International Journal of Advanced Scientific Research
ISSN: 2456-0421; Impact Factor: RJIF 5.32
Received: 12-11-2018; Accepted: 14-12-2018
www.allscientificjournal.com
Volume 4; Issue 1; January 2019; Page No. 15-21

E-Government for emergency management: use of multimedia big data platform for flood emergency management in Sri Lanka

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Abstract
Loss of innocent life and damages of valuable properties are the great tragedy during disaster. Hence, the effective disaster management is one of prime concern for authority and policy makers. Computer generated data, satellite and sensor networks data, at present crowed sourcing and social media bring the more prospect to improve disaster management. There for no doubt that, the modern age of "big data" opened new avenues for natural disaster management, because big data has possibilities to provides data in visualizing, analyzing, and predicting natural disasters. Flood emergency management is very complex in nature due to complexity of cooperation, collaboration and information sharing among stakeholders. Information technology (IT) play significant role in harmonizing data among interest groups. With the advancement of new technology big data play significant role with collaboration e-government, in emergency management field. Past few decades it was observed lots of emergency management issues in Sri Lanka due to lack of collaboration and cooperation in sharing of disaster information. So, this paper will discuss possible e-government framework for flood emergency management using available and real-time big data to manage future flood in Sri Lanka.

Keywords: E-government, big data, IT, emergency management

1. Introduction: Case Report

Flood is considered to be the most common and brutal natural disaster all over the world. Managing such a scenario is vital for the sustainable development of a country [1]. But, comprehensively managing the emergencies are extremely difficult due to its complex nature. Disasters always disrupt the social, cultural, economic, and physical environment which cannot recover soon. Most importantly, the frequent disaster like flood causes great damages annually with changing geo-climatic condition. Such frequent disasters are a huge threat to city life and economy development of the country. The hazard or disaster sometimes cannot be avoided but the negative impacts on the public and their property can be mitigated through effective management strategy [2]. Effective emergency management relies on a thorough integration of comprehensive emergency management plans at all levels of different stakeholders. The activities at each level (Government, group, community or citizen) affect the other levels either positively or negatively. The primary objectives of emergency services are hazard identification, risk assessment and controls, and stakeholder liaison to prepare for emergencies and continuing education on incident management structure, training and exercises etc. with the complexity of the situation this objective cannot be materialized effectually. So, it is important to have an effective emergency management mechanism for all level to guarantee the safety of public and property.

With the changing trends of information technology (IT) and its inherent harmonizing qualities (sharing information, cooperation and coordination) and functions are effectually used for manage the emergency situation in modern disaster management environment [3]. Most importantly the components of IT like, information communication technologies (ICTs) spatial information, decision support system (DSS) and disaster information management systems, mobile, social media, crowdsourcing, satellite technology and cloud computing have been utilized to help organizations to process and share real-time information, establish diverse communication channels, engage a broad network of stakeholders, and harmonize the different agencies within short time period [4, 5]. Information collaborations were largely effective, and also worked to bring broader attention to the performs of crowdsourcing, disaster mapping and big data analytics to the traditional emergency management operations. Importantly the acceleration of the process of on-time reactions through IT in every function of disaster management will give much more advantage to the government and the citizen [2, 3].

According to [6] big data is characterized by 5Vs (Volume, Velocity, Variety, Veracity, and Values), which make more challenging to deal with. In many cases this large volume data generated through crowdsourcing, social media and sensor networks etc. Due to the large volume of data with different variety difficult to manage unless otherwise not have a proper mechanism. As mention by Lv [7]. those big data coming from different levels (stakeholders) or layers of data platforms. As per many scholars argued e-government considered the possible platform to link a variety of stakeholders together to achieve common purpose [8, 9]. E-government is capable to make digital interaction among government organizations (G2G), government to citizen (G2C) and government to different organizations (G2B). This interaction with different level of government organizations (local, provincial, national and international) make easier and more comparable to manage public affairs.

