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Long Paper

Resource Location-Intelligence Model Conceptualized for Mayon Volcano Danger Zones in Albay, Philippines

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Abstract

Purpose – This paper presents a cloud-based GIS that aims to store, retrieve, manipulate and analyze Disaster Risk Reduction and Management (DRRM)-database human resource data for students, professional volunteers, emergency responders, social and health workers. The location-intelligence is significant in maintaining public safety and peace and order during disaster and post-disaster phases. Locating trained personnel during emergency response stage is critical in DRRM given that responders can also be exposed to disaster risks together with the evacuees during crisis.

Method – The researchers tried to put into the picture how spatial integration could enhance existing Local Government Unit (LGU) information systems. Enhancing existing information systems with human resource or household locations (x, y) is critical in analyzing and validating incoming real-time data or emergency incident reports. Reliable reports and location can be quickly collected, processed and manipulated to produce crisis maps from the DRRM databases stored at the cloud GIS at real-time. Crisis maps should be produced timely for complex emergencies and response operations.The sampling covered geographic locations intersecting the outer boundary of the Mayon 6-kilometer danger zone stretched up to the 10-kilometer buffering at least 2,898 families

or 15,049 residents distributed in 25 barangays of 2 cities and 6 municipalities of Albay Province. The researchers tried to highlight how spatial integration could enhance existing LGU information systems by considering human resource locations (x, y) as fundamental in integrating incoming numerous real-time information from emergency incidents. The data are quickly collected, manipulated then processed with other data retrieved from the readily-available DRRM database, to simultaneously alert the concerned government agencies and responders, thru a Human Resource Location Intelligence System stored at the cloud GIS.

Results – The proposed system can generate tailored maps (combining both official and latest unofficial information from the ground during emergencies),which indicates visualization of the extent of ash fall along with lahar prone map layers during disaster phase or post disaster phase. The layers are processed through a model-builder tool to quickly disclose real-time people and critical infrastructures at risk.
Conclusion – This study providesreal-time exposure critical to responding to clearing operations, emergency response, retrieval of cadaver, and so on, and better understanding of how to enhance DRRM.

Practical Implication – The proposed systemslocation-intelligence is significant in maintaining public safety and peace and order during disaster and post-disaster phases.

Keywords – cloud, GIS, DRRM, location-intelligence, spatial-integration

INTRODUCTION

Most, if not all, the families that are at high-risk (Abante & Abante, 2018a; Abante & Abante, 2018b; Abante, 2017) were already given housing-units or have been resettled in safer locations.However, basic social services such as schools, hospitals or health units, market or places of worship are inaccessible. Meanwhile, those who were moderately to lowly susceptible to volcanic related hazards are constantly evacuated adopting the Zero Casualty Strategy (Salceda, 2012) of the Provincial Government of Albay. The people dwelling inside the 10-kilometer buffer zone are farmers tilling the rich ground of the Mayon foot slopes making it difficult to implement the Philippine Disaster Risk Reduction and Management Act of 2010 (RA 10121), National Integrated Protected Areas System Act of 1992(RA 7586), and the Expanded National Integrated Protected Areas System Act of 2018 (RA 11038) coalesced with Mayon 6-kilometer Permanent Danger Zone (Martinez, 1999) ordinance. There is much to be learned from the 2018 Mayon Volcano Eruption, in which the existing evacuation protocols, and evacuation practices (Lasco, Delfino, & Rangasa, 2012) are seemingly not appropriate for the situation.Evacuees were brought to uncomfortable and unsafe temporary shelters exposing them to vulnerable respiratory related illnesses. The food and water were contaminated causing food and water poisoning.

LITERATURE REVIEW

The flashflood triggered by volcanic debris deposited on Mayon Volcano foot slopes in 2006 and carried by heavy rain due to typhoon Reming (Durian) (Luna, 2009). Storing sensitive information collected through email or social media platform is important to update and maintain DRRM database (Balilo, Gerardo, Medina, & Byun, 2017a, 2017b). The province of Albay has been exposed to climate hazards such as tropical cyclones. The situation was aggravated by natural catastrophes such as volcanic eruptions, flash floods and mudslides (Lasco, Delfino, & Sanchez, 2008). Natural disasters in recent decades confirm that climate change is already taking place as evidenced by increasing mean temperature, changing precipitation patterns, rising sea level, and increasing frequency and growing volume of extreme weather events in Asia. Regional climate studies have expressed and projected that the worse is still to occur. Based on the report of International Strategy for Disaster Reduction (ISDR), Asia registered the highest number of Hydrometeorological disasters at 1,532 occurrences in the period 1991–2005 among all regions in the world (Uy, Takeuchi, & Shaw, 2010).

