Sri Lankan Military can transform itself into a technologically advanced outfit when involved in national disaster management activities. The technology inclusion and developing capabilities required for this aspect can be realized by developing a Mission Capability Package which utilizes the information products provided by various resources such as remote sensing, WebGIS and Sentinel Asia. MCP shall be developed at KDU at a new Centre of Excellence in Disaster Management in Sri Lanka. OCDS, Tri Forces, Police and DMC have to be the main stakeholders in this process. This will ensure the Sri Lankan Military is involved in the national disaster management activities with more focus, capability and a vision to reduce the loss of lives, livelihood and infrastructure during a disaster.

V. RECOMMENDATIONS

It is recommended that a Mission Capability Package on Disaster Management is developed in Sri Lanka jointly by the Disaster Management Centre, OCDS, Tri Forces and Police and KDU. KDU can be the catalyst in this process by obtaining membership of Sentinel Asia program and undertaking a range of training and capacity building activities for disaster management community in Sri Lanka.

The civilian community which are stakeholders of the disaster management functionality in Sri Lanka, DMC, NBRO, Met Department, Survey Department, National Water Supply and Drainage Board, Department of Agriculture, etc. shall be entrusted to develop a coordinating mechanism based on Internet and ICT which is simultaneously shared with the disaster managers at site.

The Impact, response and part of recovery can be undertaken by the Military through the MCP discussed above and Civilian disaster management community can take the lead in managing the last part of recovery, reconstruction, prevention, mitigation and preparedness phases. It is also mandatory that both Military and Civilian community are kept aptly informed about all phases of the disaster management cycle.

Whilst appreciating the support of international organizations that provides data to Sri Lanka, it is also recommended that Sri Lanka develop its capabilities to become a data provider by acquiring necessary human resources and technological infrastructure in the future.

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