According to the statics of the Disaster Management Center (DMC) of Sri Lanka (http://www.dmc.gov.lk), the number of flood victims is getting increased in acceleration rate (figure 1). But authorities are unable to manage the situation due to managerial, technical and administrative issues [10]. It seems that there is a problem in an emergency management framework while sharing information and coordination different stakeholders during pre and post-emergence. In many occasions, originations work in a limited environment due to the weakness of information harmonizing. But no one has come up with a comprehensive IT-based administrative solution to address this issue. In such a scenario, the purpose of this study is to identify possible e-government framework for flood emergency management in Sri Lanka using available big data.

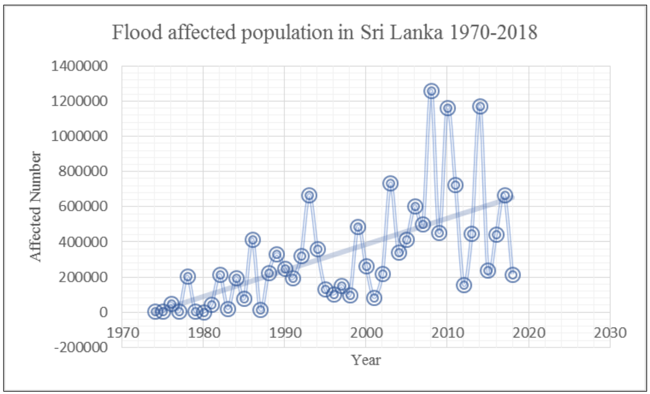

Fig 1: Flood affected the population in Sri Lanka since 1970 -2018 (Sources DMC)

2. Big Data in Emergency Management

The big data is known as unorganized sets of information and making them into something comprehensive application [11]. Modern information- centre and computer-driven society, big data play a significant role in emergency management by increasing knowledge and improve responsiveness during emergencies. During emergencies authorities are unable to take decisions due to inaccurate and incomplete data, in that case, big data application will support to derive the solution. Because big data contain accurate, timely or near timely information which was fed by different sponsors.

The usage of smartphones, social media, crowdsourcing make close collaboration among government, citizen and business and it allowed to take decision rapidly, accurately and precisely [12]. With enhancement of IT number of big data generation has expanded, for an example satellite imagery, aerial imagery and videos from unmanned aerial vehicles (UAVs), airborne and terrestrial Light Detection and Ranging (LiDAR), simulation, spatial data, crowdsourcing, social media, sensor web and Internet of Things (IoT), mobile GPS and Call Data Records (CDR) [13]. Analyzing and observing big data patterns is not only a beneficial practice within the operation, but it can also improve the efficiency and effectiveness of emergency and disaster management organizations.

2.1 Sources of Big Data

As earlier mention, lots of sources fed the data into this big data pool. The following section will discuss a few major sources that generate big data which are important to the emergency management field. Real-time spatial data (GPS data), Satellite imagery, Volunteer Geographic Information (VGI) and social media, small satellites and unmanned aircraft vehicles data (UAVs) are some of them.

2.1.1 Satellite Remote Sensing

As mention by Yu, [13] Satellite remote sensing technology provides qualitative and quantitative opportunities in the context of disaster management by supporting wide-ranging functions such as pre-disaster risk identification, assessing post-disaster damage, responding through operational assistance, and risk reduction [14, 15]. The most significantly remote sensing imagery uses in post-disaster damage assessment through change detection. The high-resolution satellite imagery facilitates the collection of detailed information before and after a natural disaster for identify changes detection. Changes detection allowed to use rescue teams during the response phase as an immediate action, in long-term those satellite data use for mitigation mechanism for resettlement and re-engineering the land use for sustainable development [16]. Most importantly satellite images are capable of providing multidimensional data (3D) which make easier to visualize the situation than traditional 2D images. 3D data make a clearer image of the situation during the flood, then it is easy to measure water level, the degree of damage etc.