Florano's idea on mainstreaming integrated Climate Change Adaptation (CCA) and DRRM in local development plans in the Philippines came after the failure of the passive disaster management. He stresses the needs to prepare and react to disasters applying how disaster-prone Sorsogon City was able to incorporate CCA and DRR measures and strategies in its Comprehensive Land Use Plan and Comprehensive Development Plan (Lasco et al., 2012; Florano, 2015). Albay province embraces a more proactive attitude towards preparedness and mitigation under the leadership of Cedric Daep, head of the Albay Public Safety and Emergency Management Office (Bankoff & Hilhorst, 2009).

The data of the survey were gathered through interviews and focus group discussions with Albay government officials, a scientist, Albay citizens, and an official from the Office of Civil Defense in Manila (Salceda, 2012). These interviews provided the groundwork for examining the communication techniques of Albay that has been a model worth emulating by other Philippine communities. The survey revealed that essential to the potency of the Albay model was the rendering of information by city officials, as initially sourced from the warning conditions and disaster preparedness advisory bodies in Manila. Thenceforth, the information disseminated to the residents must be comprehensible regardless of the technology or interpersonal communication used (Salceda, 2012).

The long-term (prevention stage) and short-term (mitigation stage) risk management is to mainstream DRRM into land use plans and comprehensive development plans (Cortes Arevalo et al., 2014). Vulnerability and resilience to climate change in Sorsogon City draws out climate change vulnerabilities and policy reactions. The risk hot spots denote complexities of urban life.

The role of local governments is crucial in meeting the goals of the millennium declaration. Panadero stressed in his paper that an effective local monitoring system for local government units must be instituted to serve them to target appropriate and responsive interventions for poverty reduction and human growth. His insights on the needs to harmonize and integrate some of the existing monitoring tools for information to be compared across municipalities, urban centers and provinces entail information system in place and get accurate local data and information to be able to react to the demands of their constituents objectively and effectively (Panadero & City, 2004). Institutionalizing the Community-Based Monitoring System (CBMS) in the Philippines has been proven and licensed to be statistically sound, cost-effective, valid and reliable given the intended use which is to locally diagnose and monitor poverty. In contrast, she also stressed that there are 14 inadequate resources to carry out the rapid CBMS institutionalization program. She reasoned that the preparedness or political will on the part of the bulk of the local governments to institutionalize CBMS remains nascent (Capones, 2007).

The Climate Disaster Risk Assessment or CDRA (Cuevas, Peterson, Robinson, & Morrison, 2016) illustrates how the two conceptually distinct climate change adaptation (CCA) and disaster risk reduction (DRR) are mainstreamed in the development plans of local government units integrating frameworks on vulnerability analysis as well as on the development of climate-resilient local Comprehensive Land Use Plan (CLUP) and Comprehensive Development Plan (CDP) prescribed by the internal government.

The Albay Emergency Reporting and Response Tool (ALERRT) is a creature that seeks to encourage the masses to become proactive members of the community by increasing their awareness thereby improving resilience and decreasing vulnerabilities. This will furnish the citizens to have an easy means of reporting any incidents (emergencies, accidents or concerns) requiring response from any local or national government units, allow citizens to have detailed documentation of the event (image/video capture), allow concerned government sector to act based on reported scenario, and track down government actions (Figuracion, Palaoag, Ignacio, & Jane, 2016). The Provincial Information Network on Disaster Occurrences and Threats (PINDOT) is an application produced by Smart Communications, Inc. (Smart) to enable faster coordination during emergencies to facilitate immediate rescue. PINDOT was used as a smartphone application and communication tools set to spread the information of risk, however the province of Albay did not agree with PINDOT to replace the existing risk communication system of APSEMO (Altavas, Lopez-Vito, Mendoza, & Sarmenta, 2015; Salceda, 2012). The system developers of the Rapid Application Development of ebayanihan Patroller: A Crowdsourcing SMS Service and Web Visualization Disaster Reporting System explain the importance to work together in mitigating the effects of natural disasters through the eBayanihan. Through SMS services, the eBayanihan Patroller application allows access to critical information for informed decision-making (Meguerdichian, Slijepcevic, Karayan, & Potkonjak, 2001).