2.1.2 Social Media

Social media is the media for social interaction, this platforms including web-based and mobile technologies used to turn communication into an interactive dialogue [17], some application like Twitter, YouTube, Foursquare, and Flickr have been contributing significantly to disaster management [13]. Social media include a wide variety of Images/photographs, texts, audio, video, some documents (word files, power points) and GPS coordinates. It lets interaction between multi-dimension link network (one to one, one to many) through information sharing. Geotagged social media data can be collected by streaming from the Application Program Interfaces (APIs) provided by the social media companies. According to Korukcu, [18] there are "six different types of social media (1) blogs and microblogs,(2) content communities (3) social-networking sites (4) virtual game worlds (5) virtual social worlds (6) collaborative projects". It seems that there is massive unorganized data flows. During a disaster, it needs to analyze relevant data which support to manage emergencies. Social media help and enable individual users and organizations to collaborate in mutually beneficial ways in all phases of emergency management (mitigation, preparedness, and response and recovery).

2.1.3 Crowdsourcing

The crowdsourcing platforms have been developed for users to willingly contribute the required information in any kind of social phenomenon [19]. Crowdsourcing platforms are usually developed and implemented by members of the affected public, or by non-governmental organizations (NGO's) one good example is "Ushahidi" (www.ushahidi.com). The purpose of, such platforms is to improve the disaster response and resource allocation based on real-time reports from disaster victims. During Haiti earthquake in 2010 and Nepal earthquake in 2015 public extensively used crowdsourcing for response and recovery purposes, during those two events online platforms and mobile applications have been established to collect and distribute crowd sourced data during and after the earthquake [20]. Even though several successes achieved one of the challenges is the credibility of data delivery this will affect the decision-making process. In recent past government agencies also launching their own crowdsourcing platforms for disaster management [13]. The government interact with citizens during disaster situations for real-time urgent information and better coordinate search and rescue operations and reduce technological and human resources cost by allowing fast updating real-time data into the system.

2.1.4 Mobile Global Positioning System and Call Data Record

With the development of smartphone, the Mobile Global Positioning System (GPS) has emerged as an effective means of gathering a wide range of mobile sensing data, and GPS can be detected human mobility and behaviour during disasters [21]. The three basic components of GPS, absolute location, relative movement, and time transfer allowed to determine location, the magnitude of the disaster and importantly this can be used as a means of coordination both victims and response groups during disaster [22].

Call Data Record (CDR) datasets are collections of spatiotemporal traces that can characterize individual mobility and social network behaviours at very fine scales. CDR datasets contain location information and time at which a communication (call/SMS) is made, along with unique identifiers for the sender and receiver. This technology can determine population size or population density during disaster. The population size and density measure the number of phones is a connection to one communication tower in coverage area [23].

2.1.5 Wireless Sensor, Web and Internet of Things

Wireless sensor network (WSN) refers to a group of spatially dispersed and central control dedicated sensors for monitoring and recording the physical conditions of the environment and organizing the collected data at a central location [24]. WSNs measure environmental conditions like temperature, sound, pollution levels, humidity, wind, and so on. WSN can effectively act to prevent the consequences of natural disasters, like floods. For an example, the wireless node has successfully been deployed in rivers water gauge reading, where changes of the water levels can be monitored in real-time. The integration of monitored reading into a mobile network can improve situational awareness among the community. Erman *et al.*, [25] sited integrated low-cost embedded devices based on WSN and UAVs for improving the response time in critical situations, minimizing the latency, and maximizing the success ratio of delivery during an emergency.

The Internet of things (IoT) is interconnecting physical and virtual things based on existing and evolving interoperable information and communication technologies [26]. WSN play a significant role in connecting IoT for the desired purpose. Further, IoT acts as an alternative means of communication while permeant communication networks are damaged by the disaster.

2.1.6 Aerial Imagery and Videos

Aerial imagery is playing an increasingly important role in disaster management, due to its efficiency in situational awareness, prediction and monitoring [13]. Aerial images can capture in high spatial resolution images with support of unmanning aerial vehicle (UAV) or airborne capturing devices. The speciality is of UAVs can carry various types of sensors including infrared and ultra-violet, radiation sensors, weather sensors, and cameras, video, spectrum analyzers, and LiDAR reflectors [13]. It means that airborne devices can generate countless images and videos relent to requirement and situation. Those images and videos can be used for real-time decision-making situational awareness, planning purposes like evacuation routes, and support for transport logistics and survey on affected areas.

Airborne and terrestrial Light Detection and Ranging (LiDAR) has made it an important new data source for environmental applications. This method that provides the ability to extract high-quality elevation models and other features, providing reliable information about on-the-ground situations during an emergency [27]. Even though LiDAR equipment is relatively expensive and collecting and processing of data time consuming, however, Digital Elevation Models (DEMs) generated from LiDAR data can have a very high resolution and are very accurate [28].

2.1.7 Volunteer Geographic Information (VGI) and Spatial Data

Adams & Gahegan, [29] mention spatial data infrastructures (SDI) were originally conceived to be centralized geospatial data repositories containing data that came largely from authoritative sources. The advent of local sensor webs, web 2.0 and VGI, the multitude of sources produced varying quality and an uncontrolled number of images related to spatial signature. Vector-based spatial data provides fundamental provision for emergency management, including disaster forecasts, vulnerability analysis for critical facilities and human beings, damage assessment on the resource inventory and infrastructure.

3. E-government for Big Data Handling and Emergency Management

"E-government" is the use of the information communication technology's (ICT) in public administration combined with organizational change and new skills to improve public services and democratic processes and to strengthen support to the public [30]. Lv *et al*, [31] given that "e-government has become an indispensable part of government operation in modern society, the failure of the government-centric approach gave rise to the critical need for a citizen-centric perspective. The citizen-centred government was viewed as the highest level of e-government. At this level, e-government not only provided relevant and integrated information (e-information) and transaction functions (e-transaction) but fostered citizen participation and public dialogue (e- participation). The last point, e-participation, has been deemed to be crucial for meaningful civic engagement and greater government accountability".

Hu & Kapucu, [32] mention the increased access and use of ICTs raised the expectations among the public that government should go beyond from just providing information and services to increasing electronically-aided citizen involvement. With the development of ICT researchers and managers effectively realize the potential importance of E-Government systems, particularly for disaster management field. The applications which are available in e-government systems have used in environmental monitoring, prediction and decision making etc. [33]. To deliver those services, geographic spatial data and three-dimensional technologies (3D) play a significant role. One of a significant key component of e-government infrastructure is cloud computing [31]. The use of client device and cloud computing services enhance the capabilities of monitoring situation and precise decision making, for an example, big data sources like GIS application, mobile network application, satellite communication allows the collection and analyze the data and related information from various sources. This is enabling to identify emergencies and take action to manage the situation.

As new trends use of social media as a component of disaster response during the last few years. Latest research highlighted that the extent to which users contacted government agencies social media connected with the disaster, some instance social media served as a primary means of communication during emergencies [20, 34]. So, now automatically social media embedded in government mechanism in the means of communication [35]. Social media networks have been utilized for a wide range of purposes during emergencies, including locating family and loved ones, requesting help, providing supplies, coordinating volunteers, disseminating information, and psychosocial interaction [36].

E-government is comely applicable in all phase of emergency the application of e-government for the planning of the next emergency based on experience or lessons learnt in a different region. In most cases, GIS-based 3D modelling, artificial intelligence (AI), computer-based simulation is used for these phases. During the response, emergency warning and coordination of response groups use web-based technologies, mobile and wireless communication etc [37]. The use of e-government for recovery is based on ICT, information management system and spatial technology [38]. Based on above literature it seems that the there is a gradually developing relationship between use of big data and e-government for emergency management. Further figure 2 graphically represent the relationship between big data sources and e-government mechanism related to emergency management.