Location Intelligence is seen as most needed and most challenging task in wireless ad-hoc sensor networks. The writers of the WASNs explained that localized algorithms are a peculiar case of distributed algorithms where only a subset of nodes in the WASN participates in sensing, communication, and reckoning.Theydeveloped localized-algorithm to get to the bottom of wireless ad-hoc networks. The localized optimization approach was examined to see replies to fundamental problems in sensor networks: location discovery and vulnerability-based reporting (Bolon, Bull, & Ward, 2012).As mobile networks continue to develop at a high speed, a new tier of services called Location-Based Services (LBS) is coming out. The main question is how Geographic Information Systems (GIS) and geodata could be used in the context of LBS. The authors examine the properties, then relate them to ascertain the needs of LBS to present a pilot system that is using XML-based vector to get city maps that run on Java-enabled mobile terminals, PDAs and smartphones (Virrantaus et al., 2001). The Environmental Systems Research Institute (ESRI) Story Maps are web applications that are newly developed using ESRI's "five principles of effective storytelling" and user responses acquired knowledge can be effective instruments to generate geostatistics (Cope et al., 2018).

The study on "Confronting uncertainty in model-based geostatistics using Markov Chain Monte Carlo simulation" demonstrates simulation wherein the approach automatically scales the orientation and scale of the purported distribution of soil parameters using variogram estimation of soil thickness, kriging of soil pH, and spatial prediction of soil organic C content. The parameter uncertainty constitutes only a small part of total prediction uncertainty for the case studies considered but achieved a 95% prediction of uncertainty in which the result prove that conventional kriging and regression-kriging remain a viable option for production mapping (Minasny, Vrugt, & McBratney, 2011).

Recent spatial analytical web services delineate a visualization for a spatial econometric workbench (Anselin, 2012).Adaptive Distributed GIS modeling is part of a framework based on a multi-dimensional contextual approach that combines user, geographical and device settings.As the spatial attributes of the GIS components categorize different the spatial behaviors reflect user experiences within a group validates the coming and the algorithms developed (Petit, Ray, & Claramunt, 2007).This book is the winner of the 2001 Software Development Jolt Product Excellence Award offers a practical, realistic approach to managing high-speed, high-change software development projects. It shows readers how to increase collaboration and adapt to uncertainty (Highsmith, 2013).

METHODOLOGY

The approach is to design a full blown DRRM-HuRLIS tailored to support LGUs reducing disaster risks to contextually store, retrieve, processes, analyze and visualize DRRM database(s) in a distributed platform allowing various data formats intrinsic to various information system available in local and national levels of government. The

prototyping begins by designing the database schema for DRRM-HuRLIS installed, allowing LGUs to share and manage real-time database(s) or geostatistics across LGUs, concerned government agencies, academe, private entities, NGOs and public. Initially, the human resource entities such as residents, local officials and volunteers, barangays, purok, sitios, road network, temporary evacuation shelters (mostly school buildings) contained in a distance in the 10-kilometer range from the Mayon Volcano crater shall be used to develop and to test the DRRM-HuRLIS. The vulnerable and exposed residents shall be classified incident-commanders or community leaders, emergency responders and volunteers, and residents.

These factors shall be examined further to explore the information aggregation and sharing among responders and community officials, civil society organizations, private sector and unpaid workers, and the public. The database shall be designed reviewing how to bring in qualified professionals who can be tapped during complex emergency or post disaster phase as well as their distribution and availability. The DRRM-HuRLIS shall also outline the sensitivity of the marginalized-groups, PWD, Senior citizens and dependent minors, pregnant mothers, single mothers and other deprived people living within the 10-kilometer buffer shall be preserved and regularly updated.

Figure 1 illustrates how a cloud GISDRRM-HuRLIS can be designed and developed as an adaptive GIS, wherein this information systems allow real-time updating according to several factors and entities. This context model is perceived to answer the gap on protocols during the response stage of DRRM which aims to guide ground commanders and decision makers both at the local and national level of organization and evolution.

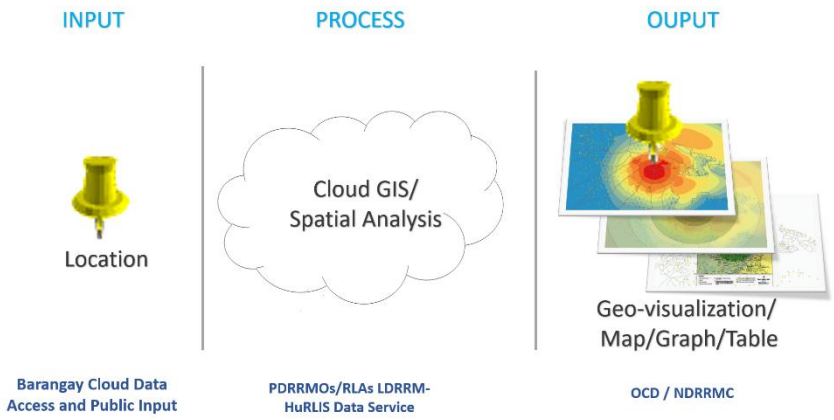

Figure 1. DRRM-HuRLIS Context Model

The prototyping is seen best as an adaptive GIS to build location-based services bounded to an interface that can convey geostatistics and querying functionality in a web as well as collecting real-time data using mobile to store data intelligently using a GIS platform to display geoinformation overlaid in a multi-hazard, vulnerability and exposure maps when integrated becomes a DRRM-HuRLIS database(s). Any location (x, y) can be assessed or measured to analyze the route or nearness to the human resources and/or

facilities relative to DRRM. Figure 2 shows point features (Cyan colored points and rows shown in left and right figures) denoting barangay location (x,y) along with corresponding attribution as shown in the table represent demographic data at barangay level.

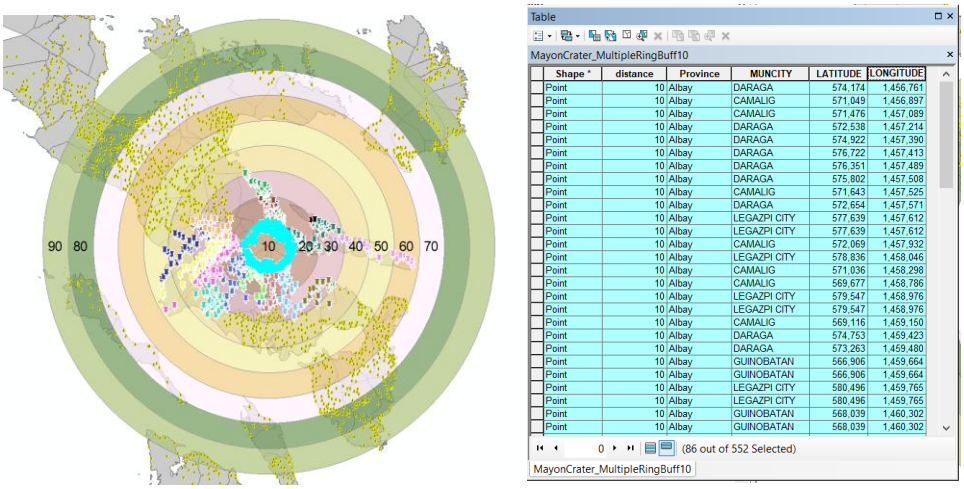

Figure 2.Geostatistics of Communities/Settlements Located within the 10-Kilomemeter Buffer Zone of Mayon Volcano