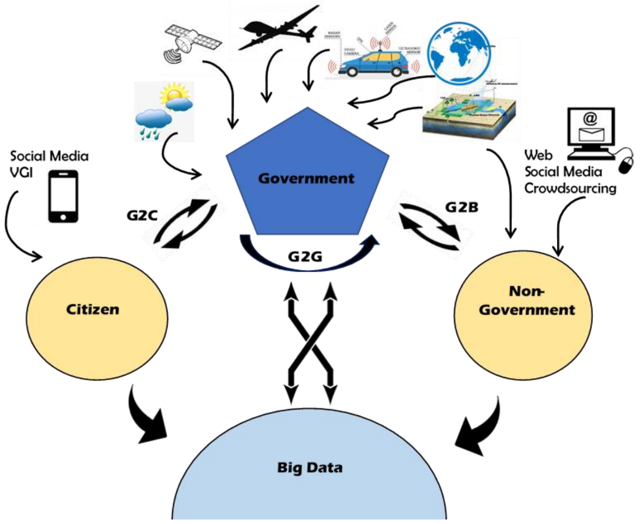

Fig 2: Graphical relationship between Big Data flow and E-government mechanism

4. Flood emergency management issues in Sri Lanka

In general, there are many sources of big data which generate a different kind of data related emergency. To make small focus this study talks about satellite remote sensing, social media, crowdsourcing, mobile GPS and CDR, wireless sensor, web and IoT, aerial imagery and videos VGI and spatial data. The most problematic part is to analyse available data and apply for emergency management purposes. When considering about Sri Lankan context authorities already used a different kind of data sources for emergency management individually, for an example Meteorological Department and Irrigation Department use sensor data for measure water height of river during rain but same data may require disaster management centre (DMC) for early warning for the public who are around inundated areas. DMC being a second user of those data, need to wait until other departments pass information. So, issuing early warning will automatically delay due to the process information passing node to node. Usually, those three organizations have a common interest but due to the problem of harmonization process, the action will delay at a certain time.

According to Perera, [39] stated DMC is the main government agency that oversees and coordinates early warnings and disaster preparedness. Yet, the agency did not broadcast any warnings before the storm arrived in communities in areas that were vulnerable to floods and landslides" in 2017. Further, it is stated that "officials said the DMC relies on information from by the Irrigation Department on floods and the National Building Research Organization on landslides, but DMC received no information from either body". In such manner, there may be many mismatches among organization in relation to coordination cooperation and information sharing. Most agonizing point is that same storm was hit and affected neighbouring Bangladesh, in the same time period. But the government of Bangladesh was able to evacuate 300,000 people prior to storm arrived [40]. Due to less coordination among region Sri Lanka fail to encounter mission effectually. So, international collaboration is most important during disaster not only emergency response but also preparedness stage too. It shows that's data are available locally and internationally, but the problem is information harmonization within G2G, G2C and G2B.

Ground-views [39]. website stated that "Sri Lanka Floods 2017: Sharing the Blame" ineffective government mechanism that leads to a devastating flood situation last few years in Sri Lanka. Further, it highlighted the less coordination among the public-private partnership and government and citizen cooperation. The study on "Issues and Challenges of Post Flood Landslide Management in Sri Lanka" by Maheshika [41], pointed out five challenging area in post-disaster management sector those are (1) Institutional Cooperation (2) Involvement of the government for emergency management (3) Rules and regulation (4) Attitude of people and (5) availability of resources. In such a manner, plenty of examples can be highlighted. But government need have a solid and comprehensive platform to link all interest groups into a one working platform to harmonize all information generated by big data for flood emergency management in Sri Lanka. So, keeping this point in mind the following conceptual model (figure 3) was developed by considering e-government and information technology theoretical background, to address future issues.

5. E-government Conceptual Model for Flood Emergency Management

Based on e-government and emergency management theoretical background, information technology service distribution following the conceptual model is drafted to coordinate all agencies to one platform which can handle emergency smoothly with the support of IT.

Derived proposed E-Government system framework backed by a study of Lv [7], and proposed model comprises of the physical resource layer, data layer, technology support layer, platform layer, application layer and monitoring layer (shown in figure 3).