RESULTS AND DISCUSSION

The study reveals the complexity of integrating the spatial and non-spatial data analysis for DRRM on human resource accounting during the 2018 Mayon Eruption. This hazard event prompted the locals, regular evacuees, responders, volunteers, visitors, travelers, DRRM practitioners and managers coming from the government line agencies, NGOs, and private sectors. Figure 3 illustrates how location services somewhat distributed within the permanent and extended danger zone of Mayon Volcano overlaid with ashfall feature layer enclosed in green and light green polygons shown in the screenshot and overlaid with lahar feature layer enclosed in purple, red and yellow polygon in the right picture shown in on top of the topographic map. Both pictures demonstrate the how location information can be collected and updated then overlaid DRRM thematic maps to guide decision makers and emergency responders. The ring buffers around the Mayon Volcano also imply ashfall could reach 90-kilometer placing Camarines Sur exposed to harmful ashfalls.

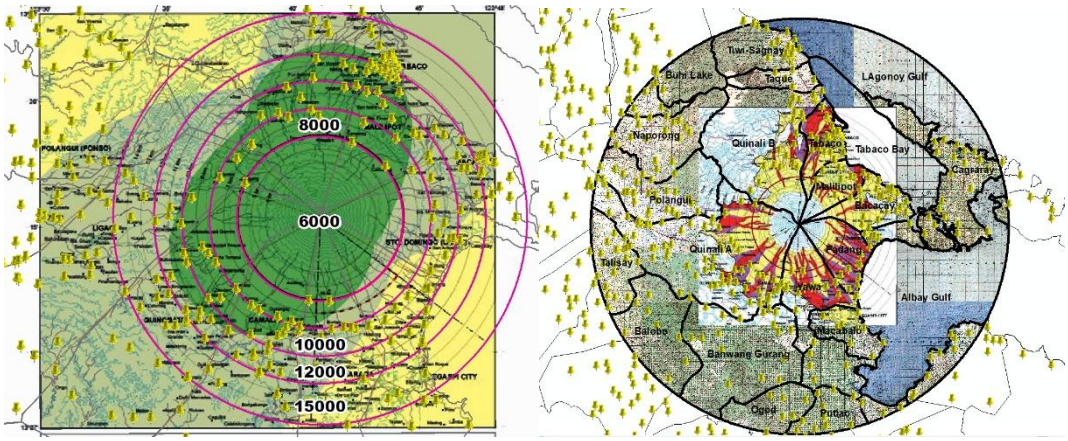

Figure 3. DRRM-HuRLIS Spatial Integration and Geo-visualization

Based on the APSEMO report since 2014, there were 40 barangays or 2,898 families or 15,049 residents situated and presently occupying the dangerous sloping areas around the volcano. Hence, there are some 25 barangays or 7,6 57 households or 36,576 residents situated within the extended danger zone per reports of APSEMO and PHIVOLS. This study brings out the consequential geographical locations of Barangay/Purok/Sitio intersecting the Mayon 6-kilometer permanent danger zone declared by the Sangguniang Panlalawigan ng Albay as shown in figures above to visualize the communities adjacent to the danger zones for pyroclastic, lahar and heavy ash falls. Figure 4 denotes how location intelligence could be mainstreamed in DRRM within the 10-kilometer buffer area symbolized by red line. It also shows how lack of information system dealing with intrinsic real-time exposure, vulnerability from volcanic landscape related hazard events may incorrectly or difficulty in making decisions to resolve without delay.

Figure 4. A Picture of Location Intelligence Spatial Data

An integrated data from different stakeholders and end-users following the communication protocols entails location-intelligence and location services. There are

some systems that are already available but remain fragmented to systematize spatial analysis. The HuRLIS shall openly designed to collect and manipulate Inputs from readily available mobile apps such as GDAC Disaster Alert, PINDOT, eBayanihan, Twitter, Facebook, etc. A cloud-based GIS platform such as the ArcGIS-Pro in is seen best to design and develop an integrated DRRM databases to be maintained at different institutions such as OCDs, PDRRMCs, CDRRMCs, BDRRMCs, RLAs, NGOs, Academe, Media and Communications, Private Sector and the public. Figure 4 along with Figure 5 imply settlements could be a group of households' physical arrangements denoting a barangay or purok or sitios in each local government units.

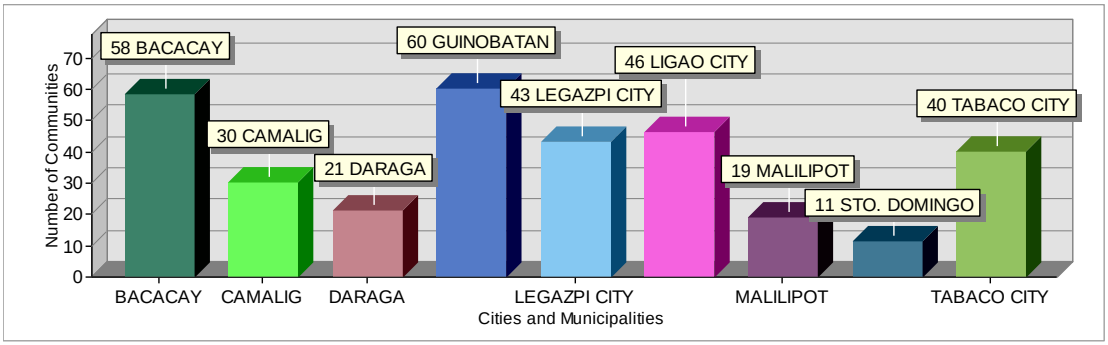

Figure 5. Graph of Settlements within the Extended 10-Km Danger Zones

The OCD Operations Manual states that the protocol when 2 or more provinces are at risk case shall be under the command of OCD thru the National Disaster Risk Reduction and Management Council. Similarly, in the case of 2 or more municipalities or cities the command is under the PDRRMCs; and if the case of 2 or more barangay it is the C/MDRRMC that is in command. However, the manual did not clearly state at what circumspectial stage of DRRM a higher command shall assume the control to respond to complex hazard events (Abante, 2017; Abante et al., 2018a, 2018b). The case of the Yolanda Disaster in the Visayas is one of the sorrowful examples of communication gap and uncertain point in time to elevate higher command to handle complex emergencies, calamities and disasters. This study openly debates the timely collect, store, retrieve, manipulate, and analyze data to share critical information during state of calamity and pre/post disaster stages.

Furthermore, there is so much to learn from the 2018 Mayon Volcano Eruption (Highsmith, 2013; Moore & Melson, 1969; Rodolfo, 1989; Rodolfo & Arguden, 1991; NDRRMC, 2018;Yanase et al., 2010; Lagmay et al., 2015) in which the existing evacuation protocols, and evacuation practices seem no longer appropriate for the situation for example evacuees were brought to uncomfortable and unsafe temporary shelters exposed to useful placing their condition vulnerable respiratory related illnesses. The food and water were seen contaminated causing instantaneous effect on food and water poisoning placing more evacuees sick and tired. The problem in accessing real-time information for risk reduction remains a challenge to the government. [38]

CONCLUSIONS AND RECOMMENDATIONS

Disaster risk relatively increases as population multiplies. As the people continue to dwell inside the 15-kilometer range from the crater of Mayon Volcano, iterative evacuation is obligatory. Thence, it is critical to maintaining public safety and peace and order during disaster and post-disaster phases. Looking after the exposed-human resources during hazard events, it requires real time information on human resource and emergency responders at risk. Real time cloud-based GIS stores data ready for retrieval to analyze situations and scenarios, thus locating trained personnel during emergency response stage is critical considering in some cases responders are also exposed to post disaster risks together with the evacuees during crisis. Crisis maps produced timely for complex emergencies and response operations.

IMPLICATIONS

Making available geostatistics intelligently and scientifically prepared for DRRM at all levels, could cushion the impact of evacuating or relocating residents to an uncomfortable temporary shelters or relocation situations. Otherwise, uncomfortable evacuees or relocated families at their discretion to flee returning to the ground they were toiling to raise crops as their livelihood near the crater of Mayon Volcano or other regions in the Philippines. The absence of innovative and integrated information systems and/or geographic data systems is an impediment to critical decision making that is important to complex emergency and response or impedes recovery from any disruptions or disasters. This concept information model is seen to provide answer to expedite the change in command from 2 or more LGU during and after state of emergency, calamity disaster phase, and post disaster phase. The negative implications include environmental and physical damaging to critical infrastructure and economic activity disruption both at local and internal contexts.

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