1. The physical resource layer contains various physical resources, such as computing resource, storage resource and the network resource, and human resource to provide the supporting infrastructure for data layers to collect data.
2. The data layer supports to stores big data from different sources and in different formats. This includes statistical data, spatial data, real-time situational data, sharing data with different countries and service providers.
3. Technology Support layer provides the fundamental technical support for data storage, data security, data sharing, resource scheduling and other core technological requirements of cloud computing, GIS, global position system (GPS), remote sensing (RS) etc.
4. The platform (cloud) layer includes different e-Government services platform like information sharing platform, risk communication, cloud networking, administration platform etc. This is the main networking layer for all activities, it connected to government, citizen and the other non-government organization in virtually or in cloud space.
5. In the application layer work as a de-centerline layer and run applications support to different phases of emergency management, this is an application for risk communication combining with space technology, mitigation and planning coordination and cooperation of response and recovery mechanism in lover level to high level etc.

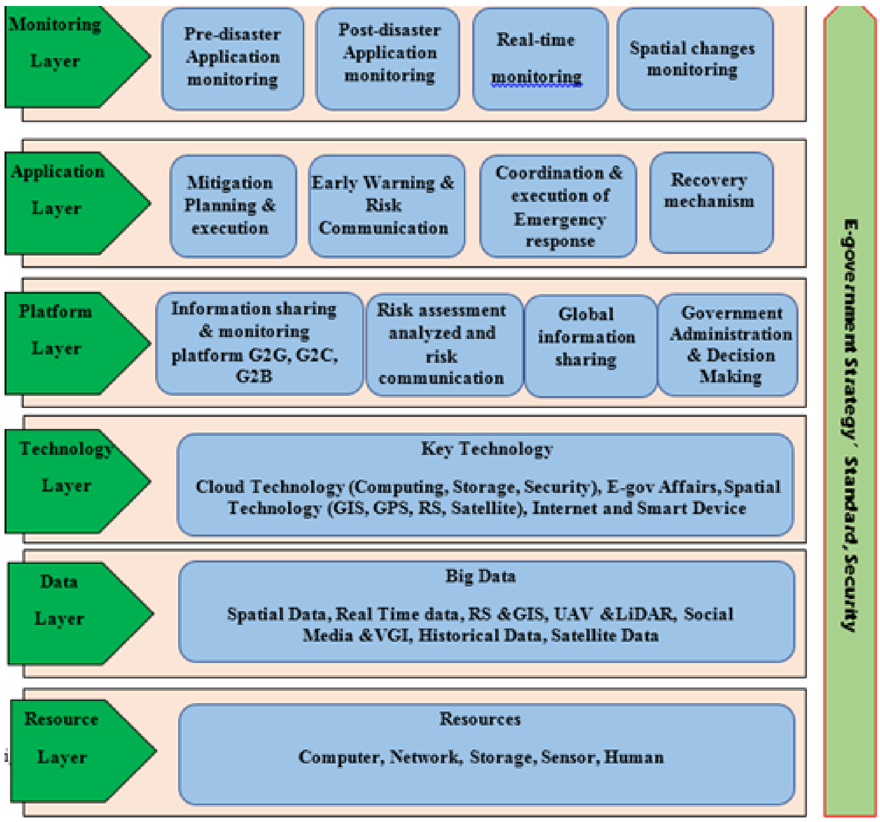

Fig 2: Propose E-government platform for flood emergency management

6. Monitoring layer comprises different monitoring aspect of emergency phases to identify the weakness to support upcoming operations. This includes organization action monitoring, monitoring interaction among G2G, G2C and G2B during an emergency. Monitoring citizen perception after each disaster etc. Monitoring can conduct either web-based or application based according to situation allowed.

Most importantly development of such framework the government needs to introduce new ICT and e-government strategies in support of the required local and international standards. Most importantly government information is vital in terms of information security, so need to establish information security in different level.

6. Conclusion

In this paper, discussed big data generation and its application for emergency management purposes. In Sri Lanka, some organization individually use big data for the different operational process. But due to some limitations data harmonization (collaboration, coordination and information sharing) not really exercise during emergency management in Sri Lanka. The cloud-based E-government system framework for disaster management gives the leverages to authority to manage emergencies with existing and emerging information and communications technologies. This permits authorities to streamline their process and improve delivery of emergency management services to citizens with support of other supportive organizations, and this improves governmental decision-making process by real-time analysis of relevant data from different big data sources and enhances operational response capabilities. Further, as future orientation this platform can be validated as fit to the different region in country or global.